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VOLUME 18, 1928

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ERRATA AND ADDENDA

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Page 21: at end of line 14: add "and one other tone."
Page 54, line 10 and footnote 5: for "Todd" read "Ladd."
Page 86, upper table, bottom of second column: for ".65" read ".0361."
Page 86, upper table, end of fifth line: for "0.96" read "0.996."
Page 86, lower table, middle of last column: for ".8355" read ".8535."
Page 126, lines 25 and 27: for "(6)" read "(8)."
Page 150, line 22: for "has" read "have."
Page 157, line 15: for "William" read "Walter."
Page 187, line 21: for "appears" read "appear."

Page 195, line 10, and page 196, line 18: References to the single type specimen of *pusio* are inexact, as shown by two additional citations.—Cope 1869 (Proc. Amer. Philos. Soc. **11**: 178) records having found four or five specimens under a stone not more than 300 feet from the entrance of Erhardt Cave. Horn 1883 (Trans. Amer. Ent. Soc. **10**: 272) states he had seen three male specimens of *pusio*. If these specimens are preserved, they were overlooked as uncertain and subsequent additions in the Horn Collection.—*H. S. Barber*.

Page 223, line 16: for "*pahpatlanuac*" read "*pahpatlahuac*."
Page 224, line 6: for "Nuhuatl" read "Nahuatl."
Page 224, line 22: for "*nora*" read "*mora*."
Page 231, line 48: for "M. E. ODELL" read "N. E. ODELL."
Page 316, line 25: for "6.757×10^{-12} "read" 6.046×10^{-12}."
Page 360, figure 1, last column: for "Carlin" read "Carlim."
Page 375, line 24: delete comma after "fenster."

Page 377, line 26: insert side-head "*Formations of Silurian age.*—" before sentence beginning "The upper part...." and begin new paragraph.

Page 413, line 25: for "absorb" read "adsorb."
Page 423, line 28: for "course" read "coarse."
Page 428, line 36: for "capabara" read "capybara."
Page 432, line 3: for "expansion" read "extension."
Page 488, line 4: for "*melandra*" read "*melanandra*."
Page 564, line 20: for "SCHWARTZ" read "SCHWARZ."

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Vol. 18 January 4, 1928 No. 1

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JOURNAL

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Vol. 18 January 4, 1928 No. 1

PALEOBOTANY.—*Weichselia from the Lower Cretaceous of Texas.*[1] Edward W. Berry. (Communicated by J. B. Reeside, Jr.)

The specimen which forms the subject of the following note is contained in a weathered half of a chert nodule picked up on the surface along the banks of a small upland stream 2 or 3 miles from Sweetwater, Nolan County, Texas. It was collected by Ernest J. Palmer, to whom I am indebted for the privilege of studying it. Over perhaps more than half of Nolan County strata of Comanchean age rest unconformably on the Permian. These Cretaceous rocks are usually considered to represent the Fredericksburg Division, but they have never been studied in detail.

Little is known of the flora of the Lower Cretaceous in the Texas region. The only considerable contribution is that by Fontaine,[2] published in 1893 and describing plants from the Glen Rose beds. About 25 species are more or less satisfactorily named, and the bulk are small scraps of coriaceous conifers and cycads, much macerated. In my review of the Lower Cretaceous floras of the world[3] these plant-bearing beds were correlated with the Aptian stage.

The present specimen is unusual in the mode of preservation. Evidently its presence in the limy marine mud was the locus for the reduction of the silica from solution and the formation of the nodule. It is unique in showing features of the frond hitherto unknown. The specimen shows parts of 8 subopposite pinnae of the usual elongate linear *Weichselia* type: these are disposed at angles of about 45° to the rachis. The rachis at the proximal end of the specimen is 2.5 millimeter in diameter; above the fourth pair of pinnae it becomes abruptly

[1] Received December 1, 1927.

[2] W. M. Fontaine. Proc. U. S. Nat. Mus. **16**: 261–282. 1893.

[3] E. W. Berry. Maryland Geol. Surv., *Lower Cretaceous*, p. 135. 1911.

attenuated and bears pinnules similar to those of the regular pinnae except that they tend to be more remote and to have their proximal margins decurrent—often markedly so. Laminar reduction and coalescence are usual in the distal end of fronds but I know of no recent ferns in which the pinnae retain their normal form and the distal rachis bears what are to all intents and purposes normal pinnules rather than reduced pinnae, although there is an approach to this feature in some species of *Pteris*.

The usual specimens of this widespread form, *Weichselia*, which have been collected and figured by authors, are coarse segments of the median

Figure 1.—*Weichselia reticulata*.

part of fronds or small distal fragments of pinnae. In so far as I have been able to determine from the literature, the present specimen is the first distal portion of a frond that has come to the notice of a paleobotanist. This, I believe, explains the rapid diminution of the rachis, the more ascending pinnae, their more nearly opposite arrangement, and the presence of pinnules on the rachis for some distance below the tip. This last feature of the specimen is unique, so far as I know.

The leaf substance is thick and the specimen shows the impression of the upper side of the pinnules with the characteristic midvein, or the weathered cherty replacement of the leaf substance. In no pinnule can the characteristic venation be positively seen in this coarser friable substance, but a number show suggestions of aerolation much like that seen in sandstone casts of the species, and in one or two of the pinnules sufficient detail is shown to render reasonably certain the conclusion that the venation was of the *Weichselia* type.

The genus *Weichselia* was proposed by Stiehler in 1857 and includes fern-like impressions earlier referred to *Pecopteris* and *Lonchopteris*. It has been discussed in recent years by Seward,[4] Zeiller,[5] Bommer,[6] Gothan,[7] Florin,[8] and Berry.[9] Despite the fact that the first specimens were figured over a century ago (1824) it is by no means settled that it is a fern. It is so often found in sandstone, especially in central Europe, that Gothan suggested that it was a dune plant, and while it might seem that this suggestion is borne out by the xerophytic character of the stomata studied by Florin, its frequent presence in mudstones and in association with lignites renders such an interpretation doubtful.

Bommer's conclusions, based upon the study of material from the Wealden of Bernissart in Belgium, are so at variance with those of all other students that one is forced to conclude that his material was not that of *Weichselia*, but represented *Laccopteris* or *Matonidium*.

It is perfectly conclusive from the material which I have examined that the fronds of *Weichselia* were bi- or tri-pinnate in habit and not digitate. Both Seward and Gothan lump all of the fossil records into a single species which the former calls *Weichselia mantelli* and the latter *Weichselia reticulata*, the latter the correct name if priority is recognized. Many authors dissent from the conclusion that but a single botanical species is represented and it certainly is anomalous to suppose that a single species ranges from the late Jurassic to the Upper Cretaceous and over at least five continents (Europe, Africa, Asia, North and South America). Some years ago Zeiller presented satisfactory evidence for the specific distinctness of the abundant South American occurrences and in this he was followed by the present writer. The genus has

[4] A. C. Seward. *The Wealden flora*, pt. 1, pp. 113–121. 1894.
[5] R. Zeiller. Rev. gén. bot. **25 bis**: 10. 1914.
[6] C. Bommer. Bull. Soc. Roy. Bot. Belg. **47**: 296–304. 1910.
[7] W. Gothan in H. Potonié. Abbild. Beschr. foss. Pflanzen **7** (**126**): 1–114. 1910.
[8] R. Florin. Svensk. Bot. Tidssk. **13**: 305–312. 1919.
[9] E. W. Berry. Johns Hopkins Stud. Geol. **4**: 52–55. 1922.

hitherto been very doubtfully represented in North American Mesozoic strata, but this doubt is more apparent than real, since I have studied a large amount of fragmentary but perfectly characteristic material from the Black Hills, and the present occurrence extends its range to Texas. It has not yet been recognized in the Kome, Kootanie, Potomac, or Pacific coast Mesozoic floras, but these are all so imperfectly known that no conclusions based upon negative evidence are legitimate.

The Texas material lacks the reflexed basal pinnules, which are the most obvious feature of *Weichselia peruviana* and may therefore be referred, at least tentatively, to *Weichselia reticulata,* with the full realization, however, that the latter species is undoubtedly a composite one.

Most authors have assumed that *Weichselia* was a fern, although Florin points out that its stomatal structure is more gymnospermous than filicalian, and it may well be that it represents some Mesozoic cycadophyte. Several authors have figured what they have considered fertile parts of *Weichselia,* but none of these are very convincing nor do they verify one another. Thus an obscurely fertile fragment[10] from the Mesozoic of Japan identified by Nathorst as *Pecopteris geyleriana* is considered by Seward to be a *Weichselia.* Neumann figured[11] what he considered to be fertile pinnules of *Weichselia* from Peru. These appear imaginary to me, and, furthermore, in the large amount of material from Peru that I have seen there has been no trace of fructifications. Trautschold years ago figured[12] an obscure fertile fragment which he called *Asplenites klinensis* from the Klin sandstone of central Russia and which was subsequently considered a *Weichselia.* Finally Gothan (loc. cit. 1910 fig. 5) figured what appears to be a fertile specimen from Quedlinburg, Saxony, showing marginal sporangia. All of these are far from clear and all differ decidedly from one another. The most that can be said is that in the case of the last and most convincing instance cited above, if it be admitted that the object shows fertile pinnae, all it proves is that a form like *Weichselia* from Saxony has fructifications of the type portrayed. It would be unwise to assume that fossils called *Weichselia* from other localities and horizons had similar fructifications.

[10] A. G. Nathorst. Denks. k. Acad. Wiss. Wien. **57:** *pl. 4, f. 3.* 1890.
[11] R. Naumann. Neues Jahrb., Beilageb. **24:** 76. *pl. 1, f. 1a, b.* 1907.
[12] H. Trautschold. Nouv. Mém. Soc. Nat. Moscou **13:** *pl. 20, f. 7.* 1870.

In case of a form-genus like *Weichselia*, as has been abundantly shown in other Mesozoic form genera—*Cladophlebis* for example, one cannot generalize from one instance, and my own feeling is that the botanical affinity of *Weichselia* is by no means settled.

BOTANY.—*Notes on Central American Rubiaceae.* PAUL C. STANDLEY, U. S. National Museum.[1]

A few months ago the National Museum was fortunate in receiving for study from the Botanical Museum of Copenhagen a large number of specimens of plants of the family Rubiaceae, collected in Central America by some of the earliest botanical collectors who visited that region. Of greatest interest were the classic specimens obtained by Oersted, the first botanist who explored Costa Rica and Nicaragua.

Oersted was especially interested in the Rubiaceae, upon which he published an important paper, describing numerous new species, some of which have remained obscure, chiefly because they have not been recollected. Included in the recent sending were most of Oersted's types, particularly in the difficult genus *Psychotria*. In some instances the National Museum was permitted to retain duplicate type material for future reference. In other cases our material has been compared carefully with the types, and the sheets annotated accordingly.

The National Museum has received also on loan a number of type specimens of Central American species of *Psychotria* from the Berlin Botanic Garden. These have made it possible to determine the status of several species not represented previously in the National Herbarium.

The accompanying notes enumerate some of the results of the study of these important collections, for whose loan the writer is deeply indebted to Dr. Carl Christensen and Dr. L. Diels. The reference material now available in the National Herbarium will facilitate materially future study in the United States of tropical American Rubiaceae, above all in the intricate group called *Psychotria*.

PENTODON PENTANDER (Schum. & Thonn.) Vatke, Oesterr. Bot. Zeitschr. **25:** 231. 1875.

An African plant, known to be established as a weed in Guadeloupe. Specimens are at hand also from Central America:

NICARAGUA: Granada, August, 1869, *Lévy* 208.

[1] Published by the permission of the Acting Secretary of the Smithsonian Institution. Received November 26, 1927.

RONDELETIA COSTARICENSIS Standl. N. Amer. Fl. **32**: 61. 1918.

Here belongs *Wendland* 792, from San Miguel, Costa Rica, collected in May, 1857, the specimen in the Copenhagen Herbarium. Oersted recognized the plant as new, and wrote upon the sheet a specific name, never published, alluding to the large stipules.

DEPPEA COSTARICENSIS Polak. Linnaea **41**: 566. 1877.

In the North American Flora (**32**: 90. 1921) this species is reduced to synonymy under *D. grandiflora* Schlecht., and perhaps properly so. The latter is the only Costa Rican species represented in the National Herbarium by recent specimens, but none of these match exactly Polakowsky's type in the Berlin Herbarium. The capsules of *D. costaricensis* are shorter than in typical *D. grandiflora*, and rounded at the base. It is probable that *D. costaricensis* is a distinct species, but further collections are necessary to establish the fact.

BOUVARDIA PALLIDA Standl. Journ. Washington Acad. Sci. **14**: 245. 1924.

Described from the Volcano of San Salvador, Salvador. The species may now be reported from another Central American country:

GUATEMALA: Las Nubes, Jan. 11, 1857, *Wendland* 208.

HOFFMANNIA GESNERIOIDES (Oerst.) Kuntze, Rev. Gen. Pl. **1**: 285. 1891.

Ophryococcus gesnerioides Oerst. Nat. For. Kjöbenhavn Viv. Medd. **1852**: 53. 1853.

The National Museum has received in exchange from Copenhagen a specimen of the type collection (the only one known) of *Ophryococcus gesnerioides*, collected by Oersted in January, 1848, on Mount Pantasmo, Segovia, Nicaragua, at 1,200 meters. Examination of this material proves that Otto Kuntze was correct in referring the plant to *Hoffmannia*. It is a well-marked species, not approached closely by any other Central American representative of the genus. The region in which it grows is little known botanically, and it is not surprising that it has not been found by other collectors. Most species of *Hoffmannia* are narrowly restricted in their distribution.

HOFFMANNIA LONGIPETIOLATA Polak. Linnaea **41**: 567. 1877.

The type, in the Berlin Herbarium, was collected on Cerro de la Carpintera, Costa Rica, *Polakowsky* 134. Although I have paid special attention to the collection of this genus, and have visited the Carpintera twice, I did not find this species there. The type is well matched, however, by the following collections:

COSTA RICA: Viento Fresco, Prov. Alajuela, alt. 1,600–1,900 m., *Standley & Torres* 47766, 47784.

XEROCOCCUS CONGESTUS Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852**: 52. 1853.

The type specimen, in the Copenhagen Herbarium, was collected at Turrialba, Costa Rica, at an altitude of 900 meters, by Oersted. The genus is a quite distinct one, related, evidently, to *Hoffmannia*, and consisting of a single species.

The plant seems to have been overlooked by later collectors in Costa Rica, and no additional material of it was obtained, apparently, until 1924, when I collected a good series of specimens. Further material was gathered in 1925–26, and there are now in the National Herbarium over 20 sheets representing the species. Why the plant should have escaped other collectors it is hard to understand, for it is abundant in the wet mountain forests at middle elevations and it is, moreover, a large showy plant, with dense, bright red inflorescences. The small juicy fruits are white when ripe.

IXORA FLORIBUNDA (A. Rich.) Griseb. Cat. Fl. Cub. 134. 1866.

Although reported from Sapoá, Nicaragua, by Hemsley, this species has not been represented in the National Herbarium by Central American specimens. It may now be reported from Salvador: Between San Miguel and Jocorro, Feb. 2, 1857, *Wendland* 437.

PSYCHOTRIA CHIAPENSIS Standl. Contr. U. S. Nat. Herb. **23**: 1390. 1926.
Cephaelis tetragona Donn. Smith, Bot. Gaz. **61**: 376. 1916. Not *P. tetragona* Seem. 1865-67.

Psychotria chiapensis was based on a single collection, *Purpus* 6963, from Chiapas. The type of *Cephaelis tetragona* was collected at Tuis, Costa Rica, *Tonduz* 11352. I had not seen the type of the latter when *P. chiapensis* was published. The differences between *Psychotria* and *Cephaelis* are altogether artificial, and *Cephaelis* can be maintained only as a matter of convenience. It is difficult to determine where a line shall be drawn in referring plants to the two groups, but it seems preferable to refer this plant to *Psychotria*.

A large number of additional specimens of *P. chiapensis* have appeared in recent collections, and these are listed below. The plant is so widely dispersed that it will be strange if an older name is not discovered for it, but so far I have been unable to find one.

MEXICO: Misantla, Veracruz, *Purpus* 5982. Jovo, *Liebmann* 11771 (Rubiaceae no. 113). Without locality, *Liebmann* 11775, 11770 (Rubiaceae no. 111), 11769 (Rubiaceae no. 93). Matlaluca, *Liebmann* 11768 (Rubiaceae no. 16). Lacoba, *Liebmann* 11773 (C; Rubiaceae no. 92). Tlapacoyo, *Liebmann* 11772 (C; Rubiaceae no. 112).

GUATEMALA: Puerto Nuevo, *Tonduz* 586. Chamá, *Johnson* 248. Finca San Luis, Depart. Retalhuleu, *Rojas* 589. Quiriguá, *Standley* 24691. Escoba *Standley* 24847.

BRITISH HONDURAS: Stann Creek, October, 1925, *N. Stevenson*. Middlesex, *Record* 11.

COSTA RICA: Las Vueltas, Tucurrique, *Inst. Fís. Geogr. C. R.* 12997. Valley of Río Tuis, *Pittier* 8212. Livingston, *Rowlee & Stork* 737.

PANAMA: Lincoln Creek, *Carleton* 86. Western Panama, *Stork* 17. Bocas del Toro, *Carleton* 274.

Known in British Honduras as "casada;" in Guatemala as "palo de agua."

PSYCHOTRIA ELONGATA Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852**: 32. 1853.

This species, collected on the Volcano of Mombacho, Nicaragua (the locality given on the label is "ad Granada"), appears to be a valid one. It is not matched by any Central American *Psychotria* in the National Herbarium.

PSYCHOTRIA GLOMERATA H. B. K. Nov. Gen. & Sp. **3**: 362. 1818.
Psychotria microdesmia Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852**: 36. 1853.

The type of *P. microdesmia*, from Jarís, Costa Rica, is evidently identical with *P. glomerata* H. B. K., a conclusion confirmed by Urban. This species, strangely enough, is not represented in recent Costa Rican collections.

PSYCHOTRIA GRACILIFLORA Benth.; Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852**: 35. 1853.

The type was collected at Naranjo, Costa Rica, by Oersted. It is well matched by the following collections:

COSTA RICA: La Palma, *Standley* 38035, 38200, 33127. La Colombiana Farm, *Standley* 36759. La Ventolera, *Standley* 34715. Cerro de la Carpintera, *Standley* 35521. Suerre, *J. D. Smith* 6602. Cañas Gordas, *Pittier* 11090. Fraijanes, *Standley & Torres* 47573, 47459, 47600. Guápiles, *Standley* 37279, 37051, 37038, 37149. La Hondura, *Standley* 37831. La Tejona, *Standley & Valerio* 45852. Viento Fresco, *Standley & Torres* 47856.

PANAMA: Between France Field and Catival, *Standley* 30178. Fort Sherman, *Standley* 31070.

PSYCHOTRIA GRANDIS Swartz, Prodr. Veg. Ind. Occ. 43. 1788.

Psychotria subsessilis Benth.; Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852:** 32. 1853.

The type of *P. subsessilis* was collected at Turrialba, Costa Rica. The name should be referred to synonymy under *P. grandis.*

PSYCHOTRIA HORIZONTALIS Swartz, Prodr. Veg. Ind. Occ. 44. 1788.

Psychotria longicollis Benth.; Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852:** 33. 1853.

P. longicollis is represented in the Copenhagen Herbarium by several specimens of Oersted's collection from Costa Rica and Nicaragua. The name evidently should be referred to synonymy under the widely distributed *P. horizontalis* Swartz.

PSYCHOTRIA LIMONENSIS Krause, Bot. Jahrb. Engler **54:** Beibl. **119:** 43. 1916.

Psychotria limonensis var. *laxinervia* Loes. Repert. Sp. Nov. Fedde **18:** 361. 1922.

The types, in the Berlin Herbarium, of both the species and the variety have been examined. The variety, from Palenque, Chiapas, differs in no important character from the type of the species, which was collected on Uvita Island, Limón, Costa Rica, *Pittier* 12681. The following specimens in the National Herbarium represent the same species:

GUATEMALA: Escoba, *Standley* 24857, 24822. Puerto Barrios, *Standley* 25084. Torolá, *J. D. Smith* 2042. Escuintla, *J. D. Smith* 2754. Cubilquitz, *Tuerckheim* 8404.

COSTA RICA: Limón, *Cook & Doyle* 440.

PANAMA: Fort Lorenzo, *Piper* 5986. Barro Colorado Island, *Standley* 31313, 40827, 41043.

PSYCHOTRIA MAGNA Standl. Contr. U. S. Nat. Herb. **18:** 131. Feb. 11, 1916.

Psychotria compressicaulis Krause, Bot. Jahrb. Engler **54:** Beibl. **119:** 44. Oct. 4, 1916.

The type of *P. compressicaulis,* in the Berlin Herbarium, *Pittier* 12412, agrees in every respect with that of *P. magna,* from Loma de la Gloria, Panama, *Pittier* 4092.

PSYCHOTRIA MARGINATA Swartz, Prodr. Veg. Ind. Occ. 43. 1788.

Psychotria nicaraguensis Benth.; Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852:** 34. 1853.

P. nicaraguensis is clearly a synonym of *P. marginata,* a fact which has already been published, I believe, by Urban.

PSYCHOTRIA PARVIFOLIA Benth.; Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1852:** 35. 1853.

The type material was collected by Oersted on the Volcano of Barba and at Naranjo, Costa Rica. This species resembles closely *P. graciliflora* in general appearance. In *P. graciliflora* the branches are glabrous and the inflorescence pedunculate; in *P. parvifolia* the branchlets are puberulent and the inflorescence sessile. The following specimens are referable to *P. parvifolia:*

COSTA RICA: Cerro de la Carpintera, *Standley* 35578. La Ventolera, *Standley* 34676. Cerros de Zurquí, *Standley & Valerio* 50396, 50271. Yerba Buena, *Standley & Valerio* 49194. Santa María de Dota, *Standley & Valerio* 44076; *Standley* 42857. Cerro de las Caricias, *Standley & Valerio* 52044, 51953, 52223. Fraijanes, *Standley & Torres* 47571, 47566.

PANAMA: El Boquete, *Maxon* 4958.

PSYCHOTRIA PUBESCENS Swartz, Prodr. Veg. Ind. Occ. 44. 1788.

Psychotria glauca Polak. Linnaea **41:** 569. 1877.

Examination of the type of *P. glauca*, from San José, Costa Rica, *Polakowsky* 377, shows that it is a synonym of the widespread *P. pubescens.* This identification is confirmed by a note by Urban attached to the type sheet in the Berlin Herbarium.

PSYCHOTRIA QUINQUERADIATA Polak. Linnaea **41:** 570. 1877.

Psychotria Morae Polak. Linnaea **41:** 570. 1877.

The types of both species, in the Berlin Herbarium, have been examined. *P. Morae* is merely a form of *P. quinqueradiata* with slightly wider leaves, and it is difficult to understand why it should have been published as a distinct species. The type material of *P. quinqueradiata* is from San José and Carpintera, Costa Rica; that of *P. Morae* from San José. The plant seems to be rare in this region at the present time, but it is one of the common shrubs of Guanacaste. The following collections agree well with the type of *P. quinqueradiata:*

COSTA RICA: El Silencio, Guanacaste, *Valerio* 124. Tilarán, Guanacaste, *Standley & Valerio* 44193, 44231, 44986, 45691. Las Cañas, *Valerio* 111. Quebrada Serena, Guanacaste, *Standley & Valerio* 46135, 46219. San Pedro, near San Ramón, *Tonduz* 17687. La Tejona, Guanacaste, *Standley & Valerio* 45904, 45833. Río Jesús, between San Ramón and San Mateo, *Brenes* 14531. Finca Las Cóncavas, *Standley* 41455. Los Ayotes, *Standley & Valerio* 45479.

PSYCHOTRIA SIGGERSIANA Standl. Journ. Washington Acad. Sci. **15:** 289. 1925.

One additional specimen, probably the first ever collected, may be cited for this species:

COSTA RICA: San Miguel, May 12, 1857, *Wendland* 779.

Psychotria Wendlandiana Oerst., sp. nov.

Shrub 2.5–3 m. high, the branchlets stout, subterete, very densely short-villous with brownish pubescence, the internodes mostly 1–2 cm. long; stipules caducous, thin, oval, 5–6 mm. long, prominently bicostate dorsally, shortly bimucronate at the rounded apex, brownish-puberulent or short-villous; petioles slender, 1–2.5 cm. long, densely short-villous with spreading hairs; leaf blades ovate-oblong to oblong or oblanceolate-oblong, 9–15 cm. long, 3–5.5 cm. wide, gradually or usually abruptly acuminate or long-acuminate, narrowed toward the base but the base itself broad and varying from truncate to deeply cordate, thin, deep green above, glabrous, beneath slightly paler, densely short-villous along the costa, puberulent on the nerves, between them glabrous or nearly so, the costa slender, prominent, the lateral nerves very slender, about 14 on each side, ascending at a wide angle, arcuate, irregularly anastomosing close to the margin; inflorescence terminal, cymose-paniculate, the panicle about 5 cm. long and 4.5 cm. broad, borne on a peduncle 1.5–3 cm. long; panicle composed of about 3 remote whorls of short spreading branches, the branches densely brown-villous with short spreading hairs, the bracts short, ovate, bicuspidate, the flowers sessile in dense glomerules at the ends of the ultimate branches; calyx and hypanthium together 1 mm. long, short-villous, the limb 5-dentate, the lobes broadly triangular, obtuse or acutish; corolla yellow, 2.5–3 mm. long, puberulent outside, the tube cylindric-campanulate, the 5 lobes ovate, obtuse, spreading or recurved, the tube short-villous within the throat; anthers included, inserted at the middle of the tube; style slender, long-exserted.

Type in the herbarium of the Botanical Museum, Copenhagen, collected at San Miguel, Costa Rica, May 13, 1857, by H. Wendland (no. 781). Duplicate specimen of the same collection in the U. S. National Herbarium. To this species are referred the following collections:

COSTA RICA: Guápiles, Prov. Limón, alt. 300 m., *Standley* 37224. La Hondura, Prov. San José, alt. 1,300 m., *Standley* 37773.

The two specimens collected by myself had been recognized as representing an undescribed species, but the material was too imperfect for description. The Wendland specimen in the Copenhagen Herbarium bears Oersted's manuscript name, and is accompanied by an exquisite pen and ink drawing showing the characters of the flowers. *Psychotria Wendlandiana* is a well-marked species, easily recognized by the unusual shape of the leaves, and especially by their cordate or truncate bases.

PALICOUREA SUBRUBRA Polak. Linnaea **41:** 571. 1877.

This appears to be a valid species, of rather rare occurrence. The type in the Berlin Herbarium, from Cerro de la Carpintera, Costa Rica, *Polakowsky* 200A, is well matched by the following collections:

COSTA RICA: Finca La Cima, north of El Copey, *Standley* 42565. Fraijanes, *Standley & Torres* 47579.

PANAMA: El Boquete, *Maxon* 5002.

BOTANY.—Shantzia, *a new genus of African shrubs related to* Gossypium.[1] FREDERICK L. LEWTON, U. S. National Museum.

Several months ago in one of the greenhouses on the grounds of the Agricultural Department at Washington, there came into flower for the first time in the United States a malvaceous shrub having large showy blossoms resembling the flowers of tropical species of cotton. This shrub having been under the observation of the writer for several years and its identity having only recently been established, it is believed that an account of its introduction and identification is worth recording. The plant is one of five grown from seed collected near Kafue, Northern Rhodesia, by Dr. H. L. Shantz, then Agricultural Explorer for the Office of Foreign Seed and Plant Introduction, on December 6, 1919. These seeds were planted in pots in one of the quarantine greenhouses under control of the Federal Horticultural Board,

[1] Received November 23, 1927.

in March, 1920. The young seedlings, when observed by the writer a few weeks later, were found to be apparently identical with other seedlings growing in the same house, under the name *Gossypium*, which had come from seeds collected in the same region in Africa by Dr. J. Burtt Davy of the Department of Agriculture, Union of South Africa, for the Office of Foreign Seed and Plant Introduction, U. S. Department of Agriculture. (*J. Burtt Davy:* no. 63, Matoppo Hills, Matabeleland, S. P. I. 48250; no. 109, Zimba, Northern Rhodesia, S. P. I. 48461; no. 189, Elizabethville, Belgian Congo, S. P. I. 48462.) All of these seedlings after developing their sixth or seventh leaf were checked in their growth and seemed to stand still for several years. It was not until they had been repotted several times into more roomy quarters or removed from the pots and set in open beds under glass that they took on any pronounced growth with the formation of flower buds.

Up to the present, seven plants have come into flower, five from the seed collected by Dr. Shantz, and two from the seed collected by J. Burtt Davy at Elizabethville, Belgian Congo. One of the latter, at the date of this writing, bears two nearly mature fruits.

Dr. Shantz preserved an incomplete herbarium specimen consisting of a short leafy branch and one mature capsule picked from the ground beneath the small tree found by him at Kafue, as the plant was not in flower at the time he was there. The involucral bracts, so important for identification in this group of plants, were wanting and appeared to have been broken off and the other evident characters were not sufficient to enable me to identify the shrub with any known species.

Having very recently come across a paper by Miss E. C. Steedman[2] on the "Trees and Shrubs of Southern Rhodesia" in which there is described under the name: *Thespesia Garekeana*, a shrub called "Wild Hibiscus" or "Mtohwi," the writer has recognized in that description the identity of the unnamed African shrubs.

The name given in Miss Steedman's list was evidently a typographical error for *Thespesia Garckeana*, credited in Index Kewensis to Ferdinand Hoffmann. The reference there given, however, disclosed the fact that a copy of Hoffmann's paper was not to be found in any library in Washington. Through the courtesy of the Arnold Arboretum and the U. S. Department of Agriculture, the writer was enabled to ex-

[2] STEEDMAN, E. C. *Trees and shrubs of Southern Rhodesia*, Pt. 1. Proc. Rhodesia Sci. Assn. **24** (1924–1925): 13, *pl. 11*, Bulawayo, 1925.

amine a copy of Hoffmann's inaugural dissertation published for the University of Jena in 1889, and containing the original description of his *Thespesia Garckeana.*

Because of the apparently very limited distribution of Hoffmann's inaugural dissertation, at least in this country, the original description of this species is given herewith:

THESPESIA GARCKEANA Fred Hoffm.[3]

Arborea? ramuli foliaque novella albido- vel ferrugineo-tomentosa; folia petiolata, cordato-rotunda, triloba lobis rotundatis, coriacea, supra stellato-aspera, subtus tomentosa, 7-9 nervia nervo medio subtus uniglanduloso; flores axillares solitarii; pedicellus 2 cm. longus, apice articulatus; bracteolae 12, lanceolatae, margine saepe complicatae, calyce duplo longiores; calyx cupuliformis truncatus integerrimus; stylus apice clavatus, 5-sulcus, albido villosus; stigmata 5, sessilia, e summo styli radiantia, sigmoidea; ovarium 5-loculare loculis pauci-ovulatis.

"Gonda, 1. Nov. 1882, V. H. No. 145a." Wahrscheinlich ein Baum. Zweige stielrund, die jungeren mit gelbweissem schülfrigen Sternfilz bedeckt. Blattstiel 5 cm lang, weiss-sternfilzig. Blattfläche 10 cm lang, herzförmig-rundlich mit 3 abgerundeten Lappen, lederig, beiderseits sternhaarigfilzig, oberseits, wenn ausgewachsen, rauh, 7-9 nervig, der mittlere Nerv unterseits etwa 1½ bis 2 cm über dem Blattstiel eindrüsig. Blüten einzeln, blattwinkelständig, ihr Stiel 2 cm. lang, an der Spitze gegliedert, ebenso wie der Kelch graubraun- der grauweiss-sternfilzig. Die Knospen sind kugelig, cr. 2 cm lang; der Aussenkelch zeigt 12 lanzettliche meist am Rande nach innen imgebogene und daher pfriemlich erscheinende, cr. 1 cm lange Blättchen, die den becherförmigen, ganz ungeteilten Kelch etwa um das Doppelte übertreffen; Staubblätter sehr zahlreich, ihre Säule oben gezahnt; Griffel keulenförmig, nach oben zu 5-rinnig und in den Furchen weiss-wollig; die 5 vom Scheitel des Griffels S-förmig ausstrahlenden Narden sind ebenfalls gefurcht; Ovarium 5-fächerig.

Durch die abgerundeten Blattlappen und die 12 Aussenkelchblätter leicht kenntlich.

Miss Steedman states in her paper:[4]

"This shrub or small tree is abundant on the gold belt and is difficult to get rid of when once it is established, owing to the suckers. The wood is soft and pliable, and the long shoots are used as whip sticks by the natives. The bark is grey and smooth and the inner bark is used for fiber."

The following is quoted from a letter from Miss Steedman to the writer, written from Gwelo, Southern Rhodesia:

"The shrub, *Thespesia Garckeana,* is very common around here. It has an underground rooting stem and it spreads all about. It is in flower now

[3] HOFFMANN, FERDINAND. *Beiträge zur Kenntnis der Flora von Central-Ost-Afrika.* Inaugural-Dissertation of the University of Jena. p. 12. Berlin, 1899.

[4] STEEDMAN, E. C. *Trees and shrubs of Southern Rhodesia,* Pt. 1. Proc. Rhodesia Sci. Assn. **24** (1924–1925): 13, *pl. 11,* Bulawayo, 1925.

Fig. 1.—*Shantzia garckeana.* Upper portion of plant flowering in greenhouse of U. S. Dept. Agr., April, 1926. Grown from seed collected by Dr. Shantz at Kafue, Northern Rhodesia. For. Pl. Introd. No. 49590. (Nat. size.)

Fig. 2.—*Shantzia garckeana.* Upper portion of plant growing in greenhouse of U. S. Dept. Agr., Oct., 1927, from seed collected by Dr. Shantz at Kafue, Northern Rhodesia. For. Pl. Introd. No. 49590. A. Mature fruit collected by Dr. Shantz at Kafue, Dec. 6, 1919. For. Pl. Introd. No. 49590. U. S. Nat. Herb. No. 1,235,736. B. Mature fruit collected by J. Burtt Davy at Zimba, 1919. For. Pl. Introd. No. 48461. (All nat. size.)

(December 28). I am always rooting it up. With regard to your question as to the fruit being edible: The inner layers of the pericarp become glutinous enclosing the seeds. The natives peel off the rind and suck this part, spitting out the seeds. It induces a great flow of saliva, hence the Dutch name "snot apple,' from the verb *snotteren* to snivel. Later the layers dry up and the fruit dehisces by five valves. The fruit to eat must be gathered when it is green and juicy. Europeans don't eat it, except children. Another interesting thing about this shrub is that it harbours the so-called cotton stainer, a red and black beetle (*Dysdercus*), so, as we are just beginning to cultivate cotton in Southern Rhodesia, we think we should destroy the shrub."

The mucilaginous property of the inner layers of the pericarp mentioned by Miss Steedman was observed by the writer when examining the dried capsule. One of the five valves was soaked for a few hours in a large test tube in about five cubic centimeters of water. The mucilage thus extracted formed so stiff a gelle that it could not be poured out of the tube. A valve from a capsule of ordinary cotton subjected to the same conditions yielded only a slight amount of mucilage.

Several authors have at various times placed in the genus *Thespesia* five or six quite different species of tropical trees or shrubs having as a common characteristic an involucre composed of from 3 to 12 narrow bracts, adnate to the base of the calyx, which are dropped before the opening of the flower. A careful examination of the gross morphology of all of these included species develops differences far more fundamental than their agreement as to the form of involucre, so that the reference of several of them to other genera is regarded by the writer as justifiable. The Rhodesian shrub described above is one of these and it is further believed that it represents a new genus which the writer takes pleasure in naming in honor of Dr. Homer L. Shantz, who first brought it to his attention.

Shantzia Lewton, gen. nov.

Shrubs or small trees, 2 to 5 meters high; woody throughout. Leaves petiolate, cordate, entire or lobed, palmately veined, with a slit-like nectary on the mid-vein below. Flowers usually single in the axils of the uppermost leaves; borne on short fruiting branches usually formed of but one internode and sometimes bearing a leaf. Peduncle bearing at its base 2 subulate, deciduous bracts. Involucre formed of 9 to 11 linear caducous bracts. Calyx cupuliform, entire, or with 1 to 5 minute teeth. Ovary 4- to 5-celled with 2 or more ovules in each cell. Capsule ovoid or obovoid, ligneous, opening tardily, the valves containing much mucilage and sugar. Seeds obovoid, angled on the ventral side, rounded on the dorsal, densely covered with short reddish-brown tomentum. Cotyledons punctate with brown dots. Species two or three; Southwest Africa.

TYPE: *Thespesia garckeana* Ferd. Hoffmann. Two specimens in the U. S. National Herbarium represent the genus: Sheet no. 1,235,735, a specimen grown in a greenhouse on the grounds of the Department of Agriculture in

Washington, from seed collected by J. Burtt Davy, no. 189, Foreign Seed and Plant Introduction no. 48462; sheet no. 1,235,736, collected by Dr. H. L. Shantz, no. 325, at Kafue, Northern Rhodesia, Foreign Seed and Plant Introduction no. 49590.

Shantzia may be distinguished from *Thespesia* by (a) its regularly dehiscing capsule, with thick woody valves containing sugar and a great quantity of mucilage; and (b) the involucral bracts numbering 9–11 instead of from 3–5.

ETHNOLOGY.—*The melodic formation of Indian songs.*[1] FRANCES DENSMORE. Bureau of American Ethnology.

The study of Indian music must be done with little coöperation on the part of the Indian beyond his willingness to sing into the horn of a phonograph. If an old song is under consideration he will say that it was received in a dream—perhaps by his grandfather. If one asks how his grandfather prepared himself to receive the song, the Indian replies, "By going without food, and going away by himself for several days." One may ask, "Did you ever see your grandfather?" The reply will probably be, "I do not mean my father's father. I mean a man who lived very long ago. Maybe my father's grandfather." The next question might be, "Where did you learn that song?" The Indian might reply, "From my father. That song is handed down in my family." The foregoing would be a typical conversation except that its facts are too familiar for such detailed inquiry. Many songs are also obtained from old men who themselves have received them in fasting dreams.

The first student of Indian music was Theodor Baker who wrote that "The Indians say that the songs connected with religious concepts were of supernatural origin and that the newer songs are only imitations of these songs."[2] The Indians had nothing corresponding to our popular music and it appears that practically all the old songs were received in dreams. This was the observation of Miss Alice C. Fletcher and is that of the present writer.

It is scarcely necessary to state that the fasting dream (or trance) was the means by which the old Indians believed that they received enlightenment on all important subjects. In a dream the medicine man accompanying a war party received knowledge of the enemy's location, or a doctor learned what ailed his patient, or a man located lost articles. If the dream promised power to accomplish some difficult undertaking there came to the mind of the dreamer a song which

[1] Received November 23, 1927.

[2] BAKER, THEODOR. *Uber der Musik der nordamerikanischen Wilden.* Leipzig. 1882.

he was told to sing in order to obtain the promised power. It is apart from the purpose of this article to discuss the stimulus to the brain produced by lack of food, and the interesting element of rhythm presented by the resultant song. The data are sufficient to show the futility of searching in such material for a conscious, preconceived tonal system. There is a wide gulf between a belief in a dream and the knowledge of the monochord and its mathematical divisions which formed the basis of the musical system of the Greeks.

Turning from the realm of inspiration we seek information concerning the actual composition of songs. For example, the Indians say that a returning war party composed a song concerning its victory, composing the song in one of its camps and singing it in the victory dance that followed its return. If there were a "professional musician" or some person corresponding to a ballad-singer in the war party we should find that the composing of the song was entrusted to him. Instead, I am informed that "the warriors made up the song," indicating that several men collaborated in producing the melody. A song was recorded among the Sioux that was the work of several men in cooperation. The song differed from the older songs in a lack of unity and coherence. It contained too many peculiarities. The same quality characterised a Winnebago song said to have been composed in the same manner. A song was never changed after being approved by the group composing it, but no trace of a system in their composition has been found.

In some tribes it appears that a steady physical motion was considered an aid to musical composition. Thus two women at Neah Bay, Washington, said that when they were young girls they composed songs together when sitting in a swing, and that a young boy was accustomed to swing them while they "made up songs." They said that they "thought of something pleasant, were swung to and fro, and pretty soon they could sing about what they were thinking." An Indian of British Columbia said that songs "came to him" as he walked, and the Indians living on the west coast of British Columbia are accustomed to go out in a "gasoline boat" when they wish to compose songs, remaining in the boats until the song is finished. None of these procedures suggests a definite system governing the form of musical compositions, nor a technical training as preparation for the work of producing songs. If these are lacking, are we not confronted by the sense of pleasure as a determining factor in the selection of tones?

It is the purpose of the present article to show, by accumulated data, that the tones which give pleasure (or satisfaction) to the Indians bear a relation to the natural laws of sound. It will be shown that the upper partials of a fundamental constitute the framework of many Indian melodies. Whether the Indians received this suggestion from sounds in nature, from the sound of the wooden flute, or from very early contact with the white race must remain a matter of conjecture. The writer has been informed of a statement that "In 1640 or near that date, the missionaries to the Indians found that they took very kindly to the hymns and other songs of the white man and were often heard singing them." This was mentioned "in contrast with the Japanese of about 1850, the Egyptians and Syrians, all of whom when visiting England were much bored with European music." It is known that music travels far among primitive folk and we cannot, at this time, determine to what extent the songs of the Atlantic seaboard were carried to the middle west, but, in the writer's observation, the upper partial tones of a fundamental are more in evidence among the songs of Indians belonging to Algonquian and Siouan stocks than among the Indians of the Mexican border and the Northwest Coast. It is scarcely possible to trace the antiquity of a song more than 150 or 200 years, which does not bridge the distance to the first contact between the Indians and members of the white race.

The permanence of a melody is proven by repeated renditions by the same or other singers. If a song is repeated after the lapse of days or months it will be found, on comparing the phonograph records, that the tempo and pitch as well as the note-values are identical, providing the records are made by a competent singer. The repetition is made with the accuracy that depends upon memory without the aid of any notation. It is the writer's custom to record several consecutive renditions of a song, the phonograph cylinder sometimes containing 8 or 10 renditions, these being uniform in every respect. The rhythmic accuracy is like that of a metronome except in songs where a *rubato* is employed, as in some of the songs for treating the sick. The melodic accuracy is naturally that of a human voice, not a mechanism, and, if recorded by a tonodeik or similar apparatus, would not show the accuracy of a cultivated voice nor of an instrument. We must allow the Indian the same latitude in "keeping the key" that we allow a member of our own race, and even more. If we do not attribute the slight variations in pitch to his peculiar manner of singing, combined with the human quality of the material under observation, we must assume that he has an ability to produce and consciously repeat minute gradations of pitch, his ability far surpassing that of our own singers. Such gradations of pitch are used intentionally and for effect by violinists but not by our singers. There is no doubt, as indicated, that the Indian produces tones distant from one another less than the interval of a semitone but his manner of tone production is entirely different from ours and the tone may often be described as unfocused. It should be clearly understood that the piano scale is used as standard of measurement by the present writer because the deviations from that scale are not given by the Indians with a consistency and sureness that justifies the use of a more finely graded standard. It would scarcely be possible to show, by any system of notation, the gradations of pitch that occur in the singing of many Indians during a period of an hour, and it would be even more impossible to study the music of a tribe or group of tribes by such a method. Individuals differ, the singing of some persons being more steady in tone and easier to transcribe in ordinary notation than the singing of others.

The student of Indian music must learn to detect the kernal or center of gravity in the tone produced by the Indian. In my observation, the Indian usually sings the tones corresponding to the octave, twelfth and fifth of the piano scale with an accuracy that would be considered acceptable in a singer of our own race. Other musicians listening to records of Indian songs have corroborated this statement. Generally speaking the intonation on the fourth and seventh above the keynote are the most uncertain, but these are the tones that occur with least frequency in Indian songs. The major third is usually given with reasonable accuracy but the interval transcribed as a minor third is more often a distinct non-major third than a minor third according to the piano scale. The accuracy of intonation varies from the overtones of a fundamental, already indicated as reasonably correct, to tones which are exceedingly difficult to determine and transcribe. If a tone is persistently sung less than a quarter tone above the pitch of a tone in the piano scale it is the writer's custom to place a plus sign above the note in the transcription. A tone persistently sung less than a quarter tone below the piano pitch is indicated by a minus sign below the note. These are the only deviations from ordinary musical notation used by the writer, the purpose being to show the characteristics of Indian songs in a simple manner, thus making it possible to analyse a large amount of material.

Mention should here be made of the Indian's ability to keep the intonation on the octave when it occurs as the boundary of a melody as well as when it is a direct progression. Many Indian songs have a compass of 8 tones and the singer may vary the accuracy of the intervals within that octave, but the highest and lowest tones of his song will be an octave apart. The same feeling for a true octave appears in songs of larger compass, and is the more interesting as the lowest tone of the octave frequently does not appear until the close of the song.

In all considerations of Indian music it should be borne in mind that our conclusions are based upon the evidence of a recording apparatus that is adapted to field work and is used under varied conditions. We have not a laboratory apparatus nor ideal working conditions but we have reliable old-time Indians, working under circumstances that place them at their ease. Whatever peculiarities appear in the record are natural to the Indians, who are conscientiously trying to sing their old songs correctly in order that they may be preserved for posterity. The same Indians, if taken to a city where a more elaborate mechanism were available, might be less able to concentrate upon their singing and thus give less reliable material. In a majority of her work the writer has used a Columbia graphophone, with specially constructed recorders. This is manipulated as quietly as possible, every effort being used to keep the Indians in an easy, happy frame of mind. The work is done chiefly with men between the ages of 55 and 80.

In some Indian songs the key is established (to use the musical phraseology) while in a lesser number of songs the relation of the tones to a keynote is less in evidence, or altogether absent. The descriptive analyses that follow such songs contain a statement that the signature indicates the pitch of certain tones but does not imply the existence of a key, in the musician's use of that term. The signature is a simpler manner of indicating the pitch than the use of sharps and flats, scattered throughout the melody.

The question may be asked whether the selection of a keynote is not a matter of education and therefore not germane to Indian songs. It has been shown that the Indian apparently has no musical system, and the designation of keynotes in his songs should not be understood as implying that he has such a system. We are accustomed to keynotes and a melody is more readily understood if we refer its tones to one basic tone. Moreover, the use of a fundamental and its upper partials as the framework of an Indian melody seems to justify the designation of the fundamental as the keynote. In songs without such a framework the keynote is inferred from the tonal material, the final tone of the song, except in a very small number of instances, being the tone which we would consider the keynote in a melody of our own race, or else its third or fifth. Thus if a song contains the tones D, E, F sharp, G, B and C sharp, with D and F sharp as prominent accented tones and D as the final tone we seem justified in giving the transcription the signature of the key of D and analysing the song in that key. It will be observed that in the tone-material cited the fifth is absent; the same course would be followed if the seventh were omitted, provided the sequence of tones suggested D rather than G as keynote. In a typical melody having the upper partials of D as its framework the principal accented tones would be D, F sharp and A, but, in many melodies, these tones appear only at the opening or at the close, the remainder of the melody being in a free form.

Only 6 per cent of the Indian songs collectively analyzed (987 in number) contain all the tones of the diatonic major or minor scale. The five-toned scales (described below) constitute 32 per cent while the remainder of the songs contain from 3 to 7 tones in a wide variety of groups. Next to the largest group is that of songs containing only the tones of the major triad (fundamental and its simplest overtones) this group constituting 14 percent of the total number. Songs containing four tones are classified as based on a major or minor triad with one additional tone. Songs that contain five tones (apart from the accepted five-toned scales) or six tones are classified as lacking certain tones of the complete octave. The largest of these groups are those in which the seventh is lacking, these groups constituting 18 percent of the total. The percentage of songs containing six tones of the octave is not large enough, in the writer's opinion, to justify the use of the term "six-toned scale." In the matter of five-toned scales, the writer has adopted the designation used by Helmholtz, giving no consideration to songs omitting tones other than the fourth and seventh of the major diatonic octave. This is the familiar series of tones represented by the black keys of a piano. In the designation by Helmholtz, the first five-toned scale (if thus played on a piano) had C sharp as its keynote, the second and fourth have D sharp and F sharp respectively, the third has G sharp and the fifth has A sharp as its keynote. The second five-toned scale, commonly called the minor pentatonic, occurs in 10 percent of the group already cited, while the fourth five-toned scale, commonly called the major pentatonic, appears as the basis of 20 percent of this group. The first five-toned scale forms the tone-material of 1 percent, and the fifth five-toned scale appears in only 2 of the 987 songs thus analysed. The keynote, in these as in the diatonic major and minor keys, is determined by the tones and their sequence, the keynote being that which would be so designated if the melody had originated in our own race.

The songs comprised in the foregoing analyses are those of the following tribes: Chippewa, Sioux, Ute, Mandan, Hidatsa and Papago.

The songs of the Pawnee, Yuma, Cocopa, Yaqui, Makah, Menominee and Winnebago, as well as songs of the Indians of British Columbia and Vancouver Island, and songs of the Tule Indians of Panama, are not included as yet in the large total, but each song has been analysed. In some instances the study of the tribe has not been completed and the material is not considered "closed" until this has been done. The Pawnee, Menominee and (probably) the Winnebago will be found similar in characteristics to the first five of the tribes in the collective analysis but interesting differences appear in the songs of the tribes living on the Mexican border and on the Northwest Coast. For example, a structure that seems peculiar to the Makah is small in compass, usually consisting of four tones with either the second or third of the compass as the most prominent and final tone. A comparison of the music of the several tribes is too large a subject for present consideration. About 1700 songs have been recorded, transcribed and analysed during the writer's study of Indian music for the Bureau of American Ethnology, covering a period of more than twenty years. Almost two hundred songs are awaiting transcription, and the large number of songs heard but not recorded has afforded valuable material for comparison.

In the method of analysis, already mentioned, the songs are classified under the following headings: (1) Tonality, determined by the distance of the third and sixth above the keynote, (2) Relation of the first tone to the keynote, (3) Relation of the last tone to the keynote, (4) Relation of the final tone to the compass of the song, (5) Number of tones (scale-degrees) comprised in song, (6) Tone material, (7) Accidentals, (8) Structure, melodic or harmonic, (9) First progression, upward or downward, (10) Total number of progressions, (11) Intervals in downward progression, and (12) Intervals in upward progression. This is followed by a similar tabulation of rhythmic characteristics. These bases of classification were devised for convenience. Consistently and steadily used they obviate all "tests by the ear," which lead to dangerous generalizations. They are a system of measurement in order that collective results can be determined. Nothing is claimed for them beyond the foregoing statements. In the songs of the Mexican border and the Northwest Coast there are a considerable number of songs now classified as "irregular." They are repeated accurately, by reliable singers, but they do not conform to the above system. Some of these contain a majority of the tones of the diatonic octave but do not end on the first, third, fifth or octave. Others are entirely free in melodic form. Further study of this group may produce interesting results but at present there is no attempt to explain them.

It is often said that "Indian songs have a minor sound," but the collective table of 987 songs shows 53 percent having a major and 42 percent having a minor tonality, a majority of the remainder being "irregular," or lacking the third above the keynote, while 5 songs have two sections, one being major and the other being minor in tonality. In this table, 20 percent begin on the octave above the keynote, 10 percent on the twelfth, 30 percent on the fifth, and 10 percent on the keynote. The songs ending on the keynote comprise 54 percent, on the fifth 33 percent, and on the third 10 percent, showing the feeling for the upper partials already mentioned.

The impression of a "minor quality" in Indian songs may be explained by the frequency of the minor third which constitutes 30 percent of the descending intervals and 25 per cent of the ascending intervals in the total of 987 songs. The only interval exceeding this in frequency is the whole tone which, with a semitone, often comprises a minor third with a "passing tone." The total number of intervals in these songs is 26,777 and the average size of an interval is 3.08 semitones. As a minor third contains 3 semitones it will be seen that the average size of an interval is approximately a minor third. The difference between the tribes is very slight in this respect.

There is a general impression that Indian songs are descending in trend. This is shown by the fact that 60 percent of the 26,777 intervals in the songs under collective analysis are descending intervals. Sixty-one percent of the songs begin with a downward progression, and in 74 percent of the songs the last tone is the lowest tone of the compass. It is particularly interesting to note this descending trend since the tone material of Indian songs has been shown to be so closely connected with the ascending harmonic series. Occasionally an Indian sings the fundamental tone of this series softly before beginning to record his song, as though "getting his balance," but this does not occur with sufficient frequency to be considered important.

Mention should be made of the large number of songs that a good Indian singer has at his command. The writer has recorded more than eighty from some individuals and been assured that a good singer has several hundred songs held in his memory. In many ceremonies the insistence upon accuracy is so strict that a singer who makes a mistake in a song must pay a heavy fine and begin the song over again. Songs are learned by Indians visiting another tribe and accredited to that tribe when used. It is also customary to credit a song to its origin within the tribe. Thus the songs belonging to a medicine man long dead are said to have been his property, and the songs in honor of warriors are kept by generations that have forgotten his deeds of valor.

The recording apparatus of the phonograph or dictaphone has made possible the preservation of Indian songs, but the opportunity for that work is rapidly passing away. The old songs are remembered correctly, with the information pertaining to them, by only the old men. It is possible to obtain old songs from men in middle life but they often do not know the meaning of the words and are uncertain of the information regarding the songs, beyond the fact that the songs belonged to the previous generation. In some instances I have recorded a song from an old man on one reservation and a middle-aged man on another reservation and found that the latter had smoothed out the interesting irregularities in the rhythm. The young Indians, now in Government Schools, have little interest in the old songs except as they occasionally learn an old melody in order to adapt it for use in a school band or orchestra. There will be no trace of the songs in imperishable stone for future archeologists to decipher. The songs given to human beings by the spirits of the night, the morning star, the dwarfs of the mountains, the birds of the air and the animals of the plain—these will have gone forever. The Indian of the present day does not hear these voices. He can only say, "My grandfather received this song in a dream."

SCIENTIFIC NOTES AND NEWS

At the celebration in honor of the Centenary of Marcelin Berthelot held in Paris on October 24, and several days following, the Washington Academy of Sciences was represented by Dr. W. E. Tisdale of the International Education Board, who on behalf of the Academy presented an address at a formal meeting presided over by Monsieur Doumergue, President of the French Republic.

On the occasion of his seventieth birthday, August 13, 1927, in recognition of his forty years of research work in Tropical America, the honorary degree of Doctor of Natural Sciences was conferred upon H. Pittier by the University of Lausanne, Switzerland, "to distinguish the merits of his work concerning the natural history of Canton de Vaud (Switzerland) and Latin America and to acknowledge his efforts in the promotion of colonial agriculture."

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, January 11.	The Geological Society.
	The Medical Society.
Thursday, January 12.	The Chemical Society.
	PROGRAM: Address of retiring president, Dr. Edgar T. Wherry.
Saturday, January 14.	The Philosophical Society.
	The Biological Society.
Tuesday, January 17.	The Anthropological Society.
	Annual Meeting
	The Historical Society.
Wednesday, January 18.	The Medical Society.
	The Washington Society of Engineers.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated Societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth on each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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VOL. 18 JANUARY 19, 1928 No. 2

BOTANY.—*Twelve new American Asteraceae.*[1] S. F. BLAKE, Bureau of Plant Industry.

This paper contains descriptions of twelve new species of American Asteraceae which have been found in the course of identification of material of that family recently received at the United States National Museum and among specimens lent for study by the curators of the Kew Herbarium, the British Museum of Natural History, and the Museum d'Histoire Naturelle, Paris. A few new names and transfers are also included.

Erigeron porteri Blake, nom. nov.

Erigeron glandulosum Porter in Porter & Coulter, Syn. Fl. Colo. 60. 1874. Not *E. glandulosum* Walt. Fl. Carol. 205. 1788, nor Poir. Encycl. **8**: 487. 1808, nor Hegetschw. Fl. Schweiz 840. 1840.

The name *Erigeron glandulosus* Porter, in common use for a plant of Colorado and Wyoming, is not available for this species owing to the previous use of the same specific name by Walter, Poiret, and Hegetschweiler. Walter's name, omitted from the Index Kewensis and not referred to in Gray's Synoptical Flora, seems from description to refer to *Chrysopsis mariana.* Poiret described under the same name the plant now known as *Chrysopsis graminifolia* (Michx.) Ell., citing Michaux's name (*Inula graminifolia*) and Walter's as synonyms, the latter with doubt. Hegetschweiler's homonym is retained by Schinz and Thellung for a species of *Erigeron* of the Swiss Alps. The last name was omitted from the original volumes of the Index Kewensis, but is included in the fifth supplement, where its date is wrongly given as 1839.

Rumfordia guatemalensis (Coulter) Blake.

Tetragonotheca guatemalensis Coulter, Bot. Gaz. **16**: 99. 1891.
Rumfordia verapazensis Blake, Contr. U. S. Nat. Herb. **22**: 609. 1924.

The type of *Tetragonotheca guatemalensis* Coulter (*J. D. Smith* 1592, Senahú, Dept. Alta Verapaz, Guatemala), recently given by Capt. John

[1] Received November 23, 1927.

Donnell Smith to the U. S. National Herbarium, is the same species as *Rumfordia verapazensis* Blake, described from the Finca Sepacuité, in the same Department. The lower leaves have deltoid, membranous blades, about 18 by 18 cm., acuminate, cordate at base, hastately about 2-toothed on the basal lobes with short, acuminate teeth 1–1.5 cm. long, and with 1 or 2 small deltoid teeth on each side above the base; the petioles are 10–11 cm. long, narrowly cuneate-winged to base.

Aspilia quinquenervis Blake, sp. nov.

Shrub; branches densely strigose; leaves lance-ovate or oblong-ovate, large, long-acuminate, rounded at base, obscurely serrulate, 5-plinerved, strigose or antrorse-hirsute on both sides, on naked petioles; heads medium-sized, in a terminal cyme of 3, radiate, yellow; involucre 6–8 mm. high, slightly graduate, the outer phyllaries obovate, strigose and ciliate, the loose ovate acutish herbaceous tips about equaling the indurate base; rays short, little exceeding the involucre; pappus without awns.

"White-wooded shrub, the branches thin, up to 5 m. long," striatulate, about 3.5 mm. thick, strigose with tuberculate-based hairs; internodes 3.5–6 cm. long; leaves opposite; petioles slender, tuberculate-strigose, sulcate above, 7–15 mm. long; blades 10.5–18 cm. long, 3–6 cm. wide, serrulate (teeth short, callous, 4–8 mm. apart), papery, above dull green, evenly and somewhat harshly tuberculate-strigose or antrorse-hirsute, beneath scarcely lighter green, antrorse-hirsute on veins and surface with scarcely tuberculate-based hairs, quintuplinerved, the two pairs of lateral veins arising within 1.5 cm. above base of blade, the principal veins prominulous on both sides, not obviously reticulate; heads (rather young) about 1.4 cm. wide, in a terminal 3-headed cyme and solitary in the uppermost axils, on slender strigose peduncles 2–4 cm. long; disk 8–9 mm. high, 7–9 mm. thick; involucre campanulate-subglobose, 6–8 mm. high, 3–4-seriate, the phyllaries rather few, the 2–3 outer series obovate to oval-obovate, 3–5 mm. wide, below indurate, strigose, and ciliate, the equal or longer herbaceous tips loosely spreading, obscurely callous-tipped, strigose and strigillose on both sides, the inner phyllaries scarcely longer, with essentially glabrous or obscurely strigillose, short-ciliate, ampliate, submembranous tips; rays about 8, yellow, neutral, the lamina about 5.5 mm. long; disk corollas puberulous on teeth, otherwise glabrous, 5.2 mm. long (tube 1.5 mm., throat 3 mm., teeth 0.7 mm.); pales obtusely acuminate, about 8 mm. long, keeled, ciliolate on keel and margin, otherwise glabrous; disk achenes (immature) nearly linear, 5.5 mm. long, densely pilose above, glabrous toward base; pappus a crown of lacerate, ciliate, connate squamallae about 0.5 mm. long and 2 trigonous, ciliate teeth about 1 mm. long.

COLOMBIA: In bushes, Rio Palace, highlands of Popayán, alt. 1500–1800 m., February, *Lehmann* (type in Kew Herb.; photog. and fragm., U. S. Nat. Herb.).

Allied to *A. nigropunctata* Blake and *A. retroflexa* Blake, but distinguished from both by characters of leaves and involucre.

Simsia grayii Sch. Bip., sp. nov.

Stem densely spreading-hispidulous and sparsely spreading-setose; leaves opposite, triangular-ovate, hastate-lobed, finely hispidulous and sparsely setose, the petioles winged throughout, connate at base into foliaceous disks; heads radiate, yellow, the disk turning purple; involucre 3–4-seriate, strongly graduate, 7 mm. high; achenes 4 mm. long, 2-awned.

Herb; stem slender, oppositely branched above with divergent or wide-spreading branches; internodes 10.5–13 cm. long; petioles 2–3 cm. long, narrowly or broadly winged to base and there dilated and connate into foliaceous disks 7–12 mm. wide; blades triangular-ovate, 6–8.5 cm. long, 3–5 cm. wide, acuminate, at base subtruncate and then shortly cuneate into the petiole, hastately lobed (lobes short, broadly triangular, obtusish), crenate-serrate except at base and apex with short callous-apiculate teeth, rather thin, above densely and harshly hispidulous and sparsely setose, beneath somewhat paler, densely and finely spreading-hispidulous, setose along the chief veins, triplinerved at base and prominulous-reticulate beneath; leaves of the inflorescence smaller, not hastate, often alternate, mostly lanceolate, their short petioles margined and at base auriculate but not connate; heads about 12 mm. wide, in cymes of 2–5 at tips of stem and branches, on very slender naked pedicels 2 cm. long or less; disk campanulate, 8–10 mm. high, 8 mm. thick; phyllaries lance-triangular (0.5–1.3 mm. wide), acuminate, with short loose subherbaceous tips, densely and finely hispidulous, tuberculate-setulose at tip, the outer very sparsely setose chiefly along midline, the inner about 5-nerved; rays 8, yellow, the lamina elliptic, 4.5 mm. long; disk corollas yellow turning purple, stipitate-glandular on tube, finely hispidulous on throat and teeth, 7 mm. long at maturity (tube 1.3 mm., throat cylindric, 4.7 mm., teeth ovate, 1 mm.); pales acute or acuminate, hispidulous, at apex short-hispid, 7–8 mm. long; achenes oval, blackish, erect-pilose, ciliate, 4 mm. long, 2.5 mm. wide; awns 2, subequal, hispidulous, 2.3 mm. long.

MEXICO: Tepinapa, Oaxaca, Oct. 1842, *Liebmann* 560 (herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.). Province of Oaxaca, *Liebmann* 561 (type in herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.). Province of Oaxaca, *Buchinger* 497 (herb. Sch. Bip.).

Related to *Simsia setosa* Blake, of Sonora, *S. tenuis* (Fernald) Blake, of Guerrero, and *S. holwayi* Blake, of Guatemala; distinguished by its combination of sparsely setose stem, hastately 3-lobed leaves, these short-pubescent beneath and with petioles margined to base, and small heads. The specimen collected by Buchinger, labeled by Schultz in 1852 as a new species under a different name, was placed in the same cover in the Schultz herbarium with *Liebmann* 560 and 561, which he named *Simsia grayii* in 1854.

Zexmenia mexiae Blake, sp. nov.

Suffrutescent, ternately branched, strigose and strigillose throughout; leaves ovate, short-petioled, acuminate, rounded at base, serrate, 5-plinerved, the blades about 8 cm. long; heads radiate, medium-sized, mostly in terminal cymes of 5–9, on pedicels usually 3–5 cm. long; involucre strongly graduate, about 8 mm. high, appressed, the phyllaries suborbicular-ovate to oblong-oval, the outer shortly callous-pointed, the inner rounded; achenes very narrowly wing-margined; pappus of 2 awns equaling the achene and a crown of basally connate squamellae 1.5 mm. long or less.

Plant 2 m. high; stem subterete, striate, gray-brown, about 4 mm. thick, rather densely strigose and strigillose with slightly tuberculate-based hairs;

internodes 8–12 cm. long; leaves opposite; petioles naked, densely strigose, strigillose, and hispid-ciliate, 3–6 mm. long; blades 6–9 cm. long, 3–4.3 cm. wide, broadly rounded or subcordate at base, serrate (teeth acutely callous-tipped, about 0.5 mm. high, 3–7 mm. apart), pergamentaceous, above more or less shining green, strigillose on surface with scarcely tuberculate-based hairs, strigose along the veins, beneath duller green, strigillose on surface and veinlets, strigose along the veins, somewhat bullate above, loosely prominulous-reticulate beneath; heads 2 cm. wide, in terminal cymes, and solitary or in clusters of 2–3 in the upper axils, the slender densely strigillose pedicels 1.5–7 cm. long; disk campanulate, 1–1.4 cm. high, 7–10 mm. thick; involucre about 5-seriate, 8–9 mm. high, 7–9 mm. thick, the outer phyllaries broadly ovate or suborbicular, abruptly and acutely callous-pointed, densely strigose, strigillose, and short-ciliate, with indurate base or lower margin and greenish apex, about 4.5 mm. long, 3–4 mm. wide, the middle ones similar but longer and broader, the inner oblong-oval, 4.5–5 mm. wide, strigillose, with short-ciliate, erose, broadly rounded, submembranous tips; rays 13, pistillate, golden-yellow, glabrous, the tube 3 mm. long, the lamina elliptic, 9 mm. long, 3 mm. wide, about 11-nerved, tridenticulate; disk flowers about 63, their corollas golden yellow, much exserted at maturity, glabrous outside, 6.5–8 mm. long (tube 2–2.7 mm., throat slender-funnelform, 4–4.5 mm., teeth ovate, papillose-margined inside, 0.8 mm. long); receptacle flattish; pales narrow, 8 mm. long, carinate, hispidulous-ciliolate on keel and toward apex, tridentate, the middle tooth obtuse, about 2 mm. long, flattish, the lateral ones short; ray achenes trigonous, 3-aristate (inner awn longest, about 2.5 mm. long), narrowly 3-marginate-winged, otherwise essentially similar to disk achenes; disk achenes narrowly obovate, strongly compressed, very narrowly wing-margined, 4.5 mm. long, 1.5 mm. wide, blackish, obscurely strigillose at apex, spinulose-ciliolate on wings, the wings adnate at base to the 2 awns, these unequal, spinulose, 3.5–4.5 mm. long, connected at base by a crown of basally connate squamellae 0.5–1.5 mm. long.

MEXICO: In woods, Palapar Redondo, Tuxpan, Jalisco, alt. 20 m., 5 Nov. 1926, *Ynes Mexia* 1049 (type no. 1,317, 609, U. S. Nat. Herb.).

Nearest *Zexmenia microcephala* Hemsl., which has much smaller, fewer-flowered heads on pedicels only 1–2 cm. long. Described by the collector as a large, coarse, erect, showy plant, with the vernacular name "tacote amarillo."

Otopappus cordatus Blake, sp. nov.

Stem and pedicels strigillose; leaves ovate, cordate, slender-petioled, 3-nerved from base, repand-dentate, rough on both sides; heads medium-sized, solitary at apex of stem and in upper axils on widely spreading pedicels about 2.5 cm. long; outer phyllaries spatulate, with spreading herbaceous tips; rays about 32, about 3 mm. long.

Shrub; branch slender, densely cinereous-strigillose with somewhat tuberculate-based hairs; leaves opposite throughout; internodes 5–7 cm. long; petioles naked, subterete, shallowly sulcate above, densely strigillose, 1.5–2.7 cm. long; blades ovate, 8.5–11 cm. long, 4.5–8 cm. wide, acuminate, cordate at base (sinus 1.2 cm. deep or less) or the upper subtruncate, repand-dentate and denticulate with unequal callous teeth essentially throughout (teeth 3–5 mm. apart), or the uppermost merely denticulate, pergamentaceous, above deep green, densely and harshly antrorse-hispidulous with glandular-tuberculate-based hairs, impressed-veined and subbullate, beneath lighter green, densely antrorse-hispidulous on all veins and veinlets, gland-dotted, 3-nerved from base and densely prominulous-reticulate, the principal veinlets for the most part diverging at a right angle from their respective veins; heads 9, 1.2–1.5 cm. wide, the lower in the axils of foliage leaves, the uppermost subtended by narrowly lanceolate bracts 2.5 cm. long; disk in flower about 9 mm. high, 12 mm. thick; involucre broadly campanulate, 4–5-seriate, graduate, 6 mm. high, the 2 outermost series of phyllaries spatulate, 3–5 mm. long, 1–1.5 mm. wide, with subindurate base and longer, obtuse, spreading, herbaceous tip, 1-ribbed, strigillose, the 2–3 inner series oblong, obtuse to acute, erect, with obscurely greenish, densely strigillose center and narrow, golden-yellow, subscarious, glabrous margin; rays about 32, fertile, golden yellow, sub-2-seriate, spreading, the tube glabrous, 0.5 mm. long, the lamina oval, bidentate, pilosulous on nerves of back, 7-nerved, 3 mm. long, 2 mm. wide; disk corollas numerous, golden yellow, essentially glabrous outside, barbellate within toward apex of teeth, 3.8 mm. long (tube 0.5 mm., throat slender-funnelform, 2.7 mm., teeth ovate, 0.6 mm.); pales very narrow, keeled, 5.5 mm. long, with firm, acute, yellow, hispidulous-ciliolate tips; ray achenes (submature) trigonous, 3 mm. long, 3-winged, the wings hispidulous-ciliolate, adnate throughout to the 3 awns, these 0.8–1.4 mm. long, connected by a crown of connate lacerate squamellae up to 0.4 mm. long; disk achenes (submature) compressed, the body narrowly obovate, glabrous, 3 mm. long, 0.8 mm. wide, 2-winged, the outer wing glabrous, narrow, adnate to the hispidulous-ciliolate awn (this 1.7 mm. long), the inner wing hispidulous-ciliolate, much broadened above and adnate to the awn (this 2 mm. long); squamellæ united into a lacerate crown 0.6 mm. long, adnate below to the awns.

Mexico: Achotla, Guerrero, alt. 900 m., Oct. 1926, *B. P. Reko* 5011 (type no. 1,269,429, U. S. Nat. Herb.).

Nearest *Otopappus salazari* Blake, but with much broader, deeply cordate, strongly reticulate, conspicuously toothed leaves, fewer and larger heads, and much shorter and more numerous rays.

Oyedaea obovata Blake, sp. nov.

Stem and branches densely appressed-pubescent; leaves elliptic-ovate or ovate, short-petioled, acute, rounded at base, obscurely serrulate, roughish above with subappressed hairs, hirsute beneath, featherveined, about 6 cm. long; heads medium-sized, short-pedicelled, in close clusters of 3–6 at tips of stem and branches; involucre 1–1.2 cm. high, the outer phyllaries with indurate base and abruptly broader, suborbicular-ovate, acute, herbaceous tip.

Shrub; branches alternate or opposite; stem stout (3–5 mm. thick), subterete, striatulate, at length glabrescent, the branches erectish, subangulate, densely and griseously appressed-pubescent or substrigose; internodes 1–3.5 cm. long; petioles stout, naked, pubescent like the stem, 5–9 mm. long; blades 4.5–7 cm. long, 2–3 cm. wide, broadly rounded to cuneate-rounded at base, obscurely serrulate (teeth minute, 2–4 mm. apart) on the slightly revolute margin, subcoriaceous, above deep green, shining, densely and finely tuberculate, more sparsely (along chief veins densely) antrorse-hirsute, beneath evenly and rather densely hirsute on surface and veinlets with spreading antrorse-curved hairs, along the chief veins antrorse-hirsute with stouter hairs, prominulous-reticulate beneath, the chief lateral veins 7–8 pairs, a pair about 1–1.5 cm. above base of leaf often more conspicuous than the others and frequently forked; heads 2.2–3 cm. wide, in close cymose clusters, usually overtopped by the leaves, the stout pedicels 1–12 mm. long, densely pubescent like the stem or the hairs sometimes spreading; disk about 1 cm. high and thick; involucre campanulate, about 5-seriate, graduate, 1–1.2 cm. high, the 2 outermost series of phyllaries obovate or broadly spatulate-obovate, with indurate base (1.5–3 mm. wide) and abrupt, subequal, suborbicular-ovate, thick-herbaceous, erect or rather loose tip (3–5 mm. wide), subappressed-hirsute, more or less ciliate, and somewhat tuberculate, the middle ones elliptic-oblong or oblong (3–4 mm. wide), with somewhat ampliate, subscarious, broadly rounded tip, less pubescent, the innermost sometimes shorter, subglabrous or sordid-glandular, with subscarious tip; rays about 10, yellow, neutral, the tube 2 mm. long, the lamina oblong, 2-dentate, about 12 mm. long, 4 mm. wide, about 12-nerved, puberulous on nerves of back; disk corollas numerous, evidently yellow, finely hispidulous on teeth, otherwise glabrous, 5.7 mm. long (tube 2 mm., throat subcylindric, 3 mm., teeth ovate, 0.7 mm.); pales narrow, acute, carinate, obscurely ciliolate toward apex, 8 mm. long; disk achenes oblong-obovate, 4 mm. long, 1.5 mm. wide, compressed, very narrowly 2-winged, sparsely appressed-pubescent on sides, short-ciliate; pappus a lacerate-ciliolate crown of squamellae 0.8 mm. long and 2 slightly unequal, slender, hispidulous awns 3 mm. long.

VENEZUELA: Agua de Obispo, Province of Trujillo, alt. 2135–2440 m., July 1843, *Linden* 1450 (type in herb. Mus. Paris, dupl. in herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.).

In Schultz's herbarium this plant was marked as a new species of *Leighia* (= *Viguiera*), under a name which it has not seemed necessary to cite, with a note indicating that Schultz suspected it might represent a new genus. The specimen in the Paris Herbarium is marked "*Viguiera?*" in Bentham's hand. The plant is definitely an *Oyedaea* near the Colombian *O. reticulata* Blake, but with denser pubescence, somewhat different leaves, and very different, highly characteristic phyllaries.

Verbesina pantoptera Blake, sp. nov.

Perennial herb, 60 cm. high, simple, 4–7-headed, hispidulous throughout; stem and peduncles very narrowly 4-winged throughout; leaves opposite to middle of stem, the blades ovate, sometimes hastately 3-lobed with obtuse lobes, acute, rounded or abruptly contracted into narrowly cuneate-winged petioles, denticulate, rough-pubescent on both sides, the blade about 5 cm. long; involucre obgraduate, loose, herbaceous, 1–1.2 cm. high, the phyllaries linear or lance-linear; rays about 13, lemon-yellow, the lamina about 1.2 cm. long.

Rootstock short (ca. 2 cm. long); stems apparently few, about 2 mm. thick, spreading-hispidulous, the 4 herbaceous wings entire, scarcely 1 mm. wide; larger leaves about 5 pairs, subremote (internodes 3.5–7 cm. long), the blades 5–6 cm. long, 2.8–3.8 cm. wide, firm-papery, dark dull green above, paler dull green beneath, above evenly tuberculate-hispidulous or short-hispid, beneath rather densely hispidulous on veins and veinlets, featherveined or obscurely triplinerved, the veins and veinlets prominulous-reticulate beneath, the petioles cuneate-winged to base, not connate, 1.2–2 cm. long, 6–8 mm. wide above, 1.5 mm. wide at base; upper leaves few (about 4), mostly alternate, lanceolate to triangular-ovate, 0.8–2 cm. wide, acuminate, acutely cuneate at base, unlobed; peduncles terminal and in the upper axils, 1–3-headed, 2–9 cm. long, the terminal one shortest; heads 2–3 cm. wide, apparently nodding except at maturity; disk 8–10 mm. high; involucre about 3-seriate, obgraduate, the outermost phyllaries linear or linear-lanceolate, acute or obtuse, callous-tipped, herbaceous essentially throughout, hispidulous or short-hispid on both sides, loose, in age reflexed from above the base, 10–12 mm. long, 1.5 mm. wide, the second series similar but shorter, 8–10 mm. long, the innermost (subtending the rays) still shorter, herbaceous above, subindurate below, acuminate; rays neutral, "lemon yellow," sparsely hirsutulous on tube and back, the tube 1.5–2.5 mm. long, the lamina elliptic, 1.1–1.3 cm. long, about 4 mm. wide, 8–9-nerved, 2–3-denticulate; disk corollas numerous, "lemon yellow," hispidulous chiefly above the middle, 7.5 mm. long (tube 1 mm., throat subcylindric, 5.3 mm. long, teeth 1.2 mm.); pales rather narrow, about 7 mm. long, hispidulous on keel and toward tip, tridentate, the lateral teeth short, the middle one elongate, nearly equaling body of pale, greenish, with slightly recurved tip; achenes (submature) broadly and obliquely obovate, 4 mm. long, 3 mm. wide including wings (these 0.2–0.3 mm. wide), very flat, 1-nerved on each side, glabrous except for the short-ciliate wings, the wings adnate at base to the awns and connected between them by a narrow undulate margin; awns 2, subulate, hispidulous, slightly unequal, 1.2–1.5 mm. long.

MEXICO: Common in open spaces in woods on lower slope of Cordilleras, trail from Tepic to Santiago, State of Nayarit, alt. 1000 m., 15 Sept. 1926, *Ynes Mexia* 632 (type no. 1,317,608, U. S. Nat. Herb.).

A species of the section *Pterophyton*, readily distinguished by its narrowly winged stems and peduncles, in combination with its comparatively long, herbaceous phyllaries. The undulate margin connecting the awns suggests the allied genus *Zexmenia*, but a longitudinal section of the achene indicates that this border is not squamelloid in origin, but is formed by the lateral confluence of the substance of the wings between the awns, which are embedded in it, and around the contracted apex of the achene body. In any case the neutral rays forbid the reference of the species to *Zexmenia*.

Verbesina heterocarpa Blake, sp. nov.

Shrub; stem softly griseous-puberulous with subappressed hairs; leaves of main stem alternate, of branches opposite, lanceolate, about 8 cm. long, acuminate at each end, short-petioled, serrulate, roughish above, softly griseous-pilose-subtomentose and densely dotted with yellow glands beneath; heads rather small, several in small terminal panicles, radiate, yellow; involucre 4–5-seriate, the inner phyllaries with acuminate subscarious tips; pales with yellowish erect acuminate scarious tips; ray achenes glabrous, their pappus of a single squamella; disk achenes pubescent, 2-awned.

Shrub 2.5 m. high, the branches alternate or opposite, about 3 dm. long; main stem subterete, 4 mm. thick, finely appressed-puberulous; branches fuscous, densely subappressed-puberulous and with some not longer more or less spreading hairs and finely gland-dotted, their internodes usually 2–4.5 cm. long; petioles naked, unappendaged, pubescent like the stem, 4–5 mm. long; blades 7–8 cm. long, 1.3–1.8 cm. wide, serrulate (teeth small, callous, mostly deflexed, 2–3 mm. apart), pergamentaceous, above dull green or purplish-tinged, densely antrorse-hirsutulous with slightly tuberculate-based hairs and gland-dotted, beneath densely pilose-subtomentose with mostly spreading hairs and gland-dotted, featherveined, the lateral veins about 15 pairs, prominulous beneath, the veinlets scarcely prominulous; heads about 1 cm. wide, in flattish or convex panicles (about 3–6 cm. wide) of 15–24 at apex of branches, the bracts lance-linear, mostly 3.5 cm. long or less, the pedicels slender, 5–15 mm. long, pubescent like the stem; involucre 4–5-seriate, strongly graduate, 5–6 mm. high, the outer 2 series of phyllaries ovate, 0.5–1.2 mm. wide, appressed, pilosulous and gland-dotted, subherbaceous above, with short, acutish, purplish, callous tips, the others ovate or lance-ovate, 1.3–2 mm. wide, with subindurate central portion and subscarious, yellowish, sharply acuminate, erect tips, usually fuscous centrally, sparsely pilosulous and dotted with sessile yellow glands; rays 6, golden yellow, pistillate, pilose and stipitate-glandular on tube and base of back, the tube 1.5 mm. long, the lamina oval, emarginate, 6 mm. long, 4–4.5 mm. wide; disk flowers 22, their corollas golden yellow, pilose and stipitate-glandular on tube, sparsely pilose on nerves of throat below, papillose on inner surface of teeth, 6 mm. long (tube 1.5 mm., throat subcylindric, 3.5 mm., teeth ovate, 1 mm.); receptacle strongly convex; pales similar to the inner phyllaries in shape and texture, about 7 mm. long, stipitate-glandular on back and above on margin and very sparsely pilose on back, with scarious, yellowish, sharply acuminate, erect or somewhat incurved tips; ray achenes (very immature) obcompressed or trigonous, glabrous or with a few hairs at apex, narrowly 2-winged, their pappus of a single squamella 0.3 mm. long or less; disk achenes (very immature) compressed, narrowly obovate, 3 mm. long, very narrowly 2-winged, pilosulous above, densely short-ciliate on wings; pappus awns 2, slender, unequal, hispidulous, 2.5–3.2 mm. long.

Mexico: In opening in oak forest on steep slope, Real Alto, Sierra Madre Occidental, Jalisco, alt. 2500 m., 29 Jan. 1927, *Ynes Mexia* 1587 (type no. 1,317,611, U. S. Nat. Herb.).

A member of the section *Saubinetia*, allied to *V. molinaria* Robins. & Greenm. and *V. oncophora* Robins. & Seaton. In the former the larger, opposite leaves are canescently subsericeous-tomentose beneath, and the involucre and pales are very different; in the latter the leaves are larger and normally alternate, the petioles are provided at base with deciduous corky auricles, the involucre is shorter and simpler, and the much shorter, firmer pales bear abrupt short mucros. The almost complete absence of pappus in the ray flowers of *V. heterocarpa* is a striking feature not found in either of the two related species.

Verbesina glaucophylla Blake, sp. nov.

Shrubby, leafy, glabrous throughout except for the obscurely puberulous pedicels; leaves chiefly alternate, lanceolate, 9–20 cm. long, acuminate at each end, short-petioled, denticulate, green above, glaucous beneath; heads discoid, whitish, about 36-flowered, slender-pediceled, numerous in a terminal concave cymose panicle; involucre 2–2.5 mm. high; pales with short recurving mucros.

Shrub 1.5–2.5 m. high; stems or branches subterete, simple or little branched, striate, glabrous, glaucescent, 3 mm. thick, pithy; internodes 5–15 mm. long; leaves alternate, or on short branches opposite below, the blades lanceolate, 1.8–3.5 cm. wide, broadest near middle, subremotely denticulate or serrulate-denticulate (teeth blunt, callous, ca. 0.4 mm. high, 3–11 mm. apart), papery to subpergamentaceous, glabrous and smooth on both sides featherveined (lateral veins about 10 pairs), finely translucent-reticulate, the strong costa whitish or purplish, the chief lateral veins prominulous; naked portion of petiole grooved above, 3–7 mm. long; heads turbinate-hemispheric, about 8 mm. high, 10 mm. wide, on terminal and axillary peduncles 7.5 cm. long or less, forming a panicle about 11 cm. wide, the bracts mostly narrowly linear, 2–20 mm. long, the pedicels mostly 8–25 mm. long, slightly puberulous especially at apex; involucre 2-seriate, subequal, the phyllaries ovate or oblong-ovate, obtuse, glabrous, subherbaceous, sometimes subtended by a few slightly longer and more herbaceous loose-tipped bracts; corollas whitish, 3.5–4 mm. long (tube densely pilose, 1–1.2 mm., throat glabrous, thick-cylindric, 1.8–2 mm., teeth ovate, short-ciliate on inner margin, 0.7–1 mm. long); receptacle convex; pales cymbiform, yellowish green, 3.5–4 mm. long, strongly carinate, sparsely hispidulous on keel, denticulate on the subscarious margin above, tipped with a short erect or recurving mucro; achenes obovate, 2.6 mm. long, 2.8 mm. wide (including wings), the body blackish, sparsely pilose near apex, about 1.2 mm. wide, the short-ciliate whitish wings about 0.7 mm. wide, prolonged above the achene and adnate to base of awns, the awns 2, subequal, hispidulous, 2 mm. long.

MEXICO: In pine forest on steep dry clay hills, Loma de Garote, trail to San Sebastian, Sierra Madre Occidental, Jalisco, alt. 1500 m., 8 Feb. 1927, *Ynes Mexia* 1649a (type no. 1,317,612, U. S. Nat. Herb.). San Sebastian, east of Arroyo Santa Gertrudis, Jalisco, 17 Jan. 1927, *Mexia* 1507.

A species of the section *Lipactinia*, distinguished by its glabrous character, its glaucescence, and its about 36-flowered heads. The two other Mexican species of this section have 7–9-flowered heads.

Verbesina rivetii Blake, sp. nov.

Stem thinly cinereous-tomentose; leaves alternate, short-petioled, oblong-lanceolate, acuminate, acutely cuneate at base, sharply serrulate, cinereous-tomentose beneath; heads small, 15–17-flowered, radiate, yellow, very numerous in a large flattish terminal panicle; outermost phyllaries oblong, pilosulous; pales slightly ciliolate.

Shrub; stem (or branch) simple below the inflorescence, 5 mm. thick, subterete, multistriatulate; internodes 1–2 cm. long; petioles stout, naked, densely cinereous- or canescent-tomentose, 4–7 mm. long; blades 6–10 cm. long, 1.5–2.5 cm. wide, serrate or serrulate above the entire cuneate base (teeth about 7 pairs, callous-tipped, 0.5–1 mm. high, usually 5–10 mm. apart), above deep green, densely and rather harshly pilosulous with antrorse-curved hairs with persistent glandular-tuberculate bases, beneath densely and softly cinereous-tomentose, pergamentaceous, featherveined, the chief lateral veins 5–7 pairs, covered by the tomentum; heads 1–1.2 cm. wide, numerous in dense cymose panicles at tip of stem and branches, together forming a panicle 20 cm. wide, the ultimate bracts minute, the pedicels mostly 6–12 mm. long, spreading-pilosulous; disk subcylindric, 1 cm. high, 4–5 mm. thick; involucre about 3-seriate, 5–7 mm. high, the phyllaries few, very unequal, the outermost oblong or ovate-oblong, about 2.5 mm. long, 1 mm. wide, subherbaceous, obtusish, callous-tipped, densely pilosulous, the innermost (subtending the rays), 5–7 mm. long, similar to the pales in shape and texture, ciliolate, on back glabrous or somewhat puberulous; rays 4–5, fertile, pilosulous on tube and base of lamina, the tube 2.2 mm. long, the lamina oval or suborbicular, 2–3-denticulate, about 8-nerved, 4–4.8 mm. long, 2.8–3.5 mm. wide; disk flowers 10–13, their corollas densely short-pilose on tube and base of throat, strongly papillose-bearded on margin of teeth within, 5.5–6 mm. long (tube 1.8 mm., throat funnelform, 3–3.3 mm., teeth ovate, 0.8–1 mm.); pales oblong, acute or acutish, blackish green, yellow-margined and -tipped, short-ciliate, essentially glabrous dorsally, about 8 mm. long; ray achenes compressed or trigonous, narrowly winged, their pappus of 2 subequal or very unequal more or less paleaceous awns 2.5 mm. long or less, sometimes reduced to short teeth; disk achenes cuneate-obovate, compressed, blackish, very narrowly 2-winged (wings ciliolate, about 0.1 mm. wide, adnate to base of awns), glabrous or sparsely hispidulous on the sides, 5 mm. long, 1.5 mm. wide; pappus awns 2, subequal, hispidulous, about 3 mm. long.

ECUADOR: Terme Nord, Nov. 1902, *Rivet* 290 (type, Mus. Paris, photog. and fragm., U. S. Nat. Herb.).

A member of the section *Lipactinia*, of the *Verbesina arborea* group, distinguished by its radiate heads, comparatively small sharp-toothed leaves, and merely ciliate pales. It is near the Peruvian *V. grandifolia* Blake, which has densely pubescent pales and very much larger leaves, those subtending the lower branches of the inflorescence in that species being about 2 dm. long, in *V. rivetii* 6 cm. or less.

Calea longipes Blake, nom. nov.

Tridax trianae Hieron. Bot. Jahrb. Engl. **21**: 350. 1896. Not *Calea trianae* Hieron. 1894.

This species was evidently referred to *Tridax* by Hieronymus because of its ciliate pappus awns. It has not the characteristic bilabiate ray corolla of that genus, and its pappus is much nearer that of *Calea*. The linear-lanceolate, attenuate awns have the scarious margin lacerate-ciliate, only slightly more so than in such a *Calea* as *C. caracasana*, and are by no means plumose as is the pappus of *Tridax*. The pappus of the ray flowers is much reduced and only 1 mm. long, while that of the disk reaches 3.5 mm. The species is not closely related to any other species of western South America, but comes near the Mexican *C. palmeri* Gray. I have examined two sheets of *Triana* 1422, the type number of *T. trianae*, from Anaporina (?), Bogotá, alt. 2600 meters (Brit. Mus., Kew), and another from herb. Triana (Brit. Mus.) labeled *Linden* 61. A recent specimen in the U. S. National Herbarium is *Ariste-Joseph* A773, doubtfully from the Department of Cundinamarca. *Stuebel* 176b, also cited by Hieronymus for his new species, has not been available for examination.

Gynoxys jamesonii Blake, sp. nov.

Shrub; branches sordidly stellate-tomentose, glabrescent; leaves petioled, elongate-lanceolate, acuminate, repand-denticulate, glabrous above, beneath densely stellate-tomentose with short grayish hairs and loosely brownish-tomentose with longer, somewhat deciduous, stellate hairs; heads small, white, radiate, crowded in ternately divided panicles, 10–11-flowered; involucre 4.5 mm. high, sordidly stellate-tomentose, somewhat glabrescent; rays 5, short.

Branches somewhat compressed, striatulate; leaves opposite; uppermost internodes 4.5 cm. long; petioles naked, densely sordid-tomentose with stellate hairs, sulcate above and beneath, 1.5–2 cm. long; blades 11–15.5 cm. long, 2–3 cm. wide, rounded to cuneate at base, repand-denticulate (teeth small, callous, 1–2 cm. apart), above dark green, glabrous except for base of costa, closely prominulous-reticulate, beneath densely and doubly stellate-tomentose (the lower tomentum of very short and dense grayish hairs, the upper of much longer, more or less deciduous brownish hairs), pinnate-veined (the lateral veins about 20 pairs, prominulous-reticulate beneath); panicles terminal and pedunculate from the upper axils, convex, 5–12 cm. wide, densely stellate-tomentose with short brownish hairs, the lowest pair of bracts linear, about 2 cm. long, the others minute, subulate, 3 mm. long or less; pedicels 5 mm. long to almost none; heads numerous, somewhat fasciculate, obovoid, 6 mm. wide, the disk 7 mm. high, 3 mm. thick; bractlets at base of involucre 2–3, subulate, appressed, 1.5–2 mm. long, stellate-tomentose, persistent; phyllaries 8, equal, 1.5–1.8 mm. wide, somewhat imbricate, oblong, obtuse, the outermost densely stellate-pubescent with short brown hairs except toward base, the middle ones stellate-pubescent along midline above, the innermost glabrous except at apex; receptacle alveolate, glabrous; rays 5, fertile, glabrous, the tube 3.5 mm. long, the lamina erectish, linear-elliptic, entire, 3 mm. long, 0.6 mm. wide, about 4-nerved; disk corollas 5–6, glabrous, 5.2 mm. long (tube 2.6 mm., throat scarcely wider, 1 mm., teeth rather narrow, 1.6 mm. long); achenes (immature) glabrous, ribbed, 1.5 mm. long; pappus of numerous yellowish-white serrulate bristles 4.5 mm. long or less; style-tips subtruncate-rounded, merely papillose-hispidulous, without evident appendage.

ECUADOR: West side of Mount Pichincha, alt. 3050 m., *Jameson* 227 (type in Kew Herb.; photog. and fragm., U. S. Nat. Herb.).

Described by the collector as a shrub with white, very fragrant flowers. Related to *G. albiflora* Wedd., *G. longifolia* Wedd., and *G. seleriana* Muschl., but distinguished by characters of leaves, heads, and involucre. The double tomentum of the lower leaf surface is like that described for *G. henrici* Mattf., but the plants are otherwise very different.

Gynoxys leiotheca Blake, sp. nov.

Branches densely velvety-tomentose; leaves elliptic or oblong-elliptic, obtuse, rounded at base, subentire, coriaceous, soon glabrous and prominulous-reticulate above, densely ochroleucous-velvety-tomentose and prominulous-reticulate beneath; heads discoid, yellow, 7–8-flowered, subsessile or short-pediceled, cymose-panicled; involucre 6–7 mm. high, glabrous or essentially so.

Shrub; branches subangulate, stoutish, densely velvety-tomentose with ochroleucous or in age fuscescent hairs; leaves opposite; petioles similarly tomentose, 1–1.8 cm. long; blades 6–9.5 cm. long, 1.8–2.8 cm. wide, short-apiculate, at base rounded or obscurely cordate, obscurely repand-denticulate with small remote inflexed callous teeth, above at first velvety-tomentose, quickly glabrate and light green, coriaceous, the chief lateral veins 11–13 pairs, diverging at a very obtuse angle; panicles terminal, rounded, many-headed, about 12 cm. wide, pubescent like the stem; heads 8–10 mm. high, subcylindric, crowded at tips of branches of panicle, the pedicels 5 mm. long or less, usually very short, the lowest branches subtended by somewhat reduced leaves; involucel of about 5 bractlets about 2 mm. long, triangular, acuminate, stiff, persistent, ciliate and somewhat tomentose; phyllaries 5–6, broadly oblong, obtuse, 6–7 mm. long, 1.8–2.2 mm. wide, substramineous, the outer about 5-nerved, the inner about 2-ribbed and with broad subscarious margin, all pilosulous-tufted at apex, on back glabrous to very sparsely pilose, especially toward apex; corollas glabrous, 8.5 mm. long (tube 3.5 mm., throat 2 mm., teeth 3 mm.); achenes glabrous, about 10-ribbed, 3.5 mm. long; pappus yellowish white, 7 mm. long.

ECUADOR: Borma, Sept. 1904, *Rivet* 671 (type, Mus. Paris; photog. and fragm., U. S. Nat. Herb.).

Distinguished by its 7–8-flowered discoid heads and practically glabrous involucre of 5 or 6 broad and blunt phyllaries. Apparently most closely allied, from description, to the radiate *G. szyszylowiczii* Hieron., of Peru.

Chuquiraga brasiliensis (Spreng.) Blake.

Ioannea brasiliensis Spreng. Neue Entd. **2**: 132. 1821.
Flotovia glabra Spreng. Syst. **3**: 506. 1826.
Chuquiragua glabra (Spreng.) Baker in Mart. Fl. Bras. 6^3: 363. 1884 (synonymy).

Sprengel's name *Ioannea brasiliensis* of 1821, the oldest name applied to this species, was cited by him in 1826 as a synonym of *Flotovia glabra.* The change in the specific name was evidently made because of the addition in 1826 of a second Brazilian species, which he called *F. tomentosa.* The type in the Schultz Bipontinus herbarium at Paris was examined by the writer in 1925.

The generic name is usually written *Chuquiragua,* but its original spelling, which should be followed, was *Chuquiraga,* both in Jussieu's Genera (p. 178. 1789), where the genus was described without mention of any specific name, and in Gmelin's Systema,[2] where a specific name (*C. jussieui* Gmel.) was first assigned, based on Jussieu's description.

Perezia longifolia Blake, sp. nov.

Stem glabrous, simple, leafy; leaves very long, lance-elliptic to nearly linear-elliptic, acuminate, cordate-clasping, spinulose-denticulate, firm, loosely reticulate, hispidulous on the veins; heads large, about 46-flowered, mostly solitary in the axils, on short or obsolete peduncles; involucre turbinate, 2.8-3 cm. high, many-seriate, the phyllaries lanceolate, acuminate, glabrous.

Herb, probably tall; stem slender (3 mm. thick), terete, hollow, purplish, glaucescent; internodes 3–5.5 cm. long; leaves alternate, 20–30 cm. long, 4–7.5 cm. wide, closely spinulose-denticulate throughout except at apex with unequal teeth, subcoriaceous, above deep green, slightly shining, roughish with minute hairs along veins and veinlets and on margin, beneath light green, roughish-hispidulous on the venation, featherveined and loosely prominulous-reticulate on both sides, the chief lateral veins about 12–15 pairs, ascending at an acute angle; heads 1–2 in the axils of the middle and upper leaves, 3 cm. high, about 2 cm. thick, on glabrous minutely bracted peduncles 1 cm. long or usually less; involucre about 7-seriate, strongly graduate, the phyllaries erect, acuminate and subcuspidate, substramineous,

[2] Syst. **2**: 1205. 1791.

dull-purplish-tipped, 1-ribbed and several-nerved; corollas (white or purple?) bilabiate, 2.3 cm. long, one lip shortly 3-toothed, the other 2-partible to base; achenes (immature) subrostrate, densely glandular and hispidulous, 6.5 mm. long.

MEXICO: Calabaza, Jalisco, 1925, *B. P. Reko* 4872 (type no. 1,269,424, U. S. Nat. Herb.).

This striking species is related to *Perezia formosa* (D. Don) A. Gray and *P. turbinata* Lex. The former has narrow, much smaller leaves, and a different type of inflorescence. The latter, a still dubious plant, Gray's interpretation of which[3] is here followed, is loosely branched above, with slender pedicels, 20–30-flowered heads, and about 3-seriate involucre.

ZOOLOGY.—*Nemic spermatogenesis: with a suggested discussion of simple organisms,—Litobionts.*[1] N. A. COBB, U. S. Department of Agriculture.

Definitions. Spermatidium: one of a plurality of cells derived from a spermatid by subdivision; a secondary, tertiary, or quaternary, etc., spermatid. *Spermule:* an individual spermatidium which, after growth and transformation, is capable of activating or fertilizing an egg,—being *not* a metamorphosed spermatid, but a descendant of a spermatid, one or more cell-generations removed.

Spermatogenesis. At the blind end of the single testis of the nema, *Spirina parasitifera* (Bastian '65) Filipjev (Figs. 1 and 2),—a free living marine species, common an inch or two deep in sand and among small stones between the tide marks of protected coasts on both sides of the North Atlantic through a wide range of latitude,—the primordial gonic elements give rise by 14-chromosome mitotic division to numerous twin cells (Figs. 2, 14), which arrange themselves tandem in the testis (Fig. 3) where each

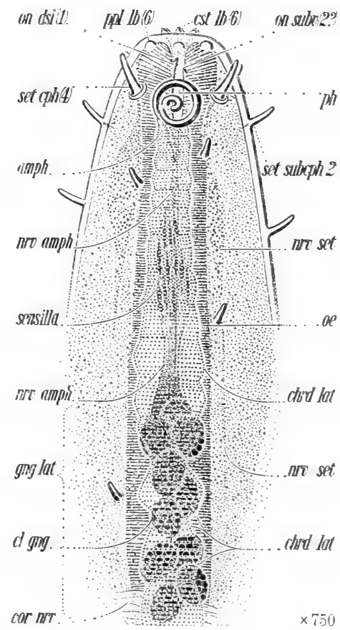

Fig. 1.—Lateral view of the head of *Spirina parasitifera.* The amphidial nerve, *nrv amph,* expands into a sensilla, then again into a 10–12 celled ganglion (seen through the lateral chord, *chrd. lat.*) joining the nerve-ring, *cor nrv.*

[3] Proc. Amer. Acad. 19: 58. 1883.

[1] The investigations were made in part at the laboratories of the U. S. Bureau of Fisheries at Woods Hole, Mass. Received December 3, 1927.

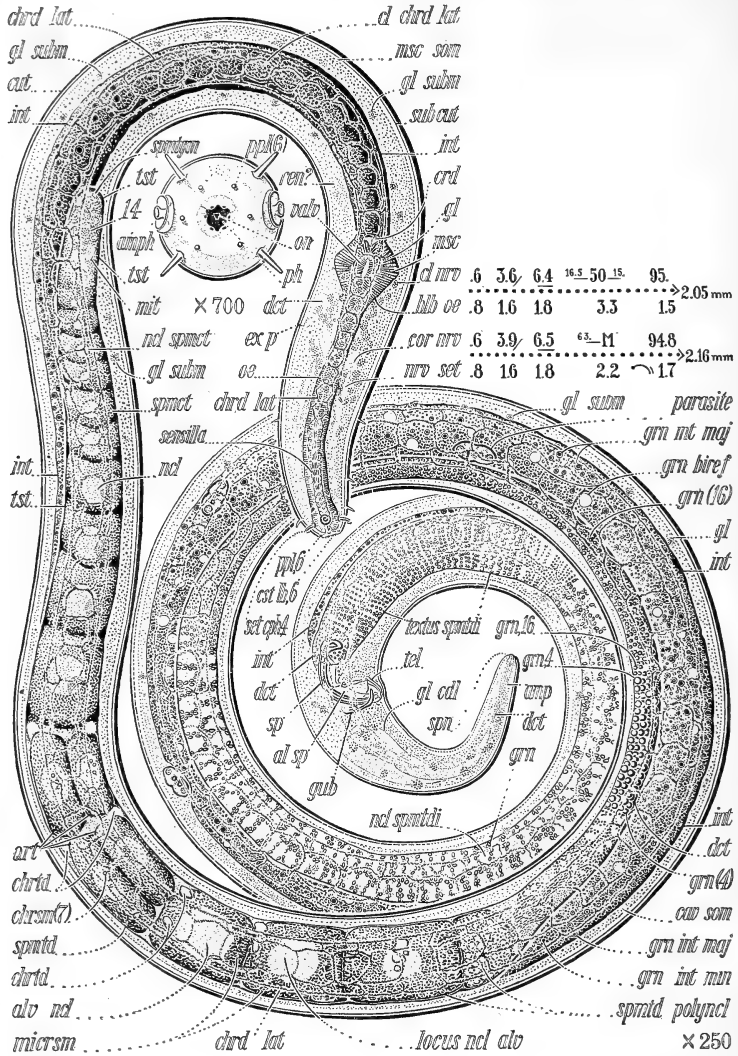

Fig. 2.—The male of *S. parasitifera* drawn from life. The tinting of drawing modified in accordance with study of stained specimens. Nearly all details shown were seen in the living specimen. The front view of head, however, is from a decapitated specimen. In life the chromosomes have not been seen definitely enough to admit of accurate counting. Most of the subsequent camera lucida drawings were obtained from fixed and stained material. In nearly all cases the fixing and staining were done simultaneously by means of acetic acid methyl green. Just to the right are placed, in the form of the decimal formula, the average measurements of specimens used. Material collected at Woods Hole, Mass., U. S. A.

The self-explanatory abbreviations are the same throughout the various figures, and are of necessary Latin anatomical terms; thus, *chrd lat, chorda lateralis*, lateral chord; *qrt*, quartet of spermatids; *chrtd*, chromatoids; *spmtd*, spermatid; *alv ncl*, alveoli of nuclear space; *micrsm*, microsomes, of spermatid; *14*, a 14-chromosome spermatogonial mitosis; *mit*, mitotic figure; *grn*, a cell of primary spermatidian tissue containing four granules; *grn 16*, cell of spermatidian tissue containing sixteen granules; *locus ncl alv*, locus of the diminishing alveolated nuclear space; *spmtd polyncl*, polynucleate spermatid in process of becoming a 64-celled tissue; *textus spmtdi*, spermatidian tissue.

cell, growing, forms a primary spermatocyte. At the end of the growth period the primary spermatocytes, one after another, divide transversely, i.e., at right angles to the nema's body axis, and then, sometimes almost simultaneously, longitudinally, to produce four similar, juxtaposed spermatids (Fig. 2, *qrt*), each soon packed with several thousand very slightly elongate microsomes, nearly all of which are located outside the large central, faintly alveolated, diminishing nuclear space. (Fig. 2, *micrsm* and *alv ncl;* and Fig. 14.)

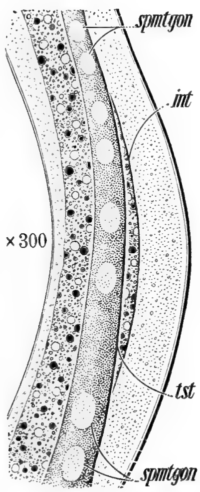

Fig. 3

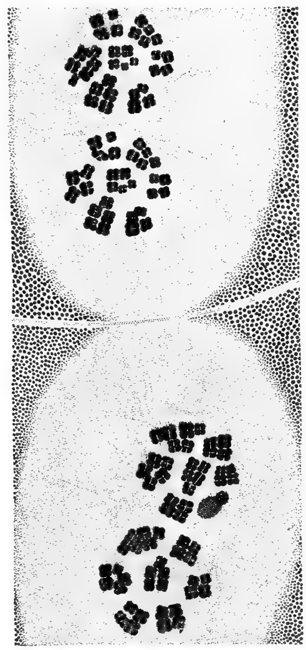

Fig. 4

Fig. 3.—View near blind end of testis of *S. parasitifera*, showing pairs of cells resulting from division of primordial nuclei. This testis had broken open and become partially evacuated so that these *pairs of cells* in tandem could readily be distinguished as such. Normally these nuclei are so packed that the mass effect obscures the fact that they are twins.

Fig. 4.—Second stage of reduction division of a spermatocyte of *S. parasitifera*, which will result in 4 similar juxtaposed spermatids, as at *qrt*, Fig. 2, each having 7 chromosomes. The compound chromosomes present considerable individuality. Between the 2 double groups of chromosomes is seen portion of the new cell wall. × 1200.

In the first of these two divisions the chromosome number is reduced to seven. Probably the smallest one of the seven chromosomes of the secondary spermatocytes differs slightly in relative size in the two cells. Thus far the spermatogenesis presents nothing very new or striking, but the amount of growth,—from 3 to 60 microns (*tst*, Fig. 2),—is worthy of note, and, connected with reduction, there is a more or less orderly (e.g. more or less definitely oriented) extrusion from the spermatids of structureless looking chromatoid substance, (*chrtd* Fig. 2 and Fig. 14), barely possibly by a very "degenerate" mitosis; these chromatoid masses are soon absorbed.

"Normally," the four cells just described would develop into four sperms, but here the spermatogenesis proceeds as follows: Moving along the testis with soldier-like precision, the two caudad members

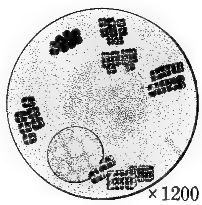

Fig. 5

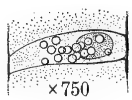

Fig. 6

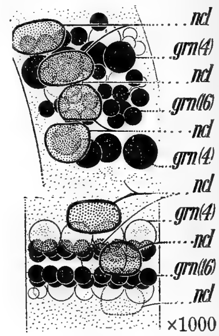

Fig. 7

Fig. 5.—Nucleus of full grown spermatocyte seen in synapsis. The nuclear membrane is still intact and the spherical nucleolus is still visible. The chromosomes are in seven pairs. It was possible to resolve the chromosomes into numerous components, suggesting a possible explanation of the difference in chromosome counts in certain nemas, e.g. in *Ascaris;* i.e. differences between counts at this stage and counts in later somatic divisions; for, should such loosely organized chromosomes later break apart, the count would be much increased.

Fig. 6.—A single spermatidium of first generation with its nucleus and sixteen granules. From life. In this case the cell wall is shown.

Fig. 7.—Above, camera lucida drawing of nuclei and granules in spermatidia of *S. parasitifera* at the point *grn* (4), Fig. 2. Below a diagram of four spermatidia. The diagram is derived from drawing above, and shows more clearly the numerical relationships of nuclei and granules. The boundaries of the spermatidia are almost invisible and are not shown. The granules are shown black, white or, when seen through the nucleus, gray. The larger ellipsoidal objects are nuclei. In the drawing, at top, and on the hither side, a nucleus with its accompanying four granules, the nucleus being this side of granules. In the drawing, on the farther side, again at top, a spermatidium three of whose granules have already given rise to four smaller granules each. In the drawing and below, a spermatidium none of whose four granules have divided, one of them shown behind the nucleus. *grn* (16) shows a spermatidium with a nucleus and 16 granules. The lower figure is only somewhat schematised. Very rarely are spermatidian cells so systematically arranged as to disclose so clearly the relationships of granules and nuclei. In this diagrammatic lower figure the far spermatidium is shown in an intermediate state. Illustration derived from material stained with methyl green.

of the quartet form a tandem, followed by the other two, also in tandem; i.e., the quartet falls into single file. These spermatids in file grow, and one after another divide internally without evidence of mitosis into 64 uninucleate elements which proceed to surround themselves with walls and *form a tissue of 64 cells.* (See lowest part of Fig. 2.) As this tissue leaves the testis and enters the duct it elongates (2-4 nuclei abreast), and each of its 64 cells in turn, following on the disappearance of the microsomes, acquires four equal, refractive, spherical granules (4 microns in diameter), and the tissues thus take on a granulated appearance,—the nuclei and cell-walls being almost completely hidden by the closely packed granules. By the time the cephalad part of each tissue enters the duct the caudad part has undergone a further change, in that the four granules, *each dividing endogenously into four similar* but smaller spherical granules, populate each cell with 16 granules (*grn 4* and *grn 16*, Fig. 2).

This very interesting behavior of the granules (Figs. 7 and 9) more than suggests a different order of mechanism from that typical

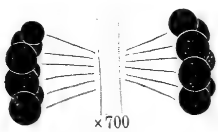

Fig. 8

Fig. 9

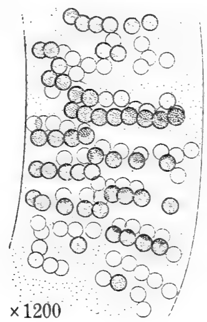

Fig. 10

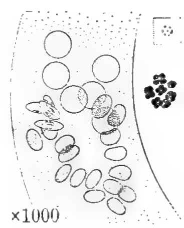

Fig. 11

Fig. 8.—Reduction division. Sublimate-acid carmine toto preparation. The smallest chromosome differed somewhat in size in the two sets. Fixation less delicate than with acid methyl green.

Fig. 9.—Two granules from the spermatidia of *S. parasitifera;*—one showing 4 smaller granules formed endogenously, the other 8. The right hand granule is from near *grn 4*, Fig. 2. The left hand granule, taken from farther back in the testis, where microscopic details are so fine that exact relationship of granules and their descendants has not as yet been fully deciphered.

Fig. 10.—Spermatidia each containing sixteen refractive spherical granules. From life. The cell walls and nuclei of this tissue are nearly invisible in life.

Fig. 11.—Nuclear spindles in later mitoses of spermatidia taking place in vas deferens. Polar views of spindles show 7 chromosomes; see small figures to right, from another part of the same specimen.

of cell division, but since irritability, ingestion, transportation, transformation and so forth, all seem involved, it appears necessary to base the concept on what is known of cell physiology and mechanics; the changes, however, are carried out on a smaller scale and doubtless with a more limited variety of molecules forming a different kind of plasm—litoplasm. In short, the facts indicate a distinctly lower order of "organism." Many of what now are often called *lower* organisms might better be regarded simply as less multiplicate. Thus certain ciliates are smaller and less multiplicate, rather than "lower," as compared with nemas for instance. This matter is briefly discussed on a later page,—under the heading, Size and Number as related to Organisms.

As the tissue proceeds along the duct, the cells containing 16 granules undergo a further diminution in the size of their granules, and a change in the number and nature of the granules, so that the cells become more transparent; at the same time the nuclei *divide mitotically,* (7 chromosomes), *giving rise to a tissue of 128 cells.* The evidence that this increase is by mitosis is as follows: 1. At the part of the duct where this change is taking place (Fig. 11) the sizes, form and position (in pairs) of the new nuclei are what would be expected from mitotic division. 2. The new smaller nuclei,—posterior to the larger, as yet undivided, nuclei,—stain more strongly. 3. Occasionally 7-element spindles can be seen. 4. No trace has been seen of any other sort of division.

Two or more such tissues as that described fill the duct of the male nema, the number of tissues varying with the age of the nema and with the copulatory history. The tissues seem to be of two styles, and, if so, perhaps correspond to the two styles of chromosomes in the secondary spermatocytes (*textus spmtdi,* Fig. 2).

Fertili ation and Syngamy. The two sexes of *S. parasitifera* seem about equally common. During copulation the male passes the spermatidian tissues on intact to the female, and afterward they may be seen in the uteri, often

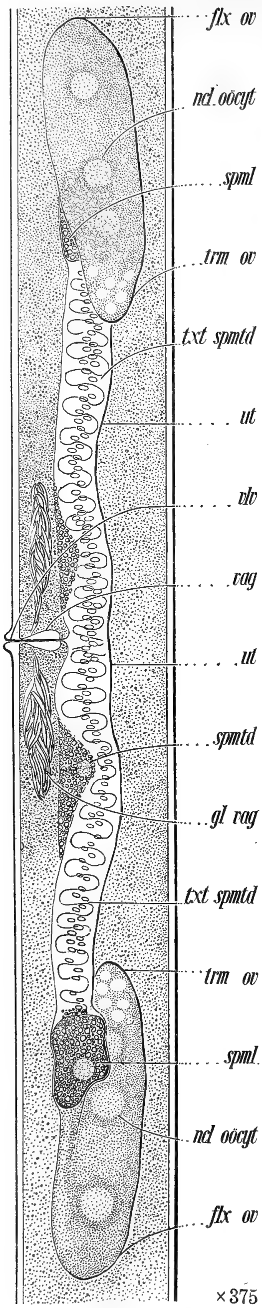

Fig. 12

Fig. 12.—Carefully proportioned free-hand sketch of gonads of female *S. parasitifera* after impregnation. The two uteri, outstretched in opposite directions, are filled with spermatidian tissue. The young ovaries are just beginning to function and the ova next the flexures, *flex ov,* are about to enter the uterus. The spermatidia adjacent to the ova about to enter the uteri have metamorphosed into spermules, *spml,* and have taken on the form characteristic of nemic sperms as hitherto described. In this case two other cells of the spermatidian tissue nearer the vulva have also begun to metamorphose. *trm,* blind end of ovary; *flex ov,* flexure of ovary; *txt spmtd,* spermatidian tissue; *gl vag,* vaginal gland, for which see also Fig. 16.

jumbled, sometimes extended along the length of the two uteri (Fig. 12).

Fertilization is preceded by increase in size of that cell of the spermatidian tissue adjacent to the ovum next to be fertilized and its transformation into a cell, spermule, having the form, and discharging the functions, of a nemic sperm as hitherto understood;—a transformation involving a growth of about 50 per cent in diameter together with a greater growth longitudinally, and a marked change in the granulation of the cytoplasm (*spml*, Fig. 12). These transformed cells, detached one by one, fertilize the eggs in what seems a normal manner. The polocytes seem normal. The female gamete has seven chromosomes (Fig. 13).

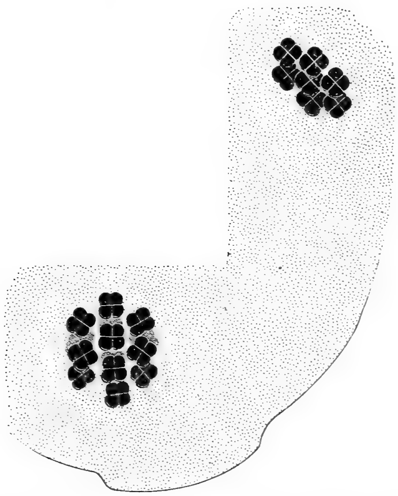

Fig. 13.—Sketch of one end of ovum of *S. parasitifera*, in synapsis. Above, male zygote. Below, female nucleus in synapsis; one group of chromosomes shown behind the other. Individuality of chromosomes obscured by their position.

This method of spermatogenesis is normal to nemas. A large number of species belonging to numerous and varied genera are known to the writer in which the general appearances in the gonad of the male so closely resemble those of *Spirina parasitifera* as to leave him no doubt that the details of their spermatogenesis will show the features here described, or something similar. The formation of the spermatidian tissue is not an essential feature; in others of the above species the spermatidia may remain separate.

Current postulates must be modified in order to account for hereditary transmission in this and similar animal species. The factors usually believed to reside wholly, or in part, in the chromosomes must here, in order to accord with the usual theories of heredity,

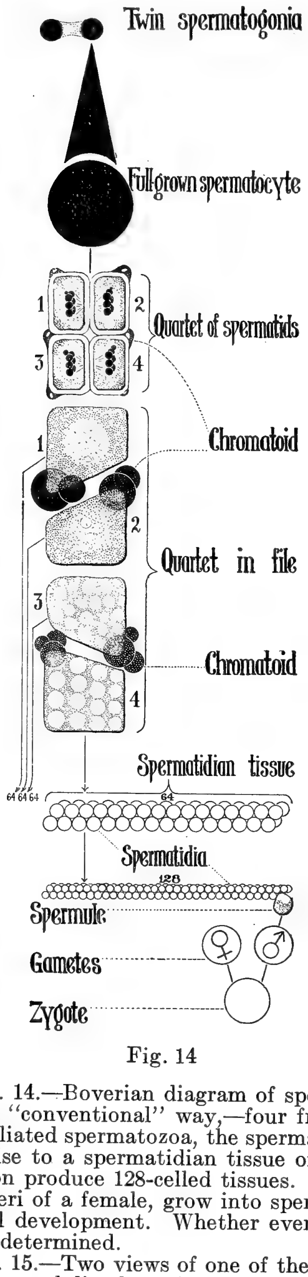

Fig. 14

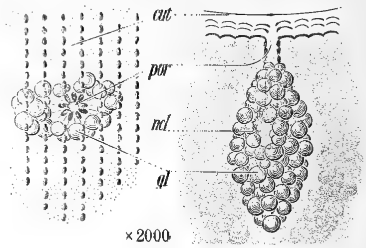

Fig. 15

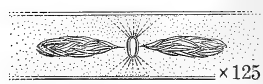

Fig. 16

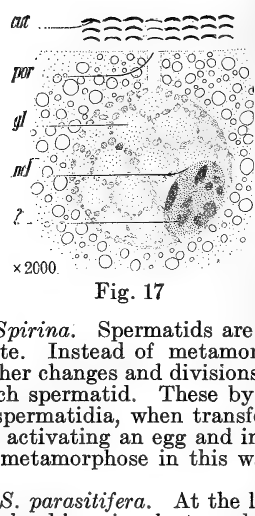

Fig. 17

Fig. 14.—Boverian diagram of spermatogenesis of *Spirina*. Spermatids are formed in the "conventional" way,—four from a spermatocyte. Instead of metamorphosing into ciliated spermatozoa, the spermatids undergo further changes and divisions, which give rise to a spermatidian tissue of 64 cells from each spermatid. These by mitotic division produce 128-celled tissues. One by one the spermatidia, when transferred to the uteri of a female, grow into spermules, capable of activating an egg and initiating normal development. Whether every one of the 128 metamorphose in this way is as yet undetermined.

Fig. 15.—Two views of one of the lateral glands of *S. parasitifera*. At the left only the pore and distal portions of gland are shown. The gland is uninucleate and consists mainly of spherical granules. Spent glands contain fewer granules than that shown.

Fig. 16.—Ventral view of vulva and vaginal glands of *S. parasitifera*. See also Fig. 12.

Fig. 17.—Lateral view of one of the lateral glands of *S. parasitifera*. The gland in a different state, or stage of development, from that shown in Fig. 4.

be "divisible" in the spermatid into numerous parts such that when they appear in the spermule they are capable of bringing about "normal" syngamy.

It will be interesting to discover how factors or genes, concepts essential to clear thinking on the subject of heredity, can be imagined to "carry on" through the mazes of the division that, extending throughout the spermatid, gives rise without mitosis to 64 apparently equivalent elements in the spermatidian tissue (see *spmtd polyncl,* Fig. 2). The spermatidian tissues (aggregates of haploid cells,—gametophores—Fig. 12) seem more clearly reminiscent of the alternation of generations in plants than any animal structure hitherto made known.

Subjoined is an alteration of the Boverian diagram illustrating the spermatogenesis here described. It will be seen that in this Boverian diagram (Fig. 14) the proportions of the camera lucida drawing (Fig. 2) are to a large extent adhered to. The microsomes and the alveolated nuclear spaces are shown with no very great departure from nature. The number and size of the microsomes is approximately correct and the new arrangement of the microsomes around 64 centers as shown in the diagram is not violently schematized. The same is true of the size, color and disposition of the chromatoid bodies. For simplicity the spermatidian tissues are reduced in the diagram to masses of 64 and 128 nuclei respectively.

The features accompanying and following the oöcytic synapsis seem at least a gesture toward the path followed in the spermatogenesis, but they have not yet been carefully studied.

Occasion for staining the gonads of *Spirina parasitifera* offered an opportunity for a more careful study of the unicellular glands of this species that "empty" through minute pores in the cuticle of most regions of the body, but particularly along the lateral fields. Unicellular structures of this character are known to be widespread among nemas, having been recorded for a great variety of free-living genera and a few parasitic genera. It is not known whether the various unicellular organs of this character hitherto recorded are homologous or whether they are connected with a variety of functions. The fact that they are well developed on aquatic forms that experiment proved to be in urgent need of oxygen has led the writer to suggest the possibility that these "glands" or some of them, may be connected in some way with respiration. This would seem in accord with the failure hitherto to observe any such organs in the vast majority of the parasitic species,—whose "respiration" it would seem natural to explain in other ways.

In *Spirina parasitifera* these organs are very small, and it therefore seems not unlikely that the present methods, when applied to more suitable material, may give results much more detailed and intelligible. The structure of one of these glands of *S. parasitifera,* so far as determined, is shown in Figs. 15 and 16. The great difference in the size of the organs in the two cases, as well as the difference in structure and space relationships, suggests the probability that the shape of the organ changes materially, perhaps rapidly, under various conditions. To this surmise it may be added that the method of collecting the spirinas, and the varying length of time between their existence under natural conditions and the time of examination, would result in a very material alteration in the environment; and it is believed that the longer this time became the less free oxygen would exist in the sea water in which the specimens were kept. This length of time varied widely.

SIZE AND NUMBER AS RELATED TO ORGANISMS

The interesting behavior of the spermatidian granules as described on pages 38 to 41 has suggested the following sketchy discussion of the relationship of organisms to size and number.

Why not vertebrates a mile long and a thousand feet high? Why not vertebrates only a quarter of an inch long? The known facts clearly indicate limits in both directions.

Among the reasons for the existence of the upper limit are, circulation difficulties due to friction in the blood vessels; accumulation of an excess of excreta in the blood during the long journey to the distant extremities and back; the difficulty of maintaining the requisite temperature at the extremities; limits set by the strength of materials,—bone could not be strong enough or muscles efficient enough properly to support and move so large an organism; food supply difficulties; space limitations connected with protecting such an organism from the elements, etc., etc.

Reasons for the non-existence of exceedingly small vertebrates also come readily to mind. The complicated vertebrate mechanism would be in the way in an organism of such small size. Why an elaborate pumping system to pump blood for a distance through which it might diffuse without such a system? So with "centralized" respiration. An internal skeleton plus the necessary protective cuticle become incompatible in this range of sizes. The competition of such imaginary small vertebrates with other organisms, say insects, of simpler structure better adapted to such small sizes would be a hopeless struggle.

Why not insects as large as moles or as small as microbes? Here again the mechanical relations of the organism to the menstrua furnish numerous reasons for the known size limits.

Generalizing, why not multicellular organisms beyond certain maximum and minimum limits? A little thought shows that limits are set by the relationships of particular mechanisms to the sizes and distances involved; and as size, in such cases, is a function of the number of cooperating cells, the limits are set in numerical terms. This becomes clearer when we consider our ability to represent a cellular organism by a strictly numerical expression, the bioequation,[2] and all the more certainly true when, continuing the same line of thought, we consider the size limits of cells.

Why do we not have cells a meter long; and why not typical cells below the limits of a micron or two? Again, among other reasons, in this range of still smaller sizes the mechanism of the typical cell becomes so complex as to "be in its own way" when the distances involved become sufficiently small and the number of properties to be transmitted sufficiently few, as will be indicated in a moment.

Size limits in these various cases are set by a fundamental necessity, having its "final" source in the size of the electronic combinations.

Particular attention is called to the fact that, usually, the size limits of "adjacent" higher and lower groups of organisms reciprocally overlap (e.g. Vertebrates and Insects); as well as to the fact that individuals of certain species of unicellular organisms are larger than some of the multicellulars; or, to emphasize by reversing, many multicellulars are smaller than some of the larger unicellulars. There is a distinct *lapping* of the size limits of one on to the size limits of the other.

Organisms of greater size; "social organisms."—Developing a more complex nervous system, the higher organisms have evolved "mental pictures" of distant and invisible things and events, and have invented means for transmitting through various media signs that represent these mental pictures. Along this path the social organisms evolved. When we speak of a social organism it is usually assumed

[2] *Biological Relationships of the Mathematical Series* 1, 2, 4, etc." This JOURNAL **15**: 235, 1925.

that we are using analogy, but an interesting formulation might be made out for homology. Are not the interactions between relatively widely separated intellectual individuals, existing in the sea of air surrounding the earth, in many ways actually homologous with the passage of stimuli, etc., through more viscous fluid media between cells? As, for instance, when two small organisms live in symbiosis; or, where cells exist together as they do in blood; or, between cells even more intimately organized.

The concept of organisms of this higher or social grade suggests the possibility of there being also lower orders of organisms at the other end of the accepted series. This idea is not new, for their existence was specifically asserted by acute observers and adventurous thinkers in the plainest of language at least half a century ago; but at that time the supporting evidence was so meagre that the idea did not rise to the dignity of an acceptable working hypothesis. Now it is quite different. Today what we know about certain small living elements, both inside and outside of cells, compels such a working hypothesis,—if mayhap we are not already beyond the hypothetical stage.

Here again, size seems a prime determining element. When a cell (really a relatively complex and large organism) transmits its exceedingly numerous properties to its "descendants," nothing short of an elaborate mobilization and census is adequate to the coming transmigration. Hence follow mitosis and its complications.

We are perhaps prone to forget that every cell has, in a great degree, to care for itself; and so *must* have many of the multitudinous properties characteristic of the groups of cells constituting higher organisms. It *must* nourish itself. "You can take the horse to food (or vice versa), but you cannot make him eat;—he must do that himself," seems to summarize the situation. If the cell assimilates ("eats"), and is to continue, then it must have mechanism adequate to select, transport, digest, excrete, etc., and at least to take some part in reproducing itself. All this complexity is because of the *number* of its characteristics, and because of the size, i.e., the distances involved. But what if all these be a hundredfold or more reduced, and the system be at the same time "isolated" or individualized? Plainly, the requirements would call for a simpler mechanism; cell-mechanism would be so complicated as to be in the way. Under such conditions simpler organisms, organisms simpler than cells, seem a logical necessity.

Litobionts.—I have ventured to suggest a general or inclusive name, Litobionts, for the organisms which my observations lead me to believe to exist, these very organisms of lower grade;—(λιτος, simple), simple-organisms. The Litobionts have distinctive characters, such as small size, and simplicity of composition, but nevertheless, live, assimilate, grow, multiply;—not only segmenting somewhat after the manner of some higher, more or less filamentous organisms, but *multiplying by endogenous division*, this latter being one of the present observations, the endogenous process being exemplified in the "granules" of the spermatidia of *Spirina*. (See p. 41.)

Yet it is possible to over-emphasize the smallness of Litobionts. It seems likely that we have been looking at Litobionts a long time,—Litobionts of the larger size,—without recognizing their nature, just as observers previous to the time of Schleiden and Schwann had been looking at cells without recognizing their nature.

Just as the multicellular and unicellular organisms overlap each other in the matter of size, so the unicellular organisms (having the characteristic properties of cells as now defined) overlap the Litobionts. There are unicellular organisms smaller than some Litobionts. Or, in reverse, some Litobionts larger than some unicellular organisms.

That the Litobionts are much simpler than cells, is indicated by a number of considerations. Their effects on light indicate that in the main, they are composed of a smaller number of kinds of molecules of a more orderly arrangement,—what may perhaps be thought of as forming a simpler plasm, Litoplasm. The fact that some of them are soluble in certain chemical reagents (e.g. acetic acid), is another indication of relative simplicity. In a word, we must conceive of the Litobionts as made up of a smaller number of kinds of simpler molecules manipulated through very much smaller distances, and therefore necessarily (a matter of "economy," "least resistance") by simpler mechanism. It is quite conceivable that some Litobionts may be smaller than some of the largest molecules. Not needing these large and complex molecules, the mass of the Litobiont may even be smaller than that of some such molecules.

The duality characteristic of all matter must lead, however, to an arrangement of the parts in Litobionts such that we can only think of them at present largely in terms of what we know of cell physiology and mechanics; simply because knowledge progresses exclusively through the known to the unknown. Our knowledge of cells must be one of the main sources of our Litobiont concepts.

We may at least suspect the existence of organisms, or quasi-organisms, simpler than Litobionts. Is not a living "being" composed of a comparatively small number of chemical elements, say approaching some of the carbohydrates in composition, not only thinkable, but are there not experimental data almost justifying science in its present state in postulating such "beings"?

SCIENTIFIC NOTES AND NEWS

The third meeting of the International Union of Scientific Radio Telegraphy held at Washington from October 10 to 28, 1927, was the largest and most successful of the three that have taken place up to the present time. The first was held at Brussels in 1922. The Washington meeting included both general sessions and sessions of its technical subdivisions called "commissions" and was arranged according to the following program:

Oct. 10,	General Session	
11,	Commission	II, Wave Propagation
12,	"	I, Radio Measurements
13,	Public Session	
14,	Commission	III, Atmospherics
17,	"	II, Wave Propagation
17,	"	IV, Liaison
18,	"	I, Radio Measurements
18,	"	III, Atmospherics
20,	"	III, "
20,	"	IV, Liaison
24,	"	I, Radio Measurements
26,	"	II, Wave Propagation
26,	"	IV, Liaison
27,	"	III, Atmospherics
28,	General Session.	

The public and general sessions were held under the chairmanship of Gen. Ferrié, President of the Union. The presiding officers at the session of the commissions were as follows: I, Radio Measurements, Dr. D. W. Dye (England); II, Wave Phenomena, Dr. L. W. Austin (U. S. A.); III, Atmospherics, Prof. R. Mesny (France); IV, Liaison, Prof. G. Vanni (Italy).

The papers presented in the public session, October 13, were as follows:

L'emploi de cellules photoélectriques associées à des lampes à plusieurs électrodes, à la solution de divers problèmes concernant la mesure du temps. Gen. G. Ferrié.

International comparison of frequency standards. Dr. J. H. Dellinger,

The Navy's primary frequency standard. R. H. Worrall and R. B. Owens.

Precision determination of frequency. J. W. Horton and W. A. Marrison.

A radio-frequency oscillator for receiving set investigations. G. Rodwin and T. A. Smith.

The effect of reaction on the received signal strength. Dr. B. van der Pol.

An automatic recorder for radio signals and atmospheric disturbances. E. B. Judson.

Experiences in radio compass calibration. F. A. Kolster.

Apparent night variations in crossed-coil radio beacons. H. Pratt.

Investigation of downcoming waves (a) on the existence of more than one ionized layer, (b) on the influence of the earth's magnetism on wireless transmission. Prof. E. V. Appleton.

Ionization in the upper atmosphere. Dr. E. O. Hulburt.

A theory of the upper atmosphere and meteors. H. B. Maris.

Les ondes ultra-courtes. Prof. R. Mesny.

Experiments on radio wave projectors. E. F. W. Alexanderson.

Height of reflecting layer in August 1927 and the effect of the disturbances of August 19. O. Dahl and L. C. Gebhardt.

The relation between radio reception, sunspot position and area. G. W. Pickard.

On the influence of solar activity on radio transmission. Dr. L. W. Austin and Miss I. J. Wymore.

Seasonal variation in signal strengths of the 20-meter wave from Nauen in Japan. T. Nakagami and T. Ono.

Diurnal variation in signal strengths of short waves. T. Nakagami and T. Ono.

A note on the short-wave long-distance transmission. T. Minohara and K. Tani.

The directional observations on atmospherics in Japan. E. Yokoyama and T. Nakai.

Relations entre les parasites atmosphériques et les phénomènes météorologiques. Capt. R. Bureau.

The meetings concluded with a formal dinner tendered to the visiting delegates by the executive committee of the American section on October 28. The persons who attended the meetings from the various countries were as follows:

Australia; Prof. J. P. V. Madsen.

Belgium; Prof. R. B. Goldschmidt.

Canada; Major W. A. Steele, J. W. Bain.

France; General Ferrié, P. Brenot, Dr. LeCorbeiller, Comm. Jullien, Prof. R. Mesny, Capt. Bion, Capt. R. Bureau.

Germany; Dr. H. Harbich.

Great Britain; Prof. E. V. Appleton, Dr. D. W. Dye, E. H. Shaughnessy, Capt. P. P. Eckersley, Capt. A. L. Harris.

Holland; Dr. B. van der Pol, E. F. Volter, G. C. Holtzappel, G. Scholet.

India; T. G. Edmunds.

Ireland; T. S. O'Muineachain.

Italy; Prof. G. Vanni.

Japan; Capt. T. Minohara, Prof. E. Yokoyama, T. Nakagami, S. Inada.

Norway; H. Petersen.

Switzerland; E. Nussbaum, H. Eggli.

United States of America; Dr. L. W. Austin, E. F. W. Alexanderson, Dr. R. Bown, Dr. G. Breit, Major W. R. Blair, Miss M. A. Brower, Prof. W. G. Cady, Dr. J. H. Dellinger, F. W. Dunmore, O. Dahl, Dr. H. T. Friis, Dr. E. O. Hulburt, E. L. Hall, Dr. A. Hund, J. W. Horton, V. E. Heaton, E. B. Judson, Dr. C. B. Jolliffe, S. S. Kirby, Prof. A. E. Kennelly, F. A. Kolster, G. W. Pickard, T. Parkinson, H. Pratt, Gen. C. M. Saltzman, Gen. G. O. Squier, Dr. G. C. Southworth, Dr. A. H. Taylor, Prof. E. M. Terry, Dr. Tuve, Dr. W. Wilson, Dr. L. P. Wheeler, Miss I. J. Wymore.

On December 6th Neil M. Judd, Curator of American Archeology, United States National Museum, returned to Washington after six months field work for the National Geographic Society at Pueblo Bonito. Pueblo Bonito is a prehistoric Indian village in northwestern New Mexico and is the most remarkable of all the pre-Hispanic pueblos of the Southwest. The past summer marked the seventh and concluding season of The Society's explorations. Mr. Judd is now engaged upon preparation of his final reports which will be published by The Society.

The Petrologists' Club met at the Geophysical Laboratory on December 20. Program: W. F. Foshag, *The hematite (martite) deposit at Durango, Mexico;* C. P. Ross: *Some aspects of magnetite-specularite intergrowths.* J. W. Greig presented an informal communication on *The supposed evidence for liquid immiscibilty in rocks at Agate Point, Ontario.*

Representative Sinnott introduced in the House of Representatives on December 15 (by departmental request) a bill (H.R. 7480) "To authorize the transfer of the geodetic work of the Coast and Geodetic Survey from the Department of Commerce to the Department of the Interior." The bill makes the Geological Survey responsible for the execution of geodetic surveys in the interior of the United States, including also variation-of-latitude, gravity, and seismological observations. The Coast and Geodetic Survey would be renamed the "United States Coast Survey." The bill was referred to the Committee on Interstate and Foreign Commerce.

On January 10 Dr. Charles G. Abbot was elected Secretary of the Smithsonian Institution by the Board of Regents. Dr. Abbot had been Acting Secretary since the death of Dr. Walcott.

Professor H. H. Bartlett of the University of Michigan spent a few days preceding and following the Christmas meetings of the Botanical Society of America at the National Herbarium, preparing for distribution his botanical collections of 1926–27 from Formosa and Sumatra. The most complete sets are going to the U. S. National Herbarium, the University of Michigan, Dr. E. D. Merrill, and the Gray Herbarium.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, January 19.	The ACADEMY.
	Joint meeting with The Philosophical Society. Speakers: DR. GEORGE H. HALLETT, JR., and DR. L. B. TUCKERMAN.
Saturday, January 21.	The Philosohpical Society.
	Program: E. O. HULBURT—Ionization of the Upper Atmosphere. 45 min. (Illust.)
	W. J. ROONEY—Earth-Resistivity Measurements and Their Bearing on the Location of Concealed Geological Discontinuities.
	The Helminthological Society.
Wednesday, January 25.	The Geological Society.
	The Medical Society.
Saturday, January 28.	The Biological Society.
Tuesday, February 1.	The Botanical Society.
Wednesday, February 2.	The Medical Society.
	The Washington Society of Engineers.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated Societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth on each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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GEOLOGY.—*The amount of the geologically recent negative shift of strand line on Oahu.*[1] James B. Pollock, University of Michigan. (Communicated by H. H. Bartlett.)

Many observers of islands of the Pacific region from the early explorers to the present time have noted evidence of change of strand line in the form of raised coral reefs, of elevated terraces and wave-cut benches above present sea level in both elevated limestones and on volcanic shores. The earlier observers interpreted these facts as indicating the elevation of the lands in relation to a constant sea level. More recently the view has been presented that such changes may have been due to a lowering of sea level relative to a stable land.

If the latter is the correct interpretation it could hardly do otherwise than affect the whole ocean, and evidence for the same amount of shift should be found in widely separated localities in all the oceans. Of course local differential movements might mask or even completely hide the evidence for the general shift, yet if the shift has actually been a general change of sea level the evidence must be available in many localities and the exact mount of the shift becomes of prime importance. It has been difficult for observers to determine from a study of wave-cut benches and sea caves where the sea level stood during the time when the caves and benches were cut, and different men in the same region have interpreted the evidence differently. On the Island of Tutuila, American Samoa, Daly[2] noted sea caves cut at the present sea level and their relation to that level, compared them with similar caves cut at the higher level before the

[1] Paper number 272 from the department of Botany, University of Michigan. Received December 5, 1927.

[2] Daly, R. A. *The Geology of American Samoa.* Carnegie Inst. Washington Dept. Marine Biology **19**: 95–143. 1924 (Publication 340).

last shift, and concluded that the shift was 6 meters or 20 feet. Chamberlin,[3] studying wave-cut benches in the same region, thought the shift was somewhere from 12 to 20 feet, and most likely 12 to 15 feet.

Wentworth and Palmer[4] studied the wave-cut benches on the Hawaiian Islands, and concluded that a negative shift of the strand line here occurred later than the origin of the youngest tuff cones on Oahu, to the amount of about 12 feet, or somewhere between 10 and 15 feet.

Todd and Hoffmeister[5] conclude that the benches they observed indicated a shift of 6 to 8 feet on Fiji and 9 to 10 feet on Tonga.

The author had a sojourn of two years in the Hawaiian Islands, from the summer of 1922 to that of 1924, during which period he made a study in considerable detail of the coral reefs on Oahu, both living and fossil. Incidental to this study certain observations seemed to establish the fact that the amount of the shift on Oahu, estimated by Wentworth and Palmer at about 12 feet, was really more nearly equal to that estimated by Daly for Tutuila, Samoa. It is the object of this paper to present the evidence for this conclusion.

The locality in which the decisive observations were made was on the east shore of Pearl Harbor on the Island of Oahu, the location of the great Naval Station of the United States in the Pacific Ocean region.

Pearl Harbor consists of a series of broad, pouch-like bays commonly known as the Pearl Lochs. The outlets of all the lochs converge to a single channel which forms the entrance to the harbor.

At an early stage of its development Pearl Harbor was a broadly open bay which during long geological time has become largely filled, in part with calcareous deposits of all the kinds of material found on the neighboring coral reefs, in part by detritus from erosion of the surrounding highland, and in part by volcanic tuff. The latter is particularly in evidence on the eastern shore of the harbor near which is a considerable number of craters known as the Salt

[3] Chamberlin, R. T. *The Geological Interpretation of the Coral Reefs of Tutuila, American Samoa.* Carnegie Inst. Washington Dept. Marine Biology **19:** 145–178. 1924.

[4] Wentworth, C. K. and Palmer, H. S. *Eustatic Benches of Islands of the North Pacific.* Bull. Geol. Soc. Amer. **26:** 521–544. 1925.

[5] Todd, H. S. and Hoffmeister, E. *Recent Negative Shift in the Strand Line of Fiji and Tonga.* Journ. Geol. **35:** 542–556. 1927.

Lake craters, since one of them is so near sea level that it always contains a small lake in which there is a deposit of salt on the bottom at low stages though it is not connected directly with the sea. All the craters in this vicinity have been long extinct but during the period of their activity whenever they were in a state of eruption quantities of fine ashes drifted on the northeast trade wind toward the southwest forming a broad, gently sloping ridge from the Salt Lake craters to the channel entrance of Pearl Harbor. This deposit of volcanic ash was one of the major factors in the partial closing of the broad outlet of the original bay, converting it into a nearly closed series of lochs.

Immediately adjacent to the east short of Pearl Harbor is a small crater known as Makalapa crater. The highest point of its crater rim is about 100 feet above sea level and on one side it slopes down rather steeply to the Pearl Harbor shore. At the foot of this slope runs the Oahu railway and the cuts along its right of way afford some opportunity to see the formation of the region. On this slope are located the great oil tanks which the Doheny oil interests constructed for the United States navy. In laying the foundations for these tanks and digging the trenches for the pipe lines connecting the oil tanks with the pumping station, slopes were leveled down, depressions in the land were filled up, and in the process the materials composing the land of this region were disclosed to a considerable depth below the land surface from near sea level to an elevation of about 50 feet above that level. Some of the oil-pipe ditches were excavated to a depth of 35 feet below the surface of the tuff. Preliminary to the work of construction of the oil tanks this region was surveyed with contour lines having a vertical interval of ten feet, and stakes were set to mark the contour levels. The construction engineers very kindly allowed the author access to the blue prints of the survey, and with the stakes marking the contour lines it was possible to get very accurately the elevation of any given spot within the limits of the survey. Along several of the trenches for the pipe lines, observations were made of the calcareous deposits laid down during the last period when the sea stood higher than its present level, that is, the period during which were cut the benches observed in many localities in the Hawaiian Islands by Wentworth and Palmer. Those observers state that the eustatic shift took place much later than the origin of the most recent tuff craters on Oahu, and in the Koko Head region they found the bench of the time preceding that shift cut into the tufaceous materials at the base of those craters. They also assert that the Salt Lake craters are enormously older than those of Koko Head region. They were therefore completed before the shift of strand line and might be expected to exhibit in one way or another evidence of the sea level before the shift.

Even with the sea 20 feet higher than its present level, Pearl Harbor would still be a more or less inclosed bay, and the shore in the region of Makalapa crater would be protected from the great waves of the open ocean by the extension of the low ridge previously described, running from the Salt Lake craters to the Pearl Harbor outlet. Perhaps because of this protection the sea, during its higher level, made calcareous deposits but did not cut a bench around Makalapa crater. It was fortunate that the author was able to make his observations of these deposits during the period of construction of the oil tanks, and he is under obligation to the construction engineers for the opportunity of seeing their blue-prints and obtaining the information as to the elevation of significant materials. They frequently informed him whenever any such materials were opened up to inspection. It was chiefly owing to this assistance that the amount of the last shift of strand line could be fixed with a nearer approximation to accuracy than had previously been done.

Though the accuracy of survey lines was available only around the Makalapa crater, observations pointing to the same general conclusions were made along the outlet channel where the low ridge of tuff from the Salt Lake craters meets that channel. The shore cliff in that vicinity is composed of the tuff layers separated by thin sheets of calcareous material in its lower portions, but these tuff layers are capped by a continuous deposit of calcareous material in which coral fragments, shells, etc., are embedded in calcareous sand. In this locality calcareous deposits were traced to an elevation of 15 feet but the highest limit was not determined. In neither of these two localities, Makalapa crater and the harbor channel, were calcareous deposits seen at an elevation higher than 25 feet above present sea level, though in other localities within Pearl Harbor, namely, on Ford Island and the Waipio peninsula, there are calcareous deposits up to an elevation of about 40 feet. These facts indicate very clearly that deposits of tuff from the Makalapa crater and in the lower part of the ridge from the Salt Lake craters were laid down subsequently to any submergence of Oahu that was greater than 25 feet, and that when the last eruption from these craters occurred and for some time afterward, the sea stood somewhat less than 25 feet higher on the land than it does at present.

The calcareous deposits used to determine the highest level at which they occurred were mostly in pockets or depressions around the base of the Makalapa tuff cone, and some of them may still be seen in part along the railway cut in this vicinity. It is likely, however, that the upper portions of all of them in this region have been completely hidden or removed in the extensive operations in the construction of the oil tanks, and will never again be open to observation. Even though the upper portions had been covered up by tuff carried down over them by rain, the sections along the pipeline ditches, running up the slopes as they did, made complete exposures of the depth and elevation of the calcareous deposits.

The field notes of the observations, written for each on the spot at the time the observation was made, show that at five different points within the Makalapa area a record was made of the highest elevation at which the calcareous deposits appeared. At two of these points traces of calcareous material were recorded as occurring up to 25 feet, but more marked at 22 to 23 feet. Two others were recorded as at 22 feet, and one at 21 to 22 feet. At the highest level the materials were in very thin layers, fine-grained and friable. At slightly lower levels shells and coral fragments were recognizable, and still lower, clumps of coral that might have been in place as they grew. In one pocket there were quantities of a bryozoan.

Critical facts in these observations are that the extreme elevation at which any of the calcareous materials were seen in this region was 25 feet above present sea level; that these highest layers were thin, fine-grained and friable, like the sand at the top of the sea beach; that at about 22 feet these deposits were greater in quantity, and at least one exposure at this level was seen to contain shells and coral fragments; that at still lower levels the number of coral fragments increased; and that at about 15 feet there was a bed of coral that seemed to have grown in place where it was seen.

In the interpretation of these facts it was assumed that the highest calcareous deposits, those at 25 feet elevation, were at the top of the beach above high tide, and the question was presented, how many feet would this be above high tide. As an aid in answering this question it had been noted that on a shore where the waves came in from the open ocean but were broken by a coral reef a few hundred feet off shore, the highest part of the sandy beach was 7 feet above high tide. In the region around Makalapa crater, where there would be not only the protection from the waves of the open ocean afforded by the coral reef off the entrance of Pearl Harbor, but also the added protection afforded by the ridge of tuff previously mentioned, it is believed that the highest part of the beach would be not more than five feet above high tide at the most. High tide level of the period before the last shift would therefore be 20 feet above present sea level, and the calcareous materials seen at 22 feet, may still have been tossed up by the waves 2 feet above high tide. Since the range of the tide in the Hawaiian Islands is three feet, the tide range as a whole was at least 17 feet higher in the time preceding the shift than at present.

There is still a little uncertainty on two points as to the correctness of these figures. In the first place it may be that in this protected situation and on a steep shore the waves would not deposit materials as much as five feet above high tide. Perhaps it would be only four feet instead of five. In that case the range of tide for the earlier time would be from 18 to 21 feet higher than at present. The second point of uncertainty is due to the failure of the writer to note whether the sea level used by the engineers in charge of the oil tank construction was "mean tide level" or "mean low tide." The difference is one and one-half feet. It is believed the latter was the sea level datum used by them, which agrees with the figures first given. If, however, the other datum was the one used, the whole tide range of the earlier period would be one and one-half feet higher. Accepting both uncertainties we may say that in the period preceding the last shift of strand line the sea stood higher than at present by an amount between 17 and 20 feet on the Island of Oahu. This conclusion can be drawn with a very high degree of certainty as to its accuracy.

The author believes he has presented more reliable data than any previous writer whose work is known to him as a basis of approximating the amount of the last land-sea level shift on the Island of Oahu, whatever the final conclusion which will be reached as to whether it was a shift of land or a shift of sea. It is impossible to know how much wave-cut benches were lowered below the level of the sea that cut them, hence the uncertainty of the conclusions of Wentworth and Palmer, as well as those of many others. Sea caves also may have quite different dimensions in relation to the sea that excavated them, depending on the resistance of the materials in which they are excavated. The good fortune which allowed the recognition of the materials characteristic of the beach above high tide in continuation with those of a lower level, coupled with the opportunity of determining the elevation above sea level by accurate surveys, all make for a higher degree of accuracy than has previously been attained.

As to whether the shift was an elevation of the land or a lowering of water, the most convincing evidence for the latter will be the proof that around many islands as well as along the shores of the continents there has been a similar shift in the same direction and of a similar amount. If the shift was one of the land the chances are almost infinitely against its being of the same degree in many widely separated localities in all the oceans, while if there was a lowering of the water it would within a short time affect all the lands in all the oceans. Of course it must be granted that local shifts of the land may mask or entirely hide the effects of a change in water level, nevertheless it is of great importance to determine as exactly as possible, the amount of apparent shifts of land or sea wherever found. It would seem that the evidence of wave-cut benches such as those observed by Wentworth and Palmer should be interpreted to mean a higher sea level at which they were cut than those authors were led to believe. Also, the interpretation of Chamberlin in Tutuila, Samoa, based on wave-cut benches, is likewise probably too low, and should allow a greater shift than he supposed, or at least it should be the upper limit of his allowance, namely about 20 feet. Sea caves, which are cut partly above and partly below tide level, may, in all probability, be a safer guide to the former sea level than wave-cut benches. If we accept Daly's interpretation of the former sea level on Tutuila, which was based on the sea caves, the shift in Hawaii is practically identical with that in Samoa, in direction and degree.

CONCLUSIONS:

1. The last negative shift of strand line on Oahu involved a change of land-sea level somewhere from 17 to 20 feet.

2. This agrees very closely with the findings of Daly on Tutuila, Samoa, and is greater than Wentworth and Palmer believed was indicated by the evidence furnished by the wave-cut benches on Oahu and other islands of the Hawaiian group.

PALEONTOLOGY.—*A caddis case of leaf pieces from the Miocene of Washington.*[1] EDWARD W. BERRY. (Communicated by JOHN B. REESIDE, JR.)

The aquatic larvae of the so-called caddis flies (*Trichoptera*) construct a variety of protective cases of a variety of materials. These are frequently fossilized, and are especially liable to be encountered in continental deposits, since the larvae inhabit all sorts of fresh water environments.

Last year I described[2] a new type of fossil caddis case constructed of leaf pieces, which occurs very abundantly in the lower Eocene (middle Wilcox) of western Tennessee, in what were interpreted as lagoonal deposits. These cases were broad and depressed, and were neatly constructed of symmetrically cut pieces of drift leaves.

The habit of utilizing leaf fragments in the construction of the cases of the larvae—the so-called caddis worms or caddis fly worms—has, of course, been frequently noted among existing forms, and is especially pronounced in the family Limnophilidae. The architectural plan adopted varies both with the species and with the seasons, but in no case are the leaf pieces known to be as symmetrically uniform as in this lower Eocene form, although this is approximated in the genera *Glyphotaelius* and *Pycnopsyche.* Consequently the pseudogeneric term *Folindusia* was coined for the fossil form made of leaf pieces, in conformity with the term *Indusia,* which has long been used for generically indeterminable fossil caddis cases of the familiar sand grain type.

The new Miocene species which is the subject of this note may therefore be referred to *Folindusia,* and described as

Folindusia miocenica Berry, n. sp.

Cases relatively large, depressed, two faced with sharp edges, somewhat over 3 times as long as wide, decreasing slightly in width from in front backward, amounting to about 1 millimeter in a length of 2.5 centimeters. Size ranging from 1.5 to 2.5 centimeters in length by 4 to 7.5 millimeters in width. Constructed entirely as far as observed of relatively small vegetable fragments. In the specimen figured these are all small and irregularly cut fragments of leaf blades, but in smaller cases fragments of small sticks or perhaps pieces of petioles ("ballast sticks") are incorporated, and in one specimen a long piece of this kind occupies one margin. Both monocotyledonous and dicotyledonous leaves are mined and there is apparently no selection since, although the fragments are much too small to be determined,

[1] Received December 12, 1927.

[2] EDWARD W. BERRY. U. S. Nat. Mus. Proc. **71**(**14**): 1927.

observed differences in texture and areolation of the pieces in a single case show that several species of leaves are represented, and that the "worm" did not get all of its building material from a single leaf. The number of pieces on one face of a case amounts to slightly in excess of 50, which is in striking contrast to the Eocene species *Folindusia wilcoxiana* in which the number was from 5 to 8.

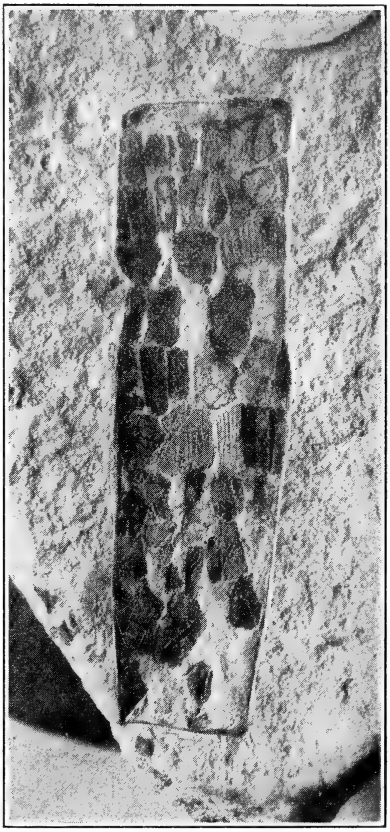


Figure 1.—*Folindusia miocenica* Berry, n. sp. × 3. Miocene of Spokane, Washington.

Folindusia miocenica was found in the fine grained, diatomaceous clays of the Latah formation at the Brick-yard exposure in Spokane, Washington. These clays carry an especially rich, varied, and well preserved mesophytic terrestrial flora of later Miocene age amounting to over 150 species. The conditions of deposition have been interpreted by Pardee and Bryan[3] as lacustrine, and due to stream damming by flows of the so-called Columbia lavas.

The philosophy of such flat cases is obviously to prevent them from being readily capsized or rolled to the consequent discomfort of the relatively small occupant, and consequently such cases may be considered as evidence of some current action.

The present species is obviously distinct from *Folindusia wilcoxiana* in the larger number of much smaller and more irregular leaf pieces used. It probably belongs in the same family, Limnophilidae, incidentally a rather large and widely distributed group, which is especially prominent in the faunas of ponds and slow streams.

BOTANY.—*Studies of Venezuelan Bignoniaceae.—I.* Ceratophytum, *a new genus of vines.*[1] H. PITTIER, Caracas, Venezuela.

The genus *Adenocalymna* was fully described for the first time by P. de Candolle[2] from notes and Brazilian specimens left by von Martius. It included originally 19 species, one of which (*A. bra-*

[3] J. T. PARDEE and KIRK BRYAN. U. S. Geol. Survey Prof. Paper **140**: 15–16. 1927.

[1] Received December 9, 1927.

[2] D.C. Prodr. **9**: 199.

chybotrys) is doubtful, another one (*A. Guillemini*) has not been seen again by modern monographers of the genus, and the remaining 17 are characterized by the biseriate disposition of the ovules, with the exception of *A. macrophyllum* and *A. Salzmanni* for which this character has not been ascertained. Two of the other species (*A. floribundum* and *A. plicifolium*) have since been transferred, the first one to *Arrabidaea* and the second to *Memora*. Besides, *Adenocalymna splendens*, created in 1896 by Bureau and Schumann, and which shows 8-seriate ovules, lately became the type of Hassler's genus *Chodanthus*.

It seems evident, first, that the intention of the authors of genus *Adenocalymna* was to include in it only species with biseriate ovules, and secondly, that most modern students of the group have supposed this arrangement to be a fundamental character. If we consider, then, that we have in the two species described hereafter a third type of such arrangement, namely an 8-seriate disposition of the ovules, and also, that the shape and size of the fruit is absolutely *sui generis*, the tendrils always trifurcate and the insertion of the inclosed stamens densely villous, their separation to form a distinct genus will appear as sufficiently justified. Besides, the affinities of the group would be with *Haplophytum* or with *Distictis Mansoana*, rather than with *Adenocalymna*.

On account of the likeness of the capsule of the type species to a goat's horn, I propose for the new genus the name of *Ceratophytum*, which is self-explanatory.

Ceratophytum Pittier, gen. nov.

Calyx tubuloso-campanulatus apice truncatus vel subquinquedentatus, extus lepidotus, plus minusve distincte glandulosus, intus glaber, eglandulosus. Corolla tubuloso-campanulata basi in tubo contracta, apice lobata lobis subaequantibus suborbiculatis, extus plus minusve dense puberula intus prope insertionem staminum dense villosa. Stamina manifeste didynama inclusa, thecae glabrae, divaricatae; staminodium breve, filiforme. Discus annularis vel cupulatus, conspicuus. Ovarium sessile, lateraliter compressum, plus minusve sulcatum vel angulatum cum stylo obsolete articulatum, ovulis numerosis, 8-seriatim placentis binis pro loculo affixis anatropis; stigmata subfoliacea. Capsula magna elongato-linearis, septo parallele compressa, apicem versus attenuata; extus sublaevis, septifrage dehiscens. Semina applanata, alata, alis membranaceis, subhyalinis, interdum apicem truncatis—Frutices scandentes, vulgo glaberrimi. Folia decussata plerumque ternata vel interdum conjugata cirrho terminali 3-furcato clausa; phylla stipulas simulantia non notata. Flores majusculi, speciosi, albi vel partim lutescentes, racemos umbelliformes decussatos terminales referentes, bracteis bracteolisque minoribus deciduis vix notatis. Species 2, venezuelenses.

Ceratophytum capricorne Pittier, sp. nov.

Frutex scandens, ramis crassis, cortice griseo, rugoso verruculis cicatricibus foliolorum delapsorum intermixtis obtectis, ramulis teretibus, laevibus, glaberrimis, parce lenticellatis, longitudinaliter striatis; foliis membranaceis

Figure 1.—Right side: Capsule of *Ceratophytum capricorne*, full view reduced to $\frac{2}{5}$ natural size. Left side: above, apex of same, front view; below, side (left) and front view of base, all reduced to $\frac{7}{8}$ natural size.

glaberrimis, vel novellis vix puberulis, plerumque ternatis, summum interdum conjugatis cirrho terminali trifurcato clausis, longe petiolatis, petiolis teretibus, supra obsolete canaliculatis; petiolulis modice longis supra anguste canaliculatis, terminali longiore; laminis late ovatis obovatisve basi rotundatis subcuneatisve, apice late rotundatis brevissime et obtuse acuminatis interdum utrinque obtusis retusisve, supra solute viridibus costa venisque primariis circa 5 prominulis, subtus pallidioribus, laxe reticulatis, costa venisque prominentibus; inflorescentia brevi, terminali, e basi ramosa, floribus apice pedunculorum 4–6 umbellulatis, rhachide minute puberula, bracteis diminutis, caducissimis; pedicellis gracilibus calyce subaequantibus vel longioribus; calyce tubuloso-campanulato, apice truncato vel sinuato, extus rufulo-furfurescente, intus glabro, glandulis nullis vel 10 obsoletis; corolla tubuloso-campanulata, extus tubo basilari brevi aurantiaco excepto alba minutissime furfuraceo-flavescente, intus flava, prope insertionem staminum dense villosa, demum glabra, lobulis orbicularibus, basi plus minusve contractis, utrinque albis; staminibus brevibus, circa dimidium corollae aequantibus, filamentis minutissime adpresso-puberulis, antheris divaricatis, glabris, staminodio filiformi; disco annulari crasso glabro; ovario leviter compresso, anguloso vel plus minusve sulcato, minutissime lepidoto; ovulis pro loculo numerosis, 8-seriatis; stylo glabro apicem versus attenuato; capsula elongata, laevi vel rugulosa, glabra, valde arcuata, lineari-lanceolata, apicem versus sensim attenuata, applanata, apice grosse mucronata, valvis lignosis medio longitudinaliter sulcatis carinatisque; seminibus alatis.

Frutex ut videtur e rupibus pendens, multicaulis, 5–6 m. longus. Petioli 3–8 cm. longi; petioluli laterales 1–1.4 cm. longi, terminale 1.5–3 cm. longum. Laminae 8–10 cm. longae, 5–7.5 cm. latae. Pedicelli 9–17 mm. longi. Calyx 11 mm. longus. Corolla circa 7 cm. longa, tubo basilari 7 mm. longo, lobulis 1.5–1.6 cm. longis latisque. Stamina majora circa 27 mm. longa, minora 15 mm., omnes 7 mm. supra basin corollae affixa; thecae circiter 3 mm. longae; staminodium 3–4 mm. longum. Discus 1.5–2 mm. altus. Ovarium 3.5–4 mm. longum; stylus 3.1–3.3 cm. longus. Capsula crasse pedunculata circa 40 cm. longa, 3.8 cm. lata; semina cum alis 4.5–5 cm. lata, circa 1.5 cm. longa.

VENEZUELA: Between Catia and Blandín, on the road from Caracas to La Guaira, hanging from rocks; flowers and fruits May 11, 1924 (*Pittier* 11527, type, in the herbarium of the Commercial Museum at Caracas, and cotype in the U. S. National Herbarium at Washington, D. C.).

As further distinctive characters between this species and those of genus *Adenocalymna*, we may mention the length of the capsule, which is gradually attenuate with a flattened subquadrangular transverse section. The fruits of none of the original species of *Adenocalymna* are known, with the exception of three cases in which they were subsequently described as "*subteretes*" or "*subcylindricae*" and as much shorter and narrower than those of either of the two species of *Ceratophytum*. The calyx of *C. capricorne* is decidedly truncate, devoid of marginal lobules and of the subsessile glands on the inner surface as reported by Schumann. The leaves are mostly 3-foliolate and, when conjugate, end in a trifurcate tendril, whereas this is described as simple in every case when it has been observed in the *Adenocalymna* species.

It is most certain that a more complete comparative study of more copious materials will show further divergences. For the present I only indicate those which happened to strike me and at the same time express my conviction that genus *Adenocalymna*, as constituted at present, is an heterogeneous and unsustainable complex.

Ceratophytum brachycarpum Pittier, sp. nov.

Frutex alte scandens, ramis crassis, angulosis, ramulis glabris, striatis, copiose verruculosis, cortice griseo vel nigrescente obtectis; foliis longe petiolatis plerumque ternatis, interdum conjugatis cirrho terminali glabro, valido, 3-furcato clausis; petiolis gracilibus, teretibus, striatis, parcissime lenticellatis, supra anguste canaliculatis; petiolulis brevibus, striatis, canaliculatis, terminali lateralibus vix duplo longiore; foliolis coriaceis ovatis, basi plus minusve obliquis subemarginatisve et leviter complicatis, apice subacuminatis obtusisve, supra laete viridibus, opacis, costa impressa, venis venulisque prominulis, subtus vix pallidioribus, glandulis impressis praecipue secundum costam interspersis, costa venisque circa 6 prominentibus, venulis laxe reticulatis prominulis; inflorescentia brevi, modice pedunculata, pedunculo crasso puberulo, floribus pedicellatis ad apicem pedunculorum secundariorum umbellulatis; pedicellis puberulis calycem plus minusve aequantibus; calyce campanulato, margine scarioso irregulariter parceque dentato, plus minusve distincte glanduloso, glandulis nigrescentibus elongatis, demum extus dense lepidoto, irregulariter glanduloso, glandulis globosis, intus laevi; corolla alba (in sicco cinnamomea), tubuloso-campanulata basi in tubo brevi angusto contracta, lobulis suborbicularibus, imbricatis, subaequantibus, extus furfuraceo-velutina, intus lobulis et insertione staminum dense villosa exceptis glabra; staminibus glabris, filamentis quam corollae tubo dimidium brevioribus, antheris divaricatis; staminodio filiformi; disco annulari-cupulato, plus minusve plicato et margine sinuato; ovario leviter applanato, lateraliter sulcato, extus lepidoto, ovulis pro loculo numerosis, 8-seriatis; stylo modice longo, glabro, stigmatibus lanceolatis; capsula crassa, lignosa, applanata, subrecta vel arcuata, lineari-lanceolata, apicem versus attenuata, grosse mucronata, extus laevi, villoso-punctulata, punctis impressis, valvis medio leviter canaliculatis, basi bigibbosis, seminibus alatis.

Petioli 4.5–7.5 cm. longi; petioluli laterales 0.7–2.4 cm., terminales 1.5–3.7 cm. longi; laminae 8.5–13 cm. longae, 4.5–9 cm. latae. Pedunculi primarii 1.5–3 cm., secundarii 0.5–1 cm. longi; pedicelli 1–1.5 cm. longi. Calyx 1 cm. longus, supra 7 mm. diam. Corolla circa 7 cm. longa, tubo basilari 6 mm. longo, lobulis 1–1.5 cm. longis, 1.3–1.7 cm. latis. Stamina majora circa 2.3 cm., minora 1.5 cm. longa, omnes circa 8 mm. supra basin tubo affixa; thecae 4 mm. longae; staminodium 5 mm. longum. Discus circiter 1.5 mm. altus. Ovarium circa 4 mm. longum; stylus plus minusve 3 cm. longus. Capsula 16–24 cm. longa, 3 cm. lata; semina cum alis circa 3.3 cm. lata, 1.4 cm. longa.

Venezuela: Near Garabato, between Villa de Cura and Magdaleno, Aragua; flowers and fruits May 7, 1925 (*Pittier* 11805, type, in Herb. Comm. Mus., Caracas, co-type in U. S. National Herbarium, Washington, D. C.). La Sanguijuela, between Alpargatón and Urama, Carabobo, fruits December 17, 1920 (*Pittier* 9153); vicinity of El Sombrero, Guárico, in light forest; flowers and fruits April 17, 1927 (*Pittier* 12366); near Sarare, Lara, in light forest; flowers and fruits April 9, 1925 (*Pittier* 11754).

This species differs from the preceding in the coloring of the corolla, the dimensions of the several parts and, principally, in the size of the capsules and seeds. Besides, the valves of the capsule are copiously punctate, a character not perceptible in those of *C. capricorne* and the glandular system is more developed in the leaves, calyx and corolla.

Before closing this contribution, I wish to add that the type-specimens of both species have been submitted to Mr. Sprague, the well known authority on the *Bignoniaceae,* who concurred in the opinion that they represent a new genus. I am sincerely obliged to him for his kindly aid.

ZOOLOGY.—*New marine mollusks from Ecuador.*[1] PAUL BARTSCH, United States National Museum.

A recent shipment of mollusks collected by Mr. J. M. Reed, of Guayaquil, Ecuador, at Salinas in Guayaquil Bay, for the Southern California Conchology Club, and transmitted by that Club to the U. S. National Museum for determination, contains a number of new things which are here described.

This collection as well as the two transmitted by Dr. R. A. Olsson[2] some time ago from which we also described a lot of new material, show that the region in question offers rich opportunities to the careful collector, and it is hoped that more work of the kind will be done here to make known to us that fauna. I am informed that the sponsors and heaviest backers of Mr. Reed's expedition have been Messrs. A. M. Strong, W. L. Brown, and C. E. White.

Mangilia whitei, new species

Fig. I.—1.

Shell small, elongate-conic, white with two slender reddish-brown bands which cover the two spiral threads anterior to the suture. The axial sculpture consists of broad, rounded ribs which are only slightly elevated at the summit and increase rapidly toward the middle of the space between the suture and summit and then again decrease anteriorly toward the suture, disappearing shortly after reaching the base. The spaces that separate these ribs are about half as wide as the ribs. The spiral sculpture consists of rather broad cords which are separated by channels almost as wide as the cords. Of these cords, 7 occur between the summit and the suture. Suture well constricted. Base attenuated, slightly concave on the left side, marked by 13 low, broad spiral threads. Aperture oval, strongly channeled anteriorly and moderately notched at the posterior angle, the outer lip

[1] Published by permission of the Assistant Secretary of the Smithsonian Institution. Received December 28, 1927.

[2] *New Mollusks from Santa Elena Bay, Ecuador.* Proc. U. S. Nat. Mus., No. 2551, **66:** 1–9, *pls. 1–2. Additional new mollusks from Santa Elena Bay,* Ecuador. Proc. U. S. Nat. Mus., No. 2646, **69:** 1–20, *pls. 1–3.*

reinforced within by a strong callus which bears 9 poorly developed lirations on the inside, the strongest one of which is immediately anterior to the posterior notch, from which they grow consecutively weaker anteriorly; there is a strong varicial-like rib immediately behind the aperture on the outside.

The type (Cat. No. 367966 U. S. N. M.) has 7 whorls, and measures—length, 5.3 mm.; greater diameter, 2.5 mm.

Olivella guayaquilensis, new species

Fig. I.—10.

Shell of medium size, elongate-ovate with the spire decidedly elevated; the first 5 turns flesh-colored, the fifth flesh-colored with a narrow brown zone near the summit and another in the suture; the last whorl is flesh-colored with a narrow brown zone at the summit, and another zone about 3 times as wide separated from this by a pale zone about as wide as the dark zone at the summit; this is followed by a broad light spiral zone which is as wide as the broad spiral brown zone immediately posterior to the first fold of the base; a narrow brown zone is present on the anterior half of the first fold and a much broader one which extends over almost half the base anterior to the second fold; the interior of the aperture is yellowish-white with 2 broad spiral bands of brown, one at the posterior angle and the other extending anteriorly from the middle; the extreme outer edge of the aperture is yellowish-white. The whorls are polished, scarcely marked by incremental lines; microscopic spiral striations are present. Suture narrowly channeled. Periphery rounded. Base rather stout, marked by 2 conspicuous folds below the periphery and 4 oblique threads on the columellar border. Aperture moderately broad, acutely channeled posteriorly, moderately deeply notched anteriorly; outer lip thin at the edge; inner lip strongly reflected as a heavy callus bearing the folds referred to above; parietal wall marked by a rather stout callus.

The type (Cat. No. 367975 U. S. N. M.) has 7 whorls, and measures—length, 15.6 mm.; greater diameter, 6 mm.

Olivella salinasensis, new species

Fig. I.—12.

Shell oval with the spire very short; early whorls flesh-colored, later ones pale brown, the last with vermiculations, arrow-shaped markings and dashes of yellowish-white, the points of the arrows being protractively directed; the interior of the outer lip is mottled at the edge, and brownish-flesh-colored within. The first 3 whorls form a mucronate apex, the next 3 expand very rapidly and are separated by a rather deeply impressed channeled suture; the last whorl is marked by fine retractively slanting, incremental lines and microscopic spiral striations. Suture channeled. Base moderately long with a single impressed line a little anterior to the periphery; the parietal and basal callus are marked by folds of which the first two are slender, and these are about one-fourth of the length of the aperture anterior to the posterior angle of the aperture; they are followed by a heavy fold which in turn is followed by two a little less conspicuous, succeeded by a narrower one which is followed by 2 heavy folds which in turn are followed by 2 a little less strong; the outer lip is thin; the aperture is narrowly channeled posteriorly and deeply notched anteriorly.

The type (Cat. No. 367976 U. S. N. M.) has almost 7 whorls, and measures—length, 10.7 mm.; greater diameter, 5.2 mm.

Mitra salinasensis, new species

Fig. I.—16.

Shell rather large, oval; early whorls flesh-colored with a narrow zone of brown posterior to the suture; the last whorl chestnut-brown, a little paler on the posterior two-thirds between summit and suture; the interior of the aperture dark chestnut-brown except the posterior zone just referred to; the folds on the columella are bluish-white. The first 3 whorls are marked by 5 rather strongly incised spiral threads which are not quite of equal width or spacing; on the next turn these become much enfeebled, and on the last they are altogether lost; the entire surface of the last whorl is marked by fine incremental lines and fine spiral striations. Suture moderately constricted. Periphery well rounded. Base moderately long, the anterior half marked by 14 spiral threads which grow consecutively stronger from the middle of the base anteriorly, and likewise more closely approximated. Aperture somewhat lunate, conspicuously channeled anteriorly; outer lip thin; inner lip bearing 4 conspicuous folds which grow consecutively weaker from the posterior anteriorly, and which are of equal spacing.

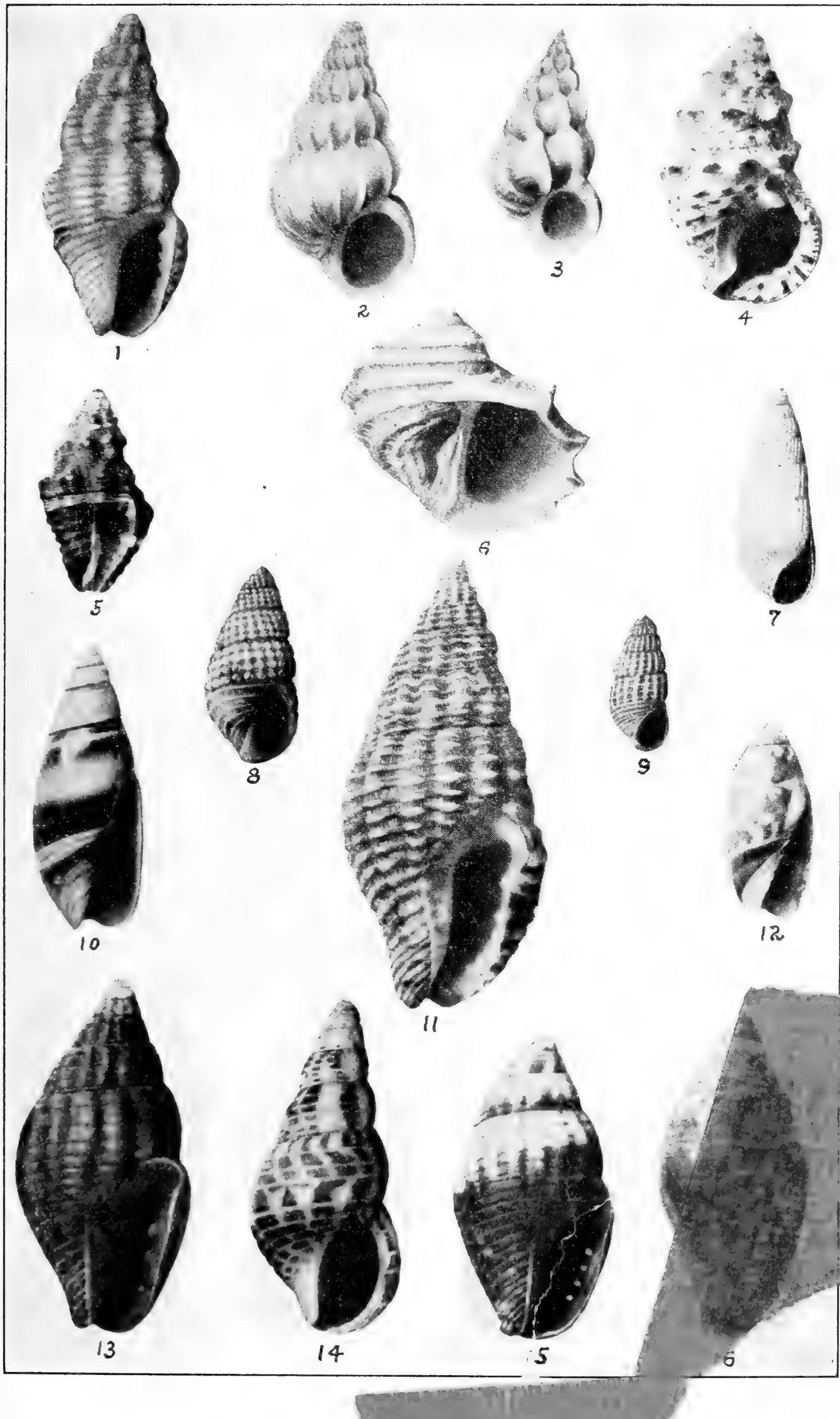
The type (Cat. No. 367982 U. S. N. M.) had 6 whorls, and measures—length, 27.8 mm.; greater diameter, 12.7 mm.

Engina mantensis, new species

Fig. I.—5.

Shell moderately large, chestnut-brown, paler at the tip with a conspicuous yellowish band immediately below the periphery. Early whorls decollated. Postnuclear whorls marked by 10 axial ribs on each turn which are almost truncated on the middle of the turns and fade rapidly posteriorly while anteriorly they extend to the umbilicus; on the early whorls these ribs show above the suture as a series of nodules; on the last turn the nodule becomes bifid; on the base 6 additional series of nodules are present; these nodules in reality are the intersection of strong spiral cords and the ribs; in addition to these stronger spiral cords, less conspicuous spiral threads are present which are separated by spaces about as wide as the threads; of these threads, 17 are present between the summit and the suture on the last turn. Base about four times as long as the space between the summit and the periphery on the last turn, marked in addition to the stronger nodules by spiral threads of the same strength as those on the spire. Aperture irregular in outline, white within but brownish on the outer lip except where the light zone is present; strongly channeled anteriorly and less so posteriorly; the posterior channel is rendered conspicuous by a heavy callus on the parietal wall and on the outer lip; the outer lip also bears in addition to the strong spiral lamella bordering the posterior channel 5 spiral lamellae anterior to the light zone; a series of 8 slender, short spiral lamellae are present on the parietal wall and posterior half of the inner lip; the anterior half of the inner lip is reflected over the columella with a very heavy callus.

The type (Cat. No. 367970 U. S. N. M.) was collected by Mr. Jones at Manta, Ecuador. It has 6 whorls, and measures—length, 17.2 mm.; greater diameter, 9.3 mm. This specimen has been in the collection of the U. S. National Museum for some time and is not part of the material received from the Southern California Conchology Club.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Anachis whitei, new species

Fig. I.—11.

Shell small, elongate-conic, ground color flesh-colored, variously marked with spots, blotches and streaks of dark brown, rust-color or yellowish. The sculpture of the nuclear whorls is partly eroded; that of the postnuclear turns consists of strong, slightly retractively curved axial ribs, of which 12 occur upon the third, 14 upon the fourth, fifth and sixth, and 16 upon the last turn. These ribs are separated by spaces a little wider than the ribs. In addition to the strong axial ribs, the whorls are marked by fine axial threads both on the ribs and in the spaces that separate them. The spiral sculpture consists of strong, decidedly elevated spiral cords, of which 4 are present on the third to fifth, 6 upon the sixth and the last turn between the summit and the suture. The junction of the axial ribs and the spiral cords forms elongate nodules having their long axis parallel with the spiral sculpture, while the spaces enclosed between them are oval pits with their long axis also parallel with the axial sculpture. Suture strongly constricted. Periphery well rounded. Base about twice as long as the last whorl between summit and suture, marked by the feeble continuations of the axial ribs which evanesce shortly after leaving the periphery, and 13 strongly elevated spiral cords which grow consecutively weaker from the periphery toward the base. The spaces that separate these spiral cords are about as wide at the periphery as the cords, but become narrower toward the base; they are marked by slender, rather closely spaced axial threads. Aperture of irregular shape, strongly channeled anteriorly and less so posteriorly; outer lip thick within, marked a little behind the edge on the inside by 6 denticles which grow consecutively weaker from the posterior anteriorly; the columellar wall is covered by a rather thick callus which also extends over the parietal wall.

The type (Cat. No. 367977 U. S. N. M.) has almost 8 whorls, and measures —length, 7.7 mm.; greater diameter, 3.4 mm.

Anachis strongi, new species

Fig. I.—13.

Shell small, ovate; early whorls flesh-colored, the later dark chestnut-brown, with an even darker band on the posterior half of the base; the aperture is dark chestnut-brown with a reddish tinge, paler within. Early whorls eroded, the succeeding turns are almost appressed at the summit, marked by low, broadly rounded axial ribs, of which 16 seem to be present upon all the turns; in addition to these low ribs, the whorls are marked by slender incremental lines. The spaces that separate these ribs are a little narrower than the ribs. The spiral sculpture consists of 4 strongly incised, equal and equally spaced lines between the summit and suture. Suture slightly constricted. Periphery well rounded. Base almost twice the length of the portion between summit and suture of the last turn, the anterior half marked by 7 incised spiral lines which separate spiral bands about twice as broad as these lines which are flattened; on the columellar portion 8 additional incised spiral grooves separate an equal number of considerably more elevated spiral cords. Aperture rather narrow, decidedly channeled anteriorly and feebly so posteriorly; outer lip thick within, narrowing toward the edge, marked by 7 denticles within, of which the first, which marks the anterior termination of the posterior channel, is slender, while the two succeeding are very heavy; the next 3 anterior to this are much less strong, about equaling the first, the last being feeble; the columellar and parietal walls are covered by a thick callus.

The type (Cat. No. 367978 U. S. N. M.) has 5.5 whorls, and measures—length, 6.0 mm.; greater diameter, 3.0 mm.

Anachis reedi, new species

Fig. I.—15.

Shell small, broadly ovate, flesh-colored with a narrow zone of brown at the suture and a broad zone of much darker brown on the anterior third of the base; the posterior two-thirds being of the same color as the zone anterior to the periphery; the interior of the aperture shows the same zonation, with the ground color a little darker flesh-colored than the exterior. Nuclear whorls eroded. Postnuclear whorls appressed at the summit, somewhat inflated, well rounded, marked with feebly developed, low axial riblets which are merely indicated on the early turns, and of which 20 are present on the last volution. In addition to these axial ribs, fine, closely spaced incremental lines are present on the ribs as well as the spaces that separate them. The spiral sculpture consists of 5 strongly incised spiral lines which are most conspicuous in the intercostal spaces. Suture feebly impressed. Base about twice as long as the space between the summit and the suture, the extreme posterior portion marked by the feeble continuation of the axial ribs, and the entire surface by closely spaced incremental lines. The spiral sculpture consists of 5 deeply incised continuous spiral lines on the posterior third which separate broad, low rounded spiral cords, and 13 strongly incised lines which separate 12 rather strong, well rounded spiral cords on the anterior two-thirds of the base which grow consecutively weaker from the posterior anteriorly. Aperture oval; outer lip thick within, bearing 4 conspicuous denticles on its middle half; the inner lip and parietal wall are covered with a thick callus.

The type (Cat. No. 367979 U. S. N. M.) has almost 6 whorls, and measures—length, 5.3 mm.; greater diameter, 2.8 mm.

Epitonium strongi, new species

Fig. I.—2.

Shell rather large, broadly elongate-conic, white, thin. Nuclear whorls decollated. Postnuclear whorls inflated, strongly rounded, marked by very broad, slightly retractively curved, lamellar axial ribs, of which 14 occur upon the first and second, 16 upon the third and fourth, 14 upon the fifth and sixth, and 16 upon the last. These riblets extend equally strong over the whorls from the summit to the periphery, and on the last whorl over the base to the umbilicus, here, however, they become somewhat reduced. The broad spaces between the axial riblets are marked by incremental lines and microscopic, very closely spaced spiral striations which, however, become apparent only under very high magnification. Suture strongly constricted. Periphery inflated, well rounded. Base short, strongly rounded, marked by the continuation of the axial ribs which become fused at the umbilical region. Aperture broadly oval, peristome continuous, reinforced by a callus which replaces the columella on the inner lip and which is marked by 6 spiral threads; the rest of the peristome is considerably thickened.

The type (Cat. No. 367967 U. S. N. M.) has lost the nuclear turns; the 7.5 remaining measure—length, 15.9 mm.; greater diameter, 8.5 mm.

Epitonium reedi, new species

Fig. I.—3.

Shell of medium size, broadly conic, white with a flush of brown on the last turn which is particularly emphasized on the basal portion thereof. The last two turns of the nucleus are present and appear to be smooth. Postnuclear whorls inflated, strongly rounded; the first postnuclear whorl is marked by 14 slender, only slightly elevated, almost vertical axial riblets; on the second postnuclear turn only 10 axial riblets are present, and here they are much more elevated and also somewhat thicker with a decided angle about one-third of the distance between the summit and the suture anterior to the summit. This state of affairs obtains on the third and fourth turn, but here the angle becomes dulled, and the ribs increase materially in thickness; on the rest of the turns the angle is lost, but the axial ribs become very much thickened and are marked by a series of lines of growth; they are also conspicuously posteriorly reflected. Ten of the axial ribs are present upon all the whorls except the first; the spaces separating the axial ribs are marked by 6 spiral threads between the summit and suture which are of about the same strength and spacing on the first postnuclear whorl; the spaces separating these threads are about as wide as the threads. On the second postnuclear turn the spiral threads become obsolete on the posterior half of the whorls between the summit and suture, but remain strong on the anterior half, the posterior half being marked by numerous slender, closely spaced spiral threads; the basal portion of the intercostal spaces on the last turn are also marked by conspicuous spiral threads, while the ribs here are very much thickened and become fused at the umbilicus. Aperture broadly oval; the outer and basal lip very much thickened, that of the parietal wall a little less so, while on the inner lip the shell is reinforced by a rather strong callus which shows spiral markings.

The type (Cat. No. 367968 U. S. N. M.) has 8.5 whorls (having lost the extreme nuclear tip) and measures—length, 12.7 mm.; greater diameter 6.8 mm.

Turbonilla (Turbonilla) salinasensis, new species

Fig. I.—7.

Shell small, elongate-conic, bluish-white. Nuclear whorls 2.5, forming a depressed helicoid spire whose axis is at right angles to that of the succeeding whorls, in the first of which the nuclear spire is about one-fourth immersed; the left outline of the nuclear spire projects very slightly beyond the left side of the postnuclear turns. The first 4 postnuclear whorls are slightly rounded, the rest almost flattened, weakly shouldered at the summit and marked by retractively curved axial riblets which are about twice as wide as the spaces that separate them; of these riblets, 30 occur upon the second of the postnuclear turns, 26 upon the third and fourth, 36 upon the fifth, 38 upon the sixth and the last turn. These ribs extend fairly strong to the summit of the turns which they slightly crenulate. The intercostal spaces, on the other hand, are but feebly impressed and terminate a little posterior to the suture, leaving a narrow smooth zone in the suture. Suture moderately constricted. Periphery well rounded. Base moderately long, well rounded, marked by slender incremental lines. Aperture oval; posterior angle acute; outer lip thin; inner lip slightly curved and slightly reflected, adnate to the preceding turn for almost half its length; parietal wall glazed with a very thin callus.

The type (Cat. No. 367972 U. S. N. M.) has 7 postnuclear whorls, and measures—length, 3.7 mm., greater diameter, 1.2 mm.

Odostomia (Crysallida) salinasensis, new species

Fig. I.—8.

Shell small, elongate-ovate, bluish-white. Nuclear whorls small, deeply, obliquely immersed in the first of the succeeding whorls, above which about half of the tilted edge of the last portion only projects. Postnuclear whorls slightly rounded, feebly shouldered at the summit, marked by retractively curved, broad, low rounded axial ribs, of which 18 occur upon the first and second, 24 upon the third and fourth, and 26 upon the last turn. These ribs are considerably wider than the spaces that separate them. The spiral sculpture consists of 4 strong threads between summit and suture which render the axial ribs conspicuously nodulose; the spaces between the broad spiral threads are less than half the width of the threads. Suture strongly channeled. Periphery with a rather strong channel. Base moderately long, marked by 6 strong spiral cords; the spaces separating these spiral cords are a little wider than the cords and are crossed by slender axial threads. Aperture oval; posterior angle acute; outer lip thin at the edge; inner lip strongly curved, provided with an oblique fold at its insertion; the parietal wall covered by a moderately thick callus.

The type (Cat. No. 367973 U. S. N. M.) has 6 whorls, and measures—length, 3.2 mm.; greater diameter, 1.5 mm.

Odostomia (Crysallida) reedi, new species

Fig. I.—9.

Shell very small, elongate-ovate, bluish-white. Nuclear whorls small, deeply, obliquely immersed in the first of the succeeding turns above which only a portion of the tilted edge of the last portion projects. Postnuclear whorls almost flattened, very feebly shouldered at the summit, marked by rather strong, well elevated, obliquely, protractively slanting axial riblets, of which 18 occur upon the second and 20 upon the rest of the turns; these riblets terminate conspicuously at the summit which they render slightly crenulated. The spaces that separate the axial ribs are a little wider than the ribs; in addition to the axial sculpture, the whorls are marked by 4 spiral threads which are a little more than half the width of the spaces that separate them and which render the junction with the axial ribs feebly nodulose. The spaces enclosed between the axial ribs and spiral threads form conspicuously impressed, rounded pits. Suture well constricted. Periphery well rounded. Base moderately long, well rounded, marked by 12 spiral threads which grow consecutively feebler and more closely spaced from the periphery anteriorly; the spaces between these spiral threads are crossed by slender axial threads. Aperture broadly oval; outer lip thin; inner lip reflected over and appressed to the base for two-thirds of its length, marked with an oblique fold at its insertion; parietal wall covered with a thin callus.

The type (Cat. No. 367974 U. S. N. M.) has almost 6 whorls, and measures—length, 2.3 mm.; greater diameter, 1 mm.

Thericium browni, new species

Fig. I.—4.

Shell moderately large, brownish sooty, blotched with splashes of dark brown and white; these are usually arranged in alternating series so that on the base the tubercles are dark, while the spaces that separate them are light; the aperture is light smoky gray with alternating spots of brown and gray at the edge, some of which extend inward as streaks into the outer lip; the deeper portion of the outer lip is darker in tone than the outer edge. The early whorls have the sculpture eroded; on the next to the last it consists of a row of very strong tubercles which is about two-thirds of the distance between the summit and the suture anterior to the summit, and a row of finer tubercles a little below the summit; on the next to the last whorl the anterior row of tubercles is very strong, while on the last it is materially reduced; in addition to this sculpture the whorls are marked by numerous fine, somewhat wavy incised spiral lines. The base is about twice as long as the posterior portion of the last turn and is marked by 4 spiral series of tubercles which are brown while the spaces that separate these tubercles, which are a little larger than the tubercles, are white. On the base the spiral threads between the nodules, which are quite numerous, are a little stronger than those on the spire. Aperture irregular in outline, very strongly channeled anteriorly and moderately strongly channeled posteriorly; the callus on the parietal wall near the posterior angle forms a strong spiral lamella which forms a conspicuous channel between the posterior edge of this and the outer lip; the rest of the parietal wall is covered by a thin, translucent callus, while on the columellar lip the callus is thicker and smoky white; the outer lip is moderately expanded and curved almost in a semicircle.

The type (Cat. No. 367969 U. S. N. M.) has 5.5 whorls remaining, and measures—length, 23.1 mm.; greater diameter, 14.8 mm.

Alaba guayaquilensis, new species

Fig. I.—14.

Shell elongate-conic, the first four turns flesh-colored, the rest horn-brown with the varices flesh-colored; the interior of the aperture pale brown; the incised spiral lines are also flesh-colored. The first 3 whorls are well rounded, smooth, excepting incremental lines; beginning with the fourth, 5 incised spiral lines are present between the summit and suture. The whorls are marked at irregular intervals by strong, almost vertical varices; on the last turn there is one which crosses the entire whorl, preceded at almost regular intervals by 4 which extend but little beyond the deeply incised spiral lines anterior and posterior to the periphery. Suture slightly constricted. Periphery well rounded. Base moderately long, well rounded, marked by fine incremental lines and 5 strongly incised spiral grooves. Aperture broadly oval; posterior angle acute; outer lip thin at the edge with a strong varix immediately behind it; inner lip rather stout; parietal wall covered by a thin callus.

The type (Cat. No. 397981 U. S. N. M.) has 7 whorls, and measures—length, 5.7 mm.; greater diameter, 2.5 mm.

Fossarus guayaquilensis, new species

Fig. I.—6.

Shell small, helicoid, white. Nuclear whorls partly eroded. The later turns marked by 3 very strong spiral keels between summit and suture, and

3 additional strong spiral keels on the base; anterior to these 3 strong spiral keels near the edge of the columella are 2 additional spiral cords of considerably lesser strength than the keels; the space between the summit and the first spiral cord, which is almost on the middle of the turn between summit and suture, is marked by 7 slender spiral threads; 8 slender spiral threads are present between the first and second keel, 2 of these being on the anterior half of the first keel. The space between the second and third keel is marked by 10 spiral threads, of which 4 are present on the anterior half of the second keel, and 2 on the posterior half of the third; the space between the third and fourth keel is marked by 15 spiral threads, of which 5 very slender ones are present on the anterior half of the third and the posterior half of the fourth keel; the space between the fourth and fifth is marked by 10 spiral threads, of which 4 are on the anterior half of the fourth, and 4 in the space between the fourth and fifth keel, and 2 on the posterior half of the fifth keel; the space between the fifth and sixth keels is also marked by spiral threads; of these, 4 are on the anterior half of the fifth, and 3 in the space that separates them; anterior to this, the slender spiral threads are less conspicuous. In addition to the spiral sculpture, the whorls are marked by rather strong incremental lines amounting almost to riblets which give to the spaces between the strong spiral keels a somewhat cloth-like appearance. Base short, openly umbilicated; the umbilical wall is marked by strong incremental lines but devoid of spiral sculpture. Aperture of irregular outline, rendered strongly fluted by the spiral keels on the outer lip which is fairly thick; the inner lip is lunate, being slightly protracted at the anterior angle of the aperture and extending as a claw-like element at its junction with the outer lip on the parietal wall.

The type (Cat. No. 367971 U. S. N. M.) has 3.5 whorls remaining, and measures—length, 3.7 mm.; greater diameter, 4.1 mm.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

960TH MEETING

The 960th meeting was held at the Cosmos Club October 1, 1927.

Program: PAUL R. HEYL: *Wave mechanics.* The concept of the atom as set forth by Bohr involves the assumption that a revolving electron will not radiate energy. This assumption runs counter to accepted ideas, but has been tolerated because the Bohr atom works well.

The wave mechanics of Schrödinger furnishes us with a concept of the atom which is free from this objection and which retains all the good features of the Bohr atom. In addition it permits of half-quantum numbers which seem to be demanded by experimental evidence, but for which there was no room in Bohr's theory. It also gives a means of calculating the intensity of spectral lines, which no earlier theory was capable of doing. (*Author's abstract.*)

961ST MEETING

The 961st meeting was held at the Cosmos Club, October 15, 1927.

Program: CHESTER SNOW: *A magneto-electron theory of gravitation.* (This JOURNAL **17**: 457–464. 1927.)

A. J. Henry: *Abnormal summers in the United States.* The summer of 1927 in Washington, D. C., was the third coolest in that city in the last 50-odd years. This fact led to a short statistical study of abnormal summer temperatures, not only in Washington but elsewhere in the United States.

This study was based upon thermometric observations mainly for the 50-odd years since the early seventies and on observations for more than 100 years at two New England stations, New Haven, Conn., and New Bedford, Mass. It was shown that abnormal summers are rarely, if ever, general over the entire continental United States but tend rather to be localized in certain sections of the area, cool summers in the region extending eastward from the lower Missouri Valley to the eastern seaboard and warm summers more in the central areas west of the Appalachians and east of the Rocky Mountains. The range in the summer means is least on the coast and greatest in the interior. The extreme oscillation in the summer mean (the mean of June, July and August) is eleven degrees at Saint Paul, Minn., and the smallest oscillation is about half that amount at San Francisco and Santa Fe, New Mex.

The outstanding cool summer for New England, the only part of the country which has a thermometric record of more than 100 years was that of 1816, although the summer of 1812 at Salem, Mass., was cooler. For the remainder of the country there have been four noteworthy cool summers in the last 50-odd years, viz., those of 1903, 1907, 1915 and 1927. Of these 1915 was the coolest, 1903 the second coolest and 1927 the fourth. Warm summers have been distributed quite irregularly and more or less locally. The summer of 1926 at Portland, Oregon, was the warmest ever experienced; at San Francisco, the highest mean was reached in 1888 and at San Diego in 1871. East of the Rockies there was a group of warm summers 1889–1901, also in the middle seventies and again in 1919–1920. (*Author's abstract.*)

962d meeting

The 962d meeting was held at the Cosmos Club October 29, 1927.

Program: H. B. Maris: *A theory of the upper atmosphere and meteors.* The force of gravity acting on the atmosphere of the earth causes the heavier gases to settle downward and the lighter gases to rise to higher altitudes by diffusion, and winds unhindered by diffusion would by convection keep the composition of the air uniform at all elevations. The classical ideas of the change in atmospheric pressure with altitude (e.g. Humphreys, Jeans, Chapman and Milne, etc.) have been based on the assumption that convection is negligible, at least in the upper atmosphere, and that each gas was through diffusion in gravity equilibrium with its own partial pressure. Investigation has shown, however, that diffusion is of importance only at elevations greater than 100 km.

The ordinary equations of diffusion show at once that if the air were uniformly mixed at all altitudes and then left free from all convection currents, there would be a constant flow of lighter molecules upward and of heavier molecules downward, which would be independent of the altitude until a level was reached where the diffusing gas would be in gravity equilibrium. This "diffusion" level for hydrogen would move from infinity down to 142 km. in one day, at the end of five days it would be at a height of 127 km. and in 50 days it would be at 113 km. The corresponding levels for helium would be at 137, 120 and 106 km. respectively. The new calculations give hydrogen and helium contents above 150 km. roughly 1/100,000 of the values previously calculated.

Recent use of the upper atmosphere as a medium for transmitting electromagnetic radiation of wave-length 10 to 10,000 meters has emphasized the importance of knowledge or at least of a theory of changes which occur in the upper atmosphere between day and night conditions during different seasons of the year. Absorption of solar and terrestrial radiation by the air must determine any theory of temperature distribution in the upper atmosphere. Humphreys has discussed this problem and has suggested that it should have been worked out but no attempt has been made previously to apply radiation and absorption coefficients and solve for the thermal condition of the upper atmosphere or to estimate probable temperatures at elevations greater than 20 km. for the radiation conditions of day and night or winter and summer.

Water vapor above 11 km. absorbs a little over 20 per cent of black body radiation from below at earth temperatures while carbon dioxide absorbs nearly 40 per cent. Ozone absorbs only about 2 per cent but its presence is important because it absorbs about 4 per cent of the solar radiation at an altitude where most of the re-radiation must be by the ozone itself. Temperature calculations based on these absorption coefficients show that for a 50° latitude above a height of sixty kms. we should expect a temperature of about 250°K during a winter day with a drop to 220° during the night. The atmosphere at the base of the stratosphere cannot be in radiation equilibrium, but it must receive more radiant energy than it loses both from above and below during a 24 hour day. The temperature condition of the earth's surface is in very unstable equilibrium. The loss in heat by radiation from the warm equator is much less than from the cooler polar regions. An increase in temperature at sea level near the equator would not result in an increase in the energy lost by radiation from these regions, but would actually result in a decrease. Loss of heat by radiation from the earth depends, not on the condition of the surface, but on the temperature at the base of the stratosphere and absorption in the stratosphere. A slight change in the carbon dioxide of the air would have a tremendous influence on the climate of the earth. If the carbon dioxide content of the air were increased from the present 0.03 per cent to 0.1 per cent tropical plants would probably grow in the polar regions. On the other hand if this protecting sheet decreases from 0.03 per cent to 0.01 per cent, ice would probably be found near the equator.

Since the present theory leads to low densities of the atmosphere above heights of 100 km., densities one hundred thousandth of those of classical tables at 300 km., the facts about the appearance of meteors require explanation. It seems possible to do this following to a certain extent the ideas of Sparrow and to a certain extent those of Lindemann. When a high speed meteor strikes an air molecule, it is assumed that the energy of the impact violently ejects atoms, molecules and possibly small particles of molecular dimension from the body of the meteor. This ejected material by virtue of its velocity carries into the air the energy which eventually gives the light of the meteor trail. For example, when a nitrogen molecule strikes an iron meteor which has a velocity of 40 km. per second, the energy of the impact is sufficient to raise the temperature of 1800 molecules 1000°C. or to evaporate 56 molecules of iron, or to evaporate and ionize 24 molecules of iron. As a result of this impact a mass many times that of the nitrogen molecule is ejected from the meteor principally in the form of highly energized iron atoms which have velocities slightly greater than that of the meteor itself. The inelastic collisions of these iron atoms with the molecules of the air result in the visible trail. The excitation energy of these collisions may be as high as 155 volts for nitrogen or 280 volts for argon. Much of this energy may be radiated in the ultra-violet or even soft X-ray region, and it is probable that not more than one-tenth of the total radiation is in the visible part of the spectrum. Therefore, the total mass of the meteor must be much more than that derived by Lindemann and Dobson from their considerations of the relation between the mass of a meteor and its light. The temperature changes in the upper atmosphere from evening to morning, and from winter to summer, given by the present theory leads one to expect appearance of meteors at heights which are greater by say 5 km. in the evening than in the morning and in the summer than in the winter. It would be interesting to know whether this difference has been observed.

Recent studies of the propagation of electromagnetic waves over the earth's surface have emphasized the need of a theory and definite conclusions concerning diurnal and seasonal changes in temperature and composition of the atmosphere at heights greater than 50 km. It is the purpose of this discussion to take what steps are possible toward the meeting of this need. (*Author's abstract.*)

F. Wenner: *A principle governing the distribution of electric current in systems of linear conductors.* A brief resume is given of the procedures which have been developed for determining the distribution of direct current in systems of linear conductors. In this connection reference is made to practically all the laws, theorems, principles and procedures generally considered to pertain to this particular field of investigation. Consideration is then given to a principle which when employed usually leads more directly to the solution of problems than does any of the procedures commonly used.

This principle applies to systems of linear conductors in which the currents are proportional to the impressed electromotive forces; the electromotive forces may be any function of time, and may be distributed in any manner throughout the system; and the branches may contain resistance, inductance, capacitance or any two or all of these in series, may be so arranged as to move with respect to a permanent magnet, thus developing counter electromotive forces, and may be connected by contacts or mutual inductances or both of these. For such a system of conductors the current in any branch is that which would result if all impressed electromotive forces were replaced by a single impressed electromotive force, located in the particular branch and equal to the drop in potential which originally would have appeared across the break had this branch been opened. While this principle is a logical consequence of well-known laws, it has been used but very little and seems to be practically unknown. It is shown here that it may be used to advantage in all or practically all cases in which the conductors form a series-parallel combination or a network which may be changed to a series-parallel combination by opening the branch in which it is desired to determine the current. (*Author's abstract.*)

963d meeting

The 963d meeting was held at the Cosmos Club November 12, 1927.

Program: Howard S. Rappleye: *Observer's patterns.* In the work of first-order leveling as carried on by the U. S. Coast and Geodetic Survey the rods are read by estimating tenths of centimeter gradations. Each rod is read at three points. The height of the instrument and consequently the height at which the rods are read being purely accidental there should be about an even distribution among the ten digits in the resulting estimated millimeters. This paper is a preliminary statement of results obtained by tabulating over 30,000 separate estimations of millimeters.

The results were grouped for different observers and for different observing conditions. The diagrams or "patterns," by means of which the results were shown, displayed some startling differences between the work of different observers and even for the same observers under different observing conditions.

The possibility of devising a test, to determine the fitness of a particular observer for this class of work, before taking the field with a level party was discussed. Certain other practical results, such as a limit on the length sight, which may possibly arise from this investigation were noted. (*Author's abstract.*)

James Stokley: *The optical planetarium.*

In an informal communication Frederick E. Brasch spoke of the "Newton Commemoration Program" and accompanying exhibits at the American Museum of Natural History.

H. E. Merwin, *Recording Secretary.*

BIOLOGICAL SOCIETY

709th meeting

The 709th meeting of the Biological Society was held in the assembly hall of the Cosmos Club October 22, 1927 at 8:10 p.m., with Vice-president Wetmore in the chair and 63 persons present. Under suspension of the rules W. H. White was elected to membership. The chairman announced the resignation of Dr. T. E. Snyder as Corresponding Secretary and expressed the gratitude of the Society for his faithful service. On motion of S. A. Rohwer, Wm. H. White was elected Corresponding Secretary for the remainder of Dr. Snyder's term.

T. S. Palmer called attention to the 45th Annual Meeting of the American Ornithologists Union to be held in Washington November 14–17.

A. Wetmore stated that a dead specimen of a rare shrew, *Sorex fontinalis*, was picked up about three weeks ago by Miss Margaret Wetmore, in the path along the Canal at Lock 11. This is the westernmost record for the species in this region.

J. M. Aldrich: *Collecting flies in the West* (illustrated).—The speaker described his experiences during the past summer in collecting diptera on a cross-country automobile trip, making special reference to accommodations for tourists at the auto camps along the road, and illustrating his talk with a number of lantern slides. In discussion, C. W. Stiles called attention to the fact that public auto camps, unless strictly supervised by State officials, are likely to become menaces to public health.

H. C. Oberholser: *The lure of the waterfowl* (illustrated).—Owing to the difficulties in their study, the waterfowl are one of the most fascinating groups to the bird student. The speaker, in the course of his travels over the country, has found a widespread interest in their conservation. The problems presented by the concentration of waterfowl in restricted areas during the winter, and by the preservation of sufficient marshland for breeding purposes, were described and illustrated by photographs. The German carp, which has been introduced in many of their favorite resorts, has greatly diminished the supply of available food for ducks and geese. Monthly censuses of waterfowl are now being taken on designated days at stations scattered throughout the United States and Canada, and are expected to afford definite information as to the number of ducks and other waterfowl in the country. Lantern slides of a number of the favorite resorts of waterfowl were shown.

S. F. BLAKE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. J. WALTER FEWKES retired as Chief of the Bureau of American Ethnology, Smithsonian Institution, on January 15. His retirement will allow him to complete manuscripts on certain field researches already accomplished, and he will at the same time continue to cooperate in the work of the Bureau.

A meeting to commemorate the life and services of CHARLES DOOLITTLE WALCOTT, Secretary of the Smithsonian Institution from 1907 to 1927, was held in the Auditorium of the Natural History Building, January 24, Chief Justice TAFT presiding. Addresses were delivered by JOHN C. MERRIAM, JOSEPH S. AMES, GEORGE OTIS SMITH, and CHARLES G. ABBOT.

The Petrologists' Club met at the Geophysical Laboratory on January 17. Prof. WALDEMAR LINDGREN of the Massachusetts Institute of Technology, at present chairman of the Division of Geology and Geography of the National Research Council, spoke on *Hot springs and magmatic emanations.*

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, February 7.	The Botanical Society.
Wednesday, February 8.	The Geological Society.
	The Medical Society.
	The Archaeological Society.
	Address by Sir John Garstang, Director of the British School of Archeology in Palestine, on recent research in Palestine, illustrated. The meeting will be held at the British Embassy.
Thursday, February 9.	The Chemical Society.
	PROGRAM: W. C. HANSEN, L. T. BROWNMILLER, and R. H. BOGUE (presented by W. C. HANSEN, Bureau of Standards)—Studies on the system calcium oxide-alumina-ferric oxide.
	E. N. BUNTING, Bureau of Standards—The system SiO_2-ZnO.
	J. H. HIBBEN, Bureau of Standards—Radiation and collision in chemical gas reactions.
Saturday, February 11.	The Biological Society.
Wednesday, February 15.	The Medical Society.
	The Washington Society of Engineers.
Saturday, February 18.	The Philosophical Society.
	The Helminthological Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated Societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth on each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication. To facilitate the work of both the editors and printers it is suggested that footnotes be numbered serially and submitted on a separate manuscript page.

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PHYSICS.—*The association of water with serpentine.*[1] P. G. NUTTING, U. S. Geological Survey.

Various minerals are known to take up and part with water with changes in humidity and temperature. The water may be either dissolved, adsorbed or chemically combined as part of the molecule. Quite commonly water is held in all three ways at once. Chemical analyses for combined water in minerals are usually based on the assumption that adsorbed and dissolved water are driven off by heating for some time to 110°C. at room humidities. This preliminary study of a typical hydrous silicate was undertaken to determine whether it is possible to distinguish between these three kinds of association and to arrive at concepts of the energy changes involved. It is incidental to a comprehensive study of adsorption in oil sands.

The literature of the subject of water association is fairly extensive. Of recent investigations, that by A. S. Coolidge[2] appears to be most closely related to the specific problem in hand. Of particular interest is his discussion of the various types of adsorption-vapor pressures curves.

The investigation of systems of which only one component is volatile by the method of weighing is very simple in theory. The elimination of effects due to the container and to variations in room humidity is more difficult. The adsorption of air and water on platinum and on pyrex beakers was first investigated and is described elsewhere (to

[1] Published by permission of the Director, U. S. Geological Survey. Received January 3, 1928.

[2] LAMB and COOLIDGE. Journ. Amer. Chem. Soc. **42**: 1146. 1920 (adsorption by charcoal). A. S. COOLIDGE. *Ibid.* **48**: 1808. 1917 (theory); **49**: 708. 1927 (water and charcoal); **49**: 1949. 1927 (mercury and charcoal).

appear in *Science*). Weighings at various temperatures were made while the material (in a small platinum crucible) was suspended in a small vertical furnace directly under the balance. Material at various humidities was conditioned in closed desiccators over sulphuric acid solutions for 24 hours, then weighed at intervals of 1, 2, 5, 10, 15 and 20 minutes, and the weighings plotted. Since the container reaches equilibrium with the atmosphere of the room in less than 5 minutes, extrapolating the plotted curve backward to zero of time gives the true weight of the conditioned material to within 0.1 mg. This program was tested by a preliminary run on analcite, $NaAlSi_2O_6 \cdot H_2O$, for Dr. W. H. Bradley of the Geological Survey.

The serpentine used was suggested and selected by C. S. Ross of the Geological Survey and analyzed by F. A. Gonyer in the laboratories of the U. S. National Museum. It was crushed and sized between 150 and 300 mesh sieves (0.15–0.05 mm.) and consisted entirely of clear homogeneous grains of a yellowish green tint with no appearance of weathering or leaching. Its composition is $3MgO \cdot 2SiO_2 \cdot 2H_2O$ with part of the Mg replaced by ferrous iron. The H_2O is supposed to come off in two steps on heating.[3] The molecular weight is 278, of which $2H_2O$ forms 12.95 per cent. The analysis follows:

COMPOSITION OF SERPENTINE TESTED

F. A. GONYER, ANALYST

	Per cent	Ratios		
SiO_2	35.56	.590	.590	1.73
Fe_2O_3	4.62	.029	.053	0.16
Al_2O_3	2.46	.024		
MgO	39.88	.989	1.022	3.00
CaO	0.10	.002		
NiO	0.22	.003		
FeO	2.02	.028		
H_2O to 110°	0.88	.049	.884	2.59
H_2O above 110°	15.04	.835		

Serpentine over dry P_2O_5 at 26° loses water down to 17.61 per cent (2.37 molecules) and reaches equilibrium. In 24 hours the sample reached a weight of 0.8661 gm.; in 48 hours, 0.8661 gm., having been exposed to room humidity (47 per cent) between the two runs. This was taken as the base weight throughout. Exposed to a saturated atmosphere for 24 hours, it came back to the same base weight over

[3] F. W. CLARKE. *Constitution of the natural silicates*, p. 94.

P_2O_5 in 24 hours. With air removed, the weight reached over P_2O_5 was 0.8656 gm. Evidently the air pressure has a slight effect on the retention of moisture.

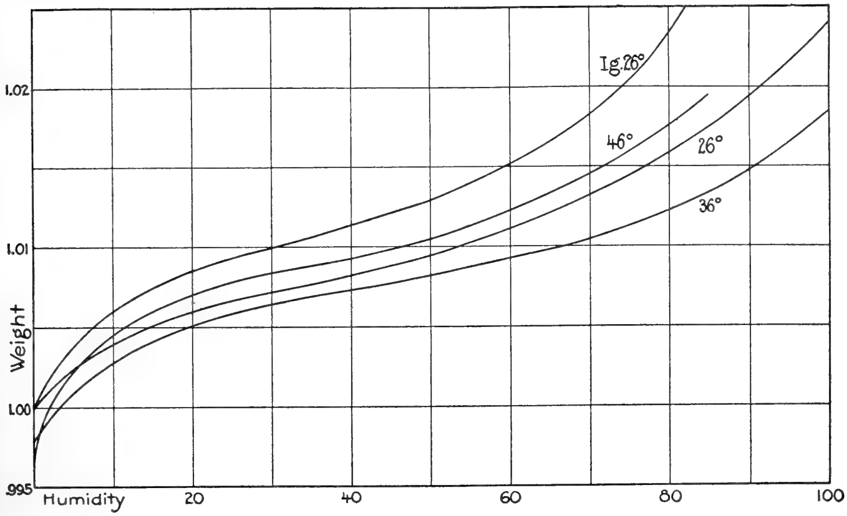

Fig. 1. Weight - Humidity

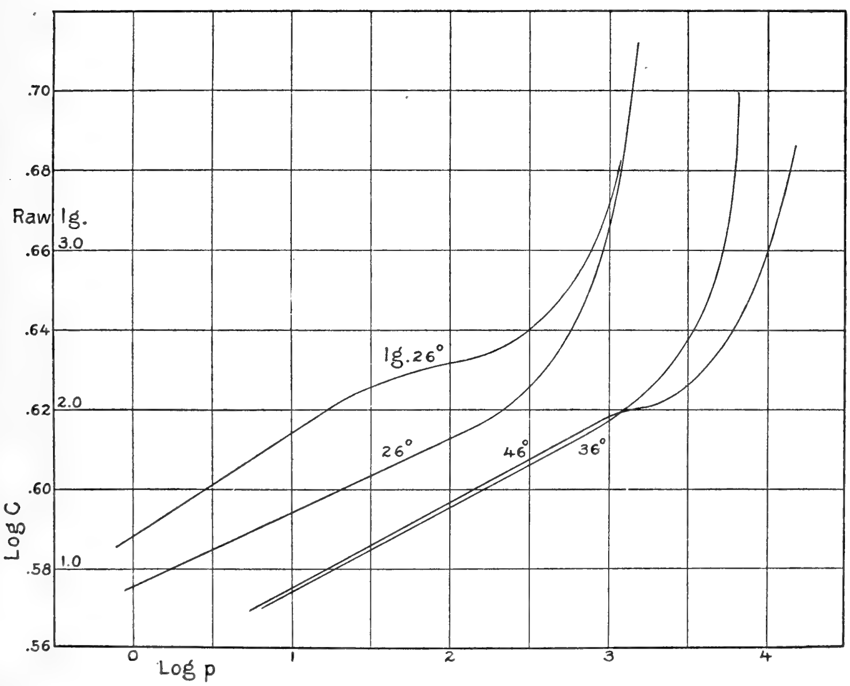

Fig. 2 Log concentration, Pressure

The moisture retained over P_2O_5 decreases slightly with rise in temperature. The relative weights found were

Temp.	26°	36°	46°	56°
Wt.	1.0000	0.9979	0.9969	0.9962

The maximum concentration of water in (or on) a mineral which has the vapor pressure zero or held against zero external pressure is an important constant, but since it varies with temperature, no definite molecular structure is indicated.

Relative weights of serpentine in equilibrium with water vapor of various concentrations are given in the following table and in Figure 1. Weights are relative to that at 26° and humidity zero as a base. Humidities range from zero (over P_2O_5) to saturation. In the last two columns for comparison are given weights relative to that at zero humidity as a base.

RELATIVE WEIGHTS OF SERPENTINE AT THREE TEMPERATURES AND VARIOUS HUMIDITIES

Humidity (Per cent sat.)	*Temperatures*				
	26°	36°	46°	36°	46°
0	1.0000	0.9979	0.9969	1.0000	1.0000
5	1.0024	1.0010	1.0024	1.0031	1.0055
10	1.0039	1.0028	1.0047	1.0049	1.0078
20	1.0060	1.0051	1.0071	1.0072	1.0103
40	1.0082	1.0075	1.0091	1.0096	1.0122
60	1.0111	1.0093	1.0118	1.0114	1.0149
80	1.0159	1.0122	1.0174	1.0143	1.0206
90	1.0194	1.0147	......	1.0168	......
100	1.0238	1.0185	......	1.0206	......

The curves are considerably flatter, i.e., the material is much less sensitive to changes in humidity, in the middle range of ordinary atmospheric humidities than under more arid or more humid conditions. The minimum slope is in the neighborhood of 40 to 50 per cent humidity. Except at the lowest humidities (under 10 per cent), serpentine will hold less water at 36° than at 26° but at 46° will hold more. This behavior would indicate a change from exothermic to endothermic adsorption (or solution) in the neighborhood of 35° but this point may better be decided by calorimetric methods. The range of molecular water at 26° is from 2.37 at zero humidity to 2.49 at 40 per cent (flattest point of curve) to 2.74 at saturation.

These data give vapor pressures of serpentine holding various proportions of water either adsorbed, dissolved or combined. Analogous curves for sulphuric acid of various concentrations are of quite similar S-shape but it does not follow that the uncombined water in serpentine is in solution, for adsorbed water in many cases also gives a curve of this form.

Ignition of this serpentine to a dull red (about 600°C.), produced a change in its properties worth noting. Material in equilibrium with air at 80 per cent humidity lost 18.8 per cent on heating, of which 12.1 per cent was regained over night. In a P_2O_5 desiccator, it reached a weight 84.9 per cent of the original weight. Taking this weight (at humidity zero) as a base, equilibria were observed at various humidities (26°C.) as follows:

IGNITED SERPENTINE AT VARIOUS HUMIDITIES

Humidity per cent	*Weight*	*Humidity per cent*	*Weight*
0	1.0000	60	1.0151
5	1.0039	80	1.0252
10	1.0062	90	1.0422
20	1.0090	100	1.0754
40	1.0113		

The ignited material takes up 50 per cent more water than the raw (see above) at the same humidities. Since at the same water concentration the vapor pressure is lower, the water is more firmly held by ignited than by raw material—a result opposite to that anticipated.

The above data on variation in weight with relative humidity may readily be converted into vapor pressures at various concentrations of water in serpentine. At zero humidity (over P_2O_5) the weight of the raw serpentine was 1.1761 times that of the completely dehydrated material. The ignited serpentine, cooled in a P_2O_5 desiccator, contained no appreciable water nor did it regain any that could not be desiccated off on exposure to various humidities for a week.

The mechanical energy of association m per gram molecule is obtained from concentration and vapor pressure from the relation

(1) $$\frac{d \log c}{d \log p} = \frac{m}{RT} = \beta p$$

Log concentration is plotted against log pressure (Figure 2) and differentiated graphically. Since $d \log c = dc/c$ is dimensionless (as is also dp/p) any convenient units may be used. This equation is applicable to such heterogeneous systems if the concentration change is due entirely to the pressure change.

The graphs show that at each temperature, the energy of association is constant for pressures up to that corresponding to about 40 per cent humidity. In other words the gas law or rather Raoult's law holds in this range and the compressibility varies inversely as the pressure. The water behaves precisely as though it were in solution in the serpentine, but the solubility is low. The ratio m/RT instead of being unity as for gases or 0.96 for water at 26° is very much lower, as in solutions of rather insoluble material. Values found from curves similar to those of Figure 2 are

VALUES OF m/RT FOUND

	0–40 per cent H	50 per cent H	90–100 per cent H
Raw serpentine 26°	.0186	.038	.261
" " 36°	.0218	.030	.202
" " 46°	.0215	.014	.172
Ignited " 26°	.65	.30	....

Water 26° (external work) $m/RT = 0.96$
Liquid water (Bridgman) $m/RT = .034 + .037 \log p$

The decrease in weight with rise in temperature is given in the table below and shown in Figure 3. It is believed that equilibrium was reached in every case. Half the effect occurred within an hour after the temperature was raised; it was practically complete in 6 hours but final weighings were made only after 24 hours. An additional 24-hour heating gave no further loss.

Two runs made at 16 temperatures each, one with serpentine in equilibrium at 26°, 80 per cent humidity, the other at 26°, 47 per cent, agreed perfectly when reduced to 950°. The maximum departure from a smooth curve was but 0.0004 per cent. The percentages below are from the curve starting at 80 per cent humidity.

PERCENTAGE WEIGHT AT DIFFERENT TEMPERATURES

26°	1.0000	500°	0.9467
50	0.9930	550	.9379
75	.9881	600	.9239
100	.9843	650	.8884
150	.9784	700	.8355
200	.9742	750	.8450
300	.9670	800	.8417
400	.9584	900	.8383

This graph shows only moderate curvatures and no straight line portions. There is no indication of any break near 100° nor near the transition temperature (573°) of silica. Its flatness above 900° indicates equilibrium and the value 0.8370 was chosen as a base weight for presumably anhydrous material. The weight at 26° was 1.1947 times this.

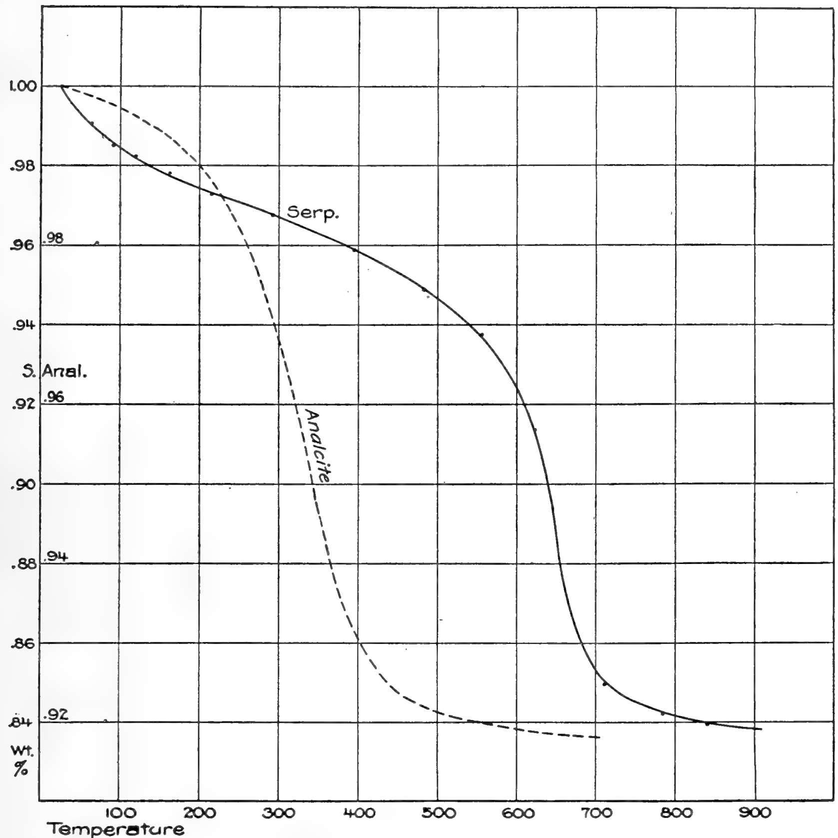

Fig. 3 Weight-Temperature

The energy per gram molecule q, necessary to free water from a material is given by the Van't Hoff equation, which certainly applies to this case. In dimensionless form this is

$$\frac{d \log c}{d \log T} = \frac{q}{RT} = \alpha T \qquad (2)$$

Multiplying through by T to split out the constant q/R, this becomes

$$\frac{d \log c}{d\,(1/T)} = \frac{q}{R} \qquad (3)$$

Hence, if $\log c$ be plotted against $1/T$, a straight line portion will indicate constancy of molecular energy of association q through the corresponding range of temperatures. This graph is shown in Figure 4.

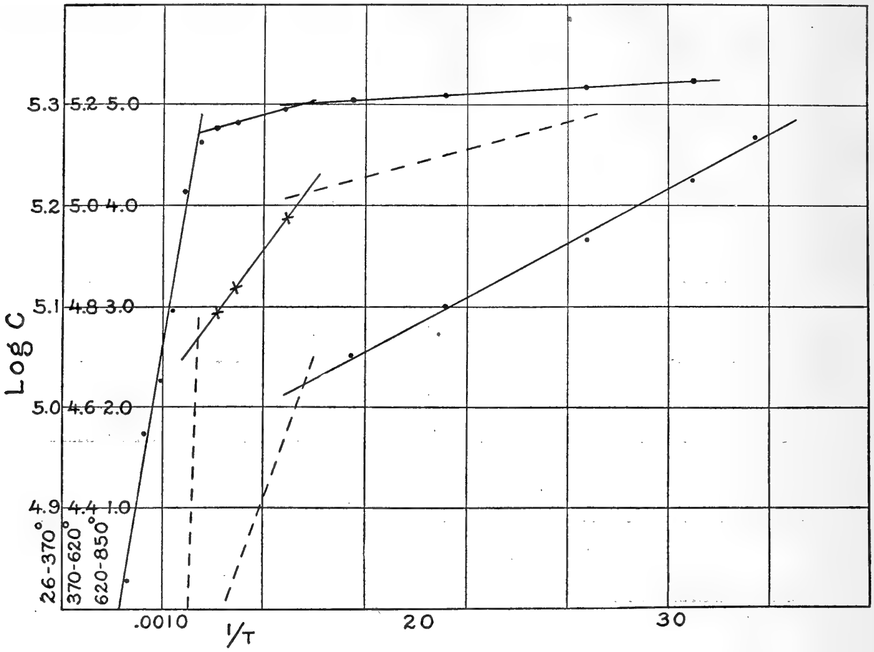

Fig. 4 Log C-1/T

The whole curve from room temperature to 850° breaks up into three straight lines (26°–368°–620°–850°) differing enormously in slope and sharply differentiated. The values are

ENERGY OF ASSOCIATION

	q/R	q
26°–368°	142 deg.	282 cal/gm. mol.
368°–620°	680 "	1350 "
620°–850°	17200 "	34140 "

The break between straight lines is very abrupt, an observation at 622° lies very near the corner between adjacent straight lines. The three intervals of constant energy are indicated by cross lines on the graph of Figure 3.

This evidence is rather convincing that water exists in raw serpentine in three distinct forms, somewhat as ordinarily supposed, and with widely different energies of association—adsorbed, monohydric, and dihydric. But the weight-temperature curve does not show this nor does the customary preheating to 110°C. by any means completely remove all but hydrated water; this temperature should be 368° instead.

At the lower transition point (368°) the indicated water content (read from the curve) is 14.90 per cent which is 36.058/18 = 2.003 in molecular proportion. At the higher point however (620°) the water content is 9.26 per cent, corresponding closely (1.246) to 1.25 molecules of water, not to a single molecule as might be assumed.

Perhaps the simplest interpretation of these results is that below 368° the material consists of $2H_2O$-serpentine containing a variable amount of adsorbed and dissolved water decreasing to 0 at 368° but requiring a constant (!) amount of energy 15.7 cal./gm. to drive it off. Between 368° and 620° the molecules are progressively breaking down from $2H_2O$ to $\frac{5}{4}H_2O$ and requiring 75.0 cal./gm. of energy in the process. At 620° the associated water is all $\frac{5}{4}H_2O$. Above 620° the material is a mixture of $\frac{5}{4}H_2O$ and anhydrous serpentine, the removal of this last water requiring 1897 cal./gm. throughout. The constancy of the energy of association over each of the three ranges (Berthelot's Principle) is remarkable, particularly in the lowest, suggesting a higher hydrate.

This method of thermal analysis of a two component system appears to be quite effective in dissecting out hydrates. It is rather remarkable that the specific energy of dehydration should be independent of temperature for adsorbed water as well as for molecular water. The method is being applied to other minerals. The curve for analcite is shown in Figure 3 for comparison. Further results will be published later.

BOTANY.—*New South American Loasaceae*.[1] ELLSWORTH P. KILLIP, U. S. National Museum.

Among specimens of Loasaceae from South America recently submitted to me for determination, several appear to represent new species. Descriptions of these follow, the various divisions referred to being those of Urban and Gilg's excellent monograph[2] of the family.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 3, 1928.

[2] Nov. Act. Acad. Caes. Leop. Carol. Vol. 76. 1900.

Loasa heucheraefolia Killip, sp. nov.

Plant perennial; stem subligneous, up to 1 cm. in diameter, tomentulous, sparingly to densely setose with very slender setae; leaves alternate or subopposite; petioles 2 to 4 cm. long; blades orbicular in outline, 3 to 6 cm. long, 3.5 to 6.5 cm. wide, shallowly and irregularly 7-lobed (lobes undulate or irregularly crenate), cordate at base with a narrow sinus, tomentulous, pilosulous and sparingly setose on both faces; flowers 5-merous, axillary, solitary (?), the peduncles 1 to 1.5 cm. long; calyx broadly turbinate, 8 to 10 mm. long, 10 mm. wide, densely pilosulous, setose, the lobes oblong-lanceolate, 8 mm. long, 4 mm. wide, acute; petals obovate, 15 mm. long, 8 mm. wide, rounded at apex, narrowed at base, strongly concave, white; scales rectangular, 5 mm. long, 4 mm. wide, incurved, 3-nerved, the nerves slightly inflated, terminating in a filament about 3 mm. long; staminodia 2 within a scale, linear-subulate, 1.2 to 1.4 cm. long; stamens about 50, the filaments about 1 cm. long, the anthers oval, about 1.2 mm. long; mature capsules not seen.

Type in the herbarium of the Field Museum of Natural History, no. 518960, collected at Tambo de Pariocota, Peru, altitude about 1000 meters, October 8, 1922, by Macbride & Featherstone (no. 2543).

Series *Floribundae.* Though mature fruit is not present, the general habit of the plant and the shape of the scales suggest a relationship with *L. pallida* Gill. It is readily distinguished from this by the shape of the leaves and the longer filaments in which the scale-nerves terminate.

Loasa puracensis Killip, sp. nov.

Perennial herb, 60 to 100 cm. high; stem minutely pubescent with grayish curved subhyaline hairs, with numerous slender brownish setae intermingled; leaves alternate or subopposite, membranous, hispidulous, sparingly setose, tomentose on nerves; petioles up to 10 cm. long, grayish-tomentose and densely short-setose; leaf blades suborbicular to lance-ovate, 3 to 12 cm. long and wide, subpalmately lobed, the lobes 5 or 7, triangular, extending less than one-third distance to midnerve, acuminate, sinuate-dentate; flowers 5-merous, terminal and axillary, the peduncles up to 3 cm. long, densely setose; calyx obconic, densely rufo-setose, the lobes lanceolate, 5 to 10 mm. long, 4 to 5 mm. wide at base, acuminate, tomentulous; petals flat, obovate, 1.3 to 1.5 cm. long, 0.6 to 0.7 cm. wide, rounded at apex, slightly narrowed in lower quarter, orange-red, tomentulous, especially without; scales rectangular, petaloid, 5 mm. long, 4 mm. wide, birostrate (beaks 1.5 mm. long), bearing on outside near middle 2 suborbicular sacs, the neck barely 1 mm. longer than sacs, narrowed toward apex; staminodia 2 opposite each scale, linear-lanceolate, 5 mm. long, 1 mm. wide at base, puberulent; stamens about 60, the filaments about 1 cm. long; anthers oblong, barely 1 mm. long; capsule obconic, 2 to 2.5 cm. long, cano-tomentose and densely rufo-setose.

Type in the U. S. National Herbarium, no. 1,142,158, collected on open hillside, Mount Puracé, Department El Cauca (Central Cordillera), Colombia, altitude 3100–3300 meters, June 11–13, 1922, by F. W. Pennell and E. P. Killip (no. 6682).

Series *Grandiflorae.* Related to *L. acuminata* Wedd.; differing in smaller flowers, shape of scales, and indument of staminodia.

Loasa rugosa Killip, sp. nov.

Perennial herb, about 35 cm. high; stem stout, nearly 1 cm. thick, minutely pilosulous and densely rufo-setose; basal leaves numerous, the cauline few; petioles 2 to 6 cm. long; leaf blades reniform, 2.5 to 3.5 cm. long, 4 to 7 cm. wide, shallowly and irregularly 5 to 9-lobed, deeply cordate, coriaceous, strongly rugose, nearly glabrous above, rufo-tomentose on nerves and veins beneath; peduncles stout, up to 4 cm. long; calyx obconic, densely setose with yellow-brown setae, the lobes ovate-lanceolate, up to 2 cm. long, 1 cm. wide, acute; petals 5, obovate, 4 cm. long, 2.5 cm. wide, orange; scales petaloid, rectangular, 12 mm. long, bilobate to below middle (lobes erect 2 mm. wide), bearing 2 suborbicular appendages on outside near base; staminodia 2 within each scale, linear-setaceous, 15 mm. long, densely pilosulous; stamens about 50; filaments 2 to 2.5 cm. long; anthers linear-oblong, 2 mm. long; capsule broadly obconic, 2 to 2.5 cm. long, 2 cm. wide, densely setose with dark brown setae.

Type in the herbarium of the Field Museum of Natural History, no. 535435, collected at Tambo de Vaca, Peru, altitude 4000 meters, June 10–24, 1923, by J. F. Macbride (no. 4350). Duplicate in U. S. National Herbarium.

Series *Grandiflorae*. Related to *L. peltata* Spruce; differing in non-peltate, thicker, strongly rugose leaves and much larger flowers.

Loasa cuzcoensis Killip, sp. nov.

Annual herb, 30 to 40 cm. high, or higher; stem stout, up to 1 cm. thick, longitudinally striate, clothed with small whitish hairs and with numerous dark-brown setae; leaves alternate or subopposite; petioles 0.5 to 3.5 cm. long; blades ovate to lance-ovate in outline, 5 to 12 cm. long, 3 to 10 cm. wide, subpinnately lobed (lobes 7 to 9, acute, the basal usually the longer), sharply serrate, truncate to subcordate at base, hispidulous, sparingly setose; flowers 5-merous, borne toward ends of stem and branches, the peduncles up to 3 cm. long; calyx cylindric-obconic, densely covered with dark brown, divaricate setae, the lobes ovate, 5 to 6 mm. long, acute; petals obovate, about 1.5 cm. long, 0.6 cm. wide, cucullate distally, unguiculate toward base, pilosulous without, pale yellow (?); scales triangular-ovate, about 5 mm. long, bisaccate toward base (sacs much-inflated), callous-thickened toward apex, otherwise smooth, the marginal teeth lanceolate, scarcely 1 mm. long; staminodia 2 within each scale, subulate, 4 to 5 mm. long; stamens about 60, the anthers ovate, about 0.5 mm. long, purplish; capsule cylindric-obconic, 2 cm. long, nearly 1 cm. wide.

Type in the U. S. National Herbarium, no. 1,283,242, collected near San Sebastian, Cuzco Valley, Peru, altitude 3200 meters, January, 1927, by F. L. Herrera (no. 1465).

A second Herrera specimen, "Cuzco, 3000–3600 meters, July 1923," is clearly this. Probably Pennell's 13571, from Sacsahuaman, above Cuzco, belongs here.

This and the following species belongs to the complex series *Saccatae*, and apparently come nearest *L. ferruginea* and *L. poissoniana*. From both of these this and *L. hastata* differ in shape of leaves and in the size and other details of the flowers.

Loasa hastata Killip, sp. nov.

Annual herb, 50 to 75 cm. high; roots densely fibrous; stem stout, up to 1.2 cm. in diameter toward base, erect, somewhat succulent, densely covered with short (about 0.5 mm.) retrorse or divaricate pale setae, with numerous longer (up to 2 mm.) brown setae toward summit; leaves alternate, or the lower subopposite, sessile (or the lower with slender petioles up to 1.5 cm. long), varying from ovate-lanceolate (lower) to hastate, 3 to 10 cm. long, 1.5 to 7 cm. wide, acuminate to a subacute or obtuse apex, subcordate or subtruncate at base, irregularly sinuate-lobed, hispidulous above, finely pilosulous beneath; flowers 5-merous, borne at ends of stem and branches, forming a pseudo-raceme; calyx obconic, densely covered with long (3 to 4 mm.) light brown setae, the lobes ovate-lanceolate, 6 to 7 mm. long, acute, occasionally with a few minute teeth at margin, setiferous; petals 1.3 to 1.5 cm. long, unguiculate below, cucullate above, about 1 cm. wide, "green-tinted," sparingly setiferous on nerves without; scales triangular-ovate, about 6 mm. long, bisaccate (sacs strongly inflated), "bright yellow and red, shading into a rose-pink," the neck with 2 horizontal thickened bands, the teeth lanceolate, about 1 mm. long; staminodia 2 within each scale, narrowly lanceolate, filiform toward tip, about 8 mm. long, minutely papillose; stamens 60 to 75, 6 to 7 mm. long, the anthers ovate, scarcely 1 mm. long, "whitish"; capsule subcylindric, 2 cm. long, 0.5 cm. wide, pilosulous and densely covered with long, divaricate setae.

Type in the herbarium of the Field Museum of Natural History, no. 516950, collected in wet sunny places at Matucana, Peru, altitude about 2500 meters, April 12 to May 3, 1922, by Macbride & Featherstone (no. 416). Duplicate in U. S. National Herbarium.

Series *Saccatae.*

Cajophora taraxacoides Killip, sp. nov.

Low, apparently perennial herb, with leaves numerous and rosulate at base and stems suberect, 1 to 4 cm. long; petioles 4 to 6.5 cm. long, subequaling or longer than blades; blades narrowly lanceolate, 4 to 7 cm. long, 1.5 to 3 cm. wide, deeply pinnate-lobed or pinnatisect (lobes triangular ovate, sinuate-dentate, 4 to 6 to a side, the lower nearly opposite, the upper alternate), hispid above, the hairs thickened at base, hirsutulous beneath, both faces with a few slender setae, the nerves and veins strongly impressed above; peduncles very slender, 5 to 10 cm. long; calyx cylindric-obconic, straight, densely covered with short whitish hairs with a few setae intermingled, the lobes linear-lanceolate, about 8 mm. long, the margin cleft into a few filiform subulate teeth; petals 5, cymbiform, 1 to 1.2 cm. long 0.7 to 0.8 cm. wide, yellow; scales strongly saccate, carinate, 6 mm. long 3 to 4 mm. wide, bilobed at apex, bearing on outside 3 slender threads 2.5 mm. long; staminodia 2 within each scale, narrowly linear, about 4 mm. long; stamens about 50, 4 to 5 mm. long; capsule recurved, subcylindric, 2.5 cm. long, 0.6 cm. in diameter, straight.

Type in the U. S. National Herbarium, no. 921784, collected in the Department of Andalgalá, Province of Catamarca, Argentina, February 12, 1917, by P. Jörgensen (no. 1158).

Section *Orthocarpae,* Series *Pleiomerae.* From *C. pycnophylla,* a near relative, this species is distinguished by its less deeply cut leaves and long petioles and by details of the flower structure.

Cajophora pauciseta Killip, sp. nov.

Lax, apparently decumbent herb, 20 cm. long, or more; stem slender, densely and finely pilosulous, with numerous stiffer subretrorse hyaline hairs and a few slender white setae intermingled; leaves opposite; petioles up to 5 cm. long, about half as long as blade; blades lanceolate or ovate-lanceolate in general outline, 5 to 10 cm. long, 2 to 5 cm. wide, deeply and regularly pinnate-lobed (lobes opposite, about 6 pairs, dentate or dupli-dentate, acutish), thin-membranous, densely covered above with short (about 1 mm.) stiff appressed hyaline hairs, glabrous on nerves, densely cano-tomentose beneath; peduncles subterminal, erect, 4 to 5 cm. long; calyx obconic, densely clothed with yellowish brown bristles; the lobes lanceolate, about 1 cm. long, 0.2 cm. wide, remotely denticulate; petals 5, cymbiform, 1.5 to 1.8 cm. long, 1 to 1.3 cm. wide, unguiculate at base; scales sac-like, 10 to 12 mm. long, 7 mm. wide, slightly keeled at midnerve, 3-nerved (nerves not terminating in free threads), bidentate at apex, the teeth lanceolate, 2 mm. long; staminodia 2 within each scale, linear, about 12 mm. long, papillose at margin; stamens about 100, 1.2 to 1.4 cm. long, the anthers broadly ovate.

Type in the U. S. National Herbarium, no. 1,044,294, collected in rocky soil, vicinity of Oroya, Peru, altitude 3300 to 4000 meters, by A. S. Kalenborn (no. 48).

This species belongs to the small group of the Section *Orthocarpae* represented by *C. coronata*, *C. cirsiifolia*, and *C. cymbifera*. The scales are shaped like those of *C. cymbifera* but are tridentate, not with a triangular lobe; the leaves are proportionately narrower.

Cajophora tenuis Killip, sp. nov.

Slender scandent herb; stem less than 1 mm. thick, sparsely pilosulous, nearly destitute of bristles; leaves opposite, petiolate (petioles 2 to 3.5 cm. long), lanceolate in general outline, 3 to 5 cm. long, 1.5 to 3 cm. wide, acute at apex, cordulate at base, pinnately 6-lobed (lobes ovate, sinuate-denticulate, extending about halfway to midnerve), thin-membranous, densely appressed-pilosulous above, hirsutulous beneath; inflorescence subterminal, the flowers solitary, the peduncles very slender, up to 5 cm. long, bearing numerous short retrorse bristles toward end; calyx obconic, densely covered with yellowish setae about 2 mm. long, the lobes narrowly linear, 6 to 7 mm. long, entire; petals 5, cymbiform, 16 to 18 mm. long, 10 to 12 mm. wide narrowed at base, finely hirsutulous and sparingly setose, pale cream-colored; scales saccate-convex, 8 mm. long, 3 mm. wide, 3-nerved, finely puberulous, shallowly bidentate at apex, bearing 3 slender threads about 3 mm. long; staminodia 2 within each scale, 9 to 10 mm. long, thickened toward apex; stamens numerous, about 10 mm. long; capsule narrowly oblong, 20 mm. long, 4 mm. in diameter (not fully developed), spirally twisted.

Type in the herbarium of the Field Museum of Natural History, no. 534636, collected in dense shrubbery, Maria del Valle, Peru, altitude about 2200 meters, April 30, 1923, by J. Francis Macbride (no. 3560). Locally known as "ortiga."

The shape of the capsules would place this near the Argentine species *C. cernua* (Section *Dolichocarpae*) in Urban and Gilg's monograph. That plant, however, is more robust, has differently shaped leaves, and differs in several details of flower structure.

Cajophora macrantha Killip, sp. nov.

Vine; stem terete, about 2.5 mm. thick, sparingly setulose with slender retrorse bristles; leaves opposite, petiolate (petioles 1 to 2.5 cm. long), lanceolate in general outline, 5 to 8 cm. long, 3 to 5 cm. wide, acuminate, pinnatifid to about halfway to midnerve (segments ovate-lanceolate, regularly serrate-dentate), cordate at base, setulose above, appressed-hirsutulous on nerves and veins beneath; flowers 5-merous, subterminal, the peduncles about 5 cm. long; ovary broadly obconic, 1 cm. long, 1.2 cm. wide at throat, densely setose, the lobes linear-oblong, 1 to 1.2 cm. long, 0.3 cm. wide, irregularly toothed, the teeth narrowly linear; petals slightly cymbiform, 2.8 to 3 cm. long, 2.2 to 2.3 cm. wide, slightly narrowed at base, white; scales deeply concave, 9 to 10 mm. long, 7 to 8 mm. wide, finely papillose, green, the margin truncate, slightly thickened, dorsal thread none; staminodia linear, about 10 mm. long; stamens about 75, 10 to 12 mm. long, the anthers linear-oblong, 1.5 mm. long.

Type in the herbarium of the Field Museum of Natural History, no. 535555, collected at Tambo de Vaca, Peru, altitude about 3600 meters, June 10–24, 1923, by J. Francis Macbride (no. 4468). Duplicate in U. S. National Herbarium.

Section *Dolichocarpae.* Obviously related to *C. contorta* from the shape of the scales, the proposed species differs in its less deeply cut leaves, larger flowers, and longer, proportionately narrower anthers.

Cajophora madrequisa Killip, sp. nov.

Herbaceous vine; stem terete, 1.5 to 2.5 mm. thick, sparingly appressed-setulose; leaves opposite, petiolate (petioles 1 to 2 cm. long), lanceolate or oblong-lanceolate, 3 to 6 cm. long, 1.5 to 3 cm. wide, acuminate at apex, subtruncate or cordulate at base, pinnately lobed (lobes broadly ovate or suborbicular, dentate or denticulate, subopposite, 5 or 6 to a side) or merely denticulate toward apex, finely appressed-hispidulous above, rufo-tomentose beneath; flowers solitary or in 2 or 3-flowered cymes, the peduncles up to 8 cm. long, densely retrorse-hirtellous; calyx obconic, about 1 cm. wide at throat, densely rufo-setose, the lobes narrowly linear or lance-linear, up to 20 mm. long, 3 mm. wide, subulate-dentate; petals 6, cymbiform-concave, 17 to 19 mm. long, 10 to 12 mm. wide, scarcely narrowed at base, tomentulous, hirtellous without, apparently light yellow; scales convex (dorsal view), 5 to 6 mm. long, 3 to 4 mm. wide, shallowly bidentate at slightly narrowed apex, bearing 3 slender threads 1.5 mm. long; staminodia 2 within each scale, lance-linear, 12 mm. long, 2 mm. wide at base, each bearing a suborbicular appendage dorsally near base; stamens about 100, 12 to 15 mm. long, the anthers ovate-orbicular, 1.2 mm. long; capsule clavate, 5 cm. long, 1.2 cm. in diameter at summit, tapering to a short stipe, spirally twisted to right.

Type in the U. S. National Herbarium, no. 604480, collected in the Lucumayo Valley, Peru, altitude 1800 to 3600 meters, June 18, 1915, by O. F. Cook and G. B. Gilbert (no. 1294). The local name is given as "madrequisa."

In the Monograph of Loasaceae all of the climbing species described have 5-merous flowers and twisted capsule. The ten species having six or seven petals are all erect, rigid plants and were placed in the section *Orthocarpae*, characterized as "numquan volubilis" and as having straight or very slightly twisted capsules. Subsequent to the publication of the Monograph, Urban and Gilg described[3] a climbing species with six petals, *C. scarletina*, and associated it with *C. mollis* of *Orthocarpae*. Whether the capsules of this species are straight or twisted is not stated. *Cajophora madrequisa* apparently should be placed with the climbing species with twisted capsules (*Dolichocarpae*), the section being amended to include species with six petals. *Cajophora scarletina* perhaps belongs here too. From *C. madrequisa* it differs in having more deeply cut leaves and larger scarlet flowers and in being far more densely setose.

Cajophora pedicularifolia Killip, sp. nov.

Scandent herb; stem about 2 mm. thick, subquadrangular, glabrous, the distal portion and petioles beset with short whitish setae; leaves opposite, petiolate (petioles 1 to 2 cm. long), lanceolate or oblong-lanceolate, 5 to 10 cm. long, 1.5 to 4 cm. wide, acuminate, subtruncate or cordulate at base, symmetrically 6 to 8-lobed (merely dentate toward apex; lobes broadly ovate, 1 to 1.3 cm. wide, dentate to subentire), bearing on upper surface, mainly toward margin, numerous translucent setae 1 to 1.5 mm. long, beneath nearly glabrous but with a few setae on nerves and veins, dark green above, paler beneath; flowers 5-merous, solitary in upper axils, the peduncles 3 to 5 cm. long; calyx turbinate, 1 cm. long, densely covered with yellowish bristles, the lobes lanceolate, 1.3 to 1.5 cm. long, 0.4 to 0.5 cm. wide, acuminate, subulate-dentate; petals oblong-cymbiform, 2.2 to 2.4 cm. long, 1 to 1.2 cm. wide, cucullate toward apex, scarcely narrowed at base, finely pulverulent, setiferous outside near midnerve, apparently yellow; scales ovate-rectangular, 7 mm. long, 6 mm. wide, 3-nerved, truncate at apex, bearing just below apex 3 narrowly linear filaments 4 to 5 mm. long, and 2 transverse ridges, the upper ridge arcuate between the filaments; staminodia 2 within each scale, narrowly linear, 9 to 10 mm. long, densely papillose; stamens about 100, 15 to 18 mm. long, the anthers oblong, blackish; capsule subcylindric, 10 to 12 mm. long, 5 mm. wide (not fully developed), densely setose.

Type in the U. S. National Herbarium, no. 1,177,715, collected at Unduavi, North Yungas, Bolivia, altitude 3300 meters, November 1910, by O. Buchtien (no. 2898). Duplicate in New York Botanical Garden Herbarium.

The character of the scales indicates that this species belongs to the small section *Bicallosae*. From the two known species, *C. stenocarpa*, of Peru, and *C. arechavaletae*, of Uruguay, *C. pedicularifolia* is readily distinguished by the shape of the leaves, smaller flowers, and proportionately broader scales.

[3] Bot. Jahrb. Engler **45**: 470. 1911.

ZOOLOGY.—*The screw-nemas,* Ascarophis *van Beneden 1871; parasites of codfish, haddock and other fishes.*[1] N. A. Cobb, United States Department of Agriculture.

The *screw-nemas,* as it is here proposed to call them, have yet to be adequately studied. Not very much has been added to van Beneden's original description. Almost nothing is known about their life history and habits. However, the present communication adds considerably to our knowledge of their morphology. The suggested explanation of the remarkable screw form, and its probable mode of evolution, presents the nemic cuticle in a new rôle. (See Figs. 5, 6, and 7.)

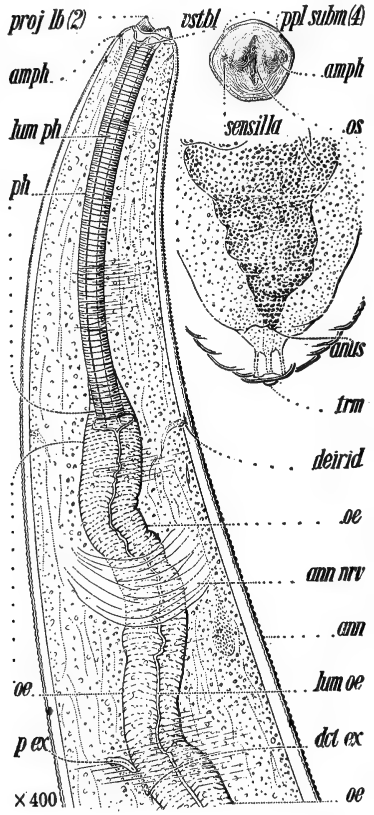

Fig. 1.—Head and tail end of *Ascarophis helix* n. sp. Above, to the right, front view of the lip region. The head end is nearly a ventral view, but slightly oblique. The tail end is a dorsal view, and the anus, being on the far side, is but indistinctly shown.

Considering the number of screw-nemas thus far seen, it is remarkable that *no males have been discovered.* Nicoll records screw-nemas as "extremely numerous" in haddock. Van Beneden found them originally in the codfish; Nicoll, in the codfish and haddock, and in the fishes *Hippoglossus vulgaris* and *Cotus bubalis;* and MacCallum now finds a species in the sting-ray.

Nemas so widespread and numerous *probably have economic significance.* This probability can not be dismissed by citing the absence of definite evidence to the contrary, for, at rather frequent intervals nowadays, nematologists are showing that nemas long known and lightly regarded, are not only of some importance in their relationship to mankind but sometimes of great importance; and the multitudinous ways in which this comes about may well give pause to any who, basing their views on past records and much current opinion, see in the presence of such parasites merely an interesting phenomenon.

[1] The investigations were carried on at the laboratory of the United States Bureau of Fisheries, at Woods Hole, Mass. Received January 3, 1928.

For example, it is now found that the presence of nemic parasites not infrequently has a profound effect upon the reproductive organs of the host, a limited number of the parasites even *producing complete sterility in a host otherwise apparently normal.* That such cases in their most definite form have thus far been found mainly in the invertebrate phyla does not invalidate the application of the idea to vertebrates, even were such cases wholly unknown in the vertebrata,—which they are not. Considering the well known universal specificity of certain chemical reagents,—chloroform for instance, a "universal" anaesthetic,—we should be prepared to accept without very much surprise some such universal specificity in the action of some hormones, particularly sexual hormones, whose origin traces back to *comparatively* simple, but fundamental, ancestral cell phenomena.

Again, there is abundant evidence of *high infant mortality* in a great variety of animals and plants, *due to nematism.* This, coupled with our ignorance of the early life histories and food habits of fishes, even common ones, makes it unwise to ignore the possible economic importance of the nemic parasites of fishes.

Many other examples could be cited of the multitudinous and unexpected ways in which nemas are being shown beneficial or injurious to mankind.

Ascarophis helix n. sp.

1.1	1.5	23.	28 ʻ57.ʼ 41	99.8	13.2mm.
0.6	0.7/	0.8	1.2	0.2	

The thick layers of the transparent, colorless, naked *cuticle* are traversed by obvious plain transverse striae, which *vary markedly* in different portions of the body. On the head, however, the transverse striae are hard to resolve; yet critical examination of the striae immediately on and behind the lip region even resolves them into rows of dot-like elements. In this region the crenations of the contour seem duplex, four double crenations a short distance behind the head occupying 10 microns, so that each crenation encompasses about 1.25 microns. In the latitude of the nerve-ring the striae are 1.7 microns apart; thence backward they are gradually coarser and more distinct, each striation becoming a double line. Furthermore, it is soon apparent that the striations pass around the body in the *form of right-handed helices*—coarser and coarser, and more oblique, with increasing latitude, so that at the base of the long neck the coils are about 8 microns apart and lie at an angle of about 23° with a transverse plane. This obliquity increases until, near the middle of the body, it reaches a maximum of about 30° (Fig. 2). Thence onward, however, the obliquity diminishes. Somewhat behind the middle of the body, *certain coils of the helix fade,* so that the other, now more prominent, striae are as much as 20 microns apart, while their width is nearly two microns,—namely the distance apart of the double "lines" representing the striae. This "dropping out," or fading, of course, is evidence of the existence of a *plurality of helicoid "striae."* In this way the body of the nema takes on the external form of an ordinary multiple-threaded screw. Here, in the middle, the contour of the body has become very coarsely and very pronouncedly *compound-crenate.* The more pronounced striae come to subtend twelve minor ones (Fig. 3). Finally near the tail end, the more pronounced striae subtend six minor ones (Fig. 3); this is near where the body is bluntly rounded off, in a hemispherical-conoid manner, in the course of a distance equal to about one and one-half body widths (Fig. 1). At first sight the deceptive appearance of the cuticle toward the posterior end of the nema *suggests moulting,* and consequent wrinkling of the cuticle. Longitudinal "striations," about 2 microns apart, due to the attachment of the musculature, are visible in most regions of the body. Posteriorly these longitudinal "striae" are still slightly oblique, and this slight obliquity extends practically to the terminus. There are no cuticular wings. With the nema in profile the lateral chords appear about one-seventh as wide as the body.

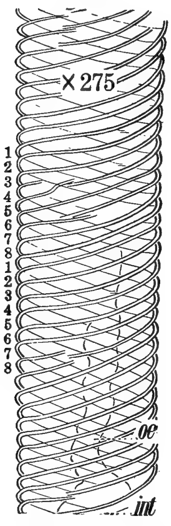

Fig. 2.—Camera lucida drawing of an oblique view of the eight-fold helicoid striae of *Ascarophis helix,* at lat. 23°, near the beginning of the intestine. The anastomosing occurs opposite the lateral chords.

The groove-like unarmed "vestibule" is very simple and shallow,—about as deep as the height of the two prominent, lateral, forward-pointing, conical *labial projections* (Fig. 1, *proj. lb.*). The vestibule leads through the slit-like mouth opening into a *long, uniform, tubular pharynx,* extending more than halfway to the nerve-ring. The pharynx is a *marked feature* of the front end, though it is so transparent and dimly refractive that it might, perhaps, under some circumstances, rather easily be overlooked (Fig. 1). Van Beneden seems to have figured the pharynx; Nicoll not, or at least not definitely. The mouth seems to lead into a minute pharyngeal or vestibular cavity, not very much wider than the amphids, perhaps six to eight microns wide,—a little longer dorso-ventrally than transversely. The median axil between the two lips is not sharp and distinct. The inner surfaces of the conical labial projections are not uniformly rounded and striated, like the outer surfaces,—for, near the middle, in their inner lateral lines or fields there are refractive longitudinal elements extending from the tips back to the mouth opening. It seems quite certain that there is an axial element extending to the apex of each of these conical projections, and when this is viewed in optical section, as one focuses from front to back, the appearances give rise to the opinion that there is a single innervation to each conical projection. One sees no evidence of radial musculature round the vestibule. There are no eyespots; and there is *no pigment* near the head, or elsewhere in the nema.

Returning now to the profile and dorsal views of the head;—four to five microns behind the tips of the two cephalic projections, exceedingly minute openings in the lateral region indicate the external amphids. As viewed *dorso-ventrally,* the anterior part of the walls of the pharynx, without diminishing much in thickness, *bend together* and nearly meet near the base of the vestibule, thus giving rise to the narrow mouth opening; in this anterior portion of the pharynx, the transverse striation is less apparent.

Behind the pharynx the *oesophagus* is a little less than one-third, at the nerve-ring about one-fourth, twice as far back as the nerve-ring a little less than one-third, and then again soon—rather suddenly increasing—a little more than one-third, and finally is one-half, as wide as the corresponding portion of the neck. The lining of the oesophagus is a rather distinct feature throughout its length, and finds its main optical expression as a somewhat sinuous axial element. The musculature of the oesophagus is rather fine. Behind where the above-mentioned enlargement takes place there is a considerable amount of granular matter in the oesophageal tissues.

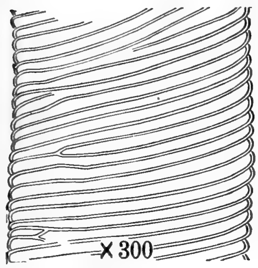

Fig. 3

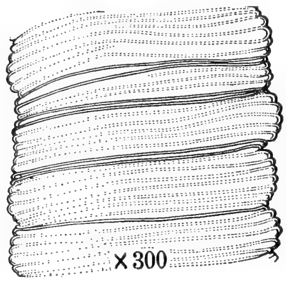

Fig. 4

Fig. 3.—Helicoid striae of *Ascarophis helix* considerably behind the middle of the body.

Fig. 4.—Camera lucida drawing of the contour of *Ascarophis helix* near the tail end of a female.

In front of this region the radial fibers are of a finer nature, closer together, and the granulation much less apparent, if present at all; in other words, there is a *distinct change in the structure of the eosophagus* at a point twice as far back as the nerve-ring. The intestine becomes almost at once two-thirds as wide as the body; it is separated from the oesophagus by a distinct cardiac collum somewhat less than half as wide as the body.

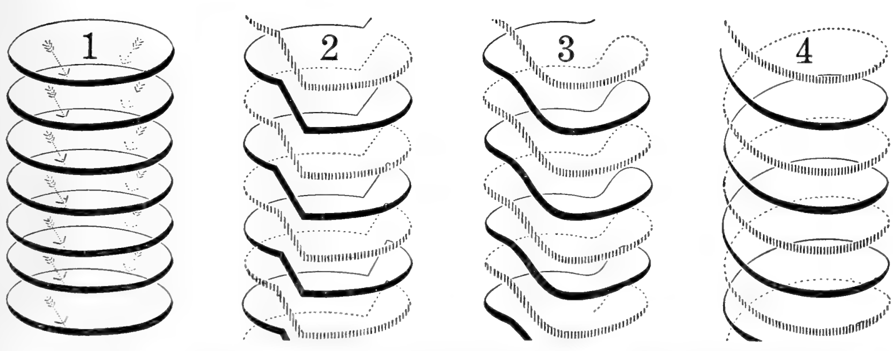

Fig. 5.—Diagrams illustrating a theory of the mode of origin of helicoid striae through anastomosing of the ordinary transverse striae of the nemic cuticle. Let 1 represent seven ordinary annules of a nemic cuticle, and suppose the anastomosing to take place on opposite sides of the nema at the places indicated by the arrows; 2 represents the anastomosing as having taken place, precisely as indicated by the arrows in 1; while 3 and 4 show the further theoretical transition to perfect helices. It will be observed that *two helices are formed.* Bilaterally symmetrical growth would necessarily lead to helices of *even* number, as exemplified in *Ascarophis.* See also Figs. 6 and 7.

The wall of the *intestine,* while not very thick, is somewhat irregular in thickness, the lumen appearing zigzag. At places the wall of the intestine is one-fourth as thick as the intestine is wide; at other places nearby its thickness may diminish by two-thirds. There is a distinct lining to the intestine, apparently made up of "columnar" elements vertical to the inner surface, though these have not been very clearly seen (Fig. 8). The granules contained in the intestinal cells are rather uniform in size, but their histological characters can not be made out on account of the state of preservation of the specimen. Well forward, near the blind end of the ovary, the intestine is not over one-third as wide as the body; and in this region the *body wall,* including the cuticle, occupies about one-fourth the radius, of which amount the vaguely retrorse cuticle occupies eight microns and the muscular tissue fifteen microns. There seems to be a *very short rectum.* The portion of the intestine just in front of the rectum is saccate, and, for a very short distance about half as wide as the corresponding part of the body; whereas in front of this enlargement the intestine is only about one-third as wide as the body.

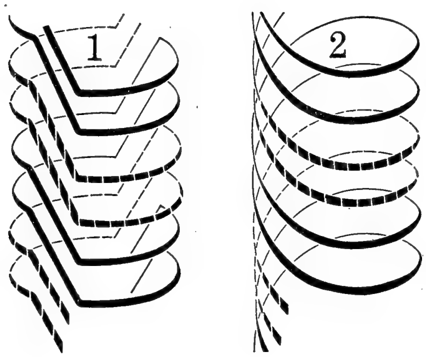

Fig. 6

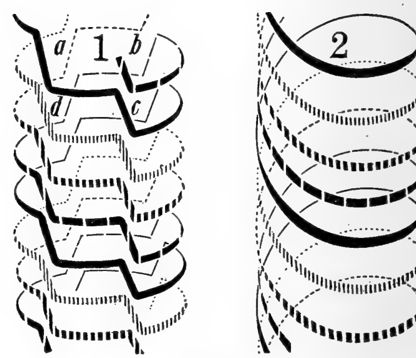

Fig. 7

Fig. 6.—Should two ordinary adjacent annules on each side of the nema behave as shown in 1, the result would be four helices; four such would originate eight helices. See also Fig. 7 and Fig. 5.

Fig. 7.—Should anastomosing take place simultaneously in successive annules opposite any four of the longitudinal chords *a, b, c* and *d,* say the four submedian, or the two lateral and the two median, the result would be eight helicoid striae. See also Fig. 6.

The blind end of the anterior *ovary,* about as wide as the distance between two of the adjacent oblique winds of the cuticular helix, is about two-thirds as far behind the cardia as this latter is behind the anterior extremity. In this region, in the body cavity, which is relatively of considerable capacity, there are *"floating" organs* made up of ellipsoidal or subspherical, fine granules, the largest of which are about eight microns in diameter (Fig. 8, *org fluit*). These "loose" organs are reminiscent of those known and figured in some of the ascarids,—e.g. *Ascaris kükenthalii.* The ovaries lie in elongate coils, and at first contain oöcytes about four microns across, which soon increase and become packed in the ovaries in the form of polyhedrons whose optical contour is often hexagonal, and which are 10 to 12 microns across where the ovary is one-third as wide as the body. The stretched-out ovary would be about twenty times as long as the body of the nema is wide, and at its greatest width about one-third as wide as the nema. *Sperms* have not been seen, nor has the extent and nature of the oviduct been observed. The two *uteri* are filled with six to eight hundred ellipsoidal *eggs* about one-third as long as the body is wide and averaging 40 × 24 microns. For a short distance near their equator the eggs are practically cylindrical. The shells are thick—a little over 2 microns—and structureless looking; are of uniform thickness throughout; and, as seen in the uteri, are *without any surface markings or appendages.* No indications were seen of "two flagellae at one pole," as noted by van Beneden and Nicoll. It is possible that appendages might arise later, e.g. from some vaginal secretion coagulated during deposition. The eggs, before deposition, contain fairly well developed *larvae.* There is a *single ovijector* of considerable length passing inward from the vulva; apparently the ovijector is several times as long as the body is wide; —say at least three times. Its walls are thick and muscular; viewed in optical section it is nearly one-third as wide as the body, being somewhat flattened when collapsed, and so, in cross-section, a little more than half as wide as long. Its lining is thin and strongly refractive; the wall, when seen in optical section, is glassy internally and fibrous externally. The *vulva* is a transverse ellipsoidal affair near the middle of the body, about one-fifth as wide as the corresponding portion of the body and interrupting two to three of the spirals. It is about twice as wide as long, is distinctly marked, and presents a double refractive contour, especially posteriorly. The excretory pore is an opening of considerable size, taking up the space of about three annules of the cuticle. For a short distance the tube is strongly refractive, then suddenly becomes almost invisible. In the specimen under examination it is impossible to follow it far enough to say whether in its course it becomes double and symmetrical or remains single and asymmetrical (Fig. 1, *p ex.*)

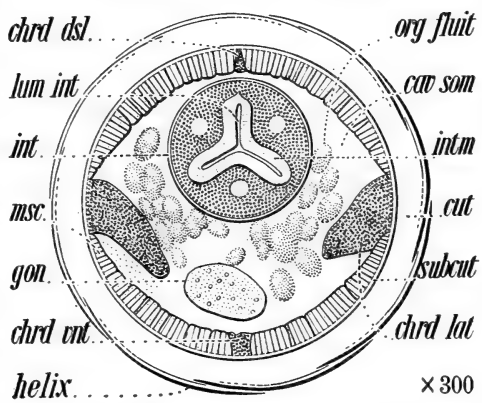

Fig. 8.—Somewhat schematized drawing of a cross-section of *Ascarophis helix*, taken not far behind the neck. Eight helices are cut, as at *helix*.

Diagnosis: *Ascarophis* having a length of 13 mm.; striae helicoid, the sub-cephalic ones very fine and not retrorse, the posterior ones very coarse and compound, their maximum obliquity,—behind the nerve-ring,—30°; the two labial projections broadly conoid; pharynx tubular, 1.1%; tail convex, and rather symmetrically short-conoid, 0.2%; eggs without polar filaments.

Habitat: Gills of the fish, *Dasyatis centrura,* sting-ray. This unusually interesting nema was discovered by my friend, Dr. G. A. MacCallum, at Woods Hole, Mass., August, 1927, while examining material collected by the Bureau of Fisheries. Hitherto members of the genus *Ascarophis* have been found only in the intestinal canal of fishes. Previously the species have been but very imperfectly described; males have not even been mentioned. The helicoid development of the outer cuticle is especially interesting. No other nemas known to me present this feature. I can only suggest that a plurality of helices has *evolved through anastomosis* such as has been frequently seen, and often figured, in cases where the annules of the nemic cuticle are a marked feature; this anastomosis, if increased in extent and systematized as shown in the diagrams (Figs. 5, 6 and 7) could give rise to helical striae. The anastomoses in *A. helix*, as far as seen, are lateral.

The facts recorded in this communication regarding the helicoid striae, and the theory of the method of their formation accord with the writer's observations (1888[2]), that the longitudinal chords are a seat of the formation of the fibrous cuticle in nemas.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

964TH MEETING

The 964th meeting was held at the Cosmos Club November 26, 1927.

Program: The evening was given to reports from the Prague Meeting of the International Geodetic and Geophysical Union.

WILLIAM BOWIE: *International coöperation.* There are very few branches of science on which international coöperation and conferences are not desirable. One of the branches which needed such coöperation very early is geodesy. About 65 years ago the geodetic association having representation from the states of the German confederation was enlarged to include all of the countries of Europe. Then, about 1886, the European Geodetic Association was enlarged to the International Geodetic Association, taking in all of those countries of the world in which geodesy was active and which cared to join.

Then there were the Seismological Association and the Astronomical Society. Besides the societies for Meteorology and Terrestrial Magnetism, there were the Geological Congress and the Geographical Congress. It would be rather difficult to estimate the number of international scientific associations that were in existence prior to the world war but, in any event, the government of the United States paid dues to seven of them. The others were not considered as being of an official nature and therefore do not appear in the list of those receiving government support.

All of those old associations and societies did notable work. They advanced greatly the various sciences involved and the periodical conferences or conventions made it possible for the workers in any one field to get together and become personally acquainted.

It has frequently been said that very little is accomplished at such conferences. I am rather inclined to differ with this view. The reports of the proceedings may indicate that nothing very definite had been accomplished by the delegates and committees in their general meetings, but the many conferences of the delegates in their rooms and in hotel lobbies and while

[2] Beiträge zur Anatomie und Ontogonie der Nematodon. Gustav Fischer, Jena, 1888.

at receptions, etc., make it possible for the organizations to which the representatives belong to develop much during the intervals between the general conferences.

Just before the end of the world war the representatives of the national academies of some of the allied countries decided to reorganize international scientific associations and societies. The result of the preliminary discussion was the calling of a meeting at Brussels in July 1919. At this conference there was organized the International Research Council and three of its Unions, those of Geodesy and Geophysics, of Astronomy, and of Chemistry. Provision was made for the later organization of eight other Unions, five of which have been created.

The Preamble to the Statutes of the International Research Council set forth the purposes of the organization and then the Statutes showed how the organization should function. The affairs of the Council are administered by an Executive Committee composed of the President, two Vice Presidents, the Secretary General and a representative of each of the Unions now organized. The headquarters of the Council are at Brussels where the meetings occur and where the archives are kept.

The meeting of the International Geodetic and Geophysical Union, held in September, 1927, in Prague, was considered to be the most successful, from a scientific standpoint, of any ever held. As a matter of fact, only two had previously been held, one in Rome in 1922 and one in Madrid in 1924.

In Madrid and also in Prague the Parliament Building was turned over to the Union for the meetings of its Sections and their various committees. There is always a most delightful entertainment of the guests, with receptions by high government officials, and there are visits to nearby places of interest during the conferences and at the end of the meeting there is usually a personally conducted excursion over the country where the meeting is held. All of the entertainment is given free to the delegates and their families except the excursion at the end of the conference and, even then, special rates on the railroads and hotels are extended.

The International Research Council and its Unions certainly justify their existence. There are now about 32 countries adhering to the Council and it is hoped that the remaining countries which have not yet joined may do so in the very near future. (*Author's abstract.*)

W. D. Lambert: *Section on geodesy.*

N. H. Heck: *Sections on oceanography, seismology, and terrestrial magnetism.* One of the important outcomes of attending a meeting of this character is coming in close touch with those who are doing outstanding work along similar lines throughout the earth, since this gives a new viewpoint on the problems involved and a better understanding of the part which should be taken by the country of each delegate. Through association both in official duties and through the American Geophysical Union with the three subjects named it is not inappropriate for one delegate to report on all three, though there was American representation in each. The effort to follow the work of three sections was very difficult and the observations are therefore not based on as full first hand information as would have been the case in attending only meetings of one section.

Oceanography. The activities in this section indicate the great complexity of this subject which includes most of the geophysical subjects relating to the land. There are a great many organizations, some of them through lack of funds accomplishing little, and the section has considered it a part of its duty to attempt to coördinate these. This is being accomplished to some extent, though with some difficulties, owing to the constitutional limitations on the activity of the section. Since the last meeting lists of oceanographers and organizations engaged in oceanographic activities have been published and will prove useful to all those interested in oceanography. International investigations in tides, standardization of instruments in use in oceanography and similar subjects have engaged a considerable portion of the section's activity.

Seismology. The national reports proved to be of great value as showing how the International work in this subject is recovering from the disintegrating effects of the war. The rise of interest in seismology in the United States, as indicated by the reports from the Carnegie Institution of Washington, the Jesuit Seismological Association, and the United States Coast and Geodetic Survey, was noted with interest. A report of considerable interest was given by Dr. Imamura for Japan which indicates that at 50 stations new instruments have replaced those shown by the great earthquake of 1923 to be inadequate. An instrument for measuring long period waves which has been developed in Japan was discussed, also a clinometer for measuring tilt by which it appears likely that severe earthquakes can be predicted one half to several hours in advance. This preliminary tilting of the earth will be further studied. Dr. Rothe, secretary of the section and head of the Central Bureau at Strasbourg, introduced the proposed nomenclature for earthquake phases of Dr. James B. Macelwane, of St. Louis University and head of the Jesuit Seismological Association and this was fully discussed though not recommended for adoption at this time. Other national reports were of considerable interest but cannot be detailed. Dr. Nikifaroff of Russia described the activities in seismology in that country, including ten new major stations and numerous minor stations in regions specially subject to earthquakes. A station is being established in the Comandorski Islands, the nearest group to the Aleutians.

Terrestrial magnetism and electricity. The range of subjects discussed was wide. The report of the activity in the United States was covered by that of the Coast and Geodetic Survey and that of the Carnegie Institution of Washington, Department of Terrestrial Magnetism and Atmospheric Electricity, the latter of which also contained much information about work in all parts of the earth. Improvements of instruments and methods was stressed in both reports. The national report of Denmark which described progress both in that country and Greenland; that of Norway which described recent important auroral investigation; that of France, which described proposed work in the French possessions in the Pacific and elsewhere; that of Japan which described proposed work in the mandate islands in the Pacific and others of considerable interest. Committees were continued or formed to study the sudden commencement of magnetic storms, a better method of magnetic characterization of days, extended study of auroral phenomena, and improved instruments and methods for investigation of geological formations, and numerous other subjects.

It was decided to recommend the adoption of Greenwich time for publication of magnetic observations, though as there was considerable opposition, no time was set for making the change. The hope was expressed that the proposed auroral program could be extended to the United States and Canada. Geophysical investigation to determine geological formations is perhaps a little outside the ordinary range of geophysics but it was decided that such work should be given encouragement, at least such work as is undertaken from the proper scientific viewpoint.

There was a resolution adopted by three different sections, Oceanography, Seismology and Geodesy recommending the investigation of deep ocean troughs by acoustic surveying, gravity determinations and seismological observations. It is hoped that work of this character will be undertaken in various parts of the earth before long. (*Author's abstract.*)

H. H. KIMBALL: *Section on meteorology.* This meeting followed immediately after the Leipzig meeting of the International Commission for the exploration of the upper air, August 27–September 3. The commission is appointed by the International Meteorological Committee, has no official standing, and no funds. Like its parent body, it is a purely voluntary organization of men engaged in a research of world-wide extent. There was an exhibition of aerological instruments in connection with the meeting.

The most important subject under discussion was the publication of the upper air data obtained by means of balloons and kites on international days. Closely related to this was the question of units of measure to be used in presenting the data. A sample volume containing the data for the year 1923 was submitted for consideration.

Dr. H. Hergesell, Director of the Aerological observatory at Lindenberg, Germany, was elected president of the Commission, to succeed Sir Napier Shaw, who declined reelection.

There are many points of similarity between the meetings at Leipzig and Prague. Sir Napier Shaw presided as president over both meetings. Most of the delegates at Leipzig were also delegates at Prague. At the latter meeting, however, the strong German delegation, and the delegates from Austria and from the U. S. S. R. (Russia) were missing.

At Prague, after the *Bureau* had reported on its work during the three years that had elapsed since the Madrid meeting, various subjects were discussed, prominent among which were, as at Leipzig, the publication of upper air meteorological data, and the units of measure to be used in their presentation. The Section was deeply interested in these subjects for the reason that at Madrid it had appropriated £500. towards defraying the expense of the publication of the sample volume. The Section also expressed a broader interest in the question of units in the form of a resolution which authorized and requested its bureau to report on the practices of the different sciences comprised within the Union with regard to units of measurement, and to invite the coöperation of the bureaus of other sections with the ultimate object of a common unitary system for all these sciences.

Other subjects assigned to commissions for consideration included solar radiation, hemispherical weather maps, scientific methods of weather forecasting, the adoption of the week as a unit of time in meteorological statistics, and the relations between the Section of Meteorology of the Union and the International Meteorological Committee. (*Author's abstract.*)

H. E. MERWIN, *Recording Secretary.*

BIOLOGICAL SOCIETY

710TH MEETING

The 710th meeting was held in the assembly hall of the Cosmos Club November 5, 1927, at 8 p.m., with Vice-president WETMORE in the chair and 75 persons present. New members elected: J. GORDON CARLSON, Mrs. DAVID J. RUMBOUGH, H. H. SHAMEL.

FRANK THONE announced that the late Dr. E. F. SMITH's collection of photographic negatives has been turned over to Science Service. It is made up principally of photographs of plant pathologists. A short special catalogue of the collection is to be published, and a complete set of prints donated to the U. S. Department of Agriculture.

J. M. ALDRICH reported that he had many interesting old records of flies collected at Grove Hill, Maryland, and Oak Grove, Virginia, and inquired whether members of the Society could assist him in locating these places.

A. WETMORE reported his observation on October 29 at Widewater, Virginia, of large flocks of Grackles made up mostly of Purple Grackles but also containing numbers of Bronzed Grackles.

The regular program consisted of reports and remarks on the International Congress of Zoology at Budapest by two of the delegates of the Biological Society, Dr. L. O. HOWARD and Dr. C. W. STILES.

Doctor HOWARD, in reporting as a delegate of the Society to the Tenth Entomological Congress held September 4 to 10 at Budapest, stated that, while he was an official delegate of the Biological Society, he was not a delegate of the United States Government,—Doctor STEJNEGER and Doctor STILES representing the Government. As Doctor STEJNEGER had not returned to the States and as Doctor STILES wished to report chiefly concerning the work of the International Commission on Zoological Nomenclature, it became necessary for the speaker to touch upon the general features of the Congress. This he was hardly prepared to do, as he had expected Doctor STEJNEGER to be able to make a full and general report on the aspects of the Congress, which would probably be more interesting to the members of the Biological Society than those which the speaker had especially noticed as he went there mainly to attend the Section on Economic Zoology of which he was President.

The Congress was largely attended, more than seven hundred being present. There were forty-eight official delegates representing twenty-four countries. England and China did not send official delegates.

He spoke especially of the opening address in the great hall of the National Museum of Hungary by the President, Professor HORVATH, and stated that this address was delivered in French, German, Italian and English. Two hundred and sixty papers were read at the Congress, twenty-five of them before the general sessions. These twenty-five were largely illustrated papers, the motion picture machine being used in several of them. There were twenty-five papers on entomology. His talk was illustrated by a number of lantern-slides from photographs which he had taken at the Congress, largely of individuals. (Author's abstract.)

Dr. STILES gave an account of his activities at the Congress, and presented the following list of amendments to the International Rules adopted at the Congress:

Amendments to the international rules of zoological nomenclature: Important notice to zoologists, physicians, veterinarians, and others using zoological names.

Upon unanimous recommendation by the International Commission on Zoological Nomenclature, the International Zoological Congress which met at Budapest, Hungary, September 4–9, 1927, adopted a very important amendment to Article 25 (Law of Priority) which makes this Article, as amended, read as follows (*italicized type represents the amendment;* Roman type represents the old wording):

Article 25.—The valid name of a genus or species can be only that name under which it was first designated on the conditions:

a) That (*prior to January 1, 1931*) this name was published and accompanied by an indication, or a definition, or a description; and

b) That the author has applied the principles of binary nomenclature.

c) *But no generic name nor specific name, published after December 31, 1930, shall have any status of availability (hence also of validity) under the Rules, unless and until it is published either*

(1) *With a summary of characters (seu diagnosis; seu definition; seu condensed description) which differentiate or distinguish the genus or the species from other genera or species;*
(2) *or with a definite bibliographic reference to such summary of characters (seu diagnosis; seu definition; seu condensed description). And further*
(3) *in the case of a generic name, with the definite unambiguous designation of the type species (seu genotype; seu autogenotype; seu orthotype).*

The purpose of this amendment is to inhibit two of the most important factors which heretofore have produced confusion in scientific names. The date, January 1, 1931, was selected (instead of making the amendment immediately effective) in order to give authors ample opportunity to accommodate themselves to the new rule.

The Commission unanimously adopted the following resolution—

a) It is requested that an author who publishes a name as new shall definitely state that it is new, that this be stated in only one (i.e., in the first) publication, and that the date of publication be not added to the name in its first publication.

b) It is requested that an author who *quotes* a generic name, or a specific name, or a subspecific name, shall add at least once the author and year of publication of the quoted name or a full bibliographic reference.

The foregoing resolution was adopted in order to inhibit the confusion which has frequently resulted from the fact that authors have occasionally published a given name as "new" in two to five or more different articles of different dates—up to five years in exceptional cases.

The three propositions submitted by Dr. FRANZ POCHE, of Vienna, failed to receive the necessary number of votes in Commission to permit of their being recommended to the Congress. Out of a possible 18 votes for each proposition, POCHE's proposition I received 9 votes, II received 6 votes, and III received 7 votes.

Zoological, medical, and veterinary Journals throughout the world are requested to give to the foregoing the widest possible publicity in order to avoid confusion and misunderstanding. C. W. STILES, *Secretary to Commission.*

711TH MEETING

The 711th meeting was held in the assembly hall of the Cosmos Club November 19, 1927, at 8 p.m., with Vice-president WETMORE in the chair and 65 persons present. New members elected: CHARLES L. BAKER, WILLIAM H. REESE.

Dr. PAUL JOHNSON reported that he had recently seen a bird picking insects out of the hair of one of the yaks at the Zoo. The bird was not identified.

F. C. LINCOLN presented recent records of the recovery of banded birds, namely of a blue-winged teal in Colombia, banded in Nebraska, and of a black-crowned night heron in Santo Domingo, banded in Massachusetts in 1924.

A. WETMORE referred to the 45th annual meeting of the American Ornithologists' Union held in Washington during the past week, and called on various visitors for remarks, namely RUTHVEN DEANE, G. F. SIMMONS, Mrs. M. M. NICE, Dr. TRACY I. STORER, and others.

HOWARD BALL read a list of birds seen on the field trip of the American Ornithologists' Union down the Potomac River on November 18, totaling 47 species.

A. J. VAN ROSSEM (illustrated): *Faunal associations of Salvador.*—The speaker, who has spent two and a half years in field work in Salvador, described the various associations and illustrated their characteristics by photographs. From the Pacific slope a volcanic range rises abruptly to 7000 feet elevation. A valley separates this from another range, reaching 9000 feet elevation on the continental divide, the eastern limit of Salvador. From the Pacific side the Arid Pacific division of the Lower Tropical zone rises to 6800 feet on the highest volcano, followed at 6800 to 7000 feet by a well-marked Sonoran association. The same zone rises to 3500 feet on the Cordillera; from 3500 to 8000 feet is Lower Transition, an essentially pure zone of pitch pine. From 8000 to 9000 feet on the Pacific side is an Upper

Tropical rain forest, composed chiefly of oak and white pine, with abundant mosses and tree ferns.

In discussion, T. S. PALMER referred to LESSON's visit, about a century ago to the Pacific Coast, including Salvador and Nicaragua. Later he received specimens from his nephew, who was on a vessel which plied back and forth between Salvador and Oceanica, resulting in much confusion of data. Mr. VAN ROSSEM pointed out that the locality "San Carlos, Central America," referred to by LESSON was the San Carlos in Salvador, which country continued to style itself "Republic of Central America" for some years after the dissolution of the countries that had been united under that name.

EDWARD FRANCIS, Hygienic Laboratory: *Tularaemia in rabbits and other animals as related to human health* (illustrated).—Dr. FRANCIS spoke of the completeness of our knowledge of tularaemia and of the abruptness with which it has become recognized as a national and international disease. Discovered by McCOY of the United States Public Health Service, in 1910, in the California ground squirrel (*Citellus beecheyi* Richardson), the disease became engrafted into the wild rabbits of the West, and then, as a disease of wild rabbits and of man it has advanced steadily across the continent, appearing anew in state after state until now, in 1927, there remains only a solid block of nine uninvaded States, composed of the six New England States, New York, New Jersey, and Delaware. Although a new disease of rodents and of man, tularaemia has now been recognized in 37 states of the United States, in the District of Columbia, and Japan. Of 420 reported cases, 17 have terminated fatally.

The great reservoir of infection in nature is wild rabbits (Jacks, snowshoes and cotton-tails); it has also been found in the ground squirrels of California and Utah, in the wild rats of Los Angeles, and in the wild mice of Contra Costa County, California. But cases of human infection, referable directly to wild rodents, have been traced only to the wild rabbits and not to rats or mice.

Transmission among wild rabbits is by blood-sucking ticks, lice and flies. Transmission to man is by ticks (*Dermacentor andersoni*), by flies (*Chrysops discalis*), and by self-inoculation or contamination while dressing wild rabbits or while dissecting infected rodents in the laboratory.

Market infections of rabbits and man, the bacteriology, symptoms in man, and prevention were discussed, the various phases of the disease being illustrated by lantern slides. Many points were brought out in the discussion which followed, especially the susceptibility of foxes, coyotes and dogs, which feed on rabbits, and the relationship of the well-known fatal epidemics of wild rabbits to tularaemia. (*Author's abstract.*)

S. F. BLAKE, *Recording Secretary.*

Obituary

BRADSHAW HALL SWALES, a member of The ACADEMY, died January 23, at his home in Washington. He was born at Detroit, Michigan, June 30, 1875, educated at the University of Michigan, and was widely known for his work on birds. Mr. Swales was an active member of the American Ornithologist's Union and other scientific societies. For some years he had been honorary assistant curator of birds at the U. S. National Museum, to which he contributed a large number of valuable specimens.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, February 21.	The Anthropological Society
Wednesday, February 22.	The Geological Society
	The Medical Society
Saturday, February 25.	The Biological Society
Wednesday, February 29.	The Medical Society
Saturday, March 3.	The Philosophical Society

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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JOURNAL

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OCEANOGRAPHY—*Ocean-surveys: Problems and developments.*[1]

J. P. Ault, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Tradition has decreed that the address upon this occasion shall deal more or less with the work with which the outgoing president has been associated. So tonight we shall discuss the problems and developments of ocean-surveys with which we have been connected for over 23 years.

We usually think of the ocean as a vast moving highway, without visible paths or sign-posts. It occupies so large a part of the Earth's surface that knowledge of its contents and physical conditions is of prime importance. Especially is this true for certain problems relating to the physics of the Earth as a whole—geophysics. Human life and its environment and the evolutionary processes in the living world are influenced in countless ways by the varying physical properties of the ocean.

In the geophysical sciences with which we are concerned tonight, terrestrial magnetism, terrestrial electricity, and oceanography, much information has been collected already, though systematic investigations are but fairly started and the vast extent of the ocean still leaves many unsolved problems.

Our knowledge of the origin of the Earth's magnetic and electric fields is still imperfect. The exact interrelation between these two fields is not known, and we are interested in securing more information regarding the close connections which seem to exist between variations

[1] Address of the retiring President of the Philosophical Society of Washington, January 7, 1928, based on lecture *Purpose and progress of ocean-surveys* at the Carnegie Institution of Washington, November 22, 1927 (published in Scientific Monthly for February 1928). Received January 14, 1928.

in magnetism, atmospheric electricity, auroral displays, earth-currents, and transmission of wireless waves. Observations over the comparatively undisturbed ocean-areas will very materially aid in the discussion of all these phenomena.

The history of ocean magnetic-surveys goes back to the time of Edmund Halley who made the first observations in the Atlantic Ocean during 1698 to 1701. Before the invention of accurate timepieces, navigation consisted of observations of the noon altitude of the Sun for latitude, and crude estimation of course and distance to determine longitude. This method was very unsatisfactory, since unknown ocean-currents and errors in reckoning made it impossible to keep accurate account of the ship's position.

Large prizes were offered for a more reliable method of determining longitude, and in 1698 Halley began his voyages in the Atlantic Ocean on the PARAMOUR PINK to "improve the knowledge of the longitude and variations of the compass." As a result of these voyages he constructed and published the first magnetic chart of the oceans, and his method of drawing lines through points of equal declination is still used in nautical charts today. His map was used for many years, not to determine the longitude, the purpose for which it was constructed, but to give the navigator his compass correction as he sailed from port to port.

The changes which have taken place in the compass variation during the more than 200 years which have elapsed since the time of Halley are shown by comparing the early maps with those of the present day. Halley himself knew of these changes and cautioned the users of his chart to take them into account.

To give some idea of the amount of these changes, it might be noted that the cruises of the CARNEGIE in the Indian Ocean in 1911 and 1920 showed that the compass was changing its direction over one-third of a degree annually in the central part of the ocean. In 1911 the navigational charts for this ocean were in error by as much as one-half point chiefly owing to lack of accurate information as to the amount of the annual change. In 1580 the magnetic needle pointed 11° east of north at London and by 1812 it pointed 24° west of north, a change of 35° in 232 years. It now points only about 16° west of north. The causes of these changes and variations are not as yet known, and their explanation constitutes one of the chief problems in the science of terrestrial magnetism.

It is with these changes that we are chiefly concerned in a study of the earth as a magnet in trying to explain the origin of the Earth's field, the causes of the changes which are observed during the day, the variation with the seasons during the year, and the secular or progressive change from year to year. We also wish to know why there is such close relation between changes in terrestrial magnetism known as magnetic storms and the occurrence of polar lights or auroras, both north and south, and changes in solar conditions, and why we have 11-year periods in magnetic changes coincident with the well-known 11-year periods in sunspot activity.

Since we cannot bring the Earth into the laboratory to study its problems, we must go out over its surface, penetrate into its interior, into its atmosphere, and into the ocean depths as far as present inventive genius will permit, and observe and record the results of experiments which nature is performing on a cosmical scale.

In order to secure the data necessary for a complete study of these various problems in magnetism, it was decided early in the organization of the magnetic-survey work of the Carnegie Institution of Washington to extend the investigations to the large ocean-areas. Since the time of Halley in 1700, occasional magnetic observations have been made at sea incidentally on voyages of discovery and exploration, such as those of the EREBUS and TERROR, the PAGODA, the CHALLENGER, the DISCOVERY, and the GAUSS. But over 200 years elapsed after Halley's survey before another expedition started out primarily to make magnetic observations at sea. The GALILEE sailed out of the Golden Gate in 1905 to survey the Pacific Ocean, making three cruises during the period August 1905 to June 1908. On these expeditions, the fruition largely of the plans and vision of Bauer and his colleagues, observations were made not only to determine the magnetic declination but also the magnetic dip or inclination and the strength of the Earth's magnetic field. The instruments used in these observations were mounted on an open bridge exposed to wind and weather, and many doubted whether worth-while observations could be made at sea with equipment then in use.

The accuracy of the results with these more or less experimental instruments and the promise of increased accuracy with new devices invented and constructed by Peters and Fleming indicated the desirability of continuing the ocean-survey. At the same time the effect of what little iron was present in the hull of the GALILEE was so difficult to control and measure in the results that it was decided to construct a specially designed nonmagnetic vessel. In 1909 the CARNEGIE was completed and began her long series of cruises in August of that year. Improvements in the instrumental equipment increased materially both the amount and the accuracy of the data secured. Since advancement and success of ocean-surveys are measured by progress in the development of instrumental equipment, full credit must be given to those who have developed this phase of the ocean-surveys executed on the GALILEE and the CARNEGIE. Tribute also should be paid to the individual members of the several expeditions, who cannot be mentioned by name, but whose chief compensation is the thought that they have helped to add something of permanent value to science and to human knowledge.

A very satisfactory distribution of stations has been accomplished, and the accuracy of present-day magnetic charts used by navigators has steadily increased since the various hydrographic offices began using the data resulting from these surveys.

At only about 80 stations do we have cruise-intersections where reliable information has been obtained regarding the changes which have taken place over a period of years, the so-called secular variation. To improve this condition, in future ocean-survey work it is planned to retrace previous cruises and reoccupy as many points as possible in order to secure the maximum of data on the amount and direction of this secular variation. Valuable information for keeping navigation charts up to date, as well as the necessary data for the advancement of theoretical studies and investigations will thus be furnished. Future cruises need not be repeated at frequent intervals, and may be supplanted altogether by more rapid and efficient methods in connection with upper-air travel and research.

The study of the Earth's electric field, that is, of terrestrial electricity including both atmospheric electricity and earth-currents, is now being carried forward side by side with the study of the Earth's magnetism. The importance of these investigations has increased in recent years because of the close relation between variations in atmospheric-electric and earth-current phenomena and variations in magnetic conditions. Recent theories regarding the nature of electricity and the constitution of matter and the rapid advances made in radio transmission have given added stimulus to the study of the earth's electric field. The Sun is included in this study because of the close connection between magnetic and atmospheric-electric phenomena and solar activity, and coöperative work with the Mt. Wilson Solar Observatory in these investigations was started last year.

Some experimental observations in atmospheric electricity were made in 1908 on the GALILEE and in 1909 to 1914 on the CARNEGIE, but it was not until 1915 that a systematic and definite program of observations was undertaken with new and improved methods and instruments devised and constructed chiefly by Swann and Fleming. A well-known European student of atmospheric electricity states that the only new contribution to this science within the past ten years was that resulting from the cruises of the CARNEGIE, which is especially valuable because of the wide distribution of information obtained.

The electric elements which have been investigated include potential gradient, both positive and negative ionic content, conductivity, and ionic mobility, penetrating radiation, and radioactive content of the air. The potential or electric charge in the air increases with height above the earth's surface, being about 100 volts at the height of one meter. This is the so-called potential gradient and is measured by noting the deflection on the fibers of an electrometer while the collector is raised one meter. There are present in the air at all times both positively and negatively charged particles called ions, about 1,000 of each kind in a cubic centimeter of air, and with our instruments it is possible to count the number with fair accuracy. Intimately connected with the number of ions in the air is the electric conductivity, or its ability to carry an electric current. Air is forced past a charged conductor at a uniform rate of speed, and the rate of discharge is noted by the changing position of the fibers in an electrometer.

Whether penetrating radiation or "cosmic rays" coming into the Earth's atmosphere from outer space can be one of the causes of the ionization of the air is one of the problems being investigated, and observations are made at sea to determine the amount and variation of this radiation by observing the rate of ionization in a closed copper vessel. The radioactive-content observations are arranged to collect and measure the amount of radioactive material, such as radium and thorium, present in our atmosphere, this being another source of ionization.

Under the action of the Earth's electric field, positive ions are traveling toward the Earth and negative ions are traveling upward in the air, giving rise to an air-earth electric current. The rate at which this interchange takes place would neutralize the earth's negative charge in a very short time were there no recharging source of energy. Various theories have been advanced to account for the source of this supply, e.g., lightning or the Sun, but the problem still awaits solution.

Conditions at sea are much more favorable for investigating the Earth's electric field than on land, where dust and smoke in the air and presence of changing cultural or permanent topographic features such as trees, buildings, or contours cloak the true characteristics of the atmospheric-electric phenomena. To improve further the atmospheric-electric results and to note the conditions at sea, dust-count observations are to be included in the program since it is known that the presence of dust in the air has a marked influence upon atmospheric-electric conditions.

In order to determine the variations which take place in the elements of the Earth's electric field during a 24-hour period, continuous observations of these changes are carried out on the CARNEGIE at frequent intervals. I will mention only the difficulties of carrying out such observations under conditions which persist at sea, insulation troubles due to condensation and to salt spray, and difficulties attending the use of instruments on a rolling ship. In dealing with insulation difficulties we have learned that our favorite slogan "Electricity never fails" has always held true. The instrument will always work if the insulation surfaces are clean and all connections are good.

A discussion by Mauchly of these 24-hour series of atmospheric-electric observations at sea on the CARNEGIE disclosed that the chief maximum of the diurnal variation of the potential gradient occurs at about 18^h Greenwich mean time all over the world, approximately the time when the Sun is in the meridian of the north magnetic pole. This conclusion was confirmed by Sverdrup during Amundsen's Arctic-Drift Expedition on the MAUD. The true physical explanation of this discovery is not yet apparent. Wait and Sverdrup point out that the rotating magnetic field of the earth induces electromotive forces in the earth's electric field, the variations of which are in remarkable agreement with the observed variations of the potential gradient over the oceans. This agreement appears too good to be accidental, but further evidence is needed for a satisfactory physical interpretation. To add to the information regarding variations of the potential gradient, an automatic photographic recording electrometer is to be mounted near the truck of the mainmast during the next cruise. Some experimental work with this apparatus was done during the return of the CARNEGIE from New York to Washington last month by W. C. Parkinson, who will have charge of the atmospheric-electric work during the next cruise.

The important contributions to the study of various geophysical problems which are being made by investigations of the Kennelly-Heaviside conducting layer and of radio transmission and variations with changing magnetic and electric conditions greatly enhance the value of the ocean atmospheric-electric data and indicate coöperative investigations along similar lines for future ocean-work. It is planned to begin at sea investigations of the conducting layer and to carry out experiments on the variations of signal-intensity, following methods already in use on land.

Important correlations between earth-current variations and changes in other geophysical and cosmical phenomena, such as solar activity, magnetic disturbances, and polar lights, have resulted from an investigation of observatory records, and the importance of these discussions in the general study of the Earth's magnetic and electric fields now warrants beginning systematic earth-current observations at sea. Some preliminary experimental work was done by O. H. Gish while the CARNEGIE was en route from New York to Washington this year in order to determine the best methods and instruments for such investigations over the oceans.

The challenge of the vast, practically unknown, expanse of the atmosphere above the Earth's surface and of the equally unexplored depths of the ocean awaits the pioneering spirit of a Langley or the ingenuity of a Lord Kelvin to penetrate their mysteries. When inventive genius makes it possible to investigate the modifications in magnetic and electric variations due to change in altitude, many new and important discoveries will be made.

The mysteries of the ocean-depths, however, are slowly being unfolded through advances in the growing science of oceanography. Up to the time of the CHALLENGER expedition in 1872 to 1876, oceanographic research had been limited to restricted areas, or was incidental to some exploratory expedition, or was associated with some national fisheries investigations. Following the stimulus given by the CHALLENGER results, oceanographic investigations were much extended, and new methods and instruments were devised. However, the vastness of the regions to be explored and the time and expense entailed in sending instruments to the bottom of the ocean-deeps leave many unsolved problems for the oceanographer. Time does not permit more than a brief mention of the pioneer work done by Forbes, Thomson, Agassiz, Murray, and others who laid the foundations of the present science of oceanography.

In spite of all the vast amount of data that has been collected, we have only a general idea of the contours of the ocean-bed and only a meager knowledge of the bottom sedimentary deposits which are of peculiar interest to the geologist in his study of the age and formation of the Earth and the changes which time has witnessed. The mapping of the configuration of the oceanic basins covering over two-thirds

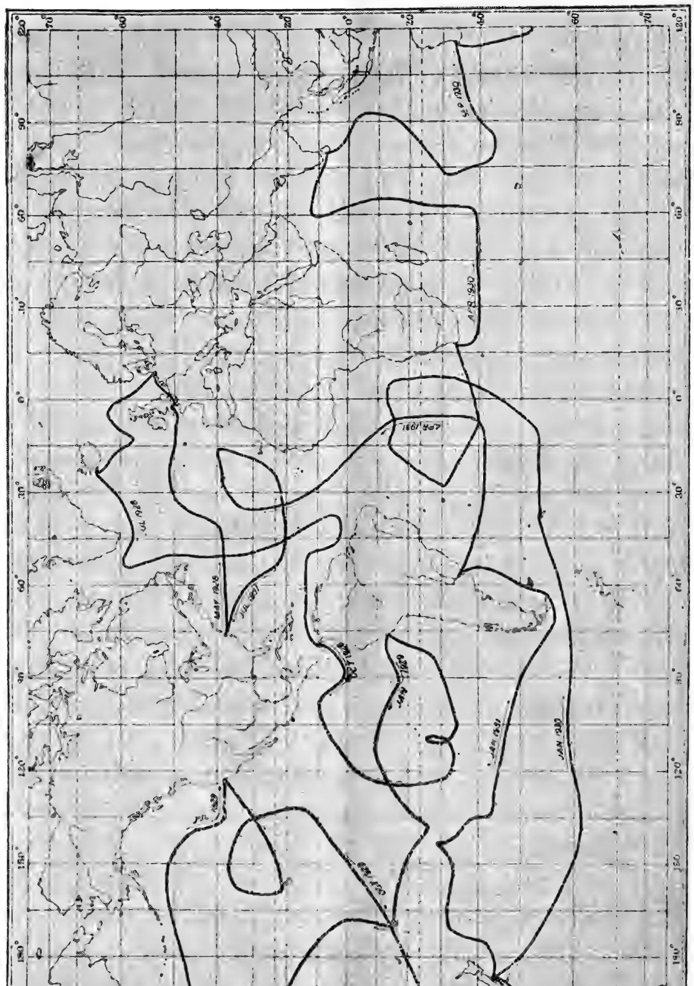


Fig. 1.—Tentative route for the seventh cruise of the CARNEGIE, 1928–31.

of the Earth's surface should be as important as the mapping of the land masses which occupy less than one-third. Such information is necessary for the geodesist in his study of the movements within the Earth's crust and for the seismologist in his study of the origin, history, and probable future development of submarine earthquakes.

The movements of vast bodies of water relatively to one another and to the land due to winds and tide, and the vertical movements due to changes of temperature and salinity make the ocean with its vast capacity for carrying heat a powerful factor in its influence upon practically every phase of life upon the Earth, in its control of climate, and in its determining effect upon man's migration and habitation.

Perhaps the most fascinating study connected with the sea is the multitudinous life found in all oceanic waters from the surface down to the deepest abyss yet explored. Physical changes in the ocean-waters have profound influences upon marine life, its variety, its amount, and its distribution. A knowledge of these influences will contribute in many ways not only to the study of evolutionary processes taking place in the sea but to the practical problem of economic use of the ocean's food resources.

Many problems of oceanography are of interest to the Carnegie Institution of Washington through the activities of its various departments and research associates. The vast extent of the ocean-areas to be covered by the next cruise of the CARNEGIE offers unique opportunity to add new and much-needed information in this science from regions never investigated.

To carry out the proposed increased program of general oceanographic work has required many structural changes on the CARNEGIE. During the past summer the vessel was in Hoboken, New Jersey, undergoing repairs and alterations. A new stateroom was added in the cabin since the technical staff is to be increased to seven, the additional man to be especially trained in chemistry and marine biology. The two lifeboats were moved from the quarter-deck to overhead platforms amidships opposite the after dome, leaving the quarter-deck free for the operation of the bronze winch, sounding wire, and special davits for handling tow-nets, water-bottles, deep-sea reversing thermometers, and bottom-samplers.

Two new laboratories were constructed on deck; one will be specially fitted for physical oceanographic, biological, and chemical work, and the other will house the radio and echo-sounding equipment.

In physical oceanography it is planned to obtain temperatures and water samples at depths of 5, 25, 50, 75, 100, 200, 300, 400, 500, 700, 1,000, 1,500, and 2,000 meters every 150 to 200 miles, with occasional series down to the bottom with a limit at 20,000 feet. To obtain a continuous record of surface-temperatures, a distant-recording thermograph has been installed with its bulb on the hull about seven feet below the water-line and with its recorder in the new laboratory. These records will be checked occasionally by the usual method, direct readings with draw-bucket and thermometer.

Water samples and temperatures will be secured by Nansen water-bottles and Richter reversing deep-sea thermometers using a series of ten on the wire at one time. The water-bottle has a capacity of $1\frac{1}{4}$ liters, and two thermometers will be used with each one in order to check the temperature. The salinity and density of each water-sample will be determined on board ship by the Wenner electric conductivity method and checked occasionally by the silver-nitrate titration method. The water-sample also will be analyzed for oxygen, nitrate, and phosphate content, and hydrogen-ion concentration.

Samples of muds and sediments from the bottom will be secured by use of the snapper-type of sampler, as modified by Vaughan, and a larger Eckman tube-sampler, as modified by Trask for deep water. It is now known that bottom-living creatures feed on organic matter found in bottom muds, and that these muds are often teeming with life. From a study of these organisms and fossil remains, together with borings from oil-wells, important conclusions have been reached regarding the origin of oil-producing deposits. The Geophysical Laboratory also is interested in the nature and derivation of inorganic marine deposits in the study of the age of the earth and the various processes of its formation.

The machinery necessary to handle water-bottles, thermometers, and bottom-samplers has been installed on the CARNEGIE. It consists of a 30-horse-power gasoline engine and a 12-kilowatt generator installed below decks in the engine-room to furnish the required electric power. A bronze winch weighing three tons, operated by a 15-horse-power electric motor, has been installed on deck. Two reels and two gypsy-heads are provided, one reel containing 20,210 feet of special aluminum-bronze stranded wire rope $\frac{3}{16}$ inch or 4 mm. in diameter, and the other containing 6,808 feet of $\frac{1}{4}$ inch or 6 mm. wire. This wire was made in Germany and was designed especially for oceanographic work after extensive tests and experiments by those in charge of preparations for the German Expedition on the METEOR, 1925 to 1927.

The gypsy-heads are to be used in handling yards, sails, hoisting lifeboats, hauling in earth-current cables, and for the general work on deck. Special bronze davits and blocks have been installed for handling the wire as it is payed out or hauled in. Platforms have been constructed on both port and starboard sides, where the observer will stand while attaching or detaching the water-bottles and thermometers to the sounding wire.

The winch has been constructed so that the reels may be operated either singly or together, thus allowing one wire to be payed out on the brake while the other wire is being hauled in. This will allow two series of water-bottles to be operated simultaneously, thus saving materially in the time required at each station.

It is planned to heave to every other afternoon, taking in all sails except those required to keep the vessel as nearly stationary as possible. To keep the wire vertical or nearly so will require skilful maneuvering, and it may be necessary to use the main engine occasionally to accomplish this result. Helland-Hansen and Nansen have carried out similar work with great success on the ARMAUER HANSEN, a sailing vessel of only half the size of the CARNEGIE. They state that[2] "owing to its special construction the ship is easily maneuvered in such a manner that the line along which the oceanographic instruments are suspended remains in a vertical position throughout the time of observation even if there is a strong drift caused by wind or current." This is essential in order to obtain correct depths by wire measurements.

As a further aid in checking the depths at which temperatures and water-samples are obtained, simultaneous use is to be made of protected and unprotected thermometers, calibrated for pressure-effects, placed at frequent intervals as the wire is lowered into the water. The difference between the readings of the two thermometers at any level will give the depth for that level. This method was used recently with success by the German Atlantic Expedition on the METEOR. To avoid rapid and excessive drift of the vessel when hove to in a strong breeze, sea-anchors will be used to check the headway. Simultaneous determinations of depths with actual wire soundings and with the echo-method, together with temperature and salinity data at all levels, will give information of great value in establishing proper formulae for the velocity of sound in sea-water in the deep basins of the ocean.

The latest type of sonic depth-finder as developed by Harvey C. Hayes has been installed on board the CARNEGIE, and frequent determinations of ocean-depths will be made as the vessel is proceeding on her way. The depth can be determined in a very few moments, the method consisting essentially of measuring very accurately the

[2] B. HELLAND-HANSEN and FRIDTJOF NANSEN. *The Eastern North Atlantic.* Geofysiske Publikasjoner **4**: No. 2, 3–4. 1926.

time-interval between a signal sent out from the ship and the return of the echo from the bottom of the sea. The United States Navy is coöperating in this work by lending the necessary equipment consisting of an oscillator for transmitting the signal, six microphones for receiving the echo, and a depth-finder for measuring accurately the interval between signal and echo. The method is accurate to within about ±5 fathoms or 30 feet for depths greater than 100 fathoms, the range over which the sonic depth-finder is designed to operate.

In marine biology it is planned to confine attention to microbiology, to determine the abundance and distribution of plankton and other microscopic organisms. Shallow-water dredging for diatoms and foraminifera will be undertaken also in coöperation with Dr. Albert Mann, a research associate of the Carnegie Institution of Washington. Quantitative distribution of plankton at various depths from the surface down to 100 meters will be determined by the examination of definite quantities of water brought up by means of special water-bottles, or by use of a hose let down to depths found practicable. Some study will be made also of surface plankton by straining a continuous stream of water through a fine-meshed net. Marine organisms also will be secured by tow-nets, and hauls both vertical and horizontal are to be made from the surface down to a depth of 150 to 200 meters, and occasionally to greater depths. A special boom-walk has been rigged in connection with the vessel's boat-boom, where the observer can walk out 30 feet from the ship's side in fair weather, dip up any marine life from the surface, or operate the tow-nets well out from the disturbing influence of the vessel and its motion through the water.

To assist the biologist, H. R. Seiwell, in his study of marine life in its native habitat at the bottom of the ocean, a diving helmet has been secured for use in shallow-water. This device has been used by amateurs at depths of 30 feet and can be used safely at depths of 50 to 100 feet.

Equipment will be carried also for securing specimens of dolphins and porpoises from regions where no specimens have been secured heretofore. Such specimens are of special interest to Remington Kellogg, a research associate of the Carnegie Institution of Washington, in his study of the evolution of the whale and other marine vertebrates.

Limited space on the vessel and time and restrictions as to power and machinery prohibit undertaking any deep-sea trawling or dredging. This work may be taken up during a later cruise when it is hoped that chief attention may be devoted to work in oceanography.

Any program of oceanographic investigations should include extensive work in marine meteorology in view of the important influence upon climate of mass movements of large bodies of heat-bearing oceanic waters. The study of the physical interchange between the surface of the ocean and the air above it is important in the study of atmospheric circulation and disturbance over the entire surface of the Earth because of the fairly normal conditions which exist at sea.

The foundations of the science of marine meteorology were laid by an American, Admiral Matthew Fontaine Maury. His book *Physical Geography of the Sea* is still a classic, although some of his theories and conclusions have been supplanted. Due to his efforts an international conference was held at Brussels in 1853, and a general program for marine meteorological observations was adopted. Maury introduced sailing directions and pilot charts which were of untold value to shipping interests, especially in the time of sailing ships. Monthly pilot charts of the great oceans are now issued in advance by the U. S. Hydrographic Office and the British Admiralty and constitute a most important aid to navigation.

While conditions at sea are fairly normal for the study of the atmosphere, yet the ocean is only a highway and the observer is always on the move from place to place. Instruments must be especially adapted for use on moving and rolling platforms, and progress in marine meteorology, as in other oceanographic investigations, has developed only as rapidly as the invention and utilization of the proper instrumental equipment has permitted.

To study the physical interchange of heat and moisture between the ocean and the atmosphere, it is planned to observe the temperature and humidity lapse-rates from sea-level to masthead. Accompanying observations of wind direction and velocity and of changes in atmospheric pressure will be made.

Variations in the amount of solar radiation received at the Earth's surface and their influence upon world-wide weather conditions have been the subject of much study in recent years by Abbot and Clayton. It has been thought worth while to include such observations in the meteorological program, together with observations of cloud systems, rainfall, evaporation, and dust-content and carbonic-acid content of the atmosphere. Additional data over the great oceanic areas to be covered by the next cruise of the CARNEGIE may be extremely valuable in the comparison of world weather with solar variation, in the determination of the rate at which the atmosphere is being charged with water vapor so vital to life on the continents, and in the study of the dynamics of atmospheric circulation over the oceans.

It is planned to compute at sea and publish promptly as the cruise progresses the pertinent oceanographic data for use of students and investigators of oceanography, as has been done heretofore in terrestrial magnetism. The physical data to be published include the following results of observations and calculations at various depths: Temperature, salinity, density observed and corrected for compression, oxygen-content, hydrogen-ion concentration, specific volume, and dynamic pressure and depth. A part of the water-samples will be tested for salinity and for gas-content, and a part will be stored below decks for later study in various laboratories. Biological specimens will be studied, sketched, and preserved for transmission to some museum.

The dynamic calculations will be made in accordance with the method devised by Bjerknes and as modified by Hesselberg, Sverdrup, and others. The dynamic conditions in the ocean may be viewed in the same light as similar conditions in the air. Winds blow obliquely from areas of high pressure towards areas of low pressure, taking into account the effect of the rotation of the Earth. The force or velocity is proportional to the gradient or difference in pressure. So in the ocean, data as to temperature and density at two points at the same level permit us to calculate the difference in dynamic pressure between the two points. This is one of the factors which cause circulation, and the direction of this circulation is affected by the rotation of the Earth.

In the biological and chemical work, chief emphasis will be placed upon the collection of data and specimens. Some analysis of water-samples and study of specimens must be done on board ship immediately after collection, and as complete a preliminary examination and report as possible of the results of these investigations will be made as the cruise progresses. Interested organizations will be furnished with water-samples, bottom-samples, and biological specimens for further study and report, and a final discussion and publication of the results of the cruise will be made by the Institution at the conclusion of the work.

The Carnegie Institution of Washington is indebted to the following institutions and organizations for coöperation by lending special equipment or by giving expert advice in planning the program of of investigations: United States Navy Department, National Museum, Bureau of Fisheries, Weather Bureau, and Coast and Geodetic Survey; Scripps Institution of Oceanography of the University of California; Museum of Comparative Zoology of Harvard University; School of Geography of Clark University; Geophysical Institute, Bergen, Norway; Marine Biological Association of the United Kingdom, Plymouth, England; German Atlantic Expedition of the METEOR; and Carlsberg Laboratorium, Copenhagen, Denmark.

In this brief discussion of ocean-surveys it is possible to present only a few of the outstanding developments and to sketch only briefly the problems as yet unsolved. The chief advances in surveys already made have come from invention of instruments capable of revealing the variations in natural phenomena in regions hitherto inaccessible. Thus the pathway to further progress in these branches of geophysics is made plain, and man's inventive genius is challenged in no uncertain terms.

PHYSICS—*The deformation of granular solids.*[1] P. G. NUTTING, U. S. Geological Survey.

Theoretical mechanics has long suffered from the lack of a function capable of representing the deformation of bodies possessing elastic, plastic, and viscous properties all at the same time. Many solids yield gradually and continuously to stresses far below their elastic limits and without losing their power of elastic recovery at any stage of strain. Solids strained beyond their elastic limits exhibit many plastic properties. Viscous fluids behave somewhat like solids above their elastic limits. The pitches studied by the writer[2] possess a remarkable combination of elastic and viscous properties. The mathematical difficulty is to represent a viscous flow in combination with elasticity in accordance with Hooke's Law.

I am indebted to Mr. W. W. Rubey[3] of the U. S. Geological Survey for geological data which led to a simple formula which in turn led by integration to a new deformation function of wide applicability having many remarkable properties.

Well borings, taken in compacted granular material of fairly uniform grain density, indicated the relation Depth × Void Ratio = Constant to within the uncertainty of measurement, allowance having been made for erosion. We have then $zR = C$ where z = depth and R, void ratio, is the ratio of void volume to that filled by grains. From this we have to obtain a relation between pressure and volume. Calling the pressure p, the (variable) density of the material ρ and the (constant) density of the grains ρ_g, we have

$$p = \int_0^z \rho \, dz$$

[1] Published by permission of the Director of the U. S. Geological Survey. Received January 14, 1928.

[2] Amer. Soc. Test. Mat. Trans. 1921; and Journ. Frank. Inst. May, 1921.

[3] Bull. Amer. Assoc. Petr. Geol. **11**. 1927

$$\frac{\rho}{\rho_g} = \frac{1}{1 + R} = \frac{1}{1 + C/z} = \frac{z}{z + C}$$

Hence by substitution and integration

(1) $$p = \rho_g C(z/C - \log (1 + z/C))$$

a function the simplest form of which is

(2) $$ay = x - \log (1 + x)$$

Substituting for z/C, $1/R = \rho / (\rho_g - \rho)$ in (1) gives

(3) $$p = \rho_g C \left(\frac{\rho}{\rho_g - \rho} - \log \frac{\rho_g}{\rho_g - \rho}\right)$$

a relation between pressure and density. Finally the relation between pressure and volume is obtained at once from (3) (since $v = 1/\rho$)

(4) $$p = \frac{C}{v_g}\left(\frac{1}{v/v_g - 1} - \log \frac{1}{1 - v_g/v}\right)$$

Put in the form of an equation of state, this is

(5) $$\left(p + \frac{C}{v_g} \log (1 - v_g/v)\right) (v - v_g) = C$$

In this equation, $v - v_g$ corresponds with $v - b$ of van der Waals, $C = RT$ and $(C/v_g) \log (1 - v_g/v) = a/v^2$. (5) reduces to Boyle's Law $pv =$ const. for large specific volumes as it should. For very large pressures, v approaches v_g, i.e. the granular material approaches a solid whose density is the grain density.

From (4) the compressibility $\beta = (dv/v)/dp$, is

(6) $$C\beta = v_g (v/v_g - 1)^2$$

a quantity approaching zero as the granular material approaches homogeneity. Eliminating C between (4) and (6) gives the dimensionless characteristic βp

$$-\frac{d \log v}{d \log p} = \beta p = (v/v_g - 1) + (v/v_g - 1)^2 \log (1 - v_g/v)$$

which is again a function of specific volume.

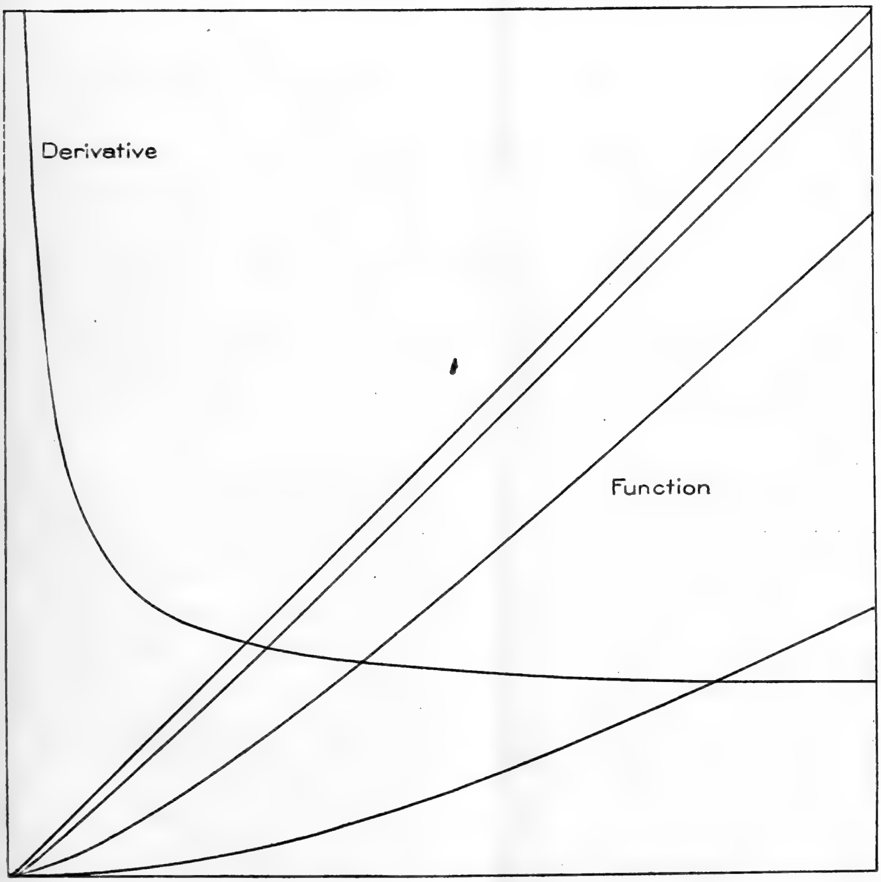
In the general equation between compressive and repulsive pressures

(7) $$p + P = \pi + \kappa$$

in which $p =$ external (transmitted) pressure, $P =$ cohesive pressure, $\pi =$ distending (static) pressure—due to contact—and $\kappa =$ kinetic (thermal) distending pressure, holding at any plane in any body, P and κ are negligibly small in loose masses of granular solids and $p = \pi$. In gases P and π are practically zero and $p = \kappa$. T. W. Richards finds P proportional to about the square and π to about the seventh power of the densities of many elementary solids and liquids over small ranges. These relations are special cases of (3) and (4).

Equation (3) between pressure and density may be used to compute grain density by eliminating C between two sets of values. This was done for water using the data of Bridgman, regarding the molecules as but small grains. The computed grain (molecular) density was 1.12 and porosity 10 per cent but both varied somewhat with pressure since the molecules are not incompressible nor are cohesive forces absent.

Such physical checks on the new function as have been given are serviceable since it rests on a purely empirical foundation. Its geometrical form is shown by Figure 1.



The Function y = x - log (1+X)

Fig. 1.—Graph of the function $y = x - \log (1 + x)$

The graph has the form of a tilted sled runner sharply curved near the origin but rapidly approaching a linear relation between the variables. In the figure, each curve is the toe of the preceding one magnified ten times.

These curves closely resemble those observed in the shear of very viscous fluids in the relation between pressure and shear. The initial curved portion of the graph has been attributed[4] to plastic properties and the straight line portion to true viscous flow. But evidently a smooth continuous function may represent both. Calling s shear, F force per unit area and t time, then

$$s - \log(1 + s) = aFt \tag{8}$$

will have the general characteristics desired. When the shear s is small it is proportional to both force and time. When it is a little larger (since $\log(1 + s) = s - \frac{1}{2}s^2 + \frac{1}{3}s^3 - \text{etc.}$) it is for a time nearly proportional to the square root of F and t but no equilibrium is ever reached.

Differentiating (8) gives for rate of shear under a constant force (ordinary viscous flow)

$$\frac{ds}{dt} = a(1 + 1/s)F \tag{9}$$

At the start when s is small, the shear is very rapid but as s becomes larger the rate steadies down to the constant value aF. The constant a is the reciprocal of the viscosity. The force derivative, $ds/dF = a(1 + 1/s)\,t$ is of the same form.

In order to fit the new function to experimental data, parameters may be introduced into (2) or (6). For example, the 1921 data on pitch by the writer referred to above is very well represented by writing for s in (6), ms^n. With time in minutes and s in millimeters, $m = 0.140$ and $n = 1.718$. In this case the rate of shear is high at the start, but decreases rapidly and approaches zero as a limit. Where n is less than unity the velocity of shear increases indefinitely as in a brittle solid stressed beyond the elastic limit. $n = 1$ corresponds to simple viscous flow. The exponential function previously proposed (J. F. I., l.c.) is a limiting special case of the new function.

These examples are sufficient to indicate the possibility of wide usefulness in the new function. Specific applications will be dealt with in later papers.

[4] BINGHAM. *Fluidity and plasticity*, p. 217, *f. 77, 81.*

CHEMISTRY.—*Examination of sulfuric acid for selenium.*[1] R. C. WELLS, U. S. Geological Survey.

In testing commercial sulfuric acid for selenium by means of aspidospermine according to the suggestion of L. P. J. Palet[2] it was found that instead of a pink color different shades and colors were developed, depending on the strength of acid and time of heating, so that the conclusions were somewhat uncertain. In order to check the results by an independent method the following scheme was devised and found to work very well.

Dissolve from 0.5 to 1.0 gm. of KBr in 3 or 4 ml. of bromine water and allow it to run through a funnel into a 200 ml. retort. Next add from 65 to 100 ml. of the sulfuric acid to be tested, so that about 100 gm. of H_2SO_4 shall be taken. Shake until the mixture is uniform. Next saturate 3 or 4 ml. of concentrated HCl with SO_2 in a 25 ml. graduate and distill the bromine and selenium bromide slowly from the retort into the graduate, allowing the neck of the retort to just touch the SO_2 solution and immersing most of the graduate in cold water contained in a casserole. The selenium bromide comes over very soon as a yellow liquid which deposits red selenium the moment the first drop runs into the SO_2 solution. Discontinue heating when the acid becomes colorless. A dilute acid may be concentrated before examination by evaporating in an open vessel, without loss of selenium. Percentages of selenium as small as one part of selenium in 10,000,000 of sulfuric acid are shown in this way on saturating the final distillate with SO_2 and allowing it to stand for a day or longer in a small corked flask.

As a result of comparison of the two methods it appeared that the tests with aspidospermine became more consistent when the portions being tested, after heating, were allowed to stand several days. Yet even under these conditions one or two of the samples out of about fifteen showed a pink color when no selenium could be found by the distillation method. When the selenium content exceeded 2.0 mg. in 100 gm. of sulfuric acid the aspidospermine gave a brown coloration instead of a pink color and selenium settled out on standing. The distillation method allowed better visual estimation of the quantities of selenium in running comparison tests with known quantities of selenium in reagent sulfuric acid.

[1] Published by permission of the Director of the U. S. Geological Survey. Received January 7, 1928.

[2] Annales de chimie analytique **23**: 25. 1918.

The method described above and depending on the volatility of selenium bromide was suggested by the procedure of Noyes and Bray,[3] but whereas they recommend the use of hydrobromic acid as a reagent and distill most of it, the distillation in the case of sulfuric acid does not need to be carried even to the point where fumes of sulfuric acid begin to go over.

PALEONTOLOGY.—*The generic name* Orbiculoidea *d'Orbigny and its application.*[1] GEORGE H. GIRTY, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, JR.)

The name proper to the most common type of discinoid in the Devonian and Carboniferous faunas of America has been a subject of languid controversy for a number of years, and the present paper is in the nature of a reply to my friend, the late Prof. C. S. Prosser, and to the arguments that he advanced as long ago as 1912. The intervening years have removed Professor Prosser from his honored sphere, but the questions raised between us are still alive. Would it were otherwise. The following broad statements will supply a background for the discussion whose details will be filled in farther on.

Discinoids were fairly abundant in Paleozoic faunas, and they are also present in living ones, but during the intervening period they appear to have been relatively rare. Of species many had of course been named among the fossil forms and of genera a few had been more or less inadequately described, but up to the publication of Hall and Clarke's monograph on the Brachiopoda[2] most of the fossil species had been referred under the living genus *Discina*. Such authors as described new genera among these fossils or in turn sought to identify those genera scarcely did more than bring confusion into the subject. To these shells Hall and Clarke accorded treatment that seems particularly elaborate. They recognized a number of generic types and for the one which we are considering here they revived a half-forgotten name of d'Orbigny's, *Orbiculoidea*. This name thus received rather widespread acceptance.

In 1909 and again in 1911,[3] having occasion to describe certain shells of this type, I gave reasons why, as I thought, *Orbiculoidea* could not

[3] *A system of qualitative analysis for the rare elements* (Macmillan, 1927), p. 37.

[1] Published by permission of the Director of the U. S. Geological Survey. Received January 14, 1928.

[2] *Natural History of New York*, Pal. **8**: Brachiopoda, pt. 1. 1892.

[3] U. S. Geol. Surv. Bull. **377**: 18. 1909; Bull. **439**: 37. 1911.

properly be used in the sense in which it was revived by Hall and Clarke, and I suggested that *Lingulidiscina* Whitfield appeared to connote the same general elements of structure; *Lingulidiscina* then might be substituted for *Orbiculoidea.* At that time and subsequently I employed the generic term *Lingulidiscina* in my own writing, but my proposal has had relatively little following, although I may fairly say that this fact reflects rather ignorance that any controversy existed or indifference to its outcome than opinion as to the merits of either name. At least no one so far as I am aware gave any reasons for employing *Orbiculoidea* in preference to *Lingulidiscina* or *Lingulidiscina* in preference to *Orbiculoidea* until Professor Prosser took up the argument in the paper above referred to.

Now there are obviously two distinct questions at issue, and these questions are measurably independent, or at least they depend on different facts and are susceptible to independent consideration. One is, whether *Orbiculoidea* is available as a generic name for this type of shell; the other is, if *Orbiculoidea* is not available what other name can be employed. Should the first question be answered in the affirmative, the second, of course, would cease to have any real importance.

The conclusions that I reached in 1909 rested on the following premises: (1) The brachiopod types that Hall and Clarke designated by the names *Orbiculoidea* d'Orbigny and *Schizotreta* Kutorga, constitute two distinct genera. (2) The name *Schizotreta* has priority of publication over *Orbiculoidea.* (3) The first species mentioned under *Orbiculoidea* (*O. forbesi*) is a "*Schizotreta*" while the second (*O. morrisi*) is an "*Orbiculoidea.*" By application of the "first species" rule to these facts, *Orbiculoidea* became a synonym of *Schizotreta* and the group of species called "*Orbiculoidea*" by Hall and Clarke was left without a name, or at least it was bereft of the name *Orbiculoidea. Lingulidiscina* Whitfield seemed available to replace *Orbiculoidea* and I used it. I propose to examine the status of each one of these premises and also to glance at certain other considerations that bear upon the same issues.

The authentic meaning of the term *Orbiculoidea* revolves about the identification of its genotype and the characters that the genotype is found to possess. A search for the facts about these points is complicated by an extraordinary number of ambiguities and inaccuracies of statement. *Absit omen.*

The following is by Hall and Clarke from page 128 of the monograph:

The definition of this term [*Orbiculoidea*] was first given in the Prodrome de Paléontologie Stratigraphique, 1849, and is in the following terms: "Coquille de contèxture cornée non perforée, dont la valve inférieure concave est pourvue d'un ouverture laterale ou crochet pour le passage d'un pedicule simple," the first example cited under this definition being the *Orbicula Morrisi*, Davidson. Mr. Dall has observed that in neither the first use of the term, nor in the second, was an example cited, and, therefore, reaches the unavoidable conclusion that *O. Morrisi*, being the first citation made by the author, must be assumed as the typical species.

Evidence is then offered for believing that *Orbicula morrisi* Davidson, had the same type of structure as the American shells with which we are now familiar under the term *Orbiculoidea*. In this way the name "*Orbiculoidea*" was brought into conjunction with the "very compact generic group" which we here have under discussion. Some of the facts employed in this chain of evidence, however, seem to be erroneous. Apparently at the time of writing the authors had not examined any of the three works of d'Orbigny mentioned, for in that brief paragraph they embody misstatements that would scarcely have found expression if they had consulted the original sources. As a matter of fact "the definition of this term" was not "first given in the Prodrome," the *Prodrome* was not published in 1849, and the first species mentioned under *Orbiculoidea* was not *Orbicula morrisi*. These errors were apparently recognized by the authors at some later date, for the following passage appears on page 160 of the same work, though no reference is made to the erroneous statement that preceded it:

The genus *Orbiculoidea* of D'Orbigny was first defined and exemplified in the Prodrome de Paléontologie, vol. i, p. 44, the date of this work being 1850, not 1849. Dall is in error in stating that *Orbicula Morrisi*, Davidson, is the first species mentioned under the diagnosis quoted. D'Orbigny here gives three species in the following order: *O. Forbesi*, Davidson, *O. Morrisi*, Davidson, *O. Davidsoni*, D'Orbigny. As no species is specially designated as the type of the genus we are compelled to assume these three as types in their order and upon their merits. It is shown on page 136 that the first of these, *O. Forbesi*, Davidson, is unquestionably congeneric with *Schizotreta elliptica*, Kutorga, Kutorga's genus having been established in 1848. As this species, therefore, can not be used as the type of Orbiculoidea, we must assume the second species as the typical representative of the genus, and upon this is based the distinction throughout the foregoing pages in the use of this term *Orbiculoidea* by D'Orbigny and by Davidson. At the place cited in the "Prodrome" the date "1847" stands after the name of the genus. The explanation of its use appears upon page lix of the Introduction, and the date of publication of the work renders its adoption untenable.

The views expressed in the two paragraphs quoted from Hall and Clarke seem to me in some respects not quite consistent. In the first passage they say "Mr. Dall has observed that in neither the first use of the term, nor in the second, was an example cited, and, therefore, reaches the unavoidable conclusion that *O. morrisi*, being the first citation made by the author, must be assumed as the typical species." Even if these expressions are to some extent a quotation from Dall, the authors manifestly concur in them. I read from this nothing else than that Hall and Clarke accept the "first species" rule in principle and also the application of the rule to the selection of a genotype for *Orbiculoidea*. What they say may be paraphrased in this wise: The first species cited by an author under a new genus must be assumed as the genotype (qualifying conditions of course being absent), and specifically, *Orbicula morrisi* being the first species cited by d'Orbigny must be assumed as the genotype of *Orbiculoidea*, both conclusions being unavoidable. In the second passage, however, they say that we are compelled to assume these three species as types in their order and upon their merits, that the first mentioned species is undoubtedly congeneric with *Schizotreta elliptica* and therefore can not be used as the type for *Orbiculoidea* (evidently because to do so would make *Orbiculoidea* a synonym of *Schizotreta*) and that, consequently, we must assume the second species as the typical representative of the genus. They appear, in this passage, not only to have forgotten their original conviction regarding the "first species" rule, but to have overlooked the fact that if Dall had already selected a genotype, they themselves had no subsequent choice. Indeed, they seem to have lost their grasp on the situation entirely. It will be worth our while to look into the facts about these critical points more closely than can be done through the passages quoted.

So far as I am informed the name *Orbiculoidea* was introduced by d'Orbigny in 1847.[4] It was again used by him in 1850,[5] and a third time in the *Prodrome*.[6] In each of these publications the genus was defined but only in the *Prodrome* were any species cited under it.

The earliest of these works was an outline of the classification of the Brachiopoda, and the definitions are rather brief. As the characters ascribed to the higher groups supplement those ascribed to the genera, it will be desirable to quote, in addition to the diagnosis of *Orbiculoidea*, that of the famly Orbiculidae in which *Orbiculoidea* was included. This family comprises four genera, *Siphonotreta, Orbicella, Orbiculoidea*, and *Orbicula*. Its distinctive characters are given as "an

[4] Acad. Sci. Paris, Comptes rendus **25**: 269. 1847.

[5] Ann. sci. nat. **13**: 351. 1850.

[6] *Prodrome de Paléontologie* **1**: 44. 1850.

exterior muscle issuing through the lower valve; shell free," and the distinctive characters of the genus *Orbiculoidea* are given as "shell corneous, not punctate (perforée), muscle pedunculate."

The description in the *Annals* is much more extended and detailed, occupying with the discussion an entire page. *Orbiculoidea* is thus described:

animal attached (fixé); shell free, regularly corneous, suborbicular, inequivalve; lower valve concave, pierced in the deepest part by an elongated opening, which is simple and lateral to the beak, and through which must have issued a simple muscular pedicle attached only to the internal parts of the valve. Upper valve conical, with the beak eccentric.

There follows a rather lengthy discussion of the relationship, both as to resemblances and differences, of *Orbiculoidea* to *Orbicula* and then to *Orbicella,* but the discussion rather throws new light on the characters cited in the description than amplifies the description with new characters. The author adds, however, that 27 species of this extinct genus are known to him, of which the first are from the "étage Murchisonien," the greatest number from the Carboniferous, and the last from the Neocomian.

The diagnosis given in the *Prodrome* although considerably condensed is in substance the same as the diagnosis given in the *Annals.* It has already been repeated in this paper in the quotation taken from Hall and Clarke. Their quotation, however, is not exact, punctuation, diacritic marks, and even whole words having been changed, but the changes do not affect the sense except in one instance, the substitution of "ou" for "au," apparently a clerical or typographic error. To again quote this description would be superfluous but the fact will bear repetition that under it three species are cited and in the following order—*O. forbesi, O. morrisi,* and *O. davidsoni.* So much for d'Orbigny's three descriptions of the genus *Orbiculoidea.*

As every one knows, the modern conception of a genus, taxonomically at least, is that the genus centers in a typical species, the genotype, and the rule for a long time held wide acceptance that if the author of a genus did not name a genotype, as nearly all the early authors failed to do, any one subsequently might select as the genotype one of the species originally cited, though he was required to select the first of those species unless this procedure in some manner thwarted the obvious intentions of the author. Proceeding under this rule and applying it to the facts set forth above, I concluded in 1909, that *O. forbesi* was the genotype of *Orbiculoidea* and that *Orbiculoidea* d'Orbigny was a synonym of *Schizotreta* Kutorga.

Professor Prosser, however, takes exception to these conclusions on the ground that an amelioration of the "first species" rule had been adopted two years prior to the publication of my report in 1909, or about the time I was engaged in writing it. He says on this subject:[7]

The above case is apparently covered by the rules reported by the International Commission on Zoological Nomenclature and adopted by the Seventh International Zoological Congress in August, 1907. Article 30, section g of these rules states that "If an author, in publishing a genus with more than one valid species, fails to designate or to indicate its type, any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.)" Section k of the recommendations to this article further says that "If some of the original species have later been classified in other genera, preference should be shown to the species still remaining in the original genus (Type by elimination)." From the above rule it appears that Hall and Clarke had the right to select a type for the genus *Orbiculoidea* and since they did, that species is the genotype and the genus *Orbiculoidea* stands.

In place of *Orbiculoidea* Dr. Girty uses provisionally *Lingulidiscina* which was proposed by Whitfield (*Lingulodiscina*) for *Lingula exilis* Hall. It has not yet been conclusively shown, however, that Whitfield's genus *Lingulodiscina* is identical with d'Orbigny's *Orbiculoidea.* Dr. Girty states that *Orbiculoidea newberryi,* which Schuchert in his synopsis of American fossil Brachiopoda referred to the genus *Lingulodiscina,* "is certainly a member of the *Orbiculoidea* group." This may have strengthened his opinion that these two genera are identical; but the reference of *O. newberryi* to *Lingulodiscina* was accidental, as is shown by the following quotation from a letter by Professor Schuchert to the writer, dated July 2, 1906: "Certainly I have made a mistake regarding *Orbiculoidea newberryi,* for it is not a *Lingulodiscina.* It is an error I can not account for. When I received your letter I remembered the species as a *Orbiculoidea.* Please make the change and I thank you for directing my attention to it."

The facts advanced by Professor Prosser undoubtedly are important and give a new turn to the *Orbiculoidea* question, bearing as they do upon both of its phases, the proper application of that name and the availability of *Lingulidiscina* to replace it. So far as they bear on the present phase, however, the validity of *Orbiculoidea,* I believe that they really lead to a conclusion quite different from his.

My objections to Professor Prosser's argument travel along two distinct lines. It is of course tacitly understood that no rules of nomenclature in biology can be actually enforced, that they are binding only as they appeal to the good judgment and impartiality of those who work in that field, but we may assume that the "first species" rule and the two rules cited by Professor Prosser, which in a measure supersede it, are on those grounds really binding on every one. If

[7] CHAS. S. PROSSER. *The Devonian and Mississippian formations of northeastern Ohio.* Bull. Ohio Geol. Surv. (**4**) **15**: 203. 1912.

that is so, the rigid "first species" rule was binding on every one up to 1907, when the new and amended rules came into force. I agree with Professor Prosser in the general thesis that I, publishing in 1909, was bound by the rules of nomenclature adopted in 1907, and I would expect him to agree with me that Hall and Clarke, publishing in 1892 were equally bound by the rules of nomenclature in force at that time. But the rule of nomenclature in force in 1892 was the strict "first species" rule and I am unable to see how Hall and Clarke "had the right" in 1892 to select the second species by virtue of an amendment that was not adopted until fifteen years later, in 1907; yet this is what Professor Prosser seems to say. Nor, I think, could the claim be advanced that a genotype selected by Hall and Clarke in violation of one part of the rule was established for ever by another part of the same rule which states that such designation is not subject to change.

The crux of the situation, however, is found in a fact that Professor Prosser seems to have overlooked, a fact that lies at its very core and that diverts from my conclusions to his own the adverse force of the rule that he invokes. He says namely "from the above rule it appears that Hall and Clarke had the right to select a type for the genus *Orbiculoidea* and since they did, that species is the genotype and the genus *Orbiculoidea* stands." It appears to me, on the contrary, not only that Hall and Clarke had no right to select the particular genotype that they did select, but that they had no right to select a genotype at all because Dall had already selected one in 1877.

At this point it is necessary to consider what author first selected a genotype for *Orbiculoidea*, and what genotype he selected. It is clear from Dall's comments that he did not know of any selection prior to his own, and it is clear from what Hall and Clarke have written that they also did not know of any prior to it. Dall's selection, therefore, appears to be the first and therefore the determining one. The only possible exception lies in the fact that Davidson, who regarded *Orbiculoidea* and *Schizotreta* as congeneric, employed *Schizotreta elliptica*, the type species of Kutorga's genus, as if it were the type species of d'Orbigny's. It is doubtful if Davidson's course has any direct bearing on the present discussion, especially as *S. elliptica* was not one of the species originally referred to *Orbiculoidea* by d'Orbigny nor indeed was it mentioned by him in any way.

The discussion must now be addressed to the question what species is to be considered as having been selected by Dall as the genotype of *Orbiculoidea*.

This work of Dall's to which reference has already several times been made, is entitled "Index to the Names which have been Applied to Subdivisions of the Class Brachiopoda," and the author apparently sets out to list all the names that had been employed for brachiopod genera, to fix or crystallize the meanings of those names by determining their typical species and to suggest the relations of the genera to one another. To many of the names he has appended notes of poignant significance and to some rather lengthy discussions. Where the selection of a genotype fell to him he seems invariably to have followed the "first species" rule. No exceptions to this practice were noted though for obvious reasons only a relatively small number of genera were canvassed. As touching *Orbiculoidea* he refers to the *Comptes Rendus* and to the *Annals* with the remark "No examples cited" and follows mention of the Prodrome with the comment:[8] "First species *O. Morrisii*, 'd'Orbigny 1847' * * *. Two other species cited as of 'd'Orbigny 1848.' It would appear as if *O. Morrisii* must be considered as the type." That *O. forbesi* is really the first species cited under *Orbiculoidea* and not *O. morrisi* has already been pointed out.

From the expressions here employed by Dall, and from the circumstance that he mentions *O. morrisi* as the "first species" though it is in fact the second species cited in the *Prodrome,* one might infer that Dall had in mind not the sequence of names in that publication but rather the date affixed to *O. Morrisi* by d'Orbigny, 1847, whereas the two other species are cited as of d'Orbigny 1848. The date for *O. morrisi,* however, is an obvious misprint for 1848, so that as regards date of citation under *Orbiculoidea,* all three species are on the same level. The scheme of citation employed in the *Prodrome,* as explained on page LIV of the introduction, is this: Under the genus is given first the name of the species, then the name of the author who referred it to its accepted genus with the date of transfer, then the citation in its original form followed by the name of the original author and the date of publication. In this instance the citation takes this form, under *Orbiculoidea*—"315. *Morissii,* d'Orb., 1847. *Orbicula Morissii,* Davidson, 1848" with the book reference and place of discovery. It is obvious at a glance that d'Orbigny could not have referred this species to *Orbiculoidea* in 1847 before it was described by Davidson in 1848. The probability that the date 1847 is a misprint instead of a reference to some transaction that no one has as yet noted, is enhanced

[8] W. H. DALL. *Index to the names which have been applied to the subdivisions of the Class Brachiopoda.* Bull. U. S. Nat. Mus. **8**: 51. 1877.

by the abundance of errors in this work, no less than three occurring within the narrow limits of these three citations. The three species referred to *Orbiculoidea* in this place were all described by Davidson under the same genus, in the same report, and of course under the same date, 1848. That d'Orbigny cites them as having been also transferred to the genus *Orbiculoidea* in 1848, is explained by the fact that he expected the *Prodrome* in which the transfer was made (and from which I am quoting) to have been published on that date as already mentioned. The date of transfer of all three species should, of course, be changed to 1849 if not to 1850, but 1847 as printed is clearly a mistake for 1848. This is one error; *Morrisii*, the name of the species, is misspelled *Morissii;* and a third error is found in the species cited as *Orbiculoidea Davidsonii.* This name was proposed in the *Prodrome* (as if in 1848) in substitution for "*Orbicula Koninckii*" Davidson 1848 (non Geinitz 1848). Davidson's species, however, was not called *Orbicula Koninckii* but *Orbicula Verneuilii*, confusion on my part being impossible because d'Orbigny gives the place of original description. Beyond reasonable question, then, the date 1847 for the transfer of *Orbicula morrisi* to *Orbiculoidea* was a misprint for 1848. All three species were transferred at the same time in the *Prodrome,* whose date should apparently be taken as 1850.

Dall was probably less liable to error in these matters than most of us, but in this instance he clearly erred in one respect or the other. He intended to name the "first species" cited under *Orbiculoidea* as the type of that genus; the fact that he actually named *O. morrisi* is capable of but two explanations. He may have been fully aware that all three species had simultaneously and for the first time been cited under *Orbiculoidea* in the *Prodrome,* but by inadvertence have mentioned the second of these instead of the first; or he may have been misled by the date appended to *O. morrisi* into the belief that that species had been transferred to *Orbiculoidea* before the two others. As regards the latter possibility, d'Orbigny's error was on the face of things so palpable in view of the year in which the species *morrisi* was published, that Dall could not have failed to notice it, and in addition he had so immediately set down the *Comptes Rendus* as the only publication by d'Orbigny in 1847 relating to the genus *Orbiculoidea* with the remark "No examples cited," all this within the space of about four lines, that he could not have interpreted the date 1847 as referring to some transaction which was at the same time unnoted and essential to note. That Dall had in mind the sequence of species in the *Pro-*

drome and that intending to name *O. forbesi* as the "first species," which in fact it was, he carelessly named *O. morrisi*, is by far the more probably conclusion. Thus, on the one hand it is fairly certain that Dall intended to name *O. forbesi* as the typical species of *Orbiculoidea;* on the other hand, it is quite certain that he named *Orbiculoidea morrisi*, apparently an act of inadvertence. The question is squarely put: the species that Dall intended to name or the one that he actually did name? If there were any doubt in my mind as to Dall's intentions, or if his intentions followed any but the sole legitimate course, and his own consistent practice, I would hesitate, but my own judgment is clear that *O. forbesi* should be regarded as having been selected by Dall as the typical species of *Orbiculoidea*. Indeed, if the "first species" rule is accepted as applying to all cases down to 1907, I do not see how *O. morrisi* could have any standing on the basis of Dall's performance.

My understanding of the "first species" rule is that the International Commission did in mass what they could not do in severalty—select the first species of all undesignated genera as genotypes. Individual workers were merely commissioned to specify the first species as each of those genera came up for revision. If they failed to name the first species, except for some valid reason, such as that to do so would thwart the original author's intention, their action was without authority and without effect.

On this understanding, if Dall's selection of a genotype for *Orbiculoidea* was the first species—as I think he intended it to be—then *O. forbesi* is the genotype. If, however, his selection was the species which he accidentally named, *O. morrisi*, his selection was void and the genus still remains undesignated so far as he was concerned. If this is true of Dall's selection it is equally true of Hall and Clarke's. *Orbiculoidea* then continued to be without a specified genotype until 1909, when I treated it as if typified by *O. forbesi*, in obedience to the first species rule. But by that time the first species rule had been modified in the terms already quoted from Prosser. Prosser's application of the modified rule to Hall and Clarke's discussion is obviously beside the mark; the modifications could not possibly apply to something that was done 15 years previously. They would apply, however, to what I did in 1909, and what I did was in some measure an infraction of them inasmuch as I used the first species as the genotype, whereas the rule reads that if some of the species have later been classified in other genera, preference should be given to the species still remaining in the original genus. This, it will be remarked, is not an injunction but a recommendation, but if it is thought to invalidate my use of *O. forbesi* as the genotype of *Orbiculoidea, Orbiculoidea* would appear to be without a valid genotype even at the present writing. In my judgment, Dall's selection should be regarded as the determining one and he should be regarded as having selected the "first species," *O. forbesi*.

The year from which *Orbiculoidea* takes its date is not beyond our present concern. The genus was undoubtedly described in 1847, whereas the genus *Schizotreta* was not described until 1848. If the genera are accepted as established on those dates and if they should prove to be synonymous, then *Schizotreta* would yield to *Orbiculoidea*, not *Orbiculoidea* to *Schizotreta*. Dall, Davidson, and d'Orbigny date *Orbiculoidea* from 1847; Hall and Clark use 1850. As the being of a genus, according to modern ideas, is centered in a typical species, a generic name can not be accepted as established until species are named under it, one of which by selection, either original or subsequent, becomes its genotype. A bald generic description does not constitute validity. If this is so, *Orbiculoidea* is validly dated only from the *Prodrome*, whereas *Schizotreta* is validly dated from 1848. But the year from which the *Prodrome* should be dated is itself somewhat doubtful.

The description of *Orbiculoidea* in the *Prodrome* occurs in the first volume, and the copy of that volume now before me bears the imprint of 1850. The third volume, by the way, is dated 1852. Dall dates the *Prodrome*, at least the first volume and consequently the genus *Orbiculoidea*, as of 1849. Hall and Clarke cite the same date in the first quotation from their monograph, but cite 1850 in the later quotation. The adoption of the date 1849 appears to be explained by a remark found on page 59 of the introduction to the *Prodrome*, where d'Orbigny says that he completed the work in 1847 and expected to publish it in 1848 but owing to political circumstances, he was unable to bring it out before 1849. That d'Orbigny was disappointed in the hope of publishing his work in 1849 seems much more likely than that it was actually published in 1849 with the false imprint 1850. Unless other facts are brought to light the first volume of the *Prodrome* and the date of the genus *Orbiculoidea* should be taken as of the year 1850. On these grounds I reach the conclusion that *Schizotreta* has priority over *Orbiculoidea*, that the type species of *Orbiculoidea* is *O. forbesi*, and that if *O. forbesi* is a *Schizotreta*, *Orbiculoidea* becomes a synonym.

Of the premises which seemed to justify me in diverting d'Orbigny's name *Orbiculoidea* from the group of species to which Hall and Clarke wished to apply it, several have already been considered. I have attempted to show that the first valid description occurs in the *Prodrome,* and that the *Prodrome* was not published until 1849, or more probably 1850, so that *Schizotreta* has priority over *Orbiculoidea.* The various attempts to select a genotype have also been discussed together with their standing under the rules of nomenclature governing such selection, with the result that Dall's selection was found to be the first and that, in pursuance of his obvious intention, it seemed best to regard the first species, *O. forbesi,* as the genotype of *Orbiculoidea.* It remains to consider whether *Orbiculoidea* and *Schizotreta* are distinct genera or subgenera, and whether *O. forbesi* is a *Schizotreta* or an "*Orbiculoidea*" as those names were employed by Hall and Clarke.

In my original discussion of *Orbiculoidea* I accepted Hall and Clarke's dictum that *Schizotreta* and "*Orbiculoidea*" were distinct genera, or as they estimated values, subgenera. On this head those authors say (p. 136) that *Schizotreta* Kutorga

may very well stand to include those forms essentially in agreement with *Orbiculoidea,* d'Orbigny, but having thicker shells and the relative convexity of the valves reversed, bearing, in fine, the same relation to d'Orbigny's genus as *Strophonella* to *Strophodonta,* among the articulate brachiopods.

Several additional characters of possible value in distinguishing the two genera are suggested by a reading of Kutorga's description. He says namely that *Schizotreta* is marked by fine radial striae (radialleistchen) and that the shell is not phosphatic (keineswegs hornartig) but like that of the other Siphonotretacaeae. The radial striae may, however, be only such irregular, almost casual lines as may be seen on some of our common Paleozoic discinoids. Furthermore, though I would interpret "hornartig" as refering to that shiny phosphatic appearance which is characteristic of discinoid shells in their fossil state, this interpretation is possibly a mistake, for the shell substance of *Siphonotreta* is described by Hall and Clarke as calcareo-corneous and apparently not different from that of *Orbiculoidea.* Therefore, the distinction suggested by Kutorga's term "hornartig," even if correctly understood, may be only a matter of preservation. Let the distinction between these genera then rest merely on the relative convexity of the valves and the thickness of the shell.

In the type species of *Schizotreta* the brachial valve is depressed convex, more often flat, and the pedicle valve strongly conical, just the reverse of the relation common in "*Orbiculoidea*." On these grounds I am fain to accept the judgment expressed by Hall and Clarke that *Schizotreta* and "*Orbiculoidea*" may advantageously be distinguished but I can not grant that the distinction between them is on a parity with that between *Strophodonta* and *Strophonella*. Passing over the fact that the distinction between those articulate genera only comes about in the later growth stages, we must nevertheless recognize that the reversal in curvature of the valves of *Strophonella* is such that though both genera are concavo-convex, in *Strophodonta* the pedicle valve is convex and brachial valve concave, whereas in *Strophonella* the pedicle valve is concave and the brachial valve convex. In the two discinoid genera, on the other hand, both valves are convex. Neither is the pedicle valve in "*Orbiculoidea*" concave as it is in *Strophonella*, nor is the brachial valve in *Schizotreta* concave as it is in *Strophodonta*. The curvature of the valves is not reversed, merely their relative convexity. The difference between *Strophonella* and *Strophodonta* may be of the same character only carried further. It is, however, carried much further. The difference between *Schizotreta* and "*Orbiculoidea*" would appear more aptly compared to that between *Rhipidomella* and *Schizophoria* or perhaps between *Dalmanella* and *Schizophoria*. In those orthoid types, however, the difference in configuration is supported and emphasized by accompanying differences in the size and shape of the muscular imprints.

Let us, however, accept Hall and Clarke's conclusion that *Schizotreta* and "*Orbiculoidea*" are valid groups distinguished by the characters set forth above, and turn to the question whether *Orbiculoidea forbesi* is a *Schizotreta* or an "*Orbiculoidea*." Hall and Clarke are very positive on this point and the conclusions that I reached in 1909 were in great measure due to an acceptance of their opinion without a personal investigation of the facts. This was ill done. To quote from Hall and Clarke—they say on p. 129 that Davidson's description of *Orbicula morrisi* supplemented by McCoy's show it to be in precise harmony with the paleozoic discinas generally, "while those species now passing under the name of *Orbiculoidea*, Davidson, are distinctive in having the relative convexity of the valves reversed, the pedicle valve being the more convex." Whether this is generally true or not, is of little moment; our concern is only with *O. forbesi* which is one of Davidson's orbiculoideas. Of this more anon. Again, on p. 136, they say, "It thus appears that there is no essential difference in *Schizotreta*, Kutorga and *Orbiculoidea*, Davidson," and on p. 160 that "*O. Forbesi*, Davidson, is unquestionably congeneric with *Schizotreta elliptica,* Kutorga." This is said to have been "shown" on p. 136, but *O. forbesi* is not mentioned on that page and the only thing that can in any sense be regarded as shown there is that all these types have the pedicle valve constructed on essentially the same plan, *Schizotreta* Kutorga as based on *S. elliptica, Orbiculoidea* of Davidson (as including if not typified by *O. forbesi*), and authentic *Orbiculoidea* d'Orbigny (as typified, according to Hall and Clarke, by *O. morrisi*).

In view of these repeated assertions, one is somewhat surprised to find Davidson both describing and figuring *O. forbesi* with the upper or brachial valve more convex than the pedicle valve. This is true whether one consults the original publication in French, appearing in 1848, or his later and better known *Monograph on British Brachiopoda.* The pedicle valve may be rather more convex than the pedicle valve of our orbiculoideas commonly is, though not abnormally so, but it is distinctly less convex than the accompanying brachial valve. If *Schizotreta* and *Orbiculoidea* are distinguished only in the manner suggested by Hall and Clarke, *O. forbesi* is an *Orbiculoidea* and not a *Schizotreta.* Davidson, it will be recalled, regarded *Schizotreta* as identical with *Orbiculoidea* and because he accepted 1847 as the date of publication for *Orbiculoidea,* he employed d'Orbigny's name in preference to Kutorga's. In discussing the brachiopod genera recognized in his monograph, he uses a figure of *Orbiculoidea elliptica* as representative of the genus *Orbiculoidea, Orbiculoidea elliptica* being of course Kutorga's species *Schizotreta elliptica,* typical of that genus. Davidson's figure, however, shows a large shell in which the upper valve is distinctly more convex than the lower, a shell markedly different in both respects from authentic *S. elliptica* of Kutorga and apparently a quite distinct species. Davidson's *Orbiculoidea elliptica* seems much more naturally associated with his *O. forbesi,* likewise a large shell, and if any distinction is to be made among them, *O. forbesi, O. morrisi,* and *O. elliptica* Davidson non Kutorga would seem to belong in one group and *Schizotreta elliptica* Kutorga in another, pretty much as d'Orbigny arranged them, though he took no cognizance of Kutorga's work nor of Davidson's identification of *O. elliptica,* which came later. If Davidson's identification of *Orbiculoidea elliptica* be accepted, then apparently *Orbiculoidea* and *Schizotreta* are the same thing, for his figure has every appearance of being a true *Orbiculoidea.* They are also the same thing if *O. forbesi* is admitted into the genus *Schizotreta,* as Hall and Clarke state positively that it should be, for the distinction that they try to make between the two genera becomes impractical if not fanciful in as much as *O. forbesi* differs less from the normal *Orbiculoidea* in the relative convexity of the valves than from typical *Schizotreta*. In either contingency *Schizotreta* and *Orbiculoidea* would appear to be synonymous, a relationship that has been maintained by a number of authors; and if the two names do cover essentially the same types of structure and configuration then I believe that *Schizotreta* should be retained in preference to *Orbiculoidea* as having had a prior valid description. The evidence seems, however, rather to indicate on the one hand that *O. elliptica* of Davidson is not the same species as *Schizotreta elliptica* Kutorga or even congeneric with it, and on the other that *Orbiculoidea forbesi* is a true *Orbiculoidea*.

Thus the two errors that I attribute to Hall and Clarke cancel each other. The type species of *Orbiculoidea* is not *O. morrisi* as they wished to make it, but *O. forbesi*. *O. forbesi* on the other hand is not a *Schizotreta* as they affirmed but a true "*Orbiculoidea.*" My previous conclusions, reached by accepting one of these premises and rejecting the other now seem to me untenable. *Orbiculoidea* now seems properly employed for the group of species covered under it by Hall and Clarke, though even the premises relied on for this conclusion are liable to revision. Where, as here, the evidence available is so largely comprised in books rather than in specimens one is especially liable to misconceptions and misjudgments, for one is dealing with part of the evidence only and with facts as they are transformed by the lenses of so many different minds.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

712TH MEETING

The 712th meeting was held in the assembly hall of the Cosmos Club December 3, 1927, at 8:10 p.m., with President GOLDMAN in the chair and 82 persons present. New member elected: F. C. BISHOP.

TITUS ULKE: *Flora of Yoho Park* (illustrated).—The speaker gave an account of his work during several summers in Yoho Park, British Columbia, illustrated by slides showing characteristic Alpine scenery and many flowers in colors. The rocks almost throughout the park are calcareous shales. Three life zones are represented, the Arctic-Alpine, the Hudsonian, and the Canadian.

G. F. SIMMONS, Cleveland Museum of Natural History: *Natural history notes from the cruise of the "Blossom" in the South Atlantic* (illustrated).—

The speaker described his experiences on the natural history cruise of the "Blossom" to western Africa and various islands of the south Atlantic, making particular mention of the birds and flora of the islands visited.

713TH MEETING

The 713th regular meeting was held in the assembly hall of the Cosmos Club December 17, 1927, at 8:10 p.m., with President GOLDMAN in the chair and 115 persons present. New members elected: ELMER HIGGINS, G. F. SIMMONS, R. O. SMITH.

F. C. LINCOLN reported the recovery of an Arctic Tern, banded in Labrador in 1927, at La Rochelle, France. This is the first time an American banded bird has been taken in Europe.

S. F. BLAKE read from a Manila newspaper a notice of the shooting of a swallow, banded in Japan, in the Philippine Islands.

PAUL G. REDINGTON: *Informal discussion of some biological problems.*—The speaker illustrated the problems presented to the Biological Survey for solution by discussing the question of placing a close season on woodcock. Evidence as to the increase or decrease of this bird under present conditions is conflicting and there is neither time nor funds for a thorough survey of actual conditions by trained ornithologists. Under the circumstances, the only practicable method of obtaining information has been the circulation of questionnaires, and the evidence derived from these points unmistakably to the general decrease of the bird in its range as a whole, although it may be holding its own in some localities. The question of tularaemia in wild animals other than rabbits was briefly referred to. The migration of caribou during the past summer near Fairbanks, Alaska, has been the greatest ever known in that region, the number of animals being estimated at 500,000 to 750,000. In discussion, CHARLES SHELDON stated that he doubted whether this migration indicated a recent great increase in numbers, and was rather of the opinion that excessive numbers in this region were due to circumstances of migration. E. P. WALKER concurred in this belief.

JOHN M. HOLZWORTH: *Motion pictures of mountain sheep, mountain goats, caribou and other big game from Alaska and Idaho* (illustrated).—The speaker showed a remarkable series of pictures taken in the region of the Salmon River, Idaho, in the Smoky River Country, in the Yukon, and elsewhere in the Northwest and gave an interesting commentary on the pictures as they were shown.

S. F. BLAKE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Smithsonian Institution has awarded the Walter Rathbone Bacon research fellowship for the years 1928–1930 to Dr. Paul Bartsch, curator of mollusks in the National Museum. Dr. Bartsch will make use of the award to collect material for the completion of a monograph on the land shells of the West Indies. The fellowship, established under the terms of the will of Mrs. Virginia Purdy Bacon of New York, became available in 1924. It is given for two years and may be extended; a report is made to Smithsonian and all collections, photographs, records and equipment become the property of the Institution.

Professor H. H. BARTLETT of the University of Michigan spent two weeks at the National Herbarium working on his Sumatran collections. The grasses have been identified at the Grass Herbarium. Most of the other phanerogams are to be determined by Dean E. D. Merrill of California, and the ferns by Dr. E. B. Copeland.

B. S. BUTLER of the U. S. Geological Survey will give a series of lectures on mining geology at the University of Arizona, and will be on leave of absence from the Survey until the end of May.

A. C. SPENCER has gone to Socorro, New Mexico, for a stay of several months to complete his work on the Santa Rita district. His headquarters will be at the New Mexico School of Mines, at Socorro.

Dr. R. S. BASSLER, Curator of Stratigraphic Paleontology in the National Museum, was recently elected Secretary of the Paleontological Society of America for the 20th year.

BAILEY WILLIS, President of the Geological Society of America, has recently been in Washington for conference on scientific matters.

Prof. C. K. LEITH of University of Wisconsin visited Washington en route to New York and the West Indies.

Dr. E. C. ANDREWS, Government Geologist of New South Wales, addressed the Geological Society of Washington, and less formally the geologists of the U. S. Geological Survey, on the geology of the Broken Hill district, Australia, and the tectonics of the Pacific.

Prof. DAYTON C. MILLER, of the Case School of Applied Science, Cleveland, Ohio, gave an experimental lecture, *Photographing and analyzing sound waves*, before the ACADEMY February 16. The general nature of sound and sound waves was discussed, and a detailed explanation of noise and tone, and of pitch, loudness and tone-quality was given. A method for obtaining photographic records of sound waves was described, and numerous photographs were shown. By means of the "Phonodeik," "living" sound waves from the speaker's voice, from various musical instruments, and from singing and whistling were projected on the screen.

The Ore Deposits Club met at the Geological Survey on February 14. T. S. LOVERING presented a paper by B. S. BUTLER and W. S. BURBANK, of the Colorado office of the Survey, on *The relation of electrode potentials of some elements to the formation of hypogene ore deposits.* There was general discussion of the question whether the solutions given off by a magma are acid during the early stages of ore-deposition. The evidence on this point is inconclusive.

DONALD C. BARTON, consulting geologist, of Houston, Texas, lectured at the Interior Department on February 16, on *The use of the torsion balance in geophysical prospecting.*

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, March 6	The Botanical Society
Wednesday, March 7	The Medical Society
	The Washington Society of Engineers
Thursday, March 8	The Chemical Society. Program: C. H. KUNSMAN—A comparison of the physical and chemical properties of electrons and ions in the activation of gases. LANSING S. WELLS—Reaction of water on the calcium aluminates in relation to the setting of cements.
Saturday, March 10	The Biological Society
Wednesday, March 14	The Geological Society
	The Medical Society
Thursday, March 15	The ACADEMY
Saturday, March 17	The Philosophical Society
	The Helminthological Society
Tuesday, March 19	The Anthropological Society. The meeting will be held in the Freer Gallery in the afternoon. Dr. CARL W. BISHOP will speak on archeological research in China.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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JOURNAL

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PALEONTOLOGY.—*Prehistoric ornithology in North America.*[1]

Alexander Wetmore, Smithsonian Institution.

When one considers that the number of forms of living birds known at the present time is approximately 25,000, the fossil species that have been discovered are remarkably few. The most recent synopsis of the fossil birds of the world, that of Koloman Lambrecht, published in 1921, includes only 700 species, part of them of doubtful identity; the list has been increased slightly in the seven years that have passed since this publication. At the present date there have been described 154 species known only as fossils from that part of continental North America which lies north of Mexico (but including the peninsula of Lower California), this being the area included by the American Ornithologists' Union in its official Check-List. To complete the roster of fossil forms for this region we must add 105 species now living whose bones are found in deposits of Pleistocene age, so that the list includes at the present moment 259 names. The total is less than that for any other group of vertebrates except the amphibia for this region. The fossil reptiles according to data supplied by Dr. O. P. Hay, now number 1011, or nearly four times the number of birds, while the amphibians (without reference to supposed members of this group named from tracks alone) reach a total of 156.

That comparatively few students have taken up serious work on our fossil birds may be due to three factors: first, the small numbers in which fossil bird bones ordinarily occur; second, the incompleteness of the specimens in most cases; and third, the lack of skeletal material in most museums for comparative use.

[1] Presidential address delivered before the Academy January 10, 1928. Received January 26, 1928.

It is true that there have been occasional deposits in Pleistocene beds in North America where bones of birds have been found in great abundance, as at Fossil Lake in Oregon, and in the pitch deposits at Rancho La Brea in California, but these are exceptional both in number of individuals and in range of species represented. Ordinarily the careful collector of vertebrate fossils finds no bird remains whatever, or at most recovers only a few fragments in the course of a season's explorations in the field. Most of these are secured incidentally in other excavations, the majority of bird bones being small and easily overlooked, or of such form as to offer little promise, so that when only partially exposed they may be disregarded by the searcher for striking specimens.

Bird remains in the fossil beds below the Pleistocene are characteristically fragmentary or broken. Leg and wing bones are those most usually encountered, with occasional parts of vertebrae, pelves, sterna or ribs. Seldom are more than the merest fragments of skulls secured, and on relatively few occasions have complete skeletons been found.

Birds as individuals exist in enormous numbers, and as there is naturally a constant mortality among them it might be expected that their remains would be abundant. There is no reason to suppose that birds were less common during the Tertiary than now; in fact there is ground to believe that they may have been more numerous prior to the Recent Period than in the present century. Our present race of civilized man was not then developed to trouble them: and there is no question but that the rising dominance of man in the last hundred years has had far reaching effect in reducing the total numbers of birds, both by his personal activity in hunting, and by the changes in ecological conditions that have attended his agricultural and commercial developments. Many of our existing species are now able to maintain their living status only through restrictions arranged for their benefit by those far-sighted persons who realize the necessity for conservation in connection with our remaining wild creatures.

It would seem then that in previous geologic ages there may have been more birds present in North America than exist today. That few seem to have been preserved as fossils is apparently due to the fact that the bones of birds are so light that they are easily destroyed. Most of the limb bones have a hollow center, with comparatively thin walls of dense, rather brittle structure, and when subjected to undue pressure are crushed or broken. Most birds die through capture by some predator, or if overtaken by disease are eaten promptly by some scavenger. As the majority are of small or medium size they are often entirely consumed, and their bones comminuted or destroyed by the strong digestion of the creature that has found or captured them.

That this destruction is the usual course when birds die will be attested by field naturalists when they reflect upon the hundreds and thousands of living birds that are seen and the relatively small number of instances in which remains of dead birds are encountered. Armies of predatory or scavenger creatures, many of them unnoticed by the average individual, destroy the carcases immediately upon death.

The bones that in past ages through fortuitous chance have escaped this destruction are frequently of little moment to the paleontologist. Bones of the toes, ends of the ulna, broken bits of the coracoid, or fragments and slivers from the shafts of long bones, all of which are common as fossils, ordinarily offer no distinctive characters, and, in the main, should be disregarded by the careful student. Unfortunately through the enthusiasm of early workers in the science these have served frequently as the basis of description for names that are now stumbling blocks in modern paleontological studies.

In work in the field I have been interested in observing the skeletal remains of birds, and have found that chance today seems to favor the preservation of exactly the same type of fragments as those found among Tertiary fossils. The body of a duck or a heron is eaten by some coyote or vulture which tears out the breast and the viscera, destroying part of the sternum, breaks the skull to obtain the brain, and mangles the wings and thighs. The remaining portions dry somewhat, and the flesh is removed either fresh or dried by the work of insects. The broken skeleton is light, and unless anchored by vegetation, blows about with the wind or is swept by running water. Bit by bit if falls apart and is scattered over the space of several square feet. Occasional bones are buried in such a way that they may be subject to decay, or, less often, where they may be preserved. Even where vertebrate scavengers are not active delicate portions and many of the more sturdy bones disappear.

Imperfect preservation is common where predatory enemies are absent. On the islets in the Hawaiian Bird Reservation thousands upon thousands of birds of moderate size live without interference from the usual enemies that prey upon birds in continental areas. It might be expected that here complete skeletons would be preserved in large quantity since there is the usual regular mortality among the assemblage. I found, however, that even here the carcases disintegrated while the thinner parts of skulls, sterna and pelves, under the combined effect of sun, rain, and wind-blown sand, were corroded away, and the firmer bones were scattered by violent gales. On Laysan Island many found a resting place in the concentrated saline waters of the shallow, central lagoon, and here on investigation I found a veritable cemetery of bird remains, mostly composed of the long bones, characteristic of fossil deposits. These thousands of fragments were being steadily buried in the sands that blew in upon them so that the lagoon at Laysan may be a possible source of fossil deposits for study in the remote future if then there still exist beings interested or capable in such research. The situation on Laysan suggests that similar conditions have operated on many oceanic islands, and that there is opportunity for discovery of extinct forms of life when these are found and properly exploited. Formation of such large deposits seems to occur only under exceptional circumstances, it being more usual for only scattered fragments to be preserved.

The certain history of the class of birds as known in North America at the present time must be considered to begin with the Cretaceous period of geologic time. It is true that there is one species called *Laopteryx priscus*, described by Marsh from the Morrison formation of southern Wyoming, that in late years, without particular reason, has been listed in the same family with *Archaeopteryx* of the Old World. As there is, however, some doubt that *Laopteryx* is actually avian, its systematic position must be considered vague until it has been more carefully studied. Another fragment, described by Emmons in 1857 as *Palaeonornis struthionoides,* from what are considered possibly Triassic beds in North Carolina, is also so doubtfully avian as not to merit consideration at this time.

The first fragment of a fossil bird from this continent of which we have record, a part of a tibia, was secured by S. W. Conrad in Cretaceous marl beds near Arneytown, New Jersey. This was mentioned in 1834 by Dr. Morton in his "Synopsis of the Organic Remains of the Cretaceous in the United States," as a species of *Scolopax,* but was not actually described until 1870 when Marsh bestowed upon it the name *Palaeotringa vetus.*

The birds found in the Cretaceous period of greatest interest are species known to have teeth, first described from specimens found by Marsh and parties under his direction in the Niobrara beds of western Kansas. Of prime importance among these are the members of the family Hesperornithidae, in which there are at present recognized five species. Several practically complete skeletons have been discovered so that in spite of their antiquity these fossil forms are fairly well known. The species of *Hesperornis* were diving birds with greatly elongated bodies, strong legs, paddle-like feet, and long necks, with the jaws set with sharply pointed teeth placed in continuous grooves. The vertebrae were saddle-shaped like those of modern birds. The lower jaw had teeth set along the entire length, but in the upper jaw teeth were placed on the maxilla alone, the premaxilla being smooth, so that apparently even at this remote date there began a tendency to tooth reduction which has resulted in the toothless jaws found in modern birds. The various species of *Hesperornis* lived in the shallow seas that covered parts of the interior of our country in the Cretaceous, and from their form seemed to have fed on fish which they captured by diving. They were so adapted for aquatic life that they had entirely lost the power of flight. In fact the wing is known from the humerus alone which is reduced to a slender, curved stylus, the head of which has so slight an articulation on the scapular arch that it is evident that it had little function. It is possible that the remaining wing elements were represented by rudimentary bones but these have not been identified, and if present at all they must have been very small.

Early constructions of the skeleton represented *Hesperornis* in an upright attitude, but on more careful examination of the articular surfaces of the leg bones it was found that the legs projected at right angles from the body so that it is doubtful if the bird could stand on them at all. It appears that *Hesperornis* presented the most highly specialized developments for aquatic life of any bird yet known. It travelled through the water by propulsion of its tremendously powerful feet, which are of such form and have such size in relation to the remainder of the skeleton that it is probable that at need the bird could develop the speed and agility in turning found in the modern shark or porpoise. On land, if it ventured at any time on terra firma, it must have progressed like a hair seal, prostrate on the breast; it is possible that it built a nest of floating vegetation in the water like the modern grebes, and seldom if ever did more than flounder out on shore to rest in the sun. If its eggs were placed on shore they must have been deposited near the water's edge like those of loons.

Marsh, deceived by the flat sternum, on which there is no keel for the attachment of flight muscles, characterized *Hesperornis* as "a carnivorous, swimming ostrich" while later authors have considered it as perhaps ancestral to the modern grebes and loons. In point of fact *Hesperornis* is so highly specialized that it is doubtful that it may be considered ancestral to any modern form other than that it represents a type of bird that lived at an earlier age. Resemblances to

Hesperornis seen in modern species appear to be merely those characterizing birds as a group, or are the preservation in a few of ancient characters which in the Cretaceous may have been developed in all forms of birds.

The second type of toothed bird, described from the Cretaceous by Marsh, is *Ichthyornis,* a genus in which seven species are at present recognized. *Ichthyornis victor* and *I. dispar,* the two that are best known, in body were about as large as a domestic pigeon. The neck was long, and the head was large and strong, with long jaws implanted with many small, sharply pointed, recurved teeth set in sockets. The wings were large, long and strong, the sternum heavily keeled and the legs and feet comparatively weak. The biconcave vertebrae, which have the form found in fish and some amphibians and are unlike those of any other bird, were the most peculiar feature of the group. *Ichthyornis* was entirely different from *Hesperornis* in that it was pre-eminently developed for flying. That it flew by feathers, and not by means of a skin membrane as do bats, is shown by tubercles for the attachment of secondary feathers on the ulna, and the ankylosis of the metacarpal elements into one bone to form a firm support for the primaries, the long wing feathers on the outer part of the wing. As a flying form it is apparently nearer the central stem from which has come our modern birds than is *Hesperornis. Ichthyornis,* however, shows primitive tendencies in that it still carries the amphicoelous or biconcave type of vertebral articulation, so that it combines the ancient with the new, as a grandmother may don the dress of a modern maiden. *Ichthyornis* has been postulated as ancestral to modern terns or skimmers, but here again I believe that resemblance is merely convergent due to the restriction placed by method in flight on the evolution of bodily form in birds. It is my belief that birds of the Cretaceous had as varied form as those of modern times, and that there is no direct linear connection between the few fossils of this time yet known and existing groups.

Certain other Cretaceous fossils, (*Apatornis celer,* and *Baptornis advenus*) from the Niobrara beds, are placed among the toothed birds. There have been described also from the Cretaceous of New Jersey three species of a genus known as *Palaeotringa* that are currently located in the modern family Scolopacidae which contains the snipes, and three more of the genus *Telmatornis* that are allocated in the family Rallidae among the rails. Another, *Laornis edvardsianus,* is considered as an anserine bird of the family Anatidae, or ducks, geese and swans. It is very probable that none of these has anything to do with the existing families in which they have been grouped, and that all should be placed lower, near *Hesperornis* and *Ichthyornis*. From the evidence of the two genera last mentioned, the only forms in which the jaws have been found, it would appear that teeth are a character to be expected in all ornithic forms of the Cretaceous, and that we should not, therefore, put any Cretaceous bird in a modern family unless its skeleton is completely known.

With the beginning of the Tertiary there is a sudden change in our known fossil avifauna. Toothed birds have disappeared, and the forms found are more like modern types so that the greater number of the approximately 25 species of fossil birds that have been described from the Eocene of North America are now placed in modern families. It may be said that a number of these have been named from very inadequate material and that some, perhaps, may not be birds, as the bones from which they have been described are so fragmentary as to make it difficult to decide whether they belong in the class Aves or elsewhere among the vertebrates. Others on further study may be found sufficiently peculiar to warrant their separation as distinct from living families.

Diatryma steini from the Lower Eocene (Lower Wasatch) of Wyoming is one of the few fossil birds found that is represented by a nearly complete skeleton. This great bird stood nearly seven feet in height and was developed for a terrestrial life. It possessed strong legs, and a heavy head, with a great, arched bill, and very small, almost aborted wings. Superficially it suggests the remarkable *Phororhacos* of Patagonia, and probably was similar in habit. It has been described fully by Matthew and Granger but has not been carefully studied so that its exact affinities are uncertainly known. It is placed at present near the cranes and rails, but does not seem to have very close affinity with either.

Another form that is known from a nearly complete skeleton is *Gallinuloides wyomingensis* from the middle Eocene (Green River) of Wyoming, a gallinaceous form, typical of a special family related to the curassows and guans, fowl-like birds that live among the branches of trees. *Minerva saurodosis* of the same age is apparently a primitive owl, while *Presbyornis* is a shore-bird placed in a separate family from any of our modern species. It seems to have resembled an avocet but probably was more aquatic and swam more readily. *Nautilornis* was an auklike form that differs from modern auks in that it seems adapted for wading as well as for swimming. Other species that have been described from this age are so fragmentary as to be uncertain in character.

Bird remains from the Oligocene of North America are as yet few so that to date only six species have been recorded. Two of these, a cormorant, and a supposed pheasant named by Shufeldt, are of uncertain status. The only important deposit of this age that has yielded much bird material to the present is one in Weld County, Colorado, where collectors from the Colorado Museum of Natural History in Denver, in exhuming great series of such mammals as *Trigonias, Symborodon* and *Archaeotherium*, have uncovered a few bones of birds. From these the speaker has recently described four species representing peculiar genera not known in modern times. *Phasmagyps patritus* is a vulture related to the living black vulture but about one half larger. *Palaeogyps prodromus*, in the same family, is more like the California condor but is only two-thirds as large, *Palaeocrex fax* is a large gallinule, apparently between two and three feet in height, and *Bathornis veredus* is a species of the shore-bird family of thick-knees or Œdicnemidae. *Bathornis* was peculiar in possessing a hind toe which is missing in living representatives of the family. Further species of extinct birds from the Oligocene will be awaited with interest since in this age we may expect the earliest species that are at all closely similar to those living today.

The 23 birds certainly allocated to the Miocene include a considerable variety of forms. In Colorado, in the deposits known as the Florissant lake beds, famous for the insect and plant remains that that they have produced during the past fifty years, there have been found remains of several birds. A plover has been described as *Charadrius sheppardianus*, while another species, a perching bird about as large as a cedar waxwing or bluebird, has been named *Palaeospiza bella* by J. A. Allen. During a recent examination of the type of the latter species I found that it is representative of a peculiar family to be known as the Palaeospizidae, which belongs near the base of the oscinine subfamily of the perching birds, immediately above the larks, or Alaudidae.

Another avian species from these same Florissant beds has had a curious history. In 1883 the paleobotanist Lesquereux named *Fontinalis pristina* from a specimen that he thought was a bit of a fossil moss. In 1916 Knowlton called attention to this species indicating that the fragment on which it was based was not a plant, but was in reality a bit of a feather. *Fontinalis* must, therefore, be transferred to the avian list where it is placed in the group of *incertae sedis* without hope ever of ascertaining its proper relationships.

Among other Miocene fossils there have been found in the beds of diatomaceous earth at Lompoc, California, a number of birds from which Loye Miller has described six species, a shearwater, three gannets or boobies, an auklet, and a shore-bird. These occur as flattened impressions or silhouettes in beds of nearly pure diatomaceous material. The birds found are mainly fish-eaters that may have come to a shallow Miocene bay to feed on myriads of herrings whose remains abound in the same beds. The most abundant bird is *Puffinus diatomicus*, a shearwater allied to the living blackvented shearwater. *Limosa vanrossemi* is a godwit much like the modern marbled godwit. *Sula willetti*, a booby somewhat like the living red-footed booby, is of interest in that it shows the same type of closed external nostril found in modern Sulidae, indicating the great antiquity of this character. The bone in these specimens has been so altered that on exposure to the air it crumbles and disappears, leaving only an impression that in turn is evanescent, as the material in which it is formed is soft and friable.

The Miocene of the Sheep Creek and Snake Creek beds of northwestern Nebraska under exploration by the American Museum of Natural History, Princeton University, the Carnegie Museum, and Mr. Harold Cook, has yielded a fair number of bones of birds from which I have described seven species, including a hawk, *Buteo typhoius*, related to the modern red-tail, two small eagles, *Geranoaëtus ales* and *G. contortus*, of a genus not found outside South America in a living state, and a kite, *Proictinia effera*. There is also a peculiar limpkin, *Aramornis longurio*, and a small paroquet, *Conuropsis fratercula*, allied to the modern Carolina paroquet but smaller. One may picture the area as a badlands section where hawks and eagles, with nests on the sides of cliffs, dropped the bones of their prey on the slopes below, to mingle with occasional bodies of the predatory birds that had brought them to the place.

The Pliocene, like the Oligocene, has fossil birds poorly represented as yet, as at present we know only 10 forms from within the limits of this age. The upper Snake Creek in Nebraska, which is placed in the lower Pliocene, has given us an eagle, and a species of chachalaca, *Ortalis phengites*, a tree-haunting, gallinaceous bird of a group not found today north of the lower Rio Grande Valley. From these same deposits within the last few weeks I have received the humerus of a crane that is seemingly identical with the existing sandhill crane, the first instance found of remains of a species still living below the Pleistocene. From beds ascribed to the Upper Pliocene in southern Arizona I have identified a small goose, *Branta minuscula,* a tree duck, *Dendrocygna eversa,* a sandpiper, *Micropalama hesternus* and a dove, *Chloroenas micula.*

Though a part of the birds of the Miocene and Pliocene are peculiar many are identified in genera existing at the present time. It is my own belief that these two ages mark the period of evolution of our modern genera of birds and that there has come comparatively little change in generic type since. In my opinion evolution among birds during the Quaternary has been concerned principally with the development of those differences that characterize species and subspecies, differences which in some cases have been so pronounced that present usage, with its close perception of minutiae, concedes them as generic. When broad, comprehensive limits are given generic groups, however, these seemingly have had their origin in the latter part of the Tertiary.

It seems probable that the bird life of the Miocene and Pliocene was even more varied and wonderful than that of today, and that a larger number of species may have existed. We are told that climatic conditions in that time had not developed such sharply marked zonal characteristics as in the Recent period, so that though the temperature was not oppressively warm it was moderate and fairly uniform at points much farther north than under modern conditions. Forms that we consider now as subtropical, in the Miocene and Pliocene ranged north into northern Nebraska, and probably further. We are aware that the present number of species in tropical and subtropical sections of America is much greater than in the temperate zone. Ecuador for example, in the geographic limits at present granted to it, has approximately the same area as the State of California. The known bird life of Ecuador at the present time numbers 1508 forms, more than for the whole of North America north of Mexico, while that of California at the end of 1924 (the latest published revision of the list) included only 594 species and subspecies. By analogy we may suppose a rich and highly varied bird life for the Miocene and Pliocene periods in North America, a fauna that since has been in part exterminated and in part restricted to more southern latitudes. Further research may be expected to increase considerably the list of fossil forms known from this section of geologic time.

With advance into the Pleistocene we come to an age in which the fossil avifauna becomes much better known through more numerous occurrence and greater abundance of specimens. Fifty extinct species have thus far been described from our Pleistocene beds, evidence of a rich avifauna. There are in addition 105 species of birds still existent whose remains have been identified in Pleistocene deposits, so that the entire group for this period includes 155 forms of birds, more than half our present list, and a considerable number when we consider the smaller figures yielded by our census in previous ages.

It may be remarked parenthetically that the fifty extinct species that have been described from the Pleistocene are definite indication of what has been said above of the probable abundance of birds at the close of the Pliocene, since these forms undoubtedly had their evolution prior to the Ice Age and were in existence at its beginning. From somewhat meager information I am inclined to regard the close of the Tertiary as the period of greatest diversity and abundance in bird life in the earth's history so far as North America is concerned, and to believe that with the rigors of climate incident to the opening of the Pleistocene, and the even more unfavorable conditions of the historic part of the Recent Period occasioned by the increase of man over the earth, there has been steady reduction and extermination among birds, a process that will continue in spite of protective regulation until most of the peculiar forms have disappeared and only the more adaptable ones remain.

To return to our Pleistocene avifauna we find several deposits that have yielded abundant bird remains. The earliest known of these important beds was that of Fossil or Christmas Lake, in the arid section of Oregon, where deposits containing hundreds of bones of birds have been explored. These, studied first by Shufeldt and later by Miller, have given a varied list of birds, mainly aquatic, of which a number have been described as species distinct from those existing today, and many have been identified as identical with living forms. Dr. O. P. Hay considers the age as first interglacial. Of the more than twenty peculiar species only one, *Palaeotetrix gillii*, is now held to be generically distinct from living birds. The flamingo, *Phoenicopterus copei*, is the most unusual species in the assemblage, as any of the other genera might be expected in this area today. It may be remarked that the flamingo is no criterion for particularly warm climate at the time mentioned, since a somewhat similar species of flamingo now ranges and nests in South America through Patagonia where the summer weather is often cold and inclement.

The deposits of bird bones from this Oregon locality are found in an old lake bed that from modern conditions might be supposed to be similar to the small alkaline lakes now common in this area. If this is true it is possible that the great abundance of bird remains is indicative of a condition in the Pleistocene similar to one that has destroyed hundreds of thousands of waterfowl in the western part of the United States in recent years. The malady to which I allude, the so-called "duck sickness," has been especially prevalent in the past twenty years in the deltas of streams flowing into Great Salt Lake in Utah, but is known in alkaline lakes in a number of other sections, including the Malheur region of Oregon. Briefly, it appears that birds, principally ducks and other aquatic species, become affected by excessive concentrations of alkalis in the waters in which they feed, and unless they can have immediate access to fresh water they become paralyzed and die. Aquatic birds of various kinds have been affected and the number of individuals known to have been thus killed in the last twenty years has been tremendous, running literally into the millions. The possibility of the accumulation of extensive deposits of bones of birds that may be preserved as fossils under these conditions is easily evident.

The most famous deposit of Pleistocene vertebrate remains in the New World is that of Rancho La Brea on the Californian coastal plain only a few miles from the business center of the city of Los Angeles. Here outpourings of asphalt from the depths of the earth have been exposed in such a way that they have served to entrap animals which were held in sticky embrace until death came to them, and then when decay had released their skeletons, to entomb the bones in a bed of tar where many have been preserved in perfect condition. The manner in which this pitch trap operated is seen in minor deposits that form today, as it is not unusual to find small mammals or birds held fast in the viscous substance. Under careful exploration the beds at Rancho La Brea have yielded bones to an aggregate of many, many thousands and have included very large numbers of remains of birds. To the present time Loye Miller has published identification of nearly sixty species, and there are unquestionably others to come as the smaller forms, the passeriform or perching birds in particular, have not yet been carefully studied. Two-fifths of the forms from these deposits are extinct. Such scavengers as vultures, which would be attracted to the bodies of dead animals, are represented in abundance, and include several extinct genera. Among these the most curious is the great *Teratornis merriami,* which is known from almost the complete skeleton, and represents the largest of flying birds, exceeding in wing spread the modern condors. Another species of great abundance was a gallinaceous bird, *Parapavo californicus,* supposed at one time to be a peacock, but now admitted as a species of turkey. The age of these deposits is placed by Hay as first interglacial.

Asphalt deposits of similar kind have been found recently near McKittrick, and near Carpinteria, California, giving additional information on the distribution of the avifauna of California in the Pleistocene, which, in its abundance of vultures and large hawks and entire lack of gulls, offers a decided contrast to that of Oregon.

Recent explorations in Florida, near Vero and Melbourne, in what are supposed to be Pleistocene beds, have yielded remains of birds in which are found the great stork known as the jabiru, and various other species. Recently a valuable collection gathered by Mr. William W. Holmes near the west coast has come into my hands for study, and on preliminary examination is found to contain a considerable variety of species. Most remarkable is a broken metatarsal of a male turkey with a trifid spur core that may represent an unknown species. Multiple spurs are known among certain pheasants, but have not been recorded among the gallinaceous birds of North America. The Holmes collection when fully identified will add considerably to knowledge of the ancient Floridian avifauna.

Cave deposits that have been explored in California and also in Pennsylvania and Maryland have contained remains of Pleistocene birds, that need not be described in detail except to remark that such offer a fertile field for investigation.

The discovery of additional forms in the Cretaceous is uncertain but if obtained will be important. At the present time only two types are well known from this period, one of diver form, and the other of flying habit that apparently fed on the wing over water. These are both so specialized that we may expect that other toothed birds existed though their possible presence is now indefinitely indicated by fragments of a few waders or marsh inhabitants. The Tertiary should give many more species than now known, particularly in its Miocene and Pliocene beds, and finally from the Pleistocene we may expect many forms in addition to those already discovered. From cavern and other deposits we may hope for more extinct species related to modern birds, some peculiar and some with relatives living today in South America.

It has been already intimated that the number of extinct species of birds from North America is far less than is to be expected. As the forms described by earlier students are passed under review it is evident that much remains to be done to decide their proper status. Many have been named from such insufficient material that their systematic position is doubtful while there are a few in which the type material is a composite of fragments that may contain remains from two or more families so that selection must be made to properly apply the name. Some that have been called birds probably are not avian and eventually will be rejected from our list. Progress is being made steadily in these matters and yearly the condition improves so that our uncertainties become fewer and fewer. Such glimpses as our few fossils give us of the life of the past are fascinating and promise high return for the most painstaking study. At the present rate with which new material comes to hand we may possibly expect to see our knowledge of palaeornithology in North America doubled in the next twenty years.

PALEOBOTANY.—*A petrified walnut from the Miocene of Nevada.*[1]
Edward W. Berry, The Johns Hopkins University.

There is in the National Museum collections a single silicified specimen of a walnut, which, despite precise data regarding the locality from which it was collected, shows such characteristic features that it fully merits description. The specimen was collected by W. M. Leite, who in July, 1885 sent it to the late Professor Joseph Le Conte, who must in turn have submitted it to the late Frank H. Knowlton, since the original letter bears the following notation in Dr. Knowlton's handwriting: "This is probably a nut of Carya (Hickory)."

Mr. Leite stated that the specimen was collected in the desert along the old emigrant road near the line of the railway, 50 miles east of Reno, Nevada. Hence it probably came from the Truckee beds[2] and is Miocene in age.

The shell of the nut is slightly yellowish on the outside, but very light in color where fractured. Both faces are partially broken away and one of these breaks exposes a complete cotyledon, similarly silicified, but black in color and strikingly contrasted with the enclosing shell.

[1] Received January 10, 1928.
[2] Clarence King. Rept. U. S. Geol. Surv. 40th Par. **1**: 412. 1878.

Although superficially this nut suggests those of the hickory, the cotyledons in all of their features are those characteristic of the existing walnuts. The differences between the two are not profound, but they are perfectly definite. These have been discussed at some length recently by the present writer in describing the petrified walnut kernels of the Titanotherium beds of Nebraska[3] and therefore need not be repeated in the present connection. The present species, obviously new, may be named and described as follows:

Fig. 1—*Juglans nevadensis* Berry, n. sp.

Juglans nevadensis Berry, n. sp.

Nut relatively small and smooth, although considerably larger than the existing *Juglans rupestris*, 1.7 centimeters high, 1.8 centimeters in width and 2 centimeters in thickness. Wall 2 millimeters thick at the sides. There is a conspicuous hilum at the base. The apex is rounded. The cotyledons are separated and not compressed, with their inner surfaces concave: the radicle is prominent, superior and pointed, and its keel extends downward to the widely rounded basal sinus lying between the basal lobes of the cotyledon: their superior lobes are also narrow and rather pointed, and similarly separated from the radicle by open rounded sinuses. The cotyledonary surfaces are nearly smooth. The surface of the nut (bony seed coat) lacks the usual corrugations so frequent in the case of the existing species of *Juglans*, but it is obscurely uneven, quite as much so as in some specimens of the existing *Juglans regia* and *Juglans sieboldiana* which I have examined.

The present species differs from the only other petrified walnut known to me—*Juglans siouxensis* (Barbour) Berry (*op. cit.*) of the Oligocene of Nebraska, in its considerably smaller size, smoother cotyledons, which have straighter side edges and more pointed lobes.

Juglans nevadensis comes from a region where the genus has hitherto been unknown in either the fossil or living state, so that although the past history of the genus has been discussed on several occasions, a few remarks are called for in the present connection. Nevada, since the elevation of the Sierra Nevada, has been too dry for the existence of *Juglans*, all the known species of which require a deep moist fertile soil. The existing species geographically nearest to the fossil are *Juglans californica* of southern California, *Juglans rupestris major* of central New Mexico and Arizona, and *Juglans rupestris* of central and west Texas and adjacent parts of Mexico and New Mexico.

All of these occur in an arid country, but are confined to stream margins or canyon bottoms where the soil is moist and deep, and hence do

[3] EDWARD W. BERRY. Amer. Mus. Nov., No. 221. 1926.

not depart from the normal environment of the eight or ten other existing species. These three species, or more probably their ancestors, have had their distribution restricted in correspondence to the shrinkage of such environments in the central and western United States during the later Tertiary.

The genus *Juglans* is said to go back to Upper Cretaceous times, and numerous fossil species have been described, especially from rocks of Tertiary age, the majority being based upon foliar remains.

The Miocene tree which bore this nut may, of course, have been a stream margin dweller, but the accumulating evidence for mesophytic climatic conditions during the Miocene in western regions now arid or semiarid, such as is furnished by the flora found in the Esmeralda formation of Nevada,[4] or the Latah formation of eastern Washington,[5] strongly suggests that we are dealing with general rather than local climatic conditions, conditions which have an important bearing on the age of uplift of the bordering mountains.

BOTANY.—*New plants from Central America.—XI.*

PAUL C. STANDLEY, U. S. National Museum.[1]

All the plants described as new on the following pages belong to the family Rubiaceae, a group to whose collection the writer has given special attention. There is no doubt that wider exploration in the Central American forests will increase greatly the number of representatives of the family known to occur in the region.

The present paper includes the description of a new species of *Houstonia* from northern Mexico, as well as notes regarding several plants of scattered families for which new data are available.

Hydrangea diplostemona (Donn. Smith) Standl.

Gilibertia diplostemona Donn. Smith, Bot. Gaz. **61**: 373. 1916.
Hydrangea inornata Standl. Journ. Washington Acad. Sci. **17**: 9. 1927.

Recently I have seen the type of *Gilibertia diplostemona.* Although not bearing a collector's number, it is evidently a part of *Pittier* 14068, upon which *Hydrangea inornata* was based.

[4] EDWARD W. BERRY. Proc. U. S. Nat. Mus. **72**: 23. 1927.

[5] EDWARD W. BERRY. U. S. Geol. Surv. Prof. Paper (in press).

[1] Published by permission of the Secretary of the Smithsonian Institution. For the last preceding paper of this series see this JOURNAL **17**: 520. 1927. Received November 21, 1927.

CAMPNOSPERMA PANAMENSIS Standl. Journ. Arn. Arb. **2**: 111. 1920

The type of this species (Anacardiaceae) was collected at the Chiriquicito Lagoon, Panama, in 1920. The tree has been collected again, in the Changuinola Valley, Panama, by Cooper and Slater (no. 154). The vernacular name is "orey."

MELOCHIA BERNOULLIANA Donn. Smith, Bot. Gaz. **35**: 2. 1903

This species, occasional in Guatemala and Salvador, has not been known heretofore from Mexico. It was collected at Santa Bárbara in March, 1841, by Liebmann (no. 535).

MELOCHIA PILOSA (Mill.) Fawc. & Rendle, Fl. Jam. **5**: 164. 1926

Sida pilosa Mill. Gard. Dict. ed. 8. 1768.
Melochia venosa Swartz, Prodr. Veg. Ind. Occ. 97. 1788.

This species, likewise, has not been known from Mexico, but it was collected at Pacho by Liebmann (no. 11874).

DIDYMOPANAX MOROTOTONI (Aubl.) Decaisne & Planch. Rev. Hort. IV. **3**: 109. 1854

Panax Morototoni Aubl. Pl. Guian. 949. 1775.

This tree, of striking appearance, is frequent in some regions along the Atlantic coast of Central America, but has not been reported from Mexico. It was collected by Liebmann (no. 585) at Lacoba in June, 1842.

POLYCODIUM STAMINEUM (L.) Greene

But a single species of *Polycodium, P. Kunthianum* (Klotzsch) C. B. Rob., has been known hitherto from Mexico. It grows in the states of Puebla and Hidalgo. In the spring of 1926 Mr. Robert Runyon collected (no. 844) at Santa Rita Ranch, Tamaulipas, altitude 1,500 meters, specimens which agree perfectly with the eastern forms of *P. stamineum*. The species is frequent in some parts of eastern Texas, but its occurrence in Mexico was scarcely to be expected.

POTALIA AMARA Aubl. Pl. Guian. 394. *pl. 151.* 1775

This genus of the Loganiaceae, consisting of a single species, has been reported from Brazil, Peru, and the Guianas, but not from North America. A specimen of *P. amara* in the Copenhagen herbarium was collected at San Miguel, Costa Rica, May 21, 1857, by Wendland (no. 977). The collector's notes state that the plant is a shrub 1 to 2 meters high, with yellow-green flowers.

CALDERONIA SALVADORENSIS Standl. Journn. Washington Acad. Sci. **13**: 290. 1923

This genus of Rubiaceae was described from Salvador, and is known also from British Honduras. It may now be reported for the first time from Mexico, where it was collected on the banks of the Chalchijapa River above Dos Ríos, State of Veracruz, January 22, 1927, by C. D. Mell. The collector reports the vernacular name as "nazareno."

Portlandia guatemalensis Standl., sp. nov.

Shrub or small tree, the young branches glabrous, obtusely quadrangular or subterete, the internodes 1.5–3.5 cm. long; stipules short-connate, intrapetiolar, 5–6 mm. long, broadly triangular, cuspidate, persistent, glabrous; leaves opposite, the petioles slender, 1–2 cm. long, glabrous, shallowly canaliculate on the upper surface; leaf blades oblong-elliptic, broadest at or near the middle, 9–16 cm. long, 3.5–6 cm. wide, narrowed to each end, acuminate, acute at base and decurrent, firm-chartaceous, deep green above, glabrous, beneath much paler, domatiate and short-barbate in the axils of the lateral nerves, elsewhere glabrous, the costa slender, salient, the lateral nerves about 7 on each side, slender, prominent, ascending, subarcuate, obscurely anastomosing near the margin; inflorescences axillary, long-pedunculate, about equaling the leaves, racemiform-paniculate, the flowers clustered at the end of the rachis and in pedunculate lateral clusters, the bracts leaflike, lanceolate or elliptic, petiolate, their blades 3–6.5 cm. long; pedicels 3–4 mm. long; hypanthium broadly turbinate, 2–2.5 mm. long; calyx lobes 5, distinct, linear-subulate, 1 cm. long, green, glabrous; corolla white, funnelform, glabrous, 4.5 cm. long, the tube very short, 2.5 mm. wide at base, the throat 2.5 cm. wide, the 5 lobes broadly ovate-triangular, obtuse, about 1.5 cm. long; stamens included, the filaments filiform, glabrous, 1 cm. long, the anthers narrowly linear, 8 mm. long.

Type in the U. S. National Herbarium, no. 1,081,354, collected in forest at Quebradas Secas, Alta Verapaz, Guatemala, altitude 750 meters, June 1, 1920, by Harry Johnson (no. 282).

Most species of *Portlandia* are West Indian. Two are known from Mexico. This is the first species to be reported from Central America. It is not very closely related to any other species of the genus.

Houstonia drymarioides Standl., sp. nov.

Perennial, with very slender rootstocks, the stems erect or decumbent, branched at base, glabrous, very slender, the plants 8–13 cm. high; stipules minute, laciniate; leaves mostly crowded at the base of the stem, the cauline ones much reduced and bractlike, many times exceeded by the internodes; basal leaves on puberulent petioles 1–2 mm. long, the blades rounded-oval to rounded-ovate, 5–7 mm. long, 4–5 mm. wide, obtuse, at base obtuse or rounded and abruptly short-decurrent, thin, scaberulous on the upper surface, glabrous beneath, the costa evident, the lateral nerves obsolete; flowers in lax cymes terminating the stems, the cymes 3 to many-flowered, the branches erect or strongly ascending, the pedicels filiform, 2.5–15 mm. long, glabrous; hypanthium and calyx together scarcely 1 mm. long, glabrous, the calyx lobes triangular, acute, erect, equaling or exceeding the hypanthium; corolla funnelform, 3.5 mm. long, glabrous outside, the tube broadened upward, the lobes oblong, obtuse, shorter than the tube; capsule 2.5 mm. broad, two-thirds inferior, broader than long, subretuse, the free portion glabrous; seeds black, oval, 0.5 mm. long.

Type in the U. S. National Herbarium, no. 1,315,865, collected on mountains south of Victoria, Tamaulipas, Mexico, altitude 1,000 meters, April 9, 1926, by Robert Runyon (no. 870). *Runyon & Tharp* 4039, collected at the same time and place, also represents the species.

Houstonia drymarioides is related to *H. gracilis* Brandeg., of Veracruz, which has leafy stems, much larger leaves, and a slightly larger corolla.

Arcytophyllum muticum (Wedd.) Standl.

Hedyotis mutica Wedd. Chlor. And. **2**: 43. 1857.

To this Colombian species belong, apparently, sterile specimens collected on Cerro de las Vueltas, Costa Rica, at 3,000 meters, *Standley & Valerio* 43618, 43677, 43859. This species, not reported heretofore from North America, is a prostrate ericoid shrub forming small dense mats in the páramos.

Rondeletia Torresii Standl., sp. nov.

Slender shrub 2.5–3.5 m. high, the branches subterete, brown, rimose, when young sparsely short-strigillose but soon glabrate, the internodes short or elongate; stipules triangular, cuspidate-attenuate, 3 mm. long, strigillose or glabrate; leaves opposite, the petioles slender, 1.3–3 cm. long, sparsely strigillose or glabrate; leaf blades lance-oblong to ovate-oblong or elliptic, 7.5–12 cm. long, 3–5.5 cm. wide, abruptly acuminate or long-acuminate, the acumination often long, narrow, and falcate, at base subobtuse to acute, often abruptly decurrent, thin, deep green above, often lustrous, sparsely puberulent along the costa and often very sparsely short-pilose elsewhere, beneath paler, puberulent along the nerves, short-barbate in the axils of the nerves, the costa slender, prominent, the lateral nerves very slender, 6 or 7 on each side, ascending, arcuate; inflorescence terminal, cymose-corymbose, long-pedunculate, usually many-flowered, lax, equaling or shorter than the leaves, the bracts minute and inconspicuous; pedicels 2 mm. long or shorter, most of the flowers sessile or nearly so; hypanthium oblong, 3 mm. long, densely whitish-strigillose, calyx lobes 4, 3 of them linear or subulate and 1.5–2.5 mm. long, the fourth elliptic or ovate, obtuse, and 4–5 mm. long, green, minutely strigillose; corolla white, densely pubescent outside with minute whitish ascending hairs, glabrous within, the tube 13–14 mm. long, naked in the throat, slightly broadened upward, the 4 lobes rounded, 3 mm. long; anthers included.

Type in the U. S. National Herbarium, no. 1,305,295, collected in wet forest at Viento Fresco, Province of Alajuela, Costa Rica, altitude about 1,800 meters, February 13, 1926, by Paul C. Standley and Rubén Torres Rojas (no. 47839). No. 47859, from the same locality, represents this species.

The nearest ally of *Rondeletia Torresii* is the Costa Rican *R. calycosa* Donn. Smith, which has linear-lanceolate calyx lobes.

Hillia Maxonii Standl., sp. nov.

Epiphytic shrub 1–5 m. long, often weak and pendent, glabrous throughout, the branches stout, obtusely quadrangular, cinereous or blackish, the internodes 3–14 mm. long; stipules caducous, broadly obovate, 12 mm. long, thin, rounded at apex; petioles very stout and broad, 3–4 mm. long, shallowly channeled on the upper surface; leaf blades oval to obovate-oval, 2–3.5 cm. long, 1–2 cm. wide, broadly rounded at apex, slightly narrowed to the very obtuse base, coriaceous, lustrous above, slightly paler and dull beneath, the costa and lateral nerves scarcely visible, the latter usually 3 on each side, straight, ascending at a very acute angle; flowers terminal, solitary, sessile; hypanthium cylindric, slightly narrowed at base, 7 mm. long, 4 mm. thick, costate; calyx lobes 4, distinct, oblong-linear, 8 mm. long, rounded at apex, green; corolla white, the tube 5 cm. long, 3 mm. thick, the 4 lobes elliptic, nearly 2 cm. long, 7–10 mm. wide, obtuse; capsule cylindric, 3 cm. long, the open valves 8 mm. wide; seeds fusiform, 3 mm. long, brown, the hairs brown, 1 cm. long.

Type in the U. S. National Herbarium, no. 1,181,212, collected at Las Nubes, south of Managua, Nicaragua, altitude 800 to 900 meters, June 28, 1923, by William R. Maxon (no. 7501). Here are referred also the following collections:

Costa Rica: Las Nubes, Prov. San José, alt. 1,900 m., *Standley* 38472. Finca La Cima, north of El Copey, Prov. San José, alt. 2,200 m., *Standley* 42771, 42599. Laguna de la Chonta, northeast of Santa Maria de Dota, Prov. San José, alt. 2,100 m., *Standley* 42187.

Related to *H. chiapensis* Standl., which has much smaller, thinner leaves, shorter stipules, and narrower capsules.

To *H. chiapensis*, which is known otherwise only from Chiapas, I have referred a collection by Prof. Juvenal Valerio and myself (no. 44733) from El Silencio, Guanacaste, Costa Rica, at 750 meters.

Hillia palmana Standl., sp. nov.

Epiphytic shrub, glabrous throughout, much branched, the older branches subterete, brownish, rimose, the younger ones obtusely quadrangular, green, slender, the internodes 5–30 mm. long; stipules thin and scarious, oblong or spatulate-oblong, 13–20 mm. long, rounded at apex, deciduous; leaves nearly sessile, the petiole 3 mm. long or shorter, stout, not sharply differentiated from the blade; leaf blades narrowly spatulate-oblong or oblong-cuneate 1.5–3.5 cm. long, 5–11 mm. wide, broadly rounded at apex, gradually narrowed to the long-attenuate base, coriaceous, dull, dark green above, slightly paler beneath, the venation obsolete; corolla white, the tube 3.5 cm. long, 2.5 mm. thick, the 4 lobes suborbicular, 1 cm. long, broadly rounded at apex.

Type in the U. S. National Herbarium, no. 1,181,721, collected between La Palma and La Hondura, Province of San José, Costa Rica, altitude 1,500 to 1,700 meters, July 17, 1923, by William R. Maxon and Alfred D. Harvey (no. 8045).

From *H. Maxonii* this plant is distinguished by its narrow leaves, long narrow stipules, and shorter corolla with broad lobes.

Hillia Valerii Standl., sp. nov.

Epiphytic shrub about a meter high, glabrous throughout, much branched, the older branches terete, brown, the younger ones obtusely quadrangular, the stout internodes 5–30 mm. long; stipules spatulate-obovate, 2.8–4 cm. long, caducous, broadly rounded at apex, thick and firm, brown; petioles stout, 5–10 mm. long; leaf blades obovate-oblong or narrowly obovate, 5–8 cm. long, 2–3.5 cm. wide, broadly rounded at apex, gradually and cuneately long-attenuate to the base, decurrent upon the petiole, coriaceous, dull, deep green above, brownish beneath, the costa stout, prominent, the lateral nerves evident, about 6 on each side, very slender, ascending obliquely, nearly straight; flowers terminal, solitary, sessile; hypanthium cylindric, 1 cm. long, 4 mm. thick, smooth; calyx lobes 4, distinct, ovate-oval, obtuse, green, unequal, 4–5 mm. long; corolla white, the tube stout, 8 cm. long, 4 mm. thick near the base, 8 mm. thick in the throat, the 4 lobes oval, about 3 cm. long and 1.5 cm. wide, obtuse or rounded at apex; capsule columnar, terete, smooth, dark red-brown, straight or slightly curved, 6–7.5 cm. long, 8 mm. thick, narrowed at base.

Type in the U. S. National Herbarium, no. 1,181,776, collected between La Palma and La Hondura, Province of San José, Costa Rica, altitude 1,500 to 1,700 meters, July 17, 1923, by William R. Maxon and Alfred D. Harvey (no. 8092).

The vernacular name is "azaharcillo." The following additional collections may be cited, the first three evidently conspecific, the others sterile and possibly referable to a distinct species:

COSTA RICA: Cerros de Zurquí, Prov. Heredia, alt. 2,300 m., *Standley & Valerio* 50749. La Palma, *Tonduz* 12440 (*J. D. Smith* 7387). Yerba Buena, Prov. Heredia, *Standley & Valerio* 50151. Cerro de las Caricias, Prov. Heredia, alt. 2,300 m., *Standley & Valerio* 52409. Yerba Buena, *Standley & Valerio* 50144, 50234. Cerros de Zurquí, *Standley & Valerio* 50691.

This species is well marked by the very large flowers and stipules. Some of the specimens have been referred to the Jamaican *H. tetrandra* Swartz, a plant with much smaller flowers.

Hillia loranthoides Standl., sp. nov.

Epiphytic shrub 1 m. high, branched, glabrous throughout, the branches obtusely quadrangular, brown or grayish, with short internodes; stipules elliptic-oblong, 18 mm. long and 6–8 mm. wide, obtuse, slightly narrowed at base, thick and firm, green, caducous; petioles 6 mm. long or shorter, very thick and stout, not sharply differentiated from the blade; leaf blades elliptic or oblong-elliptic, 4.5–7 cm. long, 2–3 cm. wide, narrowed to the obtusish apex and base, decurrent upon the petiole, coriaceous, dull, the venation obsolete, the lateral nerves scarcely visible, about 4 on each side, obliquely ascending at a very narrow angle, nearly straight; flowers terminal, solitary, sessile; capsule cylindric, 3 cm. long, 7 mm. thick, slightly narrowed toward each end, smooth, olivaceous.

Type in the U. S. National Herbarium, no. 1,254,482, collected in moist forest at Quebrada Serena, southeast of Tilarán, Guanacaste, Costa Rica, altitude 700 meters, January 27, 1926, by Paul C. Standley and Juvenal Valerio (no. 46152).

This is a relative of the West Indian *H. parasitica* Jacq., which has thinner, abruptly short-acuminate leaves, larger capsules, and thin stipules. The leaves of *H. loranthoides* resemble closely those of certain species of *Phoradendron* and *Loranthus* segregates.

Pentagonia hirsuta Standl., sp. nov.

Young branches about 1 cm. thick, hirsute; leaves sessile, broadly obovate, about 60 cm. long and 27 cm. wide, narrowed to the short-acuminate apex, rather abruptly narrowed below the middle to a narrow base about 3 cm.

wide, the base cordate-clasping, the auricles broadly rounded, 2 cm. wide, the blades entire, rather densely hirsute on both surfaces with slender spreading hairs, somewhat paler beneath, the costa salient, the lateral nerves slender, prominent, about 19 on each side, 1 to 3 times branched toward the margin; flowers sessile and clustered in the leaf axils; hypanthium densely hirsute; calyx about 24 mm. long, brown, membranaceous, hirsute with whitish hairs.

Type in the U. S. National Herbarium, no. 938648, collected in forests above Tsaki, Talamanca, Costa Rica, altitude about 500 meters, March, 1895, by A. Tonduz (no. 9415).

The material consists of a single leaf and of a few flowers so mutilated that it is impossible to determine their characters. *Pentagonia hirsuta* is easily recognized by its hirsute pubescence. Most plants of the genus are glabrous or nearly so.

Randia grandifolia (Donn. Smith) Standl.

Basanacantha grandifolia Donn. Smith, Bot. Gaz. **55**: 436. 1913.

Posoqueria grandiflora Standl., sp. nov.

Shrub 3–5 m. high, the branches terete or obtusely quadrangular, green, with short or elongate internodes, puberulent or scaberulous; stipules oblong, obtuse, nearly 2 cm. long, glabrous; petioles thick and stout, 7–20 mm. long, puberulent; leaf blades rounded-ovate to broadly elliptic or oblong-elliptic, 12.5–36 cm. long, 8–21 cm. wide, rounded to obtuse at apex, sometimes abruptly short-acuminate, broadly rounded to acute at base, usually subcoriaceous, deep green and glabrous above, beneath paler, very densely pubescent with minute spreading hairs, rather rough to the touch, the costa stout, salient, the lateral nerves 7–10 on each side, ascending, arcuate, the other venation obsolete; flowers borne in small dense terminal corymbs, the flowers pedicellate; hypanthium oblong-turbinate, 6 mm. long, glabrous; calyx 4 mm. long, shallowly lobate, the lobes broadly rounded, ciliolate; corolla white, glabrous outside, the tube slender, 19–22 cm. long, 3–5 mm. thick, the 5 lobes oblong, rounded at apex, 3.5–4 cm. long, 1–1.5 cm. wide, minutely puberulent within, the throat white-villous; filaments exserted about 1.5 cm., the anthers linear-oblong, puberulent, 8–10 mm. long, attenuate to the apex; fruit short-pedicellate, subglobose, green, about 7 cm. in diameter.

Type in the U. S. National Herbarium, no. 1,305,673, collected in wet thicket at Hamburg Finca on the Río Reventazón below El Cairo, Province of Limón, Costa Rica, altitude about 55 meters, February 19, 1926, by Paul C. Standley and Juvenal Valerio (no. 48706). The following additional collections have been seen:

Costa Rica: Hamburg Finca, *Standley & Valerio* 48753. Finca Montecristo, below El Cairo, *Standley & Valerio* 48399.

The West Indians of the banana plantations call the shrub "wild coffee."

Heretofore only one species of *Posoqueria* has been known from North America, the widely distributed *P. latifolia* (Rudge) Roem. & Schult. That differs from the present plant in being glabrous throughout, and in having much smaller flowers.

Posoqueria Pittieri Standl., sp. nov.

Tree 15 m. high, glabrous throughout, the crown rounded, the trunk 60 cm. in diameter at base, the branchlets thick and stout, ochraceous, the internodes 1–3.5 cm. long; stipules narrowly triangular, 7–10 mm. long, acute or acuminate, tardily deciduous; petioles 4–8 mm. long; leaf blades broadly obovate, 8–16 cm. long, 5–9.5 cm. wide, usually obtuse or rounded at apex, often abruptly short-acute, at base cuneate-acute to obtuse or rounded, membranaceous, drying blackish, lustrous, the costa and lateral nerves salient on both surfaces, the lateral nerves about 12 on each side, divergent at an angle of 65 degrees or more, the lower divergent nearly at a right angle, arcuate, irregularly anastomosing close to the margin; flowers in dense many-flowered short-pedunculate terminal corymbs, the bracts triangular, acute, 2 mm. long; pedicels stout, 3 mm. long or shorter; hypanthium oblong-turbinate, 5 mm. long; calyx short-cupular, 2–2.5 mm. long, very shallowly lobate, the lobes apiculate; corolla "orange-yellow" (only buds seen), the tube slender, 4.5–8 cm. long, 2.5 mm. thick, the limb in bud globose-ovoid, obtuse, 8–9 mm. long and 6 mm. in diameter; fruit subglobose, about 7 cm. long.

Type in the U. S. National Herbarium, no. 716696, collected near the hydrographic station on the Trinidad River, Canal Zone, Panama, May 17, 1914, by H. Pittier (no. 6635).

From *P. latifolia* this differs in its thin leaves, narrow acute stipules, and small corolla. The leaves of *P. latifolia* do not blacken in drying.

Posoqueria obliquinervia Standl., sp. nov.

Branchlets 4 mm. thick, glabrous; stipules not seen; petioles slender, 1–1.5 cm. long, glabrous; leaf blades cuneate-obovate to oblanceolate-oblong, 20–28 cm. long, 8–13.5 cm. wide, rounded at apex and abruptly short-acute, or the apex sometimes acute, cuneately long-attenuate to the base and decurrent, membranaceous, drying blackish, short-barbate beneath in the axils of the lateral nerves, elsewhere glabrous, the costa and lateral nerves salient on both surfaces, slender, the lateral nerves about 13 on each side, ascending at an angle of about 40 degrees, nearly straight, laxly anastomosing near the margin, connected by the faint, nearly straight secondary nerves; flowers arranged in a dense many-flowered sessile terminal corymb, glabrous, the bracts triangular-acuminate, 2 mm. long; pedicels very short or the flowers sessile; hypanthium oblong-turbinate, 4–5 mm. long; calyx 2 mm. long, shallowly lobate, the lobes rounded, apiculate; corolla tube (only buds seen) slender, 12–18 mm. long, 1.5 mm. thick, the limb in bud globose-ovoid, 7 mm. long, 5 mm. in diameter, obtuse.

Type in the U. S. National Herbarium, no. 764158, collected in forests of the Río Naranjo, Costa Rica, altitude 200 to 250 meters, March, 1893, by A. Tonduz (no. 9528).

This is clearly related to *P. Pittieri*, which it much resembles in general appearance. The venation of the leaves is so different in the two plants that I am confident they represent distinct species. The flowers of *P. obliquinervia* are still in bud, but they appear ready to open, and it seems probable, therefore, that the length of the corolla will increase little, if at all, in anthesis. If this is the case, the flowers are much smaller than those of *P. Pittieri*.

Genipa venosa Standl. sp. nov.

Tree 9–15 m. high, the ultimate branchlets stout, grayish, rimose, the internodes less than 1 cm. long, glabrate; petioles 3.5–4 cm. long, terete, narrowly canaliculate above, ferruginous-tomentose or glabrate; leaf blades obovate-oblong, 29–35 cm. long, 11.5–14 cm. wide, rounded or obtuse at apex and linear-cuspidate (cusp 1 cm. long, obtuse), gradually narrowed to the obtuse base, this slightly unequal, not decurrent, subcoriaceous, dull, glabrous or glabrate above, beneath brown-tomentose along the nerves or glabrate, elsewhere glabrous, the costa slender, salient, the lateral nerves about 24 on each side, ascending at an angle of about 60 degrees, nearly straight but arcuate toward the margin, slender, salient, parallel, anastomosing to form a collective nerve very close to the margin, the transverse nerves numerous, salient, straight or nearly so, parallel, connected by the close prominent reticulation of the ultimate nerves; inflorescence terminal, few-flowered, the branches very thick; fruit green, subglobose or oval, at maturity as much as 10 cm. long or even larger, smooth, rounded at apex, borne on a thick pedicel 1–1.5 cm. long.

Type in the U. S. National Herbarium, no. 1,254,013, collected in dense wet forest at El Arenal, Province of Guanacaste, Costa Rica, altitude 485 meters, January 18, 1926, by Paul C. Standley and Juvenal Valerio (no. 45269).

Related to *G. Maxonii* Standl., of the Canal Zone, which has thin acute leaves, with less prominent venation, and very short petioles. From *G. americana* L. this Costa Rican tree differs in its long-petioled thick leaves with prominent venation.

Faramea quercetorum Standl., sp. nov.

Shrub or small tree 2.5–4.5 m. high, glabrous throughout; branches green, obtusely quadrangular, with short or elongate internodes; stipules short-connate, forming a shallowly bilobate sheath about 2 mm. long, persistent, green, the lobes tipped with a stiff subulate green cusp 4–5 mm. long; petioles stout, 2–4 mm. long; leaf blades elliptic to elliptic-oblong, 6.5–9.5 cm. long, 2–4.5 cm. wide, gradually or abruptly acuminate, the acumen broad, obtuse, at base acute or obtuse, subcoriaceous, dark yellowish green when dry, lustrous, especially when fresh, the costa slender, prominent on both surfaces, the lateral nerves prominulous beneath, about 9 on each side, divergent at a wide angle, subarcuate, irregularly anastomosing near the margins, the ultimate nerves evident, pale, laxly reticulate; flowers borne in terminal, sessile or short-pedunculate, about 5-flowered umbels; pedicels slender, 8–18 mm. long; hypanthium globose-obovoid, 1.5 mm. long; calyx slightly over 1 mm. long, truncate; corolla violet, the tube 13 mm. long, 2 mm. thick at base, 3 mm. broad in the throat, the 4 lobes lance-oblong, obtuse, 8–10 mm. long; fruit depressed-globose, smooth, 8 mm. broad.

Type in the U. S. National Herbarium, no. 1,253,066, collected in wet oak forest near Quebradillas, about 7 km. north of Santa María de Dota, Province of San José, Costa Rica, altitude about 1,800 meters, December 24, 1925, by Paul C. Standley (no. 42999). The following additional collections have been examined:

Costa Rica: Quebradillas, *Standley* 42967, 43057, 43085.

This Costa Rican plant is related to *F. ovalis* Standl., of Panama. The latter has much broader leaves and a much smaller corolla.

Faramea hondurae Standl., sp. nov.

Shrub 3–4.5 m. high, glabrous throughout; branches slender, subterete, green, the internodes mostly 2.5–3.5 cm. long; stipules sheathing, early deciduous, 3–4 mm. long; leaves opposite, the petioles 7–10 mm. long; leaf blades narrowly oblong or lance-oblong, broadest at the middle, 12–19 cm. long, 3–5 cm. wide, abruptly caudate-acuminate, the cusp linear, obtuse, 1.5–2 cm. long, at base acute, chartaceous, deep green above, the costa prominent, beneath slightly paler, the costa and lateral nerves slender, salient, the lateral nerves about 14 on each side, divaricate at a very wide angle, nearly straight, anastomosing near the margin to form a distinct regular collective nerve parallel with the margin, the ultimate nerves prominulous, laxly reticulate; inflorescences terminal and also borne in the upper axils, sometimes bearing a large leaflike bract, cymose-paniculate, the panicles 5–6.5 cm. long, many-flowered; bracts lance-subulate, 12 mm. long, deciduous; pedicels stout, 2–3 mm. long; hypanthium turbinate, 1–1.5 mm. long; calyx broadly campanulate, 1–1.5 mm. long, shallowly 4-lobate, green, the lobes rounded, apiculate; corolla white, salverform, 5 mm. long, the tube 2 mm. thick, slightly broadened above, the 4 lobes oval-ovate, obtuse, erect, shorter than the tube.

Type in the U. S. National Herbarium, no. 1,153,105, collected in wet forest at La Hondura, Province of San José, Costa Rica, altitude about 1,400 meters, March 16, 1924, by Paul C. Standley (no. 37890). No. 36534, from the same locality, represents this species.

Faramea hondurae somewhat suggests *F. suerrensis* Donn. Smith, also Costa Rican, but the latter has larger, more conspicuously nerved leaves, and a longer, more slender corolla.

Faramea stenophylla Standl., sp. nov.

Plant glabrous throughout; branches very slender, subterete, the internodes 1.5–4 cm. long, 1–1.5 mm. thick; stipules semiorbicular, 1.5 mm. long, rounded at apex and bearing a filiform cusp 2.5 mm. long, the cusp deciduous, but the stipules persistent; petioles slender, 3–6 mm. long; leaf blades linear-lanceolate, 4.5–8.5 cm. long, 7–11 mm. wide, very long-acuminate, the acumen linear, obtuse, attenuate to the acute base, firm-membranaceous, blackish when dry, lustrous, concolorous, the costa slender, prominent on both surfaces, the lateral nerves very slender and inconspicuous, about 10 on each side, distant, irregularly anastomosing toward the margin; inflorescences terminal, 1-flowered, the peduncle slender, 2–10 mm. long, bearing at apex several subulate bracts 1.5–2 mm. long; pedicel slender, 8–14 mm. long; fruit globose, 7–8 mm. in diameter, smooth; calyx limb persistent, less than 1 mm. long, truncate; seed 1, depressed-globose, pale brown, deeply excavate at base, 6–7 mm. broad.

Type in the U. S. National Herbarium, no. 1,208,399, collected on hills at Cuyamel, Honduras, March 29, 1924, by M. A. Carleton (no. 592).

Easily recognized by the very narrow leaves and 1-flowered inflorescences.

BOTANY.—*Studies of Venezuelan Bignoniaceae.—II. Species of* Amphilophium.[1] H. Pittier. Caracas, Venezuela.

On revising our materials of this genus, it was found that the identification of one collection (*Pittier* no. 10401) with the Mexican *Amphilophium molle* Cham. & Schlecht. had been a hasty one, founded on superficial examination, and that the group referred to *A. panniculatum* H. B. K. was also represented by two forms which may be considered as specifically distinct.

Key to the Venezuelan Species

Rami et folia manifeste induta
- Calyx campanulatus, bilobus, lobi appendicula subaequantes; folia ovata vel ovato-oblonga, acuta vel breve acuminata supra scabra — 1. **A. macrophyllum** H. B. K.
- Calyx subglobosus, trilobus, lobi appendicula manifeste breviores; folia late ovata vel suborbiculares, longe acuminata, supra haud scabra — 2. **A. mollicomum** Pittier

Rami et folia haud manifeste induta; calyx bilobus
- Calyx subglobosus, coriaceus; folia ovata, acuta vel breviter acuminata basi cordata; corolla 3–3.3 cm. longa — 3. **A. panniculatum** H. B. K.
- Calyx campanulatus, membranosus; folia ovato-lanceolata, basi rotundata; corolla 4–4.2 cm. longa — 4. **A. xerophilum** Pittier

1. Amphilophium macrophyllum H. B. K., Nov. Gen. & Sp. **3**: 117. 1818
Aragua: Vicinity of Colonia Tovar; flowers December (*Karsten*, type).

2. **Amphilophium mollicomum** Pittier, sp. nov.

Frutex scandens, ramis validis, hexagonis, angulis griseis minute pilosulis exceptis glabris, brunneis, lepidotis, ramulis lateralibus florigeris praecipue angulis fulvo-tomentosis; foliis ramulorum ut videtur conjugatis, modice petiolatis, petiolis angulosis, striatis, petiolulisque molliter denseque hirsutis, laminis late ovatis suborbicularibusve, basi truncatis vel leviter emarginatis, apicem longissime angusteque acuminatis acumine obtuso, utrinque lepidotis, supra opacis parce pilosis, subtus mollissimis, pilis simplicibus rufo-fulvescentibus vestitis; nervibus 5–6 supra imprimis subtus costaque prominulis; paniculis elongatis, rachide pedunculis pedicellisque fulvo-tomentosis, pedunculis supremis simplicibus, inferioribus bifloribus, pedicellis pedunculis brevioribus; bracteis bracteolisque oblongo-linearibus, obtusis, tomentosis; calyce coriaceo, bracteolis 2, caducis suffulto, subgloboso, extus lepidoto-tomentello, trilobato, lobis late triangularibus subacutis obtusisve, puberulis, appendiculis membranaceis, irregulariter sinuato-denticulatis, lobis longioribus; corolla extus minutissime puberula, basi alba, apicem purpurascente, intus glabra, ad insertionem staminum corrugato-pulvinata; staminibus glaberrimis, thecis maturis haud divaricatis; disco pulvinato, crasso, verruculoso, margine irregulariter lobato vel sinuato, lobulis reflexis; ovario lateraliter compresso, stylo villoso, basi incrassato, stigmatibus glabris, late ovalibus, apicem rotundatis. . . . .

[1] *Studies of Venezuelan Bignoniaceae.—I* appeared in this Journal **18**: 61–66. 1928. Received January 20, 1928.

Rami florentes circa 30 cm. longi, basi 4–5 mm. diam. Petioli 3–3.5 cm., petioluli 2 cm. longi; laminae 6–10 cm. longae, 2.7–6.5 cm. latae. Panicula circa 16 cm. longa, 7–8 cm. lata. Pedunculi 1–2 cm., pedicelli 0.7–1 cm. longi. Bracteae circa 1 cm. longae, 1–2 mm. latae; bracteoli 0.8 mm. longi. Calyx circa 1 cm. longus; lobuli 5 mm. longi, 5–8 mm. lati; appendicula circiter 7 mm. longa. Corolla tota 2.7–3 cm. longa; lobi 1.5–1.7 cm. longi. Stamina 5–7 mm. supra basin corollae tubo innixa, minora 1.6 cm., majora 1.8–2 cm. longa; staminodium 7 mm. longum. Discus 2 mm. altus. Ovarium 5–6 mm. longum; stylus cum stigmate circa 2 cm. longus.

FEDERAL DISTRICT: Vicinity of Las Trincheras, 1000 m., on the old cartroad from Caracas to La Guaira; flowers July 20, 1922 (*Pittier* 10401, TYPE).

This plant differs from *Amphilophium molle* Cham. & Schlecht. in its shorter petioles and petiolules, the long and narrowly acuminate leaf-blades, not heart-shaped at the base, and provided with an indument of simple hairs, the much shorter corolla, etc. It cannot be confused with *A. macrophyllum*, on account of its trilobate calyx.

3. AMPHILOPHIUM PANNICULATUM (L.) H. B. K. Nov. Gen & Sp. **3**: 149. 1818.

ANZOATEGUI: Vicinity of Caripe and Monte Cocollar (*Humboldt & Bonpland*).

MIRANDA: La Begonia, on the railway between Los Teques and Tejerías (*Pittier* 7559); Píritu Valley, near Petare, 900 m. (*Pittier* 9877); La Malva, near Las Mostazas on the railroad between Los Teques and Tejerías (*Allart* 279).

FEDERAL DISTRICT: Near Macarao, on bushy slopes (*Pittier* 11566); hills above Antímano, 1000 m., climbing on bushes; fruits December–January (*Pittier* 12456, 12582). Flowers August to November.

The capsule and seeds of this species do not seem to have been described completely yet. They are characterized as follows:

Capsula ellipsoidea, depressa, 10–12 cm. longa, 4–4.5 cm. lata, 2–3 cm. crassa, basi attenuato-truncata, apice subobtusa, valvis sublignosis, septifragis, medium longitudinaliter sulcatis, verruculoso-rugosis. Semina pro loculo 45–50, pluri (5)-seriata, 1.1–1.3 cm. longa, 4.5–5 cm. lata, alis hyalinis.

4. **Amphilophium xerophilum** Pittier, sp. nov.

Frutex scandens, ramis annotinis hexagonis, gracilibus, glabris, juvenioribus ramulisque interdum minutissime puberulis; foliis non bene evolutis, discoloribus, conjugatis vel cirrho trifurcato terminatis; petiolis gracilibus, angulatis, supra vix canaliculatis, minute pubescentibus, petiolulis profunde canaliculatis molliculis; laminis ovato-lanceolatis, basi rotundatis, apice acuminatis acumine subacuto, utrinque lepidotissimis, supra glaberrimis, subtus axillis venarum villosis exceptis glabris; costa venisque 5–6 subtus prominulis; paniculis in apice ramulorum axillaris terminalibus, rachide anguloso pedunculisque simplicibus puberulis; bracteis bracteolisque lineari-lanceolatis plus minusve pubescentibus; calyce submembranoso, campanulato, puberulo-lepidoto, apice bilobulato, lobulis membranaceis subglabris, appendiculis lobulis subaequantibus; corolla purpurea, extus glabra, intus staminum basin dense furfuraceo-villosa; staminibus glabris, thecis haud divaricatis; staminodio brevi, apiculato; disco crassissimo, pulvinato, glabro; ovario dense rufo-tomentoso; stylo basi incrassato, puberulo, supra glabro; stigmatibus magnis, apicem sinuato-truncatis.

Rami florentes 6–15 cm. longi, basi 2–3 mm. diam. Petioli 1.5–3 cm., petioluli 0.8–2.5 cm. longi; laminae 3–7 cm. longae, 2–4 cm. latae. Paniculae (haud bene evolutae) circa 10 cm. longae. Pedunculi 0.7–1.2 cm. longi. Bracteae 0.5–0.8 cm. longae. Calyx 1.7–2 cm. longus, tubo 1 cm. longo, lobulis appendiculique 0.5–0.6 cm. longis. Corolla 4–4.2 cm. longa, lobulis 2.3 cm. longis. Stamina 7 mm. supra basin corollae innixa, majora 2.1, minora 1.9 cm. longa; staminodium 5–6 mm. longum. Discus 2 mm. altus. Ovarium 3.5 mm. longum, stylus 2.2 cm. longus; stigmata circa 5 mm. longa, 4 mm. lata.

LARA: Vicinity of Barquisimeto, in bushy savannas; flowers July 1925 (*José Saer d' Héguert* 253, TYPE.)

This species is characterized by the scarcity of the indumentation, the shape, consistence and color of the leaves, which are abundantly covered with tiny scales, the calyx and corolla much longer than in the other Venezuelan species, and by the pronounced hairy band on the inside of the corolla at the insertion of the stamens.

BOTANY.—*The history of the Franklin tree,* Franklinia alatamaha.[1]

EDGAR T. WHERRY, Bureau of Chemistry and Soils.

The Franklin tree is one of the few members of the Camellia family (Ternstroemiaceae or Theaceae) which have survived the climatic and geographic changes of late Tertiary and Quaternary times on the North American continent. Although it is rather widely known as *Gordonia pubescens* L'Heriter, the arrangement of its stamens and the structure of its fruit are so different from those in other species of *Gordonia* that it seems better classed as the representative of a monotypic genus, its name then being *Franklinia alatamaha* Marshall. Considerable interest has been shown in this plant during recent years, largely owing to the fact that it has apparently become extinct in its native place, and is preserved only in cultivation. As the data concerning it which have been published in newspaper articles are not altogether accurate, and as inquiries regarding its history are continually being made by people who do not have access to the somewhat scattered literature upon it, a compilation of the main facts regarding it is here presented.

In the year 1765 John Bartram, the first native American botanist, made a trip through the southeastern part of the United States, and in the course of it observed a new tree in the neighborhood of Fort Barrington, Georgia. The occurrence of this was described in 1791 by his son, William Bartram,[2] in the following words:

[1] Received January 11, 1928.

[2] Travels through North and South Carolina, etc. 16 and 466. 1791.

I sat off early in the morning [from Darien, Georgia, one day in May 1773], . . . and took the road up the northeast side of the Alatamaha to Fort Barrington. . . . On drawing near the fort. I was greatly delighted at the appearance of two new beautiful shrubs, in all their blooming graces. One of them appeared to be a species of Gordonia,* but the flowers are larger, and more fragrant than those of the Gordonia Lasianthus, and are sessile; the seed vessel is also very different. . . . .

This very curious tree was first taken notice of about ten or twelve years ago, at this place, when I attended my father [John Bartram] on a botanical excursion late in the autumn. . . . . We never saw it grow in any other place, nor have I ever since seen it growing wild, in all my travels, from Pennsylvania to Point Coupè, on the banks of the Mississippi, which must be allowed a very singular and unaccountable circumstance; at this place there are two or three acres of ground where it grows plentifully.

The footnote, indicated by the asterisk, gives, somewhat misspelled, the technical name which had meanwhile been assigned to the plant, *Franklinia alatahama.* [Should have been *alatamaha.*]

The original name was given by Humphrey Marshall, a cousin of the Bartrams', in the first American botanical work, the Arbustum Americanum, published in 1785. After describing its characters in detail, he gave the following account of its history:

This newly discovered, rare, and elegant flowering shrub, was first observed by John Bartram when on botanical researches, on the Alatamaha river in Georgia, Anno 1760 [should have been 1765]; but was not brought into Pennsylvania till about fifteen [eight] years after, when his son, William Bartram, employed in the like pursuits, revisited the place where it had been before observed, and had the pleasing prospect of beholding it in its native soil, possessed with all its floral charms; and bearing ripe seeds at the same time; some of which he collected and brought home, and raised several plants therefrom, which in four years time flowered, and in one year after perfected ripe seeds.

. . . William Bartram . . . has chosen to honour it with the name of that patron of sciences, and truly great and distinguished character, Dr. Benjamin Franklin. The trivial name is added from the river, where alone it has been observed to grow naturally. It delights in a loose, sandy, and moist soil.

The correspondence of the Bartrams and of Marshall with their various friends includes several references to *Franklinia,* but fails to mention further visits to the locality. However, Moses Marshall, a nephew of Humphry, found it there in 1790, as recorded in a letter to Sir Joseph Banks:[3]

In May last, I sat out upon a botanic tour, . . . to Augusta, and to Savannah town, and continuing southwest to the river Alatamaha in Georgia. I here found the *Franklinia* . . . ."

[3] W. DARLINGTON, Memorials of Bartram and Marshall, 563. 1849.

Since that date, this plant has never been seen in its native place, nor has any other colony of it ever been discovered. In 1880 and 1881 it was searched for by the South Carolina botanist, H. W. Ravenel,[4] at the instance of Professor C. S. Sargent, but no trace of it was found. From that time to the present it has been repeatedly sought by collectors from the Arnold Arboretum, the Biltmore Herbarium, the U. S. Department of Agriculture, and various nursery companies, without success.

I have made three visits to the locality, and although I have been unable to locate the plant, the following observations may throw some light on its place of occurrence and the reasons for its disappearance. The region of interest is situated at the upper edge of the Everett City quadrangle, mapped by the United States Geological Survey in 1917. As there shown, a secondary road leads northwest from Cox Station on the Seaboard Air Line to Fort Barrington Ferry, on the Altamaha River (as it is now spelled, the last syllable being accented), a distance of four miles. Ravenel's account of his visits shows clearly that he took this road, and his directions for finding the place have apparently been followed by all subsequent searchers. On reaching the swamp lying as shown on the map, between this road and Pinch's Hill, he concluded that he had rediscovered Bartram's locality of "two new beautiful shrubs in all their blooming graces," because the second of these shrubs, easily identified by Bartram's description as the Georgia-bark, *Pinckneya pubens,* grows here and nowhere else along the road. He overlooked, however, two important points.

In the first place, it seems highly improbable that the secondary road in question was there in Bartram's day, for it approaches the river gradually, whereas the builders of the fort—which has by now practically vanished—would surely have seen to it that the approach to this important point on the river was more or less perpendicular, so as to be better capable of military control. In my opinion, therefore, Bartram's route deviated from that followed by Ravenel at McClendon School, ran east of the Sandhill Bay shown on the map, and swung toward the fort and ferry at some point near the north edge of the quadrangle, probably following the trail shown thereon as terminating in the midst of the woods north of the Sandhill Bay, but which actually extends out to the highway, and can be traversed by vehicles, at least in dry weather. The Georgia-bark grows along this trail, northwest of the Sandhill Bay.

[4] American Naturalist, **16**: 235. 1882.

That this was the colony of it which Bartram saw is indicated by another circumstance, the second point overlooked by Ravenel and subsequent visitors. A large and showy patch of the Sandhill Kalmia, *Kalmia* (*Kalmiella*) *hirsuta*, grows adjacent to the more southern (Ravenel's) colony of Georgia-bark, but there is none near the more northern one. Bartram in the journal earlier referred to mentioned this Kalmia, but stated that it was observed, as a plant new to him, only after he had crossed the Fort Barrington Ferry, and had proceeded some distance farther southwest. The inference is plain that instead of the southern colony of Georgia-bark, it was the northern one that he saw, and that the Franklin tree grew with the latter.

But apparently no Franklin tree is there now; so the question remains as to how it was exterminated. The letter of Moses Marshall, earlier quoted in part, concerned the shipping of various native American plants to England, so no doubt a part of the colony was dug up for that purpose by Marshall and probably by others of his day, although that the "two or three acres" of it reported by Bartram could have been thus removed seems improbable. However, many acres of land in the vicinity of the northern colony of Georgia-bark have been burned over and more or less cleared, and it may well have been that what the collectors left was destroyed in the course of these operations.

That the species, and accordingly the genus *Franklinia,* has not become entirely extinct, is due then to the fortunate circumstance that a single one of the plants, transplanted by Bartram to an acid portion of his famous garden near Philadelphia, survived, and nurserymen, observing its ornamental value, took cuttings and brought it into the horticultural trade. Scores, if not hundreds, of plants from this source must have been distributed to various gardens, yet only a handful of them succeeded, so the extinction of the species might be still threatened, but for a further discovery made in connection with it.

In recent years it has been recognized that certain plants thrive best in soils possessing a moderate or high degree of acidity; that the Franklin tree belongs to this class is shown by two observations. In the first place, the soil of the immediate vicinity of its presumable native place is predominantly acid and the associated plants, especially the Georgia-bark, are acid-loving. The relative failure of the tree in cultivation furnishes the second line of evidence. It has been found that those native species which are commonly reputed to be incapable of cultivation are as a rule the ones that prefer the more acid soils. The reason for this is that our ordinary horticultural practices result in neutralizing acidity, and, contrary to popular opinion, the average garden soil is neutral or slightly alkaline rather than acid. Actual tests of some of the few gardens in which the Franklin tree has chanced to thrive show that they are exceptional in exhibiting a distinct soil acidity, which has not been neutralized by fertilization or cultivation. Dr. Frederick V. Coville informs me that, suspecting the Franklin tree to be a plant of acid soils, he raised seedlings successfully in such soils in 1911. The plants flowered in 1913. In 1912–13 he rooted cuttings in acid soils, with pronounced success, and in 1916 he sent small plants to the acid-soil nursery at Whitesbog, in the New Jersey pine-barrens. The trees have thrived there amazingly; the largest is now about 10 feet high and bears hundreds of flowers each year. He has used this species in his experiments on the effect of aluminum sulfate on acid-soil plants.[5]

There is a further point in connection with the Franklin tree, however, which deserves study, namely the matter of seed production. Like certain other rare species, it seems to be nearly sterile to its own pollen, and the seeds produced as a result of self-pollination are seldom viable. If it is true that all the plants now in cultivation have arisen from cuttings taken from the single individual in Bartram's garden, then carrying pollen from one to the other would be of no avail. If, however, descendants of the trees collected by Marshall or others exist cross-pollination could be expected to result in seed from which numerous new plants could be grown, and some of them might prove more vigorous and adaptable than is the present stock. With this in view I have been making an effort to track down every report of the presence of the species in hitherto unknown places. There are several specimens in old Philadelphia gardens, all apparently derived from the Bartram tree. One or two nurseries near New York City have supplied plants to estates in that vicinity, but they obtained their stock in the first place from Thomas Meehan and Sons, who utilized Bartram's garden as their original source of cuttings. The single tree at Chevy Chase Circle, Washington, D. C., also came from Meehan's. Many reports of the plant, it should be noted, have proved to be erroneous, either *Gordonia lasianthus* or a species of *Magnolia* having been mistaken for it. The hope may be expressed, however, that some day a descendant from another ancestor will be discovered, and the cross-pollination and production of seedlings in quantity may then become possible, representing the final step in the permanent preservation of this interesting plant.

[5] *The effect of aluminum sulphate on . . . acid-soil plants.* Smiths. Rept. **1926: 373.**

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, March 20.	The Anthropological Society The Historical Society The Botanical Society **Annual dinner to be given at Hotel Roosevelt.**
Wednesday, March 21.	The Medical Society The Washington Society of Engineers
Saturday, March 24.	The Biological Society
Wednesday, March 28.	The Geological Society The Medical Society
Thursday, March 29.	The Chemical Society **The 400th meeting will be held in honor of Drs. H. W. Wiley, F. W. Clarke, and C. E. Munroe.**
Saturday, March 31.	The Philosophical Society
Tuesday, April 3.	The Botanical Society
Wednesday, April 4.	The Medical Society The Washington Society of Engineers
Thursday, April 5.	The Entomological Society

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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PALEONTOLOGY.—*A Cotylosaur from the Upper Triassic of western Texas.*[1] E. C. Case, University of Michigan.

The expedition from the Museum of Geology of the University of Michigan to the Upper Triassic beds of western Texas, in the summer of 1927, recovered a small fragment of a lower jaw which proves to be that of a Cotylosaur of the family Procolophonidae. The specimen, number 2338 of the Museum collection, is the type of a new genus and species for which the name *Trilophosaurus buettneri* is proposed. The specimen is of peculiar interest in that it is the first evidence of the presence of Cotylosauria in North America in Triassic time.

The fragment contains three complete teeth and the roots of four others. The first tooth was small and cylindrical, as shown by the broken root, behind this the teeth are set transversely in the jaw and increase in size regularly toward the rear. The three complete teeth are very similar. The teeth are obscurely thecodont in insertion; they appear to be acrodont and the fibres of bones can be seen running from the root to the wall of the alveolus. Only when the teeth are broken does the root and the alveolus become apparent. This peculiarity of attachment is a characteristic of the family, as all workers upon the various genera have noted it or have been bothered by it in describing the specimens. The complete teeth show a thin upper cutting edge, divided into three lobes by slight depressions in the edge. The sides swell out slightly and then contract sharply to the root. The upper teeth fitted between the lower teeth when the jaws were closed, interlocking closely.

Fig. 1.—*Trilophosaurus buettneri* Case, n. gen. and sp., fragment of lower jaw, oblique view from above downward and backward (× 2).

[1] Received February 23, 1928.

In the other members of the family, *Procolophon* and *Thelegnathus* (?) from South Africa, *Telerpeton* from Elgin in Scotland, and *Sclerosaurus* and *Koïlioskiosaurus* from Germany, the transverse expansion of the teeth is shown in varying degree. In *Telerpeton* the cutting edge is divided into two lobes. The nearest group which shows a similar arrangement of the teeth is the Cotylosaurian family Diadectidae from the Permian beds of North America.

BOTANY.—*New plants from Central America.—XII.*
PAUL C. STANDLEY, U. S. National Museum.[1]

Descriptions of further representatives of the family Rubiaceae are presented here. There are proposed eight new species of *Hoffmannia*, a genus whose species seem to be almost unlimited in the mountains of Costa Rica, where the group is best developed. Most of the forms seem to be of very local distribution, hence it may be expected that a good many others will be discovered by new explorations.

Hoffmannia Valerii Standl., sp. nov.

Branched shrub 1–1.5 m. high, the older branches subterete, 6–8 mm. thick, the young branches subterete, their internodes 3.5–5.5 cm. long, when young densely villous with slender spreading pale hairs; stipules rounded, scarcely over 1 mm. long, caducous; petioles slender, 1–2 cm. long, villous; leaf blades elliptic or ovate-elliptic, 6.5–11 cm. long, 3.5–5.5 cm. wide, acute or acuminate with acute or obtuse tip, at base obtuse or rounded and abruptly or gradually decurrent, membranaceous, deep green on the upper surface, when young sparsely villous but soon glabrate, beneath somewhat paler, marked with numerous short linear cystoliths, villous along the nerves with slender, pale or brownish, spreading hairs, the costa and lateral nerves prominent beneath, the lateral nerves slender, ascending, arcuate, anastomosing very close to the margin; inflorescences cymose, few-flowered, dense, axillary, fasciculate, sessile or nearly so (peduncles in fruit sometimes 1 cm. long), the bracts caducous; pedicels 2–5 mm. long, glabrous or nearly so; hypanthium turbinate, 2 mm. long, glabrous or bearing a few short hairs; calyx lobes 4, narrowly triangular, 1 mm. long, acute or obtuse, sometimes bearing dorsally a few short hairs; corolla in bud lance-ovoid, acutish, 5–6 mm. long, short-villous, the 4 lobes triangular-oblong, obtuse, 3 times as long as the tube; fruit subglobose, 6 mm. long, bright red, glabrous; seeds minute, subglobose, dark brown, coarsely and deeply pitted.

Type in the U. S. National Herbarium, no. 1,206,194, collected at El Arenal, Guanacaste, Costa Rica, altitude 600 meters, March 20, 1923, by Juvenal Valerio (no. 57). The following collections are from Guanacaste.

COSTA RICA: El Arenal, in wet forest, *Standley & Valerio* 45217. Los Ayotes, alt. 600 m., *Standley & Valerio* 45437.

This species is well marked by the villous nerves of the leaves and by the very short corolla tube.

[1] Published by permission of the Secretary of the Smithsonian Institution. For the last preceding paper of this series see This JOURNAL **18**: 160. 1928. Received December 9, 1927.

Hoffmannia inamoena Standl., sp. nov.

Simple erect shrub 1–1.5 m. high, the stems stout, subterete, with short or elongate internodes, the young branches densely and minutely puberulent; stipules ovate, 1.5 mm. long, caducous; leaves opposite, the petioles slender, 1–4.5 cm. long, densely puberulent; leaf blades chiefly elliptic, sometimes ovate-elliptic, rarely oblong-ovate, 8–20 cm. long 3.5–10 cm. wide, abruptly acute or acuminate, rarely long-acuminate, with acute or obtuse, often falcate tip, at base obtuse to rounded and abruptly long-decurrent, membranaceous, green and glabrous above, beneath paler, densely and minutely puberulent beneath upon the nerves and sometimes, at least when young, over the whole surface, the costa stout, prominent, the lateral nerves slender, about 16 on each side, divaricate, usually arcuate, anastomosing to form a distinct collective nerve close to the margin, the ultimate nerves prominulous, closely reticulate; flowers fasciculate in the leaf axils or in sessile or short-pedunculate, 2 to 4-flowered cymes, the pedicels in fruit 1–4 mm. long, short-villous; calyx lobes 4, triangular-oblong, 1–2 mm. long, obtuse, short-villous; fruit subglobose, 6–7 mm. long, white, juicy, copiously villous; seeds minute, dark brown, coarsely and deeply pitted.

Type in the U. S. National Herbarium, no. 1,254,102, collected in wet forest at Los Ayotes, near Tilarán, Guanacaste, Costa Rica, altitude 600 meters, January 21, 1926, by Paul C. Standley and Juvenal Valerio (no. 45421). The following collections from Guanacaste may be cited:

COSTA RICA: Los Ayotes, *Standley & Valerio* 45432, 45345, 45529. El Arenal, alt. 500 m., *Standley & Valerio* 45214, 45181. Quebrada Serena, *Standley & Valerio* 46270, 46170, 46195.

Although flowers have not been collected, this plant is evidently distinct from all species of *Hoffmannia* previously described from Costa Rica. It is recognizable by its pale (when dried) leaves and the minute dense puberulence of the nerves.

Hoffmannia subauriculata Standl., sp. nov.

Decumbent shrub 1–1.5 m. long, the young branches obtusely quadrangular, glabrous, the internodes 5–7.5 cm. long; leaves opposite, sessile, elliptic-obovate, 15–22 cm. long, 7–9.5 cm. wide, abruptly short-acuminate, abruptly narrowed near the base into a petioliform portion about 2 cm. long and 1.5–2 cm. wide, rounded to subcordate at the base and amplexicaul, membranaceous, glabrous, deep green above, somewhat paler beneath, furnished with numerous minute cystoliths, the costa prominent beneath, stout, the lateral nerves about 15 on each side, slender, prominent, divaricate, strongly arcuate, anastomosing close to the margin; inflorescences borne on the naked older branches below the leaves, lax, many-flowered, cymose-paniculate, on slender peduncles 6.5–9 cm. long, the panicles about 5 cm. long, glabrous; bracts deciduous; pedicels slender, 6–12 mm. long; fruit oval or subglobose, 2-celled, bright red, glabrous, about 8 mm. long; calyx lobes 4, deltoid, acutish, 1 mm. long, glabrous, erect; seeds minute, subglobose, brown, coarsely pitted.

Type in the U. S. National Herbarium, no. 1,306,554, collected in moist forest at El Muñeco, on the Río Navarro, Province of Cartago, Costa Rica, altitude 1,400 meters, March 6–7, 1926, by Paul C. Standley and Rubén Torres Rojas (no. 50956).

This species may be recognized by its sessile leaves with broad bases.

Hoffmannia piratarum Standl., sp. nov.

Shrub, the young branchlets stout, obtusely quadrangular, glabrous, the internodes 1.5–3 cm. long; stipules caducous; leaves opposite, the petioles slender, 2.5–4.5 cm. long, glabrate; leaf blades lance-oblong, 10.5–20 cm. long, 5–6 cm. wide, long-acuminate, the acumen narrow, long-attenuate, often falcate, the blades membranaceous, deep green above, glabrous, beneath paler, when very young sparsely short-villous with ferruginous hairs but soon glabrate, the costa prominent, rather stout, the lateral nerves 8 or 9 on each side, very slender, strongly ascending, arcuate, irregularly anastomosing close to the margin; inflorescences axillary, solitary or fasciculate, cymose, dense, few-flowered, 3 cm. long or shorter, the peduncles 2.5 cm. long or shorter, glabrous or nearly so, the bracts caducous; pedicels 2–5 mm. long, usually sparsely short-villous; hypanthium 3 mm. long, glabrous or sparsely short-villous; calyx lobes 4, triangular-oblong, 2–3 mm. long, acute, villous-ciliate with short hairs; corolla 1 cm. long, in bud oblong, obtuse, glabrous or with a few short hairs at apex, the tube obconic, 2 mm. wide at base, 5 mm. wide in the throat, the 4 lobes oblong-triangular, slightly shorter than the tube; fruit subglobose, 2-celled, 6 mm. long, glabrous; seeds minute, subglobose, dark brown, coarsely and deeply pitted.

Type in the U. S. National Herbarium, no. 579835, collected in wet forest in the Wafer Valley, Cocos Island, Costa Rica, altitude 200 meters or less, January, 1902, by H. Pittier (no. 16259).

This insular plant is related to *H. angustifolia* Standl. and *H. psychotriaefolia* (Benth.) Griseb., but differs from both in its ciliate calyx lobes.

Hoffmannia ramonensis Standl, sp. nov.

Shrub, the older branches stout, terete, the younger ones glabrous or nearly so, the internodes 2–6.5 cm. long; stipules caducous; leaves opposite, sessile or nearly so, obovate-oblong, 14–28 cm. long, 5.5–10 cm. wide, acute, gradually narrowed below the middle, then rather abruptly long-attenuate into a petioliform portion 3–6 cm. long, this 1.5 cm. wide or narrower, acute at base, the blades membranaceous, deep green and glabrous above, beneath paler, when very young densely tomentose with loose brownish hairs, in age glabrate except along the short-villous nerves, the costa slender, prominent beneath, the lateral nerves about 14 on each side, slender, prominent, divaricate, arcuate, anastomosing close to the margin, the lower surface marked with very numerous short linear cystoliths; cymes axillary, solitary or fasciculate, umbelliform, mostly 2 to 5-flowered, the peduncles stout, 6–15 mm. long, densely brown-tomentose, the bracts caducous; pedicels stout, 2–4 mm. long, densely villous-tomentose; hypanthium turbinate, 2.5–3 mm. long, brown-tomentose; calyx lobes 4, narrowly triangular, 1.5–2 mm. long, narrowed to an obtuse apex, brown-villous on the outer surface; corolla in bud oblong-ovoid, obtuse, 6–7 mm. long, obtuse, densely villous-tomentose with brown hairs; anthers linear, 5 mm. long, narrowed to the acutish apex.

Type in the U. S. National Herbarium, no. 861910, collected along the Río Barranca at San Juan, near San Ramón, Costa Rica, altitude 1,300 to 1,400 meters, April 25, 1913, by A. Tonduz (no. 17812).

Hoffmannia ramonensis is well marked by its large, essentially sessile leaves and densely tomentose inflorescence.

Hoffmannia dotae Standl., sp. nov.

Erect branched shrub 2.5–4.5 m. high, the young branches obtusely quadrangular, glabrous or sparsely villous, the internodes 2.5–10.5 cm. long; stipules caducous; petioles 2 cm. long or shorter, often marginate to the base, glabrous; leaf blades oblong-obovate to obovate-elliptic, 19–29 cm. long, 7.5–12 cm. wide, abruptly short-acuminate with acute or obtuse tip, narrowed toward the base and abruptly long-decurrent, membranaceous, deep green and glabrous above, paler beneath, marked with numerous short pale cystoliths, at first sparsely short-villous along the nerves but soon glabrate, the costa stout, prominent, the lateral nerves about 15–17 on each side, arcuate-divaricate, anastomosing close to the margin; cymes solitary or fasciculate in the leaf axils, lax, few-flowered, 5.5 cm. long or shorter, the peduncles sometimes 3.5 cm. long; bracts caducous; pedicels 4–12 mm. long, sparsely or densely short-villous; hypanthium turbinate, 4 mm. long, sparsely short-villous; calyx lobes 2.5–3.5 mm. long, unequal, triangular or narrowly triangular, narrowed to the obtuse or acutish apex, sparsely villous; corolla red below, yellow above, 15 mm. long, glabrous or sparsely villous on the lobes, acuminate in bud, the tube 4 mm. thick, the 4 lobes linear-lanceolate, equaling the tube; anther tips slightly exceeding the corolla tube; stigma oblong, much exceeding the anthers; fruit red, oblong, 8–9 mm. long, 4 mm. thick, 2-celled, sparsely villous; seeds minute, yellowish, shallowly and coarsely pitted.

Type in the U. S. National Herbarium, no. 1,253,172, collected in moist forest near Santa María de Dota, Province of San José, Costa Rica, altitude about 1,700 meters, December, 1925, by Paul C. Standley and Juvenal Valerio (no. 43277). Nos. 43286 and 43293, from the same locality, also represent this species.

Hoffmannia dotae is related to *H. josefina* Standl., which has a smaller corolla, denser inflorescence, and obtuse flower buds.

Hoffmannia trichocalyx Standl., sp. nov.

Large weak shrub, 1–2.5 m. long, often decumbent, the branches thick and stout, terete, ochraceous, rimose, the young branchlets obtusely quadrangular, their internodes 1–4 cm. long, thinly villous or often glabrous; stipules caducous; leaves opposite, the petioles slender, 1.5–7 cm. long, sparsely villous or glabrous; leaf blades elliptic to oblong-elliptic, rarely ovate or obovate, 12–26 cm. long, 4.5–10 cm. wide, abruptly acuminate with acute tip, cuneate to obtuse at base, usually abruptly contracted and short-decurrent, chartaceous, deep green and glabrous on the upper surface, beneath usually villous along the nerves but sometimes glabrate, the costa slender, prominent, the lateral nerves 10–14 on each side, divaricate, strongly arcuate, prominent, extending nearly to the margin; inflorescences pendent, borne on naked stems below the leaves, fasciculate, 2.5–14 cm. long, few or many-flowered, the peduncles long and slender, usually short-villous, dark red, the bracts deciduous; pedicels 3–6 mm. long, sparsely or densely villous; hypanthium turbinate, dark red, 4 mm. long, densely or sparsely villous; calyx lobes 4, broadly deltoid, acutish, 2 mm. long, sparsely or densely villous; corolla 1 cm. long, bright yellow or red and yellow, glabrous or sparsely villous outside, the tube 3 mm. thick, cylindric, the lobes triangular-oblong, narrowed to the obtuse apex, about equaling the tube; fruit 2-celled, oval, 8 mm. long, 5 mm. thick, dark red, glabrous or sparsely villous.

Type in the U. S. National Herbarium, nos. 1,305,242–3 (both from the same plant), collected in wet forest at Fraijanes, Province of Alajuela, Costa Rica, altitude about 1,600 meters, February 12, 1926, by Paul C. Standley and Rubén Torres Rojas (no. 47690). Additional collections are at hand, as follows:

COSTA RICA: Fraijanes, *Standley & Torres* 47819, 47480, 47924.

The nearest relative of this species is *H. leucocarpa* Standl., also Costa Rican, which has a glabrous inflorescence and white fruit.

Chomelia (?) sylvicola Standl., sp. nov.

Shrub, glabrous throughout, the branches slender, subterete, the older ones grayish, rimose, the younger ones green, smooth, the internodes 1.5–6.5 cm. long; stipules distinct, ovate-oval, 3 mm. long, obtuse, green, deciduous; leaves opposite, the petioles slender, 7–12 mm. long; leaf blades elliptic-oblong, 6.5–8 cm. long, 2.2–2.8 cm. wide, rather abruptly attenuate to an obtuse tip, acute and decurrent at base, subcoriaceous, deep green above, dull, the venation inconspicuous, beneath somewhat paler, domatiate in the axils of the nerves, the costa slender, prominent, the lateral nerves about 6 on each side, ascending, arcuate, irregularly and laxly anastomosing near the plane margin; inflorescence terminal, cymose-paniculate, open, rather few-flowered, the peduncle 2 cm. long, the branches slender, stiff, the bracts triangular, 1–1.5 mm. long, green; pedicels slender, 10–12 mm. long, stiff; fruit obovoid, terete, finely costate, about 18 mm. in total length and 7 mm. in diameter, acute at base, lustrous, prolonged within the calyx into a conic obtuse projection 4–5 mm. long, 2-celled, the endocarp hard and osseous; calyx persistent, cuplike, 2 mm. long, green, the margin undulate.

Type in the U. S. National Herbarium, no. 1,305, 902, collected in wet forest at Yerba Buena, northeast of San Isidor, Province of Heredia, Costa Rica, altitude about 2,000 meters, February 22, 1926, by Paul C. Standley and Juvenal Valerio (no. 49196).

It is improbable that this plant belongs to the genus *Chomelia*, especially in view of its terminal inflorescence, but I have not been able to refer it satisfactorily to any other group.

Guettarda poasana Standl., sp. nov.

Shrub or small tree 3–6 m. high, the branchlets stout, compressed, glabrous, the internodes short; stipules ovate, about 2 cm. long, long-acuminate, thin, brown, glabrous, deciduous; leaves opposite, the petioles slender, 2–7 cm. long, glabrous, the blades elliptic, broadly elliptic, or elliptic-ovate, 13–19 cm. long, 5–9 cm. wide, acutish to short-acuminate at base, short-acuminate at apex, membranaceous, green above, glabrous or when young very sparsely short-pilose, the venation mostly plane, paler beneath, appressed-pilose when young, glabrate in age, the costa and lateral nerves very slender, prominent, the lateral nerves 8 or 9 on each side, arcuate, extending nearly to the margin, the intermediate veins inconspicuous, the margin plane; peduncles 3 cm. long or shorter, glabrous, the cymes bifurcate, about 9-flowered, the branches short; flowers sessile, the bractlets minute; calyx and hypanthium together 2–2.5 mm. long, the hypanthium glabrous or nearly so; calyx shallowly dentate, puberulent or glabrous; corolla pink, densely tomentose outside, the tube 15–20 mm. long, 2.5 mm. thick in the throat, the lobes suborbicular, 4 mm. long.

Type in the U. S. National Herbarium, no. 1,305,283, collected in wet forest at Viento Fresco, on the slopes of Poás Volcano, Province of Alajuela, Costa Rica, altitude about 1,800 meters, February 13, 1926, by Paul C. Standley and Rubén Torres Rojas (no. 47807). The following additional specimens have been seen:

COSTA RICA: Valley of Río Poás, alt. 2,100 m., *Pittier* 2399. Las Nubes, Prov. San José, alt. 1,800 m., *Standley* 38755, 38777.

Closely related to *G. crispiflora* Vahl, which also occurs in Costa Rica but is distinguished by its pilose stipules and densely tomentose hypanthium

Guettarda Deamii Standl., sp. nov.

Tree 3.5–4.5 m. high, the branches blackish, lenticellate, the branchlets stout, densely short-pilose, the internodes short; stipules ovate-oblong, 2.5–4 mm. long, obtuse or acutish, appressed-pilose outside, soon deciduous; leaves opposite, the petioles stout, 5–9 mm. long, densely short-pilose; leaf blades mostly oval, sometimes oblong-oval or obovate-oval, 4–8.5 cm. long, 2.5–4.5 cm. wide, rounded at base, broadly rounded at apex, chartaceous, green above, densely short-pilose or pilose-scaberulous, the venation prominulous but more or less imbedded, beneath paler, densely velutinous-pilosulous, the costa and lateral nerves prominent, the lateral nerves 8–10 on each side, subarcuate, ascending at an angle of 50 degrees or more, the intermediate veins prominulous, laxly reticulate, the margin recurved; cymes subcapitate, 3 to 5-flowered, the peduncles very stout, 3–10 mm. long, densely short-pilose, the flowers sessile; bractlets subulate, 3–4 mm. long, persistent; fruit globose, about 8 mm. in diameter, 3 or 4-celled, minutely tomentulose.

Type in the U. S. National Herbarium, no. 796136, collected on mountain ridges near Gualán, Guatemala, altitude 185 meters, June 15, 1909, by C. C. Deam (no. 6271).

A relative of *G. macrosperma* Donn. Smith, which has chiefly acute leaves, with closely appressed pubescence.

Psychotria hondensis Standl., sp. nov.

Shrub 3 m. high, the young branches stout, greenish (older ones ochraceous), obtusely quadrangular, densely puberulent or pubescent with short spreading hairs, the internodes mostly 1.5–3 cm. long; stipules persistent, erect, stiff, short-connate, broadly triangular, narrowed to the obtuse apex, densely puberulent; leaves opposite, the petioles stout, 1.3–3.5 mm. long, puberulent; leaf blades broadly elliptic to elliptic-oblong, 17.5–29 cm. long, 6–15 cm. wide, narrowed to the acute to acuminate apex, often abruptly acuminate, acute or acuminate at base and often abruptly decurrent, membranaceous, deep green above, glabrous, the venation not elevated, beneath slightly paler, densely velutinous-pubescent with short spreading hairs, the costa and lateral nerves slender, prominent, the lateral nerves 9–11 on each side, ascending, usually at a wide angle, slightly arcuate, anastomosing close to the margin; inflorescence terminal, cymose-paniculate, erect, the peduncle stout, 4–5.5 cm. long; panicles open, rather few-flowered, 5–11 cm. broad, usually broader than long, the primary branches few, opposite or verticillate, stout, divaricate, pubescent with short spreading hairs; flowers sessile or nearly so; hypanthium semiglobose, 2 mm. long, densely pubescent with minute spreading hairs; calyx 2.5 mm. long, subtruncate, distantly and obscurely repand-dentate, the teeth 5; corolla in bud 11 mm. long, densely puberulent-tomentose with fulvous pubescence, the buds obtuse; fruit subglobose, green, about 13 mm. in diameter, glabrate; pyrenes 2, 1 cm. long, nearly smooth dorsally, plane on the inner surface; seeds semiglobose, 7 mm. long, brown, deeply and narrowly sulcate from base to apex on the inner surface.

Type in the U. S. National Herbarium, no. 764151, collected in forests of the Río Hondo, Atlantic slope of Costa Rica, altitude 100 meters, August, 1901, by H. Pittier (no. 16161). The following are additional collections:

COSTA RICA: La Colombiana Farm, Province of Limón, alt. 70 m., *Standley* 36883, 36775.

This species is characterized by its large, broad, copiously pubescent leaves, and large fruit.

Psychotria Heydei Standl., sp. nov.

Young branches stout, subterete, densely villous with short spreading brownish multicellular hairs, the internodes short; stipules persistent, united to form a truncate interpetiolar sheath 3–4 mm. long, this densely short-villous; leaves opposite, the petioles stout, 1.5–4 cm. long, villous-tomentose; leaf blades elliptic-oblong, broadest at the middle, 11.5–26 cm. long, 5.5–10.5 cm. wide, acuminate, often rather abruptly so, at base obtuse to rounded, sometimes very shortly decurrent, thick-membranaceous, green above, villous-hirsute with slender yellowish hairs, beneath scarcely paler, densely villous-hirsute, the costa stout, prominent, the lateral nerves slender, prominent, about 15 on each side, arcuate-ascending, anastomosing very close to the margin, the intermediate nerves usually evident, coarsely reticulate; inflorescence terminal, cymose-paniculate, the peduncle stout, erect, 5.5–12.5 cm. long; panicles much branched, lax, many-flowered, 6–9 cm. long, 8–17 cm. wide, the primary branches opposite or verticillate, divaricate or reflexed, stout, densely villous-hirsute; bracts persistent, triangular-subulate, 7 mm. long or shorter, short-villous; flowers mostly sessile, but sometimes on pedicels as much as 8 mm. long; hypanthium 2 mm. long, densely villous; calyx 1.5–2 mm. long, 5-lobate, the lobes triangular, acutish; corolla funnelform, 13–14 mm. long, densely short-villous, the tube gradually widened upward, 3 mm. broad in the throat, the 5 lobes ovate, obtuse, 3 mm. long; anthers oblong-linear, nearly sessile, included, 3 mm. long.

Type in the U. S. National Herbarium, no. 939642, collected at Chiul, Department of Quiché, Guatemala, altitude 2,600 meters, April, 1892, by Heyde and Lux (no. 3173).

The dense pubescence and large panicles distinguish this plant among the Central American species of *Psychotria*.

Psychotria dispersa Standl., sp. nov.

Densely branched, erect shrub, 1–2 m. high, the branches slender, terete, green, the young branches usually densely pilose with short spreading whitish hairs, sometimes merely puberulent or glabrate, the internodes short or elongate; stipules green, persistent, connate into a sheath 2.5–3 mm. long, puberulent, the sheath bicuspidate on each side, the cusps 3–6 mm. long, linear, rigid, erect; leaves opposite, the petioles slender, 5–13 mm. long, minutely puberulent; leaf blades oblong-elliptic to rarely lance-oblong, 5–10.5 cm. long, 2–4 cm. wide, abruptly acuminate or long-acuminate, or cuspidate-acuminate, with acutish, often falcate acumen, narrowed to the acute, often decurrent base, membranaceous, deep green above, puberulent or pilose along the elevated costa, elsewhere glabrous, beneath paler, pubescent on the nerves with minute spreading hairs, the costa slender, prominent, the lateral nerves very slender, 12–17 on each side, arcuate-ascending, laxly anastomosing close to the margin, the intermediate nerves evident, coarsely reticulate; inflorescence terminal but in age often appearing lateral because of the elongation of the branch, usually recurved, cymose-paniculate, the peduncles slender, 1.5–2.5 cm. long, pilose with spreading whitish hairs, the panicles 2–4 cm. long, 2–3.5 cm. broad, racemosely branched, the branches 1 cm. long or shorter, chiefly opposite, divaricate, green, hirtellous, few-flowered; bracts linear, green, 2–5 mm. long, those at the base of the flowers oblong, shorter; flowers sessile or nearly so; hypanthium subglobose, 0.8 mm. long, minutely pubescent; calyx 0.7 mm. long, shallowly 4 or 5-dentate, the teeth triangular, acutish; corolla funnelform, 3–3.5 mm. long, puberulent, the 5 lobes triangular-ovate, obtuse, 1 mm. long, spreading; anthers included; fruit subglobose 3 mm. long, bisulcate, bright blue, puberulent or glabrate; pyrenes 2, obtusely 5-costate dorsally, the inner face flat, with a narrow groove from base to apex.

Type in the U. S. National Herbarium, no. 1,254,170, collected in wet forest at Los Ayotes, near Tilarán, Province of Guanacaste, Costa Rica, altitude 600 meters, January 21, 1926, by Paul C. Standley and Juvenal Valerio (no. 45548). The following additional collections have been examined:

COSTA RICA: Los Ayotes, *Standley & Valerio* 45519. La Tejona, Prov. Guanacaste, alt. 600 m., *Standley & Valerio* 45819, 45938. Tilarán, Prov. Guanacaste, alt. 600 m., *Standley & Valerio* 44304. Boca de Zhorquín, Talamanca, alt. 50 m., *Tonduz* 8591. La Colombiana Farm, Prov. Limón, alt. 70 m., *Standley* 36640, 36855, 36963, 36748, 36651. Near Guápiles, Prov. Limón, alt. 300–500 m., *Standley* 37266. Pejivalle, Prov. Cartago, alt. 900 m., *Standley & Valerio* 46869, 46971. Turrialba, *Cook & Doyle* 371. El Silencio, Prov. Guanacaste, *Valerio* 145. El Arenal, Prov. Guanacaste, alt. 485 m., *Standley & Valerio* 45223. Peralta, *Stevens* 350. Quebrada Serena, Prov. Guanacaste, *Standley & Valerio* 46156, 46223. Hamburg Finca, Prov. Limón, *Standley & Valerio* 48749. Río Colorado near Turrialba, alt. 570 m., *Tonduz* 8288. Shirores, Talamanca, alt. 100 m., *Tonduz* 9320. Valley of Río Tuis, alt. 600 m., *Tonduz* 8136. Forests of Las Vueltas, Tucurrique, alt. 650–700 m., *Tonduz* 12888. Forests of Tuis, alt. 650 m., *Tonduz* 11463.

PANAMA: Changuinola Valley, *Dunlap* 228, 382. Farm 6, between the Changuinola and Sixaola rivers, *Rowlee & Stork* 1023. Lower Changuinola River, *Stork* 98.

GUATEMALA: Chamá, Alta Verapaz, alt. 450 m., *Johnson* 402.

Psychotria dispersa is a very common shrub of the lowland forests of Costa Rica, occurring on both continental slopes. It is rather handsome and conspicuous because of the small panicles of bright blue fruit. *P. dispersa* is closely related to *P. Pittieri* Standl., with which it has been confused heretofore. In the latter, a Panamanian plant, the pubescence of the lower surface of the leaves consists of longer, closely appressed hairs.

Psychotria bella Standl., sp. nov.

Young branches obtusely quadrangular, green, stout, densely pilose with slender, whitish, spreading or ascending hairs, the internodes 1.3–3 cm. long; stipules 1–1.5 cm. long, oval, soon deciduous, green, conspicuously nerved, densely pubescent, shallowly bilobate at apex, the lobes obtuse; leaves opposite, the petioles slender, 2–3 cm. long, pilose with short spreading white hairs; inflorescence terminal, probably pendent, cymose-paniculate, the peduncle slender, 13 cm. long, thinly villous-pilose, the panicle about 6 cm. long and 8 cm. broad, the primary branches 2.5 cm. long or less, each bearing about 5 flowers; bracts pink, ovate or elliptic-ovate, 12–18 mm. long, acute, hirtellous on both surfaces; pedicels 4–6 mm. long, pilose with short slender spreading hairs; hypanthium obovoid, 2 mm. long, densely pilose; calyx campanulate, pink, 10–13 mm. long, deeply 5-lobate, the lobes oval-ovate, acute or obtuse, evidently nerved, 5–6 mm. wide, thinly pubescent; corolla funnelform, white, thinly hirtellous, the tube 18 mm. long, 2 mm. thick, the throat 4 mm. wide, the 5 lobes triangular-oblong, attenuate to the apex, about 8 mm. long, spreading or recurved; anthers partly exserted.

Type in the U. S. National Herbarium, no. 677646, collected in wet forest between Alto de las Palmas and top of Cerro de la Horqueta, Chiriquí, Panama, altitude 2,100 to 2,265 meters, March 18, 1911, by H. Pittier (no. 3250).

When growing this must be an unusually showy plant because of the large, brightly colored bracts and calyces, which differentiate it from all other Central American species of *Psychotria.*

BOTANY.—*Notes on some marine algae from Brazil and Barbados.*[1] MARSHALL A. HOWE. (Communicated by WILLIAM R. MAXON.) New York Botanical Garden.

In the summer of 1915, Dr. J. N. Rose of the United States National Herbarium, accompanied by Mr. P. G. Russell, visited the eastern coast of South America for the primary purpose of making collections of Cactaceae for use in connection with preparing the manuscript of the four-volume monograph on the Cactaceae by Doctors Britton and Rose. Incidentally, Dr. Rose and Mr. Russell, in the period from May 24 to August 18, 1915, collected on the coast of Brazil 67 numbers of marine algae, including the subsequent subdivisions of the original field numbers; and 14 numbers were picked up on the shores of Barbados on September 30, 1915. The study of this material shows it to be of sufficient interest to justify a brief report in regard to it.

Several lists of Brazilian algae have been published. The first, by de Martius,[2] in 1833, includes about 70 marine species, besides a few from fresh water. The longest list is that of de Martens[3] 1870, who, after reviewing critically the works of his predecessors and throw-

[1] Contributions from The New York Botanical Garden, No. 295. Received January 23, 1928.

[2] MARTIUS, C. F. P. DE. *Flora brasiliensis,* 1–50. 1833.

[3] MARTENS, G. DE. *Conspectus algarum Brasiliae hactenus detectarum.* Kjøb. Vid. Medd. **1870**: 297–314. 1870.

ing out 18 Brazilian records as improbable, enumerates 166 marine species and 11 fresh-water species from Brazil. Two important and critical papers by Möbius,[4] in 1889 and 1890, added about 56 species to previously published lists. There are other papers of some importance, but those named are the principal, especially in regard to the marine forms.

The present collections of marine algae on the coast of Brazil include only 40 species, but two of them, representatives of the Rhodophyceous genera *Porphyra* and *Cottoniella,* appear to be new to science, and nine others, *Enteromorpha prolifera, Codium intertextum, Sargassum polyceratium, S. Filipendula, Padina Sanctae-Crucis, Dilophus guineensis* (?), *Gelidium pusillum, Wurdemannia setacea,* and *Jania capillacea* have apparently not before been reported for Brazil, although it is reasonably certain that some of them, like *Codium intertextum,* have lurked under other names.

The collection of marine algae made in Barbados by Dr. Rose and Mr. Russell includes only twelve species, gathered near the steamer landing on September 30, 1915, but it is remarkable for the large proportion of additions to the list of 215 species of marine algae of Barbados published by Miss Vickers[5] in 1905. After making allowance for two cases in which only a matter of nomenclature is involved, there appears to be seven additions to the Vickers list, viz., *Ulva rigida, Boodlea siamensis, Chaetomorpha brachygona, Neurocarpus Hauckianus, Laurencia papillosa, Jania capillaceae,* and *Fosliella Le Jolisii.* The most notable of these is *Neurocarpus Hauckianus,* now reported for the first time as occurring outside of the coast of Brazil. The same species however, was brought from Brazil by the same collectors on loose sheets in the same package (at least when they reached The New York Botanical Garden) and the possibility of a confusion of labels or specimens at some stage of the handling is to be kept in mind. Nevertheless, there is nothing unreasonable or improbable in such an extension of the known range of *Neurocarpus Hauckianus.* Similar extensions have been made for other species first described from Brazil. For example, *Acicularia Schenckii* (Möb.) Solms, originally described from Cabo Frio, Province of Rio de Janeiro, in 1889, has since been found

[4] Möbius, M. *Bearbeitung der von H. Schenck in Brasilien gesammelten Algen.* Hedwigia **28**: 309–347. *pl. 10, 11.* 1889.

———. *Algae brasilienses a cl. Dr. Glaziou collectae.* Notarisia **5**: 1065–1090. *pl.* 1890.

[5] Vickers, A. *Liste des algues marines de la Barbade.* Ann. Sci. Nat. Bot. IX. **1**: 45–66. 1905.

to occur on several of the West Indian islands, including Barbados[6] and ranging as far north as Bermuda. It is an interesting parallel that *Neurocarpus Hauckianus* (Möb.) Kuntze, originally described from Brazil by the same author in the same paper, now appears to have its known limits extended in a similar direction.

BRAZIL

CHLOROPHYCEAE

Family Ulvaceae

Ulva Lactuca L.
Island of Paquetá, Rio de Janeiro Bay (20289); vicinity of Bahia (21301 g).

Ulva rigida Ag.
Vicinity of Bahia (19609 a); Nictheroy, Rio de Janeiro (20316 a).

Enteromorpha prolifera (O. F. Müll.) J. Ag.
Vicinity of Bahia, 19672; Island of Coco, Rio de Janeiro Bay (20269 a); Nictheroy, Rio de Janeiro (20315).

Family Valoniaceae

Anadyomene stellata (Wulf.) Ag.
Vicinity of Bahia (19609 b), a reduced form.

Family Cladophoraceae

Chaetomorpha media (Ag.) Kütz.
Vicinity of Bahia (19610).

Family Bryopsidaceae

Bryopsis Harveyana J. Ag.
Vicinity of Bahia (19606 a).

Family Caulerpaceae

Caulerpa fastigiata Mont.
Nictheroy, Rio de Janeiro (20318 a).

Family Codiaceae

Halimeda Opuntia (L.) Lamour.
Vicinity of Bahia (19679 and 19682).

Codium decorticatum (Woodw.) M. A. Howe.
Codium elongatum Ag.
Island of Coco, Rio de Janeiro Bay (20268); Island of Juparayba (20280).

Codium intertextum Collins & Hervey
Vicinity of Bahia (21301 k).

Dr. O. C. Schmidt in his valuable paper "Beiträge zur Kenntnis der Gattung Codium Stackh"[7] considers *Codium intertextum* to be a synonym of *C. adhaerens* (Cabr.) Ag. and holds *C. difforme* Kütz. distinct from *Codium adhaerens*, of which many writers have made *C. difforme* a synonym. He states that there are three main distinctions, namely the firm-membranous thallus, smaller utricles, and smaller gametangia of *C. adhaerens*, as contrasted with the loose spongy thallus and larger utricles and gametangia of *C. dif-*

[6] Reported and figured under the name *Acetabularia caraibica* Kütz by Miss Vickers (Ann. Sci. Nat. Bot. IX **1**: 58. 1905; Phyc. Barb. **1**: *pl. 49*. 1908).

[7] Bibliotheca Botanica, heft 91. 1923.

forme. These comparative distinctions may hold good for European specimens, but it seems difficult to apply them to American representatives of the group, the characters of which are commonly intermediate. It seems to us necessary either to maintain *Codium intertextum* as a species, poorly defined though it may be, or to consider both *C. difforme* and *V. intertextum* as synonyms of *Codium adhaerens*. In the present specimen from the vicinity of Bahia, the utricles are mostly 60–152μ in maximum diameter; according to Schmidt those of *C. difforme* are 100–275μ, while those of *C. adhaerens* hardly exceed 75 μ.

PHAEOPHYCEAE

Family Encoeliaceae

Colpomenia sinuosa (Roth) Derb. & Sol.
Island of Juparayba, Rio de Janeiro Bay (20278 b).

Family Fucaceae

Sargassum polyceratium Mont.
Sargassum bahiense Kütz.
Vicinity of Bahia (19612, 19680 and 21301 a).

Sargassum cymosum Ag.
Island of Coco, Rio de Janeiro Bay (20271); Island of Juparayba, Rio de Janeiro Bay (20278 a); Island of Paquetá, Rio de Janeiro Bay (20295); Ilha Grande, Distrito Federal, Rio de Janeiro (20395 a).

Sargassum Filipendula Ag.
On beach, Copacabana, Rio de Janeiro (20888). A small, presumably long-natant fragment, overgrown with Bryozoa.

Family Dictyotaceae

Zonaria variegata (Lamour.) Ag.
Vicinity of Bahia (21301 h).

Padina Vickersiae Hoyt.
Padina variegata Hauck. Not *P. variegata* Gaill.
Padina Howeana Børg.
Island of Coco, Rio de Janeiro Bay (20270); Island of Juparayba, Rio de Janeiro Bay (20282 a); Ilha Grande, Distrito Federal, Rio de Janeiro (20397 c).

Padina Sanctae-Crucis Børg.
Vicinity of Bahia (19681 b.)

Neurocarpus Hauckianus (Möb.) Kuntze
Dictyopteris Hauckiana Möb.
Vicinity of Bahia (19611 b, 19613, and 21301 c); Ilha Grande, Distrito Federal, Rio de Janeiro (20397 b).

Neurocarpus plagiogrammus (Mont.) Kuntze
Haliseris plagiogramma Mont.
Ilha Grande, Distrito Federal, Rio de Janeiro (20397 a).

Dictyota Bartayresii Lamour.
Nictheroy, Rio de Janeiro (20316 b).

Dictyota dentata Lamour.
Vicinity of Bahia (21301 j), in small quantity, with other algae.

Dilophus guineensis (Kütz.) J. Ag. (?)
Vicinity of Bahia (19606 b)—a fragment only, determination not certain.

RHODOPHYCEAE

Family Bangiaceae

Porphyra Roseana sp. nov.

Densely cespitose, tawny-violet or olivaceous; thallus very shortly stipitate, usually with several successive convolute-spreading or cornucopioid laminae or divisions from common base, the main divisions suborbicular or broadly ovate to oblong or linear-oblong, mostly 1–3 cm. long, strongly crispate,

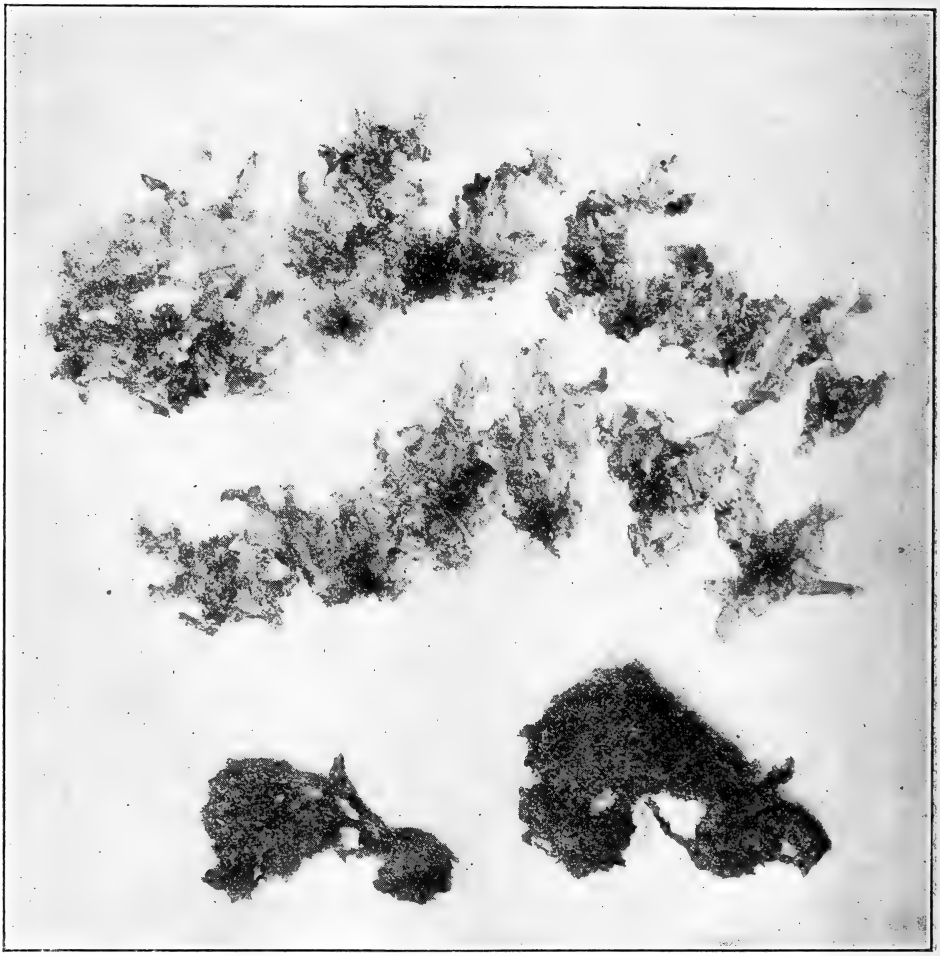

Fig. 1.—*Porphyra Roseana* M. A. Howe. Photograph of type specimens (*Rose & Russell* 20684), natural size.

monostromatic except at the extreme base, 20–30μ thick, rigid on drying and scarcely adhering to paper, the margins commonly lobulate or subdentate, the lobules often auricular, cucullate, cornute, or somewhat trumpet-shaped; cells mostly 13–25μ in maximum diameter in surface view, their protoplasts irregularly angular or sometimes fusiform, separated by spaces of 5–10μ, the basal protoplasts flagellate-pyriform; cells in sections subquadrate, the superficial walls firm, 5–10μ thick; monoicous; antheridial sori narrowly marginal, 32 antherozoids in each antheridium; sporocarps forming submarginal sori, 8 carpospores in each sporocarp.

On *Balanus* sp. etc., in the vicinity of Cabo Frio, Province of Rio de Janeiro, Brazil, *J. N. Rose & P. G. Russell* (20684), August 8, 1915.

Porphyra Roseana is probably allied to the Japanese *P. suborbiculata* Kjellm. and *P. crispata* Kjellm., but differs amply from both of them in its rigid thallus, a character that is especially remarkable in view of its thinness. It is apparently also a smaller and thinner plant than either of these, with a more cucullate-convolute base, and more pronouncedly cucullate lobes. In general habit the plant bears some resemblance to Kjellman's figure 4[8] (plate 1) of *Porphyra crispata,* though only one-fourth or one-half the size of Kjellman's figure. The cells in surface view resemble those of *P. suborbiculata,* as shown in Kjellman's figure 5 (plate 2) and in cross-section they are of about the same form as those of the same species as shown in Kjellman's figure 4 (plate 5), but lamellations are not obvious, though sometimes faintly visible in a surface view of the uncut cells.

Family CHAETANGIACEAE

GALAXAURA MARGINATA (Ell. & Soland.) Lamour.
Ilha Grande, Distrito Federal, Rio de Janeiro (20396).

GALAXAURA OBTUSATA (Ell. & Soland.) Lamour.
Galaxaura moniliformis Kjellm.

Vicinity of Bahia (21301 n); a small reduced form, of "Cameratae" structure, with *Neurocarpus Hauckianus,* etc. The type of *Galaxaura moniliformis* Kjellm. was from Bahia; it is tetrasporic and shows the "Cameratae" structure. Kjellman's var. *brachyarthra* of *Galaxaura fragilis* Kütz. [= *G. oblongata* (Ell. & Soland.) Lamour] was also from Bahia, but its cortex is quite different from that of our present plant.

Family GELIDIACEAE

GELDIUM CORNEUM (Huds.) Lamour.
Nictheroy, Rio de Janeiro (20317 b).

GELIDIUM PUSILLUM (Stackh.) Le Jolis.
Island of Coco, Rio de Janeiro Bay (20269 c), with *Hypnea spinella,* etc.

Family RHODOPHYLLIDACEAE

WURDEMANNIA SETACEA Harv.
Island of Juparayba, Rio de Janeiro Bay (20281 a), with *Hypnea spinella,* etc. Apparently the first record of this species from South America; type from Key West, Florida.

Family SPHAEROCOCCACEAE

HYPNEA MUSCIFORMIS (Wulf.) Lamour.
Vicinity of Bahia (19671); Island of Juparayba, Rio de Janeiro Bay (20278c); Ilha Grande, Distrito Federal, Rio de Janeiro (20395 b).

[8] KJELLMAN, F. R. *Japanska arter af slägtet* Porphyra. Bihang till Svenska Vet.-Akad. Handl. 23[4]: 1897.

HYPNEA SPINELLA (Ag.) Kütz.

Island of Coco, Rio de Janeiro Bay (20269 b); Island of Juparayba, Rio de Janeiro Bay (20281 b), with *Wurdemannia setacea*, etc.; vicinity of Bahia (21301 m).

Family DELESSERIACEAE

Cottoniella sanguinea sp. nov.

Pomegranate-purple, carmine, or Indian lake,[9] very soft, gelatinous, or mucous, gregarious or densely cespitose on other algae, 2–3 cm. long, pseudo-dichotomous, more or less decumbent and rhiziniferous near base; main axes strongly corticated, subcylindric or slightly complanate, 0.15–0.28 mm. in diameter, destitute of rhizoids above the decumbent base, cells of the cortex

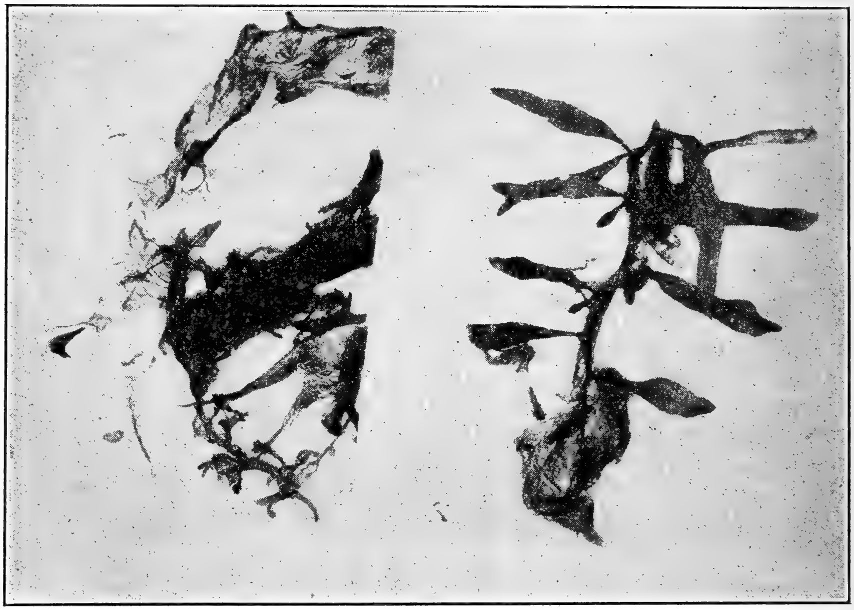

Fig. 2.—*Cottoniella sanguinea* M. A. Howe. Photograph of type specimens (*Rose & Russell* 20279), natural size.

polymorphous; corticated branches giving rise above to secund, subterete, uncorticated polysiphonioid branchlets 25–60μ broad, tapering to a monosiphonous apex, their segments mostly $\frac{2}{3}$–2 times as long as broad, the pericentral siphons four at first, soon becoming five, or four persisting, the corticated branches bearing also occasional monosiphonous branchlets; cross-section of polysiphonioid branchlets suborbicular or compressed, rarely twice as broad as high; costa wanting or very obscure; uncorticated polysiphonioid branchlets bearing secund monosiphonous filaments 0.3–0.6 mm. long, consisting of 12–20 cells, mostly 1–3 times as long as broad and bearing also occasional polysiphonioid branchlets, each of these commonly accompanied by a collateral monosiphonous filament; reproductive organs unknown.

On *Sargassum*, Island of Juparayba, Rio de Janeiro Bay, Brazil, July 17, 1915, *J. N. Rose & P. G. Russell* (20279, TYPE, and 20282 b).

[9] Colors according to RIDGWAY, *Color Standards and Color Nomenclature.*

Cottoniella sanguinea is related to *C. arcuata* Børg.,[10] known to us only from the author's description and figures, from St. Thomas of the American Virgin Islands, but it is apparently a smaller plant (2–3 cm. long *vs.* 8 cm. long), with more strongly corticated main axes, with apices of the terminal branches scarcely arcuate and with much less obvious dorsiventrality; in the older parts, cross sections commonly show five pericental siphons instead of the four of *C. arcuata.* The latter seems to be known only from a small amount of material preserved in fluid, so that no description of color is available.

Cottoniella filamentosa (M. A. Howe) Børg. (originally described as *Sarcomenia filamentosa* from the upper Florida Keys and since reported from western Cuba) differs decidedly in having much more flattened costate-alate branchlets and a pair of short alar siphons, end to end, on either margin, corresponding to each bundle of four pericentral siphons. This species was placed in the genus *Sarcomenia* with some misgivings, which were expressed at the time of its publication. It seems more in harmony with the modern idea of generic limitations among the Rhodophyceae to accept Børgesen's recently proposed genus *Cottoniella,* which now seems to include three different specific forms.

What the Guadeloupe *Polysiphonia mucosa* Crouan[11] may be we do not know except that its color is "rose carmine très vif" and that it grows a "parasite sur *Cladophora, Thalassia,* recuellis à la plage."

Family RHODOMELACEAE

DIGENEA SIMPLEX (Wulf.) Ag.
Vicinity of Bahia (21301 i).

BRYOTHAMNION TRIQUETRUM (S. G. Gmel.) M. A. Howe.
Vicinity of Bahia, (21301 d).

BRYOTHAMNION SEAFORTHII (Turn.) Kütz.
Vicinity of Bahia (19611 c, and 19681 a).

AMANSIA MULTIFIDA Lamour.
Vicinity of Bahia (19611 a and 21301 b).

VIDALIA OBTUSILOBA (Ag.) J. Ag.
Vicinity of Bahia (21301 l) in small quantity, with *Neurocarpus Hauckianus,* etc.

Family CERAMIACEAE

CENTROCERAS CLAVULATUM (Ag.) Mont.
Island of Coco, Rio de Janeiro Bay (20269 d); Nictheroy, Rio de Janeiro (20318 b).

Family CORALLINACEAE

CORALLINA SUBULATA Ell. & Soland.
Vicinity of Bahia (21301 e).

JANIA CAPILLACEA Harv.
Vicinity of Bahia (19609 d), with *Amphiroa brasiliana,* etc. and (19681 c).

AMPHIROA BRASILIANA Decaisne
Nictheroy, Rio de Janeiro (20317 a); vicinity of Bahia (19609 c and 21301 f).

[10] *The Marine Algae of the Danish West Indies* 2: 333–338. *f. 335, 336.* 1919; 477–479. 1920.

[11] MAZÉ and SCHRAMM, *Essai* 262. 1870–77.

BARBADOS

September 30, 1915

CHLOROPHYCEAE

Family ULVACEAE

ULVA RIGIDA Ag. (21190 a).

Family VALONIACEAE

BOODLEA SIAMENSIS Reinb. (21186 a).

Family CLADOPHORACEAE

CHAETOMORPHA BRACHYGONA Harv. (21190 c.)

Family CODIACEAE

HALIMEDA OPUNTIA (L.) Lamour. (21187 a).

PHAEOPHYCEAE

Family FUCACEAE

SARGASSUM POLYCERATIUM Mont. (21186 b and 21188).
Fucus foliosissimus Lamour. (*nomen nudum aut seminudum*)

Family DICTYOTACEAE

DICTYOTA BARTAYRESIANA Lamour. (21186 c).

DICTYOTA CILIOLATA Kütz. (21190 b).
Dictyota ciliata J. Ag. Not *D. ciliata* Lamour.

NEUROCARPUS HAUCKIANUS (Möb.) Kuntze. On *Halimeda Opuntia* (21187 b and 21189 a).
Dictyopteris Hauckiana Möb.
Apparently the first record for the West Indies. Type from Olinda, near Pernambuco, Brazil.

RHODOPHYCEAE

Family RHODOMELACEAE

LAURENCIA PAPILLOSA (Forsk.) Grev. (21186 e).

ACANTHOPHORA MUSCOIDES (L.) Bory. (21186 d).

Family CORALLINACEAE

JANIA CAPILLACEA Harv. (21187 c).

FOSLIELLA LE JOLISII (Rosan.) M. A. Howe. On *Thalassia* (21189 b).
Melobesia Le Jolisii Rosan.

ENTOMOLOGY.—*Two new cave-beetles related to* Anophthalmus pusio *Horn.*[1] H. S. BARBER, Bureau of Entomology.

The blind carabids of our eastern limestone caves having received so little attention since the interesting discussion of the possible sources of cave life by Garman, 1892, this notice of a new form collected near Cumberland Gap, Tennessee, in 1924, by Mr. George P. Engelhardt, together with that of the only known specimen from the Luray Cavern, was outlined, but publication was delayed until the type *A. pusio* Horn could be compared. The Luray specimen, recorded as *A.*

[1] Received January 20, 1928.

tenuis by Hubbard, 1884, and discussed under that name by Garman, has stood under the name *A. pusio* in the Hubbard and Schwarz collection and in Hubbard's unpublished notes for a long time. That *tenuis* was a *lapsus* for *pusio* in Hubbard's published note is evident from his allusion to Erhart's Cave, the type locality of the latter. In Garman's discussion, reference is also made to "*pusio* from Virginia and eastern Kentucky," and comparison is made of his new species, *A. horni*, with *A. pusio* Horn from the Carter Cave.

The four forms now under consideration are: (1) *A. pusio* Horn, 1868, known from the unique type collected by Cope in Erhardt's Cave, Montgomery Co., Virginia; (2) the unique specimen found in Luray Cavern, about 140 miles northeast of the type locality of *A. pusio*, by Hubbard and Schwarz, and here named *A. hubbardi;* (3) two specimens found in English Cave on the Powell River in Tennessee, about 200 miles southwest of the type locality of *A. pusio;* and (4) *A. horni* Garman, 1892, from crevices in the rocks and in cellars of Lexington, Kentucky. It is probable that the Carter Cave form will be found specifically distinct from *A. pusio*, but the writer has seen no specimens from this lot.

Unfortunately all structures of the type of *A. pusio* were not critically examined, but it seems to agree with the other three species in differing from other American *Anophthalmus* in their small size (less than 4 mm.), depressed form, transverse pronotum, and apical elytral striation, and in having only six setae at base of mentum. They will doubtless constitute a genus distinct from the other species for which Jeannel, 1920,[2] proposed two new generic names—*Neaphaenops* for *A. tellkampfi* and *Pseudanophthalmus* for *A. menetriesi* and its allies.

The four species here considered may be distinguished in the following table:

1. Apical recurved stria shorter, occupying apical seventh or eighth of elytral length; antennae shorter, joints 5 to 10, inclusive, measuring less than 1.4 mm...2

Apical recurved continuation of first (sutural) stria produced forward to apical fourth of elytral length, where it joins the third stria by an abrupt transverse sinuosity; the third, or subapical discal seta arising from a point at about anterior third of area thus inclosed, and forming apex of interval between second and third striae, which there unite and continue in a feeble stria, curved inward apically. Antennal joints 1 and 2 subequal in length and about a fourth shorter than joints 3 and 4, which are also equal; joints 5 to 10 longer, together measuring 1.6–1.7 mm. Length 4–4.2 mm., width 1.4–1.5 mm. English Cave, Powell River, Tennessee.................................. **A. engelhardti**, n. sp.

[2] JEANNEL, Bull. Soc. Entom. France **1920**: 154. 1920.

2. Antennal joints 1, 2, 3 and 4 subequal, apex of the recurved apical stria bent internally to join the third stria opposite anterior edge of subapical setigerous puncture.......................................3

Antennal joints 1 and 3 subequal in length, joint 2 about a fourth shorter than 3; apical stria broadly curved, but terminating in a broad, rounded shallow fossa not connected with third stria and a little in advance of subapical setigerous puncture. Length 3.3 mm., width 1.3 mm. Luray Cave, Virginia.................................. **A. hubbardi**, n. sp.

3. Form more depressed; first four antennal joints almost equal, joints 5 to 10 inclusive, measuring about 1.4 mm. Erhart's Cave, Montgomery Co., Virginia.. **A. pusio** Horn

Form more convex; antennal joint 2 slightly shorter and 3 slightly longer than 1, joints 5 to 10, inclusive, measuring 1.1–1.25 mm.; basal constriction of head continuous and distinct across occiput. Length 3.7–4.0 mm., width 1.3 mm. Lexington, Kentucky ....**A. horni** Garman

The type of *A. pusio* Horn, 1868,[3] preserved in the Academy of Natural Sciences, Philadelphia, has the pronotum more deeply impressed near posterior angles, causing the margins to be more strongly reflexed. No other specimen has been seen and those mentioned by Garman, 1892, from the Carter Cave of eastern Kentucky will probably prove to be a distinct species.

A. horni Garman, 1892,[4] is represented by a series of six specimens in the U. S. National Museum collection, received from its author and labeled "Lexington, Ky. 10.9.92." In the original description he records the pronotal measurements as 0.72 mm. long, 0.8 mm. wide before middle, and 0.66 mm. wide at base.

In *A. hubbardi* (=*tenuis* Hubbard, 1884,[5] lapsus for *pusio*; Garman, 1892, part) the pronotum is 0.65 mm. long, 0.81 mm. wide at apical fourth, and 0.60 mm. wide at base, the sides being feebly sinuate and almost evenly divergent from base to near apical fourth, thence strongly arcuate. The elytra are less convex, more densely pubescent with the striae marked on disc only by the feeble convexity of the intervals, although they are more deeply impressed basally. The tarsi are relatively shorter and stouter. The holotype (U. S. National Museum Cat. No. 40823) was collected more than forty years ago, an old note by Mr. H. G. Hubbard stating the "single specimen of *A. pusio* was found November 27, 1884, in Luray Cave, Page County, Virginia, among debris under a stairway and within twenty feet of an electric light." This species is more similar to *A. pusio* than to any other species known to me.

In *A. engelhardti* the pronotum is 0.82 mm. long by 0.95 mm. wide at apical third, and 0.75 mm. wide at base. The elytra are more convex and less densely pubescent, with the striae more definitely marked on disc. The more elongate antennae, more slender and elongate tarsi and larger size support the characters already given. The type and paratype (U. S. National Museum Cat. No. 40824) were collected in English Cave, Powell River, Tennessee, six miles south of Cumberland Gap, July 27, 1924, by Mr. George P. Engelhardt, after whom it is a pleasure to name the species.

[3] Horn, Trans. Amer. Entom. Soc. **2**: 125. 1868.

[4] Garman, Science **20**: 240–241. 1892.

[5] Hubbard, Proc. Entom. Soc. Washington **1**: 16. 1884

ZOOLOGY.—Ungella secta *n. gen., n. sp.; a nemic parasite of the Burmese Oligochaete (earthworm)*, Eutyphoeus rarus.[1] N. A. COBB, U. S. Department of Agriculture.

Ungella, n. gen.

Amphigonic nemas with protrusile, dorsally arcuate, hooked onchia (Fig. 1) and special cervical gland; oesophagus degenerate-diplogastroid; adults with posterior lateral pockets or "suckers;" 'm and 'f; males with two equal spicula and a gubernaculum, and an elongate pre- and post-anally ribbed bursa. Parasitic in earthworms. Proposed as type species is:

Ungella secta n. sp.

The transparent colorless cuticle is traversed by transverse striae, about one micron apart, hard to resolve even with high powers, at least in alcoholic specimens. In certain stages of the nema the striae are much more obvious and double in size. Though interrupted, the striae are not altered, on the lateral fields, where there are only faint single wings—non-existent or faint on the neck and anterior portion of the body, but somewhat readily seen along the middle of the body. The very slightly oblique longitudinal striae, due to the attachment of the musculature, are more readily visible than the transverse striae. (Fig. 3, *str longt*) Between the longitudinal striae are faint rows of dots, reminiscent of the cuticular markings of *Diplogaster*.

Fig. 1.—*Ungella secta.* Side, dorsal and end views of the same head. *M'br*, the intussusception membrane.

And here it may be said that, though valveless, the oesophagus also is reminiscent of *Diplogaster*; and that of all the free-living genera, *Diplogaster* is that to which *Ungella* seems most closely related. It is readily conceivable that the submedian duplex onchium (Fig. 1), could have been evolved from an armature such as characterizes one of the types of diplogastric pharynx.

Onchium. The duplex onchium of *Ungella* has its amalgamated roots movably imbedded in the head end of the nema backward for a distance equal to two-thirds the width of the head or more; it is assumed therefore that this represents the depth of the otherwise unarmed pharynx. The onchium, which can be exserted for the greater part of its length, is a strong refractive organ, colorless except distally, where it is yellowish; it is a conspicuous feature of the head, especially when protruded. The two equal claws of the onchium are joined rigidly in such a way as to make it impossible for them to be juxtaposed, and their internal structure makes plain that they represent the two ventrally submedian sectors of the oesophagus. Thus the onchium and its

[1] Investigation made in part at laboratories of the Bureau of Fisheries at Woods Hole, Massachusetts. Received January 23, 1928.

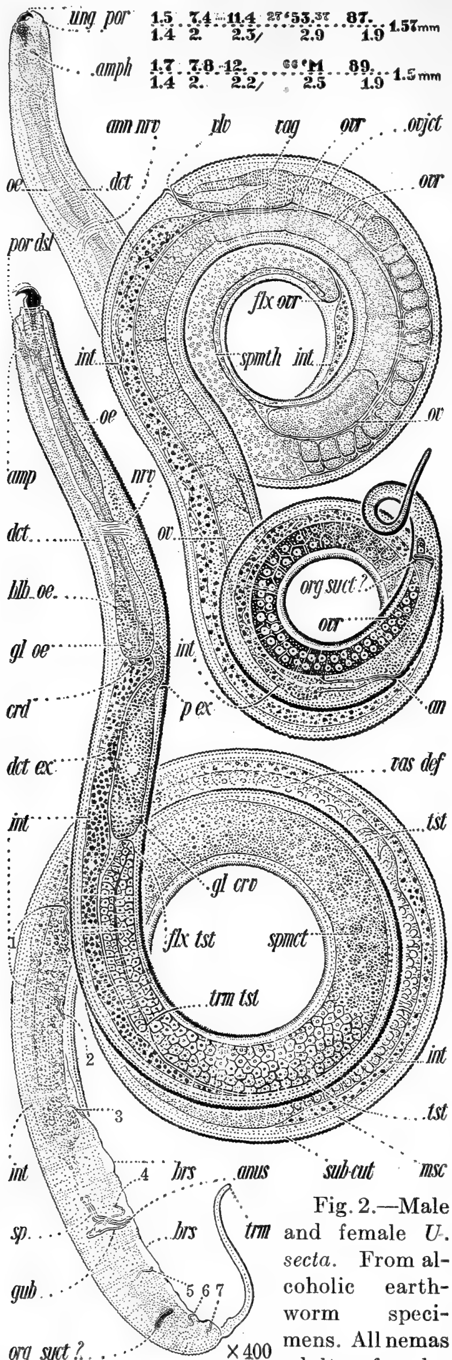

Fig. 2.—Male and female *U. secta*. From alcoholic earthworm specimens. All nemas adult, females outnumbering males.

"hilt" have the general form of the ultimate two-clawed segment of a beetle's tarsus. (See Fig. 1.) Rather weakly developed retractor muscles are attached to the amalgamated onchial apophyses. It seems not unlikely that the caudal "suckers" may also aid—as a base of resistance—in the use of the onchium, the object of which must be to claw; it must wound by clawing, hence the specific name *secta*. When the onchium is withdrawn and at rest, as in the female of Figure 2, the outer or distal parts of the two claws rest in special lateral depressions on the *outside of the front of the head* (see *concav* Fig. 1) and to that extent are not withdrawn into the head.

Oesophageal glands. The median dorsad pore in the front of the head, *por dsl*, is the exit of a large well developed *special cervical gland, gl crv.* The excretory pore of the renette, *p ex*, is farther back and ventral. There is an almost imperceptible short alteration in the oesophageal lining between the fore and after parts of the oesophagus,—probably the vestige of a median bulb. The indistinctly clavate, posterior, non-valvate, oesophageal swelling contains a single, bright, refractive, three-micron nucleus near the base in the dorsal sector, proving the presence of an *oesophageal gland.* Radial oesophageal muscles are only faintly to be seen.

Intestine. A cross-section of the intestine cuts through only about two relatively large cells. The refractive lining of the intestine often is distinctly to be seen. In the front portion of the body the wall of the intestine is hardly as thick as that of the body; here the lumen of the intestine often is more than twice as wide as the thickness of the intestinal wall.

Renette. The renette duct, *dct ex*, is distinctly refractive and nearly two microns across; it passes inward at right angles to the ventral surface and then turns backward on the left side and becomes narrower and apparently bifurcate.

Caudal "Suckers." The tissue composing the mouths of the two lateral caudal "suckers" is comparatively structureless looking, and externally partakes of the general character of the cuticle. These two large lateral openings, found on the tail of adults of both sexes, when viewed dorso-ventrally are seen to lead inward and forward into two well developed pockets or "suckers," so massive that this portion of the tail, in the median aspect appears about 50 per cent wider than the portion of the tail immediately behind (Fig. 3, *org suct*). The cavity of each organ is lined with thick striated tissue whose most obvious elements are arranged at right angles to its inner surface, which presents a very definite internal sectional contour, due to the refractiveness of this tissue; so that the whole organ is a relatively conspicuous affair. A strand (contractile?) leading forward from each "sucker" into the corresponding lateral chord is at first rather wide, then narrows (*text org suct*, Fig. 3). The "suckers" seem to make their appearance on both sexes at the last moult (Fig. 4).

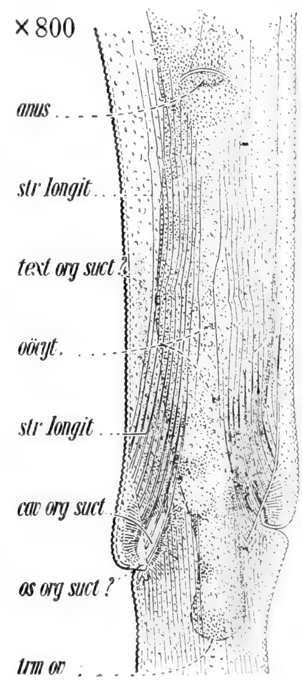

Fig. 3.—Ventral view of the post-anal region of *Ungella secta*, showing in the lower part of the figure the two lateral pockets or suckers, *cav org suct*.

Gonads. The elevated transverse vulva apparently is not very wide. Near the flexure the gonad presents a spermatheca, *spmth*, containing numerous spherical sperms of such a size that about a dozen would be required to span the body diameter. These possess refractive, faintly lobed nuclei, indicating the presence of a small number of chromosomes—probably about five. Contained in the uterus of adult females, as a rule, is a single thin-shelled, smooth egg, *ov*, about one and one-half times as long as the body is wide and about one-third as wide as long. No segmented egg has been seen in the uterus. The blind end of the ovary lies between the caudal "suckers" or somewhat farther forward. From the blind end of the ovary forward the oöcytes very soon become smaller, as if by division, and not far from the anus are arranged several abreast, and so continue, increasing meanwhile in size, for a good fraction of the distance to the vulva; thence, owing to increased size, they are arranged single file, each ovum cylindroid and somewhat longer than wide.

The male. The relatively large *gubernaculum, gub*, is single, rather shallow, nearly straight, and extends inward nearly at right angles to the ventral surface, so that its proximal end is considerably dorsad of the body axis. It appears quite as massive as the two equal spicula, and has the form of a relatively very broad, shallow, somewhat boat-like trough, deepest amidships, its depth being about one-third its length. The *long narrow bursa, brs*, presents seven *whiplash-like ribs* (1–7, Fig. 2) extending into each of the colorless, thin, glassy-looking, ventrally submedian, bursal expansions of the cuticle.

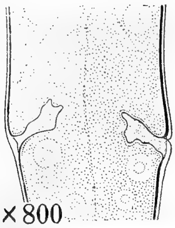

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Fig. 4.—Ventral view of the suckers of *Ungella secta* just before the last moult.

Since the suckers are common to both sexes, they can hardly be considered secondary sexual organs. Figure 4, derived from one of the few immature specimens thus far seen, seems to indicate that these interesting organs come into existence at the last moult, for, just previous to the last moult, they appear immature or "embryonic." It seems hardly possible that these organs can be homologous with the phasmids; nor does it seem possible to link them with such ventral suckers as occur for instance on male Heterachids. In short, further observation is needed fully to determine their function.

Habitat: Body cavity and muscles of the earthworm, *Eutyphoeus rarus;* fide Mr. G. E. Gates, to whom the discovery of the nema is due. Locality, Prome, Burma, India.

Diagnosis: Flexible-tailed ungellas, dimensioned as shown in the formulae and illustrations, with two practically submedian, amalgamated onchia (ungellae), having the form of the final joint of a beetle's tarsus; cervical gland just behind the cardia, its outlet dorsad on the lip region; pockets or suckers not far in front of the middle of the tail; external amphids more or less circular and opposite the base of the pharynx; oviparous; males with three pre- and four post-anal slender ribs to the bursa, as shown in Figure 2; posterior part of the tail cylindroid, fine yet blunt,—in the male distinctly set off.

Only a more careful study of the nemas thus far described as parasitic in earthworms can determine the nature and limits of most of the genera and species that have been proposed for their reception.

For literature consulted see the list of Pierantoni (Boll. Soc. Nat. Napoli, 1915, p. 150–3) and Baylis & Daubney (Synopsis, 1926).

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, April 7. The Biological Society.

Wednesday, April 11. The Geological Society.
The Medical Society.

Thursday, April 12. The Chemical Society.

Program: J. G. DAVIDSON.—*Ethylene derivatives and their technical application.*

Saturday, April 14. The Philosophical Society.

Program: L. W. KEPHART (by invitation).—*Plant exploration in the highlands of East Africa.*

Tuesday, April 17. The Anthropological Society.
The Historical Society.

Wednesday, April 18. The Medical Society.
The Washington Society of Engineers.

Thursday, April 19. The ACADEMY.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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JOURNAL

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GEOLOGY.—*A spiral graph of geologic time.*[1] David White, U. S. Geological Survey.

While the astronomer teaches the immensity of space, it falls to the geologist to cultivate the conception of geologic time. It is a task he owes to society, for some understanding of geologic time as well as of cosmic distance is an essential part of the background of any well-balanced philosophy of life. In conveying the idea of geologic time mere figures too often lose value with the student as well as the layman. Greater success is reached when the mental image envisages a picture in which numbers are coördinated with some graphic scale. Block diagrams may reflect contrasts in magnitude, but they fail in the attempt to represent geologic length of time. Straight-line horizontal diagrams in normal orientation and clock dial graphs, while passably effective, plunge the layman into the long dark pre-Cambrian, shrouded in greatest ignorance and uncertainty, with the probable result that his first impression of geologic knowledge, as well as time, is unfavorable. Only as the end of the line or the later hours of the dial are approached, the differentiative information becomes more and more exact as well as more complete. The dial has its good psychological points, but the eye travels along the endless circle to pass from the Recent again into the misty Azoic. The trouble with the geologic time graph lies mainly in its beginning and in the pre-Cambrian epochs.

The object of this note is to present an appropriate, stimulating, and more adequate form of graph for use in developing the mental picture of the lapse of geologic time and superposed geologic history. It is offered to illustrate a method, rather than definite conclusions.

[1] Received February 16, 1928.

Borrowing the idea from some recent photographs of spiral nebulae—the mothers of multiple solar systems—I have partly unwound a closely coiled spiral to form the basis of the picture. Vision of the origin and earliest history of the earth is hidden in obscure and uncertain remoteness. The spiral is so complexly intricate that not even the number of turns, and, so, the length of the time line can be discerned. Gradually the line becomes clearer, and presently one meets more or less definitely known, though perhaps distantly isolated and unrelated facts. As the coils roll wider out into clearer view the information increases in amount and diversity, and the historical record unfolds in ever growing distinctness, detail and definiteness of relations. Finally, the mind runs into the impressive facts that Recent time is incredibly brief and that the drama of the evolution of earth and life is still going on.

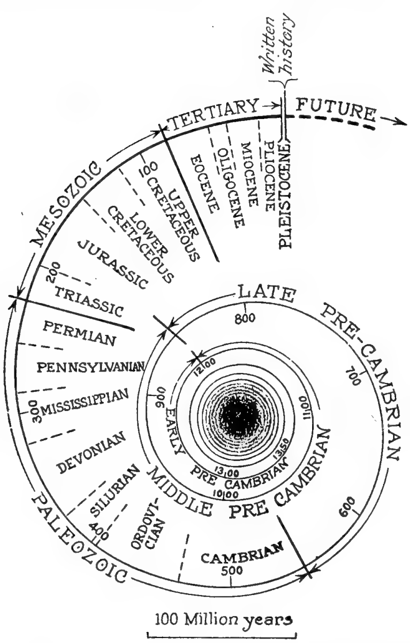

Fig. 1.—Graph illustrating geologic time and the evolution of earth's history.

In Figure 1 the numbers in hundreds (of millions of years) on the spiral accord approximately with and are adjusted to the results reached by Arthur Holmes and A. C. Lawson (Am. Journ. Sci., April, 1927), through (1) the recalculation of the formula for determining the ages of the uranium-bearing rocks by means of viewing the proportions of uranium and uranium lead with reference to the rate of decomposition of the radioactive minerals, and (2) the revisory computation of the ages of a considerable number of uraniferous rocks. In some of these calculations attention was given to thorium lead as well as radium lead. Not all the Holmes-Lawson determinations, most of which relate to Paleozoic and pre-Cambrian rocks, in many cases very indefinitely correlated, were used. The others, and still others to come, may be intercalated by the geologist who may be interested in the measurement of geologic time. The pre-Cambrian time classification is that given by the cited authors. This is the skeleton of the graph.

In laying off the accepted divisions of geologic time one million years was adopted for the Pleistocene, 60 millions for the Tertiary, and so on, in more or less agreement with the calculations by Barrell, Schuchert, and others as to relative length. The demarcation of the periods and epochs is subject to revision to suit the user's convictions.

This geologic time graph lends itself to the uses of geologists whether the object be to show the sequence and duration of the time divisions, the sequence of life, the glacial epochs, the periods of volcanism or diastrophism, or other features or time relations in earth's history.

The curve should be redrawn in better balance proportions.

BOTANY.—*The grass genus* Schizachne.[1] JASON R. SWALLEN, Bureau of Plant Industry. (Communicated by A. S. HITCHCOCK.)

The generic position of one of our native grasses, at present known as *Melica purpurascens*, has been somewhat uncertain. It was first described from North American by Michaux as *Avena striata* and later by Torrey as *Trisetum purpurascens*. From Siberia it was described by Ledebour as *Avena callosa* and from Sachalin Island by Hackel as the type of a new genus, *Schizachne*, which he compared with *Festuca* and *Bromus*. Hitchcock transferred it to *Melica* and Farwell to his new genus *Bromelica*.

An examination of *Melica purpurascens* leads to the conclusion that the species is generically distinct. The texture of the glumes suggests *Melica* but the bearded callus, the strongly nerved lemma, bifid at the apex, the divergent awn, and the brown smooth shining caryopsis are characters not possessed by any species of *Melica* of the section *Bromelica* to which the species is more closely allied than to *Festuca* or *Bromus*. Furthermore the innovations are extravaginal, while those of the section *Bromelica* are intravaginal and the culms are often bulbous at the base.

The species under consideration shows affinities with *Bromus* but the styles are exactly terminal and the caryopsis is entirely free from the palea while in *Bromus* the styles arise below the apex and the caryopsis is adherent to the palea. It also resembles species of *Festuca* but its bifid lemma and bearded callus exclude it from that genus. It differs from *Melica smithii* (Porter) Vasey, which has been grouped with it, in the bearded callus, the more deeply bifid lemma and the smooth caryopsis.

[1] Received February 4, 1928.

In view of these differences it seems best to segregate the species as the type of a distinct genus, taking up the name *Schizachne* Hack.

The geographic distribution of *Schizachne*, which is monotypic, is similar to that of a number of species mentioned by Asa Gray,[2] being found in northern North American and eastern Asia. This distribution was recognized as early as 1842 by Turczaninow[3] who referred his collections, later described as *Avena callosa*, to *Avena striata* Michx. Hultén,[4] in his Flora of Kamtchatka, also states that Asiatic specimens agree completely with the American ones.

Schizachne Hack.

Spikelets several-flowered, articulate above the glumes and between the florets, the rachilla glabrous; glumes unequal, 3 and 5-nerved respectively; lemma lanceolate, strongly 7-nerved, long-pilose on the callus, awned from just below the teeth of the prominently bifid apex; palea with softly pubescent, thickened submarginal keels, the hairs longer toward the summit; ovary glabrous, the styles exactly terminal; caryopsis dark reddish brown, very smooth and shining. Type species, *S. purpurascens.*

Schizachne purpurascens (Torr.)

Avena striata Michx. Fl. Bor. Amer. **1:** 73. 1803. Not *Avena striata* Lam. Collected by Michaux "a sinu Hudsonis ad Lacus Mistassins." Type in Muséum d'Histoire Naturelle at Paris. A fragment in the U. S. National Herbarium has been examined.

Trisetum purpurascens Torr. Fl. North. & Mid. U. S. **1:** 127. 1823. A cited specimen in the Torrey Herbarium, at the New York Botanical Garden, has been examined. It is labeled in Torrey's handwriting, "Trisetum purpurascens Tor. fl. near Montreal."

Avena callosa Turcz. in Ledeb. Fl. Ross. **4:** 416. 1853. "Catal. Baic. nr. 1295" is cited. Judging from the description and a specimen from "Vallis U-scha-gon, Siberia," *Kamerov* 163, there is no doubt that this is identical with *Schizachne purpurascens.*

Avena striata forma *albicans* Fernald, Rhodora **7:** 244. 1905. "Quebec, abundant on mossy tableland, altitude 900–1500 meters, Mt. Albert, Aug. 9, 1905." [*Collins & Fernald* 26] The characters are not sufficient to distinguish it from the species.

Melica striata (Michx.) Hitchc. Rhodora **8:** 211. 1906. Based on *Avena striata* Michx.

Melica purpurascens (Torr.) Hitchc. Contr. U. S. Nat. Herb. **12:** 156. 1908. Based on *Trisetum purpurascens* Torr.

Schizachne fauriei Hack. Repert. Sp. Nov. Fedde **7:** 323. 1909. "Insula Sachalin, in silvis prope Korsakof, Faurie 803." A portion of the type from the Hackel Herbarium has been examined.

[2] Proc. Amer. Assoc. **21:** 1–31. 1872.

[3] Bull. Soc. Nat. Moscou **15:** 16. 1842.

[4] *Flora of Kamtchatka and the Adjacent Islands* **1:** 118. 1927.

Avena torreyi Nash in Britt. & Brown, Illustr. Fl. ed. 2. **1**: 219. 1913. Based on *Trisetum purpurascens* Torr. Not *Avena purpurascens* DC.

Bromelica striata (Michx.) Farwell, Rhodora **21**: 77. 1919. Based on *Avena striata* Michx.

Description

Perennial herb; culms erect from a loose decumbent base, the innovations extravaginal; panicle simple, about 10 cm. long, the branches one or two together, more or less drooping, bearing one or two spikelets.

Distribution

Dry, moist, or rocky woods and open places, in North America from Labrador to Alaska, south in the United States to Pennsylvania, Indiana, and in the mountains to South Dakota and New Mexico; also in Asia from Kamtchatka and Sachalin Island, west to Lake Baical.

The following specimens are in the U. S. National Herbarium:

Newfoundland: Quarry, *Fernald & Wiegand* 4608. Frenchman's Cove, *Mackenzie & Griscom* 10077.

Quebec: Island of Anticosti, *Marie-Victorin, Brunel, Rolland-Germain & Louis Marie* 20546, 20547. Mount Albert, *Macoun* 40; *Marie-Victorin, Brunel, Rolland Germain & Rousseau* 17787. St. Anne River, *Allen* in 1881; *Marie-Victorin, Brunel, Rolland-Germain & Rousseau* 17762. Mount au Clair, *Fernald & Smith* 25, 464. Gaspé, *Marie-Victorin, Brunel, Rolland-Germain & Rousseau* 17768. Rivière Cap Chat, *Fernald, Griscom, Mackenzie, Pease & Smith* 25463. Longueuil, *Marie-Victorin* 3006. St. Jerome, *Victorin* 3007. Lac Tremblant, *Churchill* in 1922. Ville-Marie, *Marie-Victorin* 8040.

Ontario: Vicinity of Ottawa, *Rolland* 6089. Galt, *Herriot* in 1898 and 1901. Jones Falls, *Fowler* in 1895. Tilsonburg, *Macoun* 26077. North Shore of Lake Superior, *Wood* 20; *Macoun* in 1869.

Manitoba: Carberry, *Macoun & Herriot* 42909.

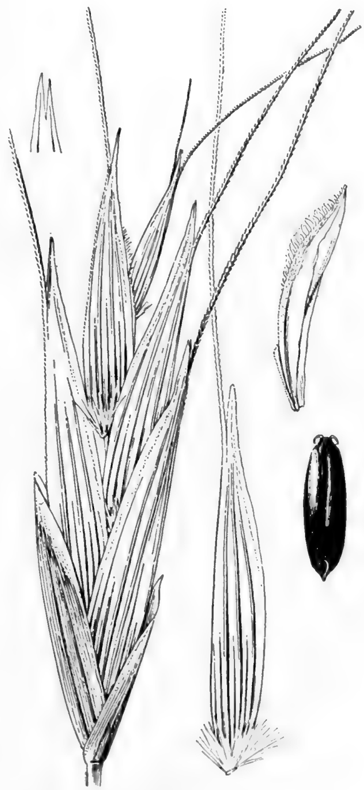

Fig. 1.—*Schizachne purpurascens*. Spikelet, floret, summit of lemma, palea, and caryopsis, × 5.

Saskatchewan: "Portage La Prairie," *Macoun* 122. Prince Albert, *Macoun* 13025.

Alberta: Red Deer River, *Brinkman* 2199. Calgary, *Macoun* 18631. Edmonton, *Hitchcock* 11390. Athabasca Landing, *Hitchcock* 11411. Jasper Park, *Macoun* 98208. McMurray, *Raup* 143, 147.

British Columbia: Field, *Hitchcock* 11538. Lucerne, *Macoun* 98203. Hazelton, *Henry* 6.

Alaska: Kenai, *Piper* 4715.

Maine: Aroostook County, *St. John & Nichols* 2148. Fort Kent, *Knight* 9; *Fellows* 2550. Somerset County, *St. John & Nichols* 2146, 2147. Farmington, *Knowlton* in 1911. Orono, *Fernald* in 1893; *Harvey* 1299. Mount Katahdin, *Fernald* in 1900. "Mt. Clifton," *Briggs* 21.

New Hampshire: Shelburne, *Deane* in 1915. Jefferson, *Booth* in 1873. Mount Washington, *Eggleston* in 1898; *Hitchcock* 16042; *Greenman* 1282. White Mountains, *Faxon* in 1878. Franconia, *Booth* in 1855.

Vermont: Lyndon, *Congdon*. Cabot, *Knowlton* in 1915. Burlington, *Flynn* in 1901 and 1902. Charlotte, *Eggleston* in 1892; *Hosford* 487; *Pringle* in 1877 and 1878. Rutland, *Kirk* 983. Townshend, *Wheeler* in 1912.

Connecticut: Salisbury, *Bissell* in 1901; *Weatherby* 3629.

New York: North Elba, *Peck* 10. Canton, *Phelps* 154. Lebanon Springs, *Harrison* in 1890. Arkville, *Chase* 7444, 7451. Jamesville, *Chase* 7490½. McLean, *Dudley* in 1881 and 1884. Ithaca, *Metcalf* 1617; *Pearce* in 1884. Chemuga County, *Lucy* 1055.

Pennsylvania: Loyalsock, Sullivan County, *Smith* 1864.

Indiana: Logansport, *Deam* 38375.

Michigan: Chippewa County, *Dodge* in 1914. Mackinac County, *Dodge* in 1912 and 1915. Schoolcraft County, *Dodge* in 1915. Douglas Lake, *Ehlers* 405. Port Huron, *Dodge* 25, and in 1904. Lansing, *Wheeler* in 1887. Grand Rapids, *Mulliken* in 1896.

Wisconsin: Hurley, *Random* in 1896. Green Bay, *Schuette* in 1878. Bellevue, *Schuette* in 1882. Winnebago County, *Kellerman*.

Minnesota: Gull Lake, *Anderson* in 1893. Minnehaha Falls, *Minns*.

North Dakota: Devils Lake, *Lunell* in 1902 and 1913.

South Dakota: Custer, *Hitchcock* 11131; *Rydberg* 1132. Nahant, *Hayward* 2412. Elmore, *Hayward* 1848.

Montana: Columbia Falls, *Williams* 823 in 1894. Belt Creek, *Scribner* 371. Barker, *Rydberg* 3363. "Lower Belt Pass," *Williams* 823 in 1889.

Wyoming: Sundance, *Griffiths* 455, 890; *Williams* 2637. Little Missouri Buttes, *Griffiths* 575. Clear Creek, *Williams & Griffiths* 13, 86. Yellowstone National Park, *Tweedy* 612.

Colorado: Pikes Peak, *Hitchcock* 1718, 1748. La Plata Mountains, *Baker, Earle & Tracy* 976. Upper La Plata, *Tracy* 4304. "Crystal Park" *Clements* 173 in 1901.

New Mexico: Pecos River National Forest, *Standley* 4185. Cowles, *Hitchcock* 22965.

Sachalin Island: Korsakof, *Faurie* 803.

Japan: Hokkaido, *Yushun Kudo* in 1907.

Siberia: Kamtchatka Peninsula, *Kamarov* in 1909. Vallis Uschagon, *Kamerov* 163.

BOTANY.—*Some errors and mistakes in taxonomic botany.*[1] H. Pittier, Caracas, Venezuela.

Botanists, like all other mortals, are subject to errors and mistakes. Few of those, for instance, who have had to describe a large number of

[1] Received March 1, 1928.

plants have been exempt from them. Many times, they are the result either of a previous description obscurely written or of a different valuation of specific characters. In other instances, species have been too hastily founded on decidedly scant materials. In all cases, the result is the inconvenience caused by a useless encumbrance of synonyms.

Other mistakes are more serious and perhaps less easy to condone. I will cite only one case, besides those which are to be rectified in this article. In a splendid work entitled *Florae Columbiae terrarumque adjacentium specimina selecta,* Karsten described his *Siphoniopsis monoica,* founded on the African *Cola acuminata* R. Br.! This tree, brought to Venezuela by negro slaves, is quite naturalized in some places and found in situations that preclude the suspicion of its being an introduced species, so that Karsten's error can be easily understood.

In two cases my own mistakes were undoubtedly much worse. In 1913, I collected at Cárdenas, Siquire Valley, in the State Miranda, Venezuela, specimens of a tree which I determined as a new species of *Monopteryx,* a genus created by Spruce and including two distinct types growing in the Upper Rio Negro. While studying and describing that supposedly new species, I could not but be struck by certain apparent discrepancies in Spruce's definition of the genus. My observations were recorded in a short paper in 1915.[2] Comparing the newly described *Monopteryx Jahnii* with the original species, I concluded that Spruce's species were based on immature flowers and that the fruits could not be drupelike, as originally supposed. Accordingly I offered an emended generic diagnosis. As an extenuating circumstance it may be explained that the genus *Monopteryx* was not represented at the time in the U. S. National Herbarium, and that my specimens looked very much indeed like the full size drawing in plate 122, vol. 15, 1, of the *Flora brasiliensis.* Relying on the characters of the supposed new species, I made another mistake in proposing to transfer the genus in question from the *Sophorae* to the *Pterocarpinae.*

A few years ago, Dr. H. Harms, of the Berlin Botanical Museum, suggested that my no. 6005, type of *Monopteryx Jahnii,* might in reality be none other than *Fissicalyx Fendleri* Benth., a Venezuelan monotypic genus of the *Geoffreainae,* which assumption was at once confirmed by my finding in the Venezuelan National Herbarium specimens of the same species from the vicinity of Hacienda de Cura,

[2] Bull. Torrey Club **42**: 623–627. *fig. 1, 2.* 1915.

near San Joaquín in the State of Carabobo (*Pittier* no. 7738), and from Hacienda Cárdenas, where the original specimens of *M. Jahnii* were collected (*Pittier* no. 7072), rightly labelled by myself this time, as *Fissicalyx Fendleri* Benth. Consequently, *Monopteryx Jahnii* Pittier is to be relegated to the synonymy of the above Venezuelan monotype.

The second of my botanical sins which I wish to atone for is that of the hasty publication of *Adenocalymna anomalum* Pittier,[3] the specific name of which referred to the bipinnate leaves. Here, the blunder is perhaps still less pardonable, because before publishing new species of the vast family Bignoniaceae, I should have known that among the Sub-family Bignonieae, there are two Venezuelan genera, and only two, *Memora* and *Pleonotoma,* with pluripinnate leaves. In the first one the stems and branchlets are terete and the tendrils simple, in the second they are tetragonous with sharp detachable angles, formed by black sclerom strings. Subsequent to the description of *Adenocalymna anomalum* both genera have been mixed together under the same cover, but my pseudo-new species, which I have not at hand, was presumably *Memora caracasana* K. Schum., while among the species with sharp cornered stems and branchlets we have *Pleonotoma variabile* Miers.

A third mistake of mine consisted in the publication, in my "*Arboles y arbustos nuevos de Venezuela*" (p. 58, 1925), of a supposed new species under the name of *Coursetia caracasana.* First, this small tree is not a *Coursetia,* and secondly, it had already been described, practically from the same locality, under the name of *Robinia ferruginea* H. B. K.[4] I was led to this too hasty publication by the fact that two different species, the above one and *Coursetia arborea* Grisebach, which commonly grow together and resemble each other at first glance when leafless, were often mixed together in herbaria. In 1923, Dr. Harms of the Berlin Botanical Museum, an acknowledged authority on leguminous plants, already cited above, published his *Humboldtiella ferruginea,* supposedly to replace *Robinia ferruginea* H. B. K. When comparing the specimens of the tree collected by me with Dr. Harms' description, I found wide discrepancies and so jumped to the erroneous conclusion that I had on hand a *Coursetia,* which, however, could not be *C. arborea* of Grisebach; hence the new name.

Later, when revising the Papillionatae of the Venezuelan Herbarium, I was surprised to find that, among the numbers cited by Dr. Harms

[3] Contr. U. S. Nat. Herb. **18**: 254–255. 1917.
[4] Nov. Gen. & Sp. **6**: 395. 1823.

as belonging to his *Humboldtiella,* one (no. 5780) apparently corresponds to *Gliricidia sepium* H. B. K., another (no. 9078) is unmistakably *Coursetia arborea* Griseb., and only one (no. 6004) belongs to the real *Robinia ferruginea* H. B. K., as do also additional collections under nos. 10310, 10375, 11956, and a few more. It would seem that Dr. Harms did not draw the generic characters of his *Humboldtiella* from a single type, but from all the materials cited by him, giving perhaps most weight to *Coursetia arborea* Grisebach. This would explain in a large measure my own mistake. After a careful study of the whole matter I have come to the conclusion that my *Coursetia caracasana* is the topotype of *Robinia ferruginea* H. B. K. and that the only character which would exclude the plant in question from *Robinia* is the absence of a conspicuous margin on the upper suture of the pod, which would certainly not be sufficient to establish a new genus.

The above facts were submitted to Dr. Harms, who with the utmost good grace accepted them with the exception of the part relating to the supposed *Gliricidia,* and agreed that, for the present, Humboldt & Bonpland's name had better be retained. I must admit, finally, that, as far as the general habit and macroscopic characters are concerned, there is little resemblance between our *Robinia ferruginea* and *Robinia pseudo-Acacia,* the only other species of the genus with which I am familiar.

The following is a full description of our *Robinia,* from specimens proceeding from the Tacagua valley, where the original plant was collected by Bonpland in imperfect specimens.

ROBINIA FERRUGINEA H. B. K., Nov. Gen. & Sp. **6:** 395. 1823.

Humboldtiella ferruginea (H. B. K.) Harms, Repert. Nov. Sp. Fedde **19:** 12. 1923.

Coursetia caracasana Pittier, Arb. y. arbust. nuev. Venez. 58. 1925.

Arbor parva, ramulis plus minusve griseo-pubescentibus, gemmis novellis, petiolis, petiolulis, pedunculis pedicellisque ferrugineo-tomentosis; foliis elongatis, imparipinnatis, plerumque 21-foliolatis, petiolulis gracilibus, suboppositis vel alternis, laminis elliptico- vel oblongo-lanceolatis, basi inaequalibus rotundatis apice acutis subacutisve, supra glaberrimis pallide viridis, costa impressa, subtus praecipue ad costam costulisque prominentibus molliter ferrugineo-pubescentibus; stipulis lineari-setaceis, subpungentibus, rigidis, ad apicem ramulorum persistentibus; racemis pedunculatis, plurifloribus praecocibus vel foliis subcoaetaneis, solitariis, vel rarius geminis; floribus longe pedicellatis; calyce basi articulato, subulato, extus ferrugineo-tomentello, intus superne et margine albido-villoso, dentibus subaequantibus, obtusis; petalis glaberrimis, vexillo transverse ovato, basi flavi-maculato, auriculato callosoque, apice emarginato, reflexo; alis longiuscule unguiculatis, lamina distincte obovata, basi intus leviter auriculata; petalis carinalibus vexillo alisque brevioribus, dorso breviter cohaerentibus breve unguiculatis, lamina late falcata, apice subacuta; staminibus 10, filamentis connatis, vexillari basi apiceque libero, utrinque capillaceo-linearibus, uninervibus, alterne brevibus longioribusque; ovario breviter stipitato, cinereo-tomentello; stylo basi glabro apicem versus utrinque villosulo; legumine subsessili, pedicellato, maturo ferrugineo-tomentoso, calyce persistente suffulto et stylo terminato.

Arbor 4–6 m. alta. Petiolum 4–10 cm. longum, supra leviter sulcatum; petioluli 1.5–2 mm. longi; laminae 1.3–3.5 cm. longae, 0.6–1.1 cm. latae. Stipulae 3–4 mm. longae. Racemi 2.5–8 cm. longi; pedicelli 5–9 mm.; flores circa 1.5 cm. longi; vexilli unguiculus 2–2.5 mm. longus, lamina circa 1.4 cm. longa, 1.7–1.8 cm. lata; alarum unguiculus 4.5 mm. longus, lamina 13 mm. longa, 8–9 mm. lata; carina 12–13 mm. longa (cum unguiculo 3 mm. longo), 5–6 mm. lata. Ovarium 9–10 mm. longum; stylus 5 mm. Legumen 10–12.5 cm. longum, circa 1 cm. latum; pedicellum 0.8–1 cm.

VENEZUELA: Quebrada de Tacagua (altitude about 720 m.) (*Bonpland*, type of the species); Caracas, January 1843 (*Moritz* 223); Escuque, Trujillo (*Moritz* 1431). Puerto Cabello, May 1874 (*O. Kuntze* 1742); Cárdenas, Siquire Valley, Miranda, 500 m., March 1913 (*Pittier* 6004); near El Consejo, Aragua, in bushes, flowers and young fruits, January 15, 1921 (*Pittier* 9159); near Las Trincheras, 900 m., valley of Tacagua, D. F., flowers May 4, pods and leaves, June 15, 1922 (*Pittier* 10310, 10375, type of *Coursetia caracasana* Pittier); Los Mariches, Miranda, in dry bushes, flowers and young leaves, November 22, 1924 (*Pittier* 11956).

TRINIDAD: *Broadway* 1431; *O. Kuntze* 1884.

Cited also from Guiana, Brazil and Panamá, but there are no data at hand to verify the identifications.

In the course of the investigations necessitated to undo the above imbroglio, dissections of the flowers of the several species in question were made. When comparing the details of those of the so-called *Coursetia arborea* Grisebach with the descriptions of genus *Coursetia* I became very doubtful as to whether this species could really be included in it. The shrubs of this group are generally more or less tomentose, often glandulous, and sometimes armed. The calyx is described as having its five teeth subequal, elongate and acute, with the two superior ones hardly connate at the base. The ovary and style are hairy in all species and the pods are more or less constricted between the seeds. The details concerning the calyx and the ovary were confirmed by the dissection of flowers of three species of Mexico and Arizona kindly sent by Dr. F. S. Blake. The calyx of *C. arborea*, on the other hand, is of very different shape, having short teeth, the two superior united almost to the tip, the lateral ones smaller and more or less acute, and the inferior one again slightly longer and sharply pointed; besides, the pubescence is hardly perceptible, while in the true species of *Coursetia* the same part is often tomentose, with the indument intermingled with glandular hairs, especially conspicuous on the margin of the segments. The shape of the petals is also different, the base of the wings and carinal petals being distinctly semi-auriculate in *C. arborea*, while it is more or less rounded or attenuate in the three species of supposed true *Coursetia* I had the opportunity to examine. But it is in the gynoecium, perhaps, where we find the most significant difference. In the three species of *Coursetia*, it is, as we just mentioned, prominently hairy and often glandulous, and either sessile or short-stipitate; the style is mostly long-arcuate and probably always ends in a capitellate stigma. In the Venezuelan species the same organ has a striking appearance: the ovary is long, smooth and long-stipitate; the style seems to be distinctly articulated on this and, after a short curve downward, bends sharply again and continues upward, long, straight and needle-like, its upper side hairy all around, and ends in a cone-shaped stigma. This character and the details of the calyx would, it seems, be sufficient to exclude the species from *Coursetia*. But we have cited other important divergences and will add that neither are the pods of our tree like those of *Coursetia*. I propose, therefore, to segregate *Coursetia arborea* Grisebach under the name *Callistylon arboreum* (Griseb.) Pittier, with the following description:

Callistylon Pittier, gen. nov.

(*Coursetia* sp., Griseb.)

Calyx late cupulatus, basi rotundatus, dentibus inaequalibus, 2 superioribus alte connatis obtusis, lateralibus brevioribus plus minusve acutis, inferiori acuto, lateralibus longiori. Vexillum suborbiculatum quam longius latior, basi emarginatum et subauriculatum, apice emarginatum, marginibus reflexis, unguiculo longiusculo, lamina basi intus obliquo vel fere rectangulari; alae falcato-oblongae, latae, semi-auriculatae, plus minusve conchoideae, apice rotundatae, longe unguiculatae; carina lata, alis brevior, pariter longe unguiculata, valde arcuata et longe rostrata, petalis pars dimidia superiora cohaerentibus. Stamina 10, inaequalia, vexillari basi et apice libero; antheris oblongis. Ovarium crasse stipitatum, 15–22 ovulatum, stylo basi crasso, glabro, geniculato, sursum abrupte curvato, parte superiora verticali longa, filiformi, apicem versus adpresse villosa; stigmate punctiformi. Legumen vix stipitatum, lineare, compressum, polyspermum, continuum, dehiscente, valvis convexis, apice stylo persistente producto; semina parva, nigra, lenticularia—Arbor parva, inermis. Folia abrupte pinnata, foliolis 12–18, petiolulatis, ovalibus, apice emarginatis mucronatisque, mucronulis fugacibus, primum oppositis demum plus minusve alternis, petiolo apice mucronato. Stipulae setaceae, rigidulae, sub-persistentibus; stipellae nullae. Racemi terminales vel folia superior axillares, haec breviores, multiflorae, pedicellis flores aequantibus vel longioribus, basi apiceque articulatis. Bracteae breves, lanceolatae; bracteolae parvae et inconspicuae. Flores albi, ima magni.

CALLISTYLON ARBOREUM (Griseb.) Pittier.

Coursetia arborea Griseb., Fl. Brit. W. Ind. 183. 1864.

Humboldtiella ferruginea (partim) Harms, Repert. Nov. Sp. Fedde **19**: 12. 1923.

Arbor parva, ramulis cinereis, tortuosis, novellis rufo-pubescentibus; foliis paripinnatis, stipulatis, glabris glabrescentibusve, petiolo gracili, basin versus leviter incrassato, canaliculato, apice mucronato, foliolis 6–9-jugis, membranaceis, petiolulatis, petiolulis saepe pilosulis, exstipellatis, laminis ovatis obovatisve, integerrimis, basi vix inaequalibus rotundatisque, apice mucronulatis primum late obtusis in aetate emarginatis, supra laete viridibus, glaberrimis, minute reticulatis, subtus pallidioribus, juveniis interdum pilosulis demum glaberrimis, costa prominente, et caeteris prominuliter reticulatis; stipulis minutis, setaceo-spinescentibus, villosulis; racemis pedunculatis, 8–15-floribus, pedunculo pedicellisque rufo-pubescentibus, pedicellis gracilibus, elongatis, postea floribus persistentibus; calyce cupulato, costulato, parce pubescenti; vexillo interdum pilosulo; alis liberis, unguiculo arcuato; petalis carinalibus basi liberis, parte superiore cohaerentibus; filamentorum pars libera tenuissima; ovario glabro vel glabriusculo. Legumine elongato primum ferrugineo-pubescenti demum glaberrimum, marginibus vix incrassatis.

Arbor 2–4 m. alta. Petiolus 5–10 cm. longus; petioluli tereti 2–3 mm. longi; laminae foliolorum 1.5–4.7 cm. longae, 1–2 cm. latae. Stipulae circa 2 mm. longae. Racemi cum pedunculo circa 2 cm. longo 3–5 cm. longi, pedicelli 1–2 cm. longi. Flores circa 2 cm. longi. Calyx 7 mm. longus. Vexillum 15 cm. longum, 19–22 mm. latum, unguiculo 5 mm. longo; alarum laminae 17 mm. longae, 8–9 mm. latae, unguiculo 4–t mm. longo; carinae unguiculum circa 3 mm. longum, lamina horizontaliter 11 mm. longa, verticaliter cum rostro 11 mm. longa. Ovarium 11 mm. longum, stylo parte horizontali 2.5 mm., verticali 8 mm. longa. Legumen 10–12 cm. longum, 0.9–1.2 cm. latum.

VENEZUELA: Vicinity of El Palito, in dry hills, 100 m., Aragua, rare, flowers September 24, 1920, fruits, Dec. 1920 (*Pittier* 9078, 9413); La Ciénega, near Valera, 550 m., Trujillo, in arid bushes, fruits, Nov. 24, 1922 (*Pittier* 10780); near El Sombrero, 130 m., Guárico, in thorn bushes, flowers and fruits (but no leaves and the latter narrower than in the type and quite glabrous), February 19, 1924 (*Pittier* 11447); near Curucutí, 300 m., D. F., on rocky slopes, flowers, August 7, 1927 (*Pittier* 12423); Humocaro, 1000 m., Lara, flowers September 25, 1922 (*Jahn* 1197); Puerto La Cruz, D. F., October 1926 (*Voronoff* 335); La Ruesga near Barquisimeto, 550 m., flowers, May and June 1925 (*Saer* 230, 247).

PLANT ECOLOGY.—*Northward range-extensions of some southern orchids in relation to soil reaction.*[1]

EDGAR T. WHERRY, Bureau of Chemistry and Soils.

In this note it is proposed to discuss six southern terrestrial orchids, notable extensions of the ranges of some of which have recently been

[1] Received January 23, 1928.

discovered: *Cleistes divaricata* (L.) Ames (often classed as a species of *Pogonia*); *Habenaria conspicua* Nash; *Habenaria integra* (Nutt.) Sprengel; *Hexalectris spicata* (Walt.) Barnhart; *Malaxis spicata* Swartz (also known as *M. floridana*); and *Ponthieva racemosa* (Walt.) Mohr. These are classed as "southern" because they are widespread in Florida and in the Coastal Plain physiographic province in neighboring States, but in more elevated provinces, as well as at sea-level farther north, they become so rare and local as to make publication of the finding of new stations worth while. No attempt is made to assign them to any "life-zone," because in the southeastern part of the United States these zones are about as lacking in significance as are those in eastern Canada.[2]

The Rosebud Orchid,[3] *Cleistes divaricata*, extends northward locally beyond its area of abundance, or, as this may be called, its "normal" area, as far as New Jersey on the Coastal Plain, whereas on the Piedmont red-clay soils it seems unable to migrate beyond Georgia. In central Alabama, where sandy soils derived from Paleozoic formations come into contact with the Coastal Plain sands, it again pushes northward far beyond its normal area. In the mountains of North Carolina it is known to grow up to elevations of 1,200 meters (3,900 feet). It has not been heretofore recorded farther northwest, but was found in September, 1927, by Dr. Francis W. Pennell and the writer on a dry ridge near Honeybee Post Office, Pulaski County, Kentucky. A specimen is in the Academy of Natural Sciences, Philadelphia.

The orange colored species known from the shape of its flowers as the Frog-arrow Orchid, *Habenaria integra*, shows a similar but more restricted range. It too has reached New Jersey on the Coastal Plain, but apparently it has not been able to extend north on either the Piedmont or the Blue Ridge province. The sands of the Appalachians furnish a route for its migration, however, and it grows at least as far up as south-central Tennessee.[4]

[2] FERNALD, Rhodora **23**: 169. 1921.

[3] Botanists often derive "common names" for plants by anglicizing the specific name and changing a letter or two in the generic name. To the writer names so derived seem pedantic and needless, for they are never used by anyone not thoroughly acquainted with the technical name itself. An effort has here been made to introduce common names which either are in actual use, or can be understood, by laymen. The name chosen for the present species may seem a bit far-fetched, but the lip of the flower does bear some slight resemblance in color and form to a slender rose bud, and this name means much more to the natives of the regions where the plant occurs than would "Divaricate Cleistia."

[4] GATTINGER, *Flora Tennessee* 62. 1901.

The Longspur Fringe-orchid, *Habenaria conspicua,* is another example of the same general behavior. In its case there appears to have been no migration beyond the normal area on the Coastal Plain, but it does follow the Appalachians, and a form of it with the lip entire was found by Dr. Pennell and the writer in September, 1927, about 5 kilometers south of Pine Knot, Whitley County, Kentucky, this bringing it within the limits of floras of the northeastern part of the United States. A specimen of this is now in Academy of Natural Sciences, Philadelphia.

All three of these plants grow far enough north and at high enough elevations to show that they are reasonably hardy, so the question arises as to why they are limited to very restricted areas beyond their normal region. It is not a matter of moisture, for the first appears to thrive equally well in meadows which are under water half the year and on the dryest kind of gravelly mountain slopes, and the other two show distinct variation in the wetness of their habitat. It is not connected with soil temperature, for while it is true that sandy soils such as these species occupy are often considered to be "warm," the bogs in which they are usually found are generally recognized to be "cool" places. Indeed, as pointed out by Fernald,[5] in Newfoundland southern species often occupy colder places than do northern ones, the explanation being that extensive areas of acid soil occur in an especially cold part of the island, and the southern species concerned are acid-soil plants. The one feature which the various soils supporting these orchids have in common is a high degree of acidity. A simple explanation of their isolation is, then, that beyond their normal areas these species are able to withstand the more or less unfavorable environmental conditions only when particularly well nourished, and their physiology chances to be such that they can best obtain the nutriment they require in strongly acid soils, which are only locally well developed in situations where the plants can grow at all.

The distribution of the Crested Coralroot Orchid, *Hexalectris spicata,* has already been discussed.[6] It crosses the Virginia Coastal Plain along marl outcrops, and even extends into Maryland on an Indian shell-heap. Farther west it reaches fairly high elevations in the mountains of Virginia, and enters Indiana, where the climate is by no means mild. Though occasionally growing in acid upland peat, it becomes luxuriant only in relatively rich soils.

[5] Fernald, Amer. Journ. Bot. **5**: 237. 1918.
[6] Wherry, This Journal **17**: 35. 1927.

The little brown-flowered orchid, which is best characterized as the Two-leaf Adder's-mouth, *Malaxis spicata*, has not heretofore been reported as growing north of Florida. That its range was wider by two States was shown when it was found by Mr. H. W. Trudell and the writer in June, 1922, near Monck's Corner, Berkeley County, South Carolina, growing in marl thrown out in the digging of the Santee Canal. A specimen has been placed in New York Botanical Garden. In August, 1927, an additional two-State extension of range was indicated when it was discovered in southern Gloucester County, Virginia, by Miss Jennie S. Jones, of Richmond. A specimen of the orchid found by Miss Jones is in the United States National Herbarium. Another colony was found a month later near Williamsburg, Virginia, by Mr. E. A. Eames, of Buffalo, New York. In both these places the plant grows in rich soil where marl outcrops near ravine-bottoms.

The Shadow-witch Orchid, *Ponthieva racemosa*, was apparently collected in Virginia by Clayton, for Gronovius[7] listed a "SERAPIAS *foliis ovatis radicalibus, scapo nudo multifloro.* Orchis s. Bifolium aquaticum autumnalis flore herbaceo, caule aphyllo, foliis subrotundis plantagineis, radice palmata. Clayton 1 & 138" which clearly describes this species. It was then lost sight of for more than 150 years, until it was rediscovered by the late E. J. Grimes[8] in 1920. The writer has observed it in several localities in James City, York, and Gloucester Counties, always in rich marly soil, and in this State as well as farther south it is more or less closely associated with the two preceding species.

Like the first set of three species, the ones just discussed seem to thrive equally well in dry and in moist situations; and here, too, the temperature relations are contradictory. It is often held by ecologists that calcareous (circumneutral) soils, which are clearly favored by these three orchids, are relatively warm,[9] and this may be the case in some places. Finding certain tropical plants on isolated shell-mounds (where the soil is circumneutral) in central peninsular Florida, Small[10] suggested that heat in the spaces between the shells enables these plants to withstand cold spells. Exactly the reverse conclusion, however, could be reached elsewhere in Florida. On the circumneutral Aspalaga bluffs of the Apalachicola River many northern plants grow in isolated colonies far south of their normal areas, and here it would

[7] GRONOVIUS, *Flora Virginica*, ed. 2. 137. 1762.
[8] GRIMES, Rhodora **24**: 149. 1922.
[9] SALISBURY, Journ. Ecology **8**: 208. 1921.
[10] SMALL, Journ. N. Y. Bot. Gard. **28**: 10. 1927.

have to be argued that coolness in spaces between the shell fragments enables them to withstand Floridian heat-waves. In Virginia, moreover, the ravine-bottoms preferred by the three warmth-loving orchids are about the coolest situations on the Coastal Plain. Their isolated distribution northward, however, can be simply interpreted by the same theory of reaction-control applied in the case of the other set, to the effect that they best obtain the nutriment they require in circumneutral soils, and beyond their normal areas can withstand the unfavorable environment only in the restricted localities where such soils are prominent.

It is inferred then, that in the cases of these six orchids, and by analogy in those of hundreds of other plants which show similar distribution-relations, the chief reason for isolation beyond the normal areas is not physical (moisture or temperature) but chemical (reaction —acidity or alkalinity).

ETHNOBOTANY.—*Remedial plants of Tepoztlan: A Mexican folk herbal.*[1] ROBERT REDFIELD, University of Chicago. (Communicated by JOHN R. SWANTON.)

The present writer, who is not a botanist, has done little more than collect the plants listed below and the accompanying ethnobotanical data.[2] The identification of the plants was made by Mr. Paul C. Standley, of the United States National Museum; the Compositae were identified by Dr. S. F. Blake of the Department of Agriculture. To these gentlemen the writer is deeply indebted, and especially to Mr. Standley for further assistance and advice on pre-Linnean descriptions of Mexican flora. A further obligation is owed to Mr. Donald C. Peattie, of Rosslyn, Virginia, who placed the plants in their proper families and furnished botanical notes.

The extensive ethnobotanies which have been collected among primitive peoples testify to the high degree of completeness with which many such peoples have explored their flora. To most primitive peoples no other aspect of the natural environment is as well known. Such knowledge is not, of course scientific. It is unreflective and unsystematized, growing empirically, and never entirely dissociated from magical art. The village populations of Mexico are composed no

[1] Received February 15, 1928.

[2] This was done in the course of an ethnological study of a Mexican village, made possible by a fellowship granted in 1926–27 by the Social Science Research Council.

longer of primitive (tribal) peoples, but of a folk to whom literacy is not unknown. City ways, much diluted, reach such villages, and city cures for rationally comprehended diseases. An interesting problem in such a village lies in the extent to and manner in which the ancient folk medicine loses ground at the expense of modern treatment, and the effect this has in causing old magical behavior to disappear.

No beginning is made on such a problem in this paper, which is no more than a catalogue of some herbal remedies in use in Tepoztlan, State of Morelos, Mexico. This town was a pueblo of the Tlahuicas, a Nahuatl-speaking tribe closely allied to the Aztecs. Its name occurs in the Mendoza[3] and Magliabecchi[4] codices, and first appears in post-columbian history in the account of Bernal Diaz del Castillo.[5] Although less than fifty miles from Mexico City, Tepoztlan is still populated by people almost entirely Indian in blood. Both Nahuatl and Spanish are spoken.

It happens that Francisco Hernandez, physician to Philip II and traveler in Mexico in the sixteenth century, a man of both medical and botanical interests, visited Tepoztlan. At least it is true that a good many plants in his list[6] are described as growing at or near Tepoztlan, Yautepec or Cuernavaca—a cluster of villages in northern Morelos. The writer hoped to be able to compare the uses which Hernandez gave for plants collected three centuries ago in this region with present uses in Tepoztlan, but it proved impossible to identify more than a few on Hernandez's list with plants on the list given below. Some ancient remedial uses probably survive, as do certainly some ceremonial uses (as, for example, decoration of altars with *Plumeria,* still called *cacaloxochitl,* and ceremonial use of *Tagetes,* called *cempoalxochitl*).

The folklore of present-day Mexico is a close compound of Indian and early Spanish elements. Most of the plants in the following list are indigenous to Mexico, but a few have been introduced from Europe. Such plants are *Ruta graveolens* L., *Ricinus communis* L., *Malva parviflora* L., *Peucedanum graveolens* (L.) Benth. & Hook., *Anagallis arvensis* L., *Borago officinalis* L., *Chrysanthemum parthenium* (L.)

[3] *Plate 9* of the Kingsborough reproduction.

[4] Commentary to Section 62.

[5] *The conquest of New Spain* (Hakluyt translation), Book **10**: (chap. 144) p. 67.

[6] FRANCISCO HERNANDEZ: *Cuatro libros de la naturaleza y virtudes de las plantas de la Neuva Espana.* Ed. by Peñafiel, Morelia, 1888 (first translated into Spanish and printed in Mexico in 1615).

Bernh., the pomegranate and the citrus fruits. These enter into the herbal pharmacopœia of Tepoztlan today, and into remedies that have precolumbian sources; but in no case, except perhaps *Ricinus communis* L., does such an introduced plant bear a Nahuatl name. No doubt the Spaniards introduced new ways of using wild plants as remedies, and no doubt they seized upon native species resembling those with which they were familiar, and instructed the Indians in their use.

But in the large the folk medicine of such a Mexican village as Tepoztlan is probably more Indian than European. The Aztecs particularly had a vast knowledge and practice of herbal medicine. The extensive list of Hernandez and the frequent references in Sahagun and the other early writers testify to this, as does equally the great body of plant lore of the contemporary Mexican population. Among the Aztecs there was something of a systematic view of disease and its treatment; there was more than one deity presiding over special forms of sickness, that had to be propitiated.

The information embodied in the following list was obtained largely from one informant, a woman of middle age. She had had a little schooling, but her life was one entirely without influence of the written word; she represented the average run of folk-culture of the town. From her were obtained the names and uses of one hundred and five local medicinal plants. (About half of these descriptions were identified with botanical names and appear below.) It is clear that the information of this one person was by no means exhausted. Yet her knowledge was probably not unusually great; she did not assume to be a *curandera* (*Tepahtiani*); as she put it, she did not "know how to boil" (*sabe hervir*). Many of her ethnobotanical items were checked against the knowledge of other persons; sometimes additional but very rarely contradictory information was obtained. The folk knowledge of the village is fairly consistent.

In the list below the Spanish name precedes the Nahuatl term for each plant. A dash in either position indicates that the informant knew no equivalent in the other language. The Nahuatl names, transcribed by a person without phonetic training, probably contain errors. The aspirate or fricative following a vowel which Spanish grammarians indicate with the *saltillo* accent is here indicated with the letter "h." An asterisk indicates that no actual specimen was identified but that the plant is sufficiently notorious to be included.

SELAGINELLACEAE

1. SELAGINELLA CUSPIDATA Spring.
——— *Tepechayohtli* ("chayote of the mountains"). A boiled infusion of this plant is taken internally for a disease of pregnancy known as *necaxanilli* ("loosening" of the female organs), in order, it is said "to fix the placenta."

AMARYLLIDACEAE

2. *POLIANTHES (TUBEROSA L.)
Azucena. Omixochitl. This plant does not grow in Tepoztlan, but is imported to combine with a species of *Laelia* for a use described under the next following name. The plant is probably the same as that known under this name to the ancient Aztecs. The name means "bone flower" and refers perhaps to its color.

ORCHIDACEAE

3. LAELIA *sp.*
——— *Tzacxochitl.* The pseudobulb of this plant is ground with that of *Polianthes* and boiled with sugar and chocolate. The resulting potion is taken by a pregnant woman to prevent the abortion which would otherwise follow when she conceives a sudden appetite that she is unable to satisfy. "All of a sudden she wants to eat something; she cannot get it; so she takes *tzacxochitl* so that the child does not fall."

The plant does not grow in Tepoztlan itself, but is obtained from the *tezcal*, a rocky area on the slopes of the mountain.

URTICACEAE

4. PARIETARIA PENNSYLVANICA Muhl.
Tripa de Judas. Tepanzozmahtli. Relatives of this plant, some of which are doubtless called by this same Spanish name, "the guts of Judas" are eaten as greens in Europe. In Tepoztlan the entire plant is eaten, boiled, as a remedy for "internal inflammations." It also enters into remedial compounds; one such is described below under no. 60, *Chrysanthemum parthenium* (L.) Bernh.

AMARANTHACEAE

5. IRESINE INTERRUPTA Benth.
——— *Tlatlancuaye.* The plant is ground up and steeped with other herbs and placed on the lungs and abdomen to reduce the fevers. One such recipe includes rose leaves, wine and coriander.

PAPAVERACEAE

6. BOCCONIA ARBOREA S. Wats.
Gediondillo. ——— A piece of the leaf is plastered on the temple with soap to cure headache. Other plants are sometimes used, and quite commonly a patch of porous plaster.

CRUCIFERAE

7. LEPIDIUM DENSIFLORUM Schrad.
Lantejilla.——— As with other crucifers, the stinging taste of this plant probably suggested its local use. It is steeped in alcohol and placed on the chest to cure a cold.

LEGUMINOSAE

8. CAESALPINIA PULCHERRIMA (L.) Swartz.

Flor de camaron. ——— This plant of wide distribution, known in English-speaking countries as "Barbados Pride." "Flower Fence," "Dwarf Poinciana," etc., is known in Tepoztlan as "shrimp flower." The leaves are boiled with the flowers of the *cabellito de angel* tree (probably *Ceiba pentandra* (L.) Gaertn.), with manzanillos, raisins, licorice and a fragment of armadillo shell to prepare a remedy, applied externally, for whooping cough.

9. CASSIA LAEVIGATA Willd.

Guajillo. Yehcapahtzin. The meaning of the Nahuatl term is "wind-medicine." Perhaps this is in reference to the fact that it is used for troubles of the respiratory tract. The plant is ground in alcohol with *Senecio salignus* DC., and the infusion rubbed on the chest.

10. ERIOSEMA GRANDIFLORUM (S. & C.) Seem.

Guayabillo. ——— An infusion of the leaves is used to wash sore feet.

11. MUCUNA sp.

Ojo de venado. ——— The seed of this tree, its appearance suggesting the local name "deer's eye," is widely worn in Mexico as a charm. The tree does not grow in Tepoztlan but the seeds are imported for sale. In many parts of Mexico the seeds are worn as a charm against the evil eye, but in Tepoztlan they are worn to keep off the evil spirits of the air that cause the disease generally known by the same name, *los aires*, or, in Nahuatl, *Yehyecahuiliztli.* These evil spirits (*yehyecatzitzin*), are an important cause of disease in Tepoztlan, and besides the numerous herbal treatments which appear in this list for troubles so caused, there are many ritualistic treatments, as well as an elaborate technique for propitiating the malevolent spirits. The *Mucuna* seeds are generally perforated, and bits of colored yarn are put through the holes. Bright-colored yarn is commonly employed in many connections to propitiate *los aires.*

RUTACEAE

12. RUTA GRAVEOLENS L.

Ruda. ——— This European plant with widespread popular remedial associations was introduced into Tepoztlan together with its therapeutic reputation. A recipe there collected provides that the plant be boiled with *Salvia microphylla* H. B. K. and an unidentified plant, apparently a mint (according to Standley), called locally *poleo del monte* or *huatlaxictzi.* The infusion is taken for abdominal pains. The plant is also used to wash persons affected by *los aires* (described under no. 59, *Piqueria trinervia* Cav.).

13. CITRUS AURANTIFOLIA (Christm.) Swingle.

Flor de limon. "Limonxochitl." Lime flowers boiled in water with cinnamon and sugar added form one of the many remedies for a disease known as *la mohina* (fretfulness; peevishness). This disease is characterized by persistent anger or ill-temper. There are a number of such strong emotional states which are considered and treated as diseases in rural Mexico. In *la mohina* various warm flavored drinks are given to soothe the patient.

MALPIGHIACEAE

14. THRYALLIS GLAUCA (Cav.) Kuntze.

——— *Xaxaxacotic.* This plant, together with *Hypericum pratense* Schlecht and two unidentified plants known as *huitlatenaxihuitl* and *ihilacatzihuitl,* is boiled and administered to pregnant women suffering from a disease called *costumbre blanca* ("white menses") or *iztaccocoliztli* ("white sickness"). This remedy is also administered for the different sickness known as *necaxanilli,* referred to under no. 1, *Selaginella cuspidata* Spring.

EUPHORBIACEAE

15. *Ricinus communis L.

Digerillo. Axaxaxoxihuitl. The leaves are boiled and administered internally for fevers. The informants knew no remedial use of the seeds, but said that the flowers, when dry, are pressed and the oil extracted for burning.

ANACARDIACEAE

16. Schinus molle L.

Pirun. ——— This common tree, introduced from Peru, enjoys a wide variety of local names and usages, both curative and culinary, in Mexico.[7] In Tepoztlan, among other uses, the leaves are steeped in water and applied to parts of the body affected with rheumatism.

MALVACEAE

17. Malva parviflora L.

Malvas. ——— This plant, of European introduction and folk medicine, is boiled with *Piqueria trinervia* Cav., *Verbena polystachya* H. B. K., and a rose known as *rosa de Castilla,* and the infusion taken internally for fevers.

18. Malvaviscus Conzattii Greenm.

Flor de molenillo. Atlatzompililli. This plant enters into recipes for cough medicines. It is boiled with *Caesalpinia pulcherrima* (L.) Swartz, and a piece of armadillo shell, both of which are often used in other combinations to treat coughs.

GUTTIFERAE

19. *Mammea americana L.

——— *Pitzli.* This word means simply "kernel." It is more particularly applied to the stone of the mamey which, ground, enters into cathartic compounds in Tepoztlan.

HYPERICACEAE

20. Hypericum pratense Schlecht.

Sangrinaria. ——— European relatives of this plant are rich in folk associations. In Tepoztlan the Mexican plant is an ingredient in the remedy described under no. 14, *Thryallis glauca* (Cav.) Kuntze.

CACTACEAE

21. Heliocereus speciosus Britton & Rose.

——— *Ahuaxochitl.* The name, meaning simply "thorn-flower," was doubtless applied to many cacti. The flowers of this species are boiled, and the infusion taken internally for colds.

[7] Paul C. Standley. *Trees and shrubs of Mexico.* Contr. U. S. Nat. Herb. **23**: 661. 1923.

LYTHRACEAE

22. Heimia salicifolia (H. B. K.) Link.

Yerba jonequil. Xonecuilli. This herb is ground up in alcohol and applied very hot for rheumatism, as one takes the steam-bath in the *temazcal*, (the pre-Columbian sweat-house still in general use throughout rural Mexico.) Hernandez has a "*xonecuilpahtli*" which he says was used as a remedy for colds, but it is not possible to identify his description.

PUNICACEAE

23. Punica granatum L.

Granada. ——— The leaves of the European pomegrante are used as a wash for the lips when they are affected by a disease characterized by whiteness of the lips and known as *camapalaniliztli* ("rotten mouth"). The leaves of the guayaba (*Psidium guajaba* L.) are added and both roasted and ground before making the infusion.

OENOTHERACEAE

24. Oenothera mexicana Spach.

Yerba del golpe. ——— As its name indicates, this plant is used for bruises. An infusion is made and minor lesions are washed in it.

UMBELLIFERAE

25. Peucedanum graveolens (L.) Benth & Hook. (Syn: *Anethum graveolens* L.)

Hinojo. ——— This European plant forms an ingredient in recipes for remedies taken internally to reduce restlessness during fevers. In one such recipe the following are boiled together with this plant: *Flor de tilia* (*Tilia* sp.); *flor de manita* (not identified); *flor de nacahuite* (*Solanum fontanesianum* Dunal); *la peonia* (*Peonia* sp.); nutmeg; cinnamon; and magnesia powder.

PRIMULACEAE

26. Anagallis arvensis L.

Coralillo. ——— The leaves of this European plant are boiled and applied to inflammations.

OLEACEAE

27. *Fraxinus sp.

Fresno. ——— The leaves of the ash are mixed with wine and applied as a poultice for headache.

LOGANIACEAE

28. Buddleia sessiliflora H. B. K.

Lengua de vaca. Pahtlaxoxoctic. The Nahuatl name of this plant means "green medicine." It is common in Tepoztlan and used for a variety of ailments.[8] The leaves are applied to the lungs to reduce fever. Mixed with suet the leaves are applied to the gums as a poultice for toothache. The plant also has a (probably purely magical) use in connection with cookery. Tortillas are cooked on a flat clay griddle, the *comal*. Some of the leaves of this

[8] As elsewhere in Mexico. See Standley, Contr. U. S. Nat. Herb. **23**: 1145. 1924.

plant are ground in *nejacote* (*nexacotl* or *nexatl*—the water in which corn is cooked with lime). Lime is added to these ground leaves and the preparation rubbed on both faces of the *comal* the first time the *comal* is used. Otherwise it is said the *comal* would break. Sometimes, when the *comal* is used thereafter, the preparation is rubbed on the upper face only.

POLEMONIACEAE

29. Bonplandia geminiflora Cav.
——— *Tetzotzo.* This plant is boiled together with *Solanum nigrum L.*, and the infusion taken as a purge. *Verbena polystachya* H. B. K. may also be added.
30. Loeselia mexicana (Lam.) Brand.
Espinoncillo. ——— This plant does not grow in Tepoztlan but is brought in from near by Cuernavaca. The leaves are boiled and the infusion taken as a purgative in fevers.

HYDROPHYLLACEAE

31. Wigandia kunthii Choisy.
Flor de chichicascle. Tzitzicaztli or *pahpatlanuac.* The leaves are ground and boiled and the infusion taken for abdominal pains.

BORAGINACEAE

32. Borago officinalis L.
Boraja. ——— This European plant is steeped in water and the infusion drunk to cool fevers.
33. Tourneffortia densiflora Mart. & Gal.
Yerba rasposa. ——— The leaves are rubbed on blisters. The scabrous character of the leaves suggests a counter-irritant.

VERBENACEAE

34. Verbena polystachya H. B. K.
Yerba de San Jose. Zanhuanaxictzi. The Nahuatl name of this plant is of course a hybrid term. It is puzzling to find a plant referred to in one of two idioms in current use as Saint Joseph's plant and in the other as the plant of Saint John. A use is described in connection with no. 17, *Malva parviflora* L.
35. Lippia dulcis Trev.
Yerba dulce. ——— Widely known in Mexico under this name, in Tepoztlan the plant is boiled with the flowers of a tree, probably *Ceiba pentandra* (L.) Gaertn., (known as *cabellito de angel* or *xiloxochitl*), and manzanillos to make a remedy applied externally for coughs.

LABIATAE

36. Ocimum micranthum Willd.
Albahaca. ——— A little of this mint is placed in the ear to stop earache.
37. Salvia mexicana L.
——— *Tlapachichin.* A use of this plant is described under no. 54, *Viguera grammatoglossa* DC.
38. Salvia microphylla H. B. K.
Mirto. ——— A use of this plant is described in connection with no. 59, *Piqueria trinervia* Cav.

39. Hedeoma piperita Benth.

Tabajillo ——— This plant is boiled with brown sugar and the liquid taken internally for abdominal pains.

SOLANACEAE

40. Nicotiana tabacum L.

Tabaco cimarron. Cuahuihitl. The Nuhuatl form given in Simeon's dictionary and elsewhere is *cuauietl*, but the local informant gave the form indicated above. The remedial use in Tepoztlan is of a boiled infusion as a wash to the abdomen for abdominal pains.

41. Solanum fontanesianum Dunal.

Flor de nacahuite. Nacahuixochitl. The plant is boiled and the liquid taken internally for cough.

42. Solanum madrense Fernald.

Flor de clamaclancle. Tlamatlantli. This plant, boiled and mixed with alcohol, is used as a remedy when a nursing baby vomits. The mother washes her breasts with the preparation and also takes a little internally. Then the child is allowed to nurse. A suggestion by the informant that the trouble came from teething tempts the writer, inexperienced in Nahuatl etymologies, to derive the local name from a Nahuatl root meaning "to quiet" and the word *tlantli* (teeth).

43. Solanum nigrum L.

Yerba nora. Tohonechichi. Both the Spanish and the Nahuatl names are common in Mexico for species of *Solanum.* This one in Tepoztlan is boiled and mixed with alcohol and applied externally for inflammations and swellings. It is also used as a wash to cool fevers.

44. Datura candida L.

Florefundia (*Florepondia*) or *Bomba.* ——— The petals are coated with grease and placed on the gums to alleviate toothache.

45. *Lycopersicum esculentum Mill. (Syn: *Solanum lycopersicum* L.)

Jitomate. Xitomatl. An infusion of tomato leaves is applied to granular eruptions.

SCROPHULARIACEAE

46. Castilleja arvensis C. &. S.

Saumyate. Catoxictzi. European species also have uses in folk medicine. The Tepoztlan use is described in connection with no. 59, *Piqueria trinervia* Cav.

ACANTHACEAE

47. Jacobinia spicigera (Schl.) Bailey.

Muicle. ——— This name is apparently a corruption from Nahuatl, but the informants regarded it simply as a Spanish term. Standley[9] gives several Mexican remedial uses and also mentions its employment as a dye. In Tepoztlan the plant is boiled in water with sugar and taken by pregnant women. It is one of a number of plants which are collected and brought to Mexico City to sell there.

CAPRIFOLIACEAE

48. Sambucus mexicana Presl.

Sauca. ——— A use of elder is indicated under no. 55, *Bidens leucantha* (L.) Willd.

[9] Standley. Contr. U. S. Nat. Herb. **23**: 1345. 1926.

COMPOSITAE

49. SENECIO. sp.

Lechugilla. Palancapahtli. This plant is boiled with the stone of the mamey, and with the yellow elder, *Tecoma stans* (L.) H. B. K., and an unidentified plant known as *sacasili,* and the resulting infusion taken internally by children suffering from constipation or indigestion.

50. SENECIO SALIGNUS DC.

Jarilla. Ac-chayatl. This plant, ground in alcohol, is combined with *Cassia laevigata* Willd. The infusion is applied externally for respiratory diseases. Standley[10] gives this same local name for the Valley of Mexico, and mentions several remedial uses.

51. TAGETES FLORIDA Sweet.

Pericón. Teyatli. The aromatic plants of this genus make them particularly eligible for folk-medicinal uses. In Tepoztlan the flowers of this species are steeped in water and the infusion used to wash new-born babies during the week after birth. At this time the mother bathes in the *temazcal,* the indigenous sweat-house of stone. If no *temazcal* is available, she may instead wash herself with this infusion.

52. TAGETES ERECTA L.

Simpasuchi. Cempoalxochitl. The "African" marigold of our gardens is the well-known "flower of the dead" of the ancient Aztecs. The plant is widely known throughout Mexico under some modification of the original Nahuatl name, still in use in Tepoztlan. The plant is frequently mentioned under this name in the sixteenth century writings. It was used by the Aztecs to decorate altars and as a part of floral offerings to certain gods. It still has such ceremonial-religious uses in Tepoztlan.[11] It is also used remedially, the flowers being boiled and the infusion drunk for stomach troubles.

53. ALOMIA ALATA Hemsl.

Yerba de Santa Maria. Zohuapahtli. The Nahuatl name, an ancient one applied no doubt to other plants, suggests a remedy for female ailments ("woman medicine"). The use cited in Tepoztlan is of the plant ground and taken in a cup of alcohol with sugar and egg for palpitations.

54. VIGUIERA GRAMMATOGLOSSA DC.

——— *Acahual.* An infusion of the plant is applied to the chests of children suffering from respiratory diseases, such as croup. The other ingredients named are lemon flowers and *Salvia mexicana* L.

55. BIDENS LEUCANTHA (L.) Willd.

——— *Tzitziquilitl.* This plant, together with *Sambucus mexicana* Presl., forms an ingredient in a remedy for eye troubles. The two plants are boiled up with some raisins and the umbilical cords each of a boy and of a girl. For this remedial use umbilical cords in Tepoztlan are not buried as in some other Mexican villages, but kept. "They are worth twenty-five centavos." The presence of the umbilical cords in the remedies is due to a magical application of the fact that an important trouble of the eyes occurs in babies (no doubt *ophthalmia neonatorum*). It is supposed to be caused by the approach to the baby of someone who has recently had sexual intercourse.

56. STEVIA MICRANTHA Lag.

——— *Calpancatoxictzi.* The plant is boiled, mixed with alcohol, and taken internally as a remedy for those ailments thought to be caused by the evil spirits of the air (*los aires,* already referred to under no. 11, *Mucuna* sp.).

[10] STANDLEY. Contr. U. S. Nat. Herb. **23**: 1627. 1926.

[11] As in many other Mexican communities. See, for example, FREDERICK STARR. *Notes on the ethnography of Southern Mexico.* Proc. Davenport Acad. Sci., **8**: 28.

57. CALEA ZACATECHICHI Schlecht.

Prodigiosa. Ahuapahtli. The plant is boiled and the infusion beaten up with egg and sugar and drunk for biliousness. Hernandez lists a plant with the same name, of undetermined identity, used at that time for similar ailments.

58. BACCHARIS sp.

Popote. Popotl. The roots are steeped in alcohol and placed on the gums to relieve toothache.

59. PIQUERIA TRINERVIA Cav.

Harta reina or *Alta reina.* ——— This plant forms a frequent ingredient in mixtures of herbs used in washing the body (it may also be taken internally) of a person afflicted by *los aires,* the evil spirits of the air already referred to. *Los aires* are found wherever there is water—near ravines, springs, fountains or water-tanks. A person going to such a place to wash or bathe may offend these spirits and in return be visted with a variety of complaints, of which the most characteristic are pustular eruptions and paralysis. Treatment of this disease—for the wide range of possible symptoms does not prevent if from being regarded as one disease, a visitation,—is in part accomplished by conciliation of the spirits through gifts and in part by treating the patient. The essential element of this treatment is washing with herbs. There are probably many recipes for such herbal compounds, the most used in the entire Tepoztlan pharmacopœia. This plant is almost invariably included. One such compound includes *Salvia microphylla* H. B. K., *Castilleja arvensis* C. & S., egg, and an unidentified plant known as *arretillas* or *pipiloxihuitl. Piqueria* is also employed for fevers (see under no. 17, *Malva parviflora* L.). The leaves may be used to wash a child afflicted with *el daño* (see under no. 60, *Chrysanthemum parthenium* (L.) Bernh.).

60. CHRYSANTHEMUM PARTHENIUM (L.) Bernh.

Alta mesa. ——— This European plant, generally known as feverfew in United States gardens, receives its local name from a corruption of *altamiza.* Its European folk reputation came with it to Mexico. In Tepoztlan the plant is common. It is cooked with *Parietaria pennsylvanica* Muhl. to form a remedy administered internally to children afflicted with *el daño. El daño* (the hurt; the injury) bears the Nahuatl name of *oquitzahtzitihque* ("making them cry"). It is the local form of the evil eye. When people with "bitter hearts" (*yolchichihque*) look upon children and praise them, the children begin to cry and can not be comforted until some one or another of the accepted remedies, some herbal, some ritualistic, is applied.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

965TH MEETING

The 965th meeting, constituting the 57th annual meeting, was held at the Cosmos Club December 10, 1927.

The Treasurer reported expenditures of $1318.89 for the year, and stated that the active membership of the Society is 235.

The following officers were declared elected for the year 1928: *President,* P. R. HEYL; *Vice-Presidents,* L. H. ADAMS and W. D. LAMBERT; *Treasurer,* O. H. GISH; *Corresponding Secretary,* E. W. WOOLARD, *Members-at-large of the Council,* N. H. HECK and L. V. JUDSON.

Program: WALTER A. MACNAIR: *Some physical measurements concerning vitamin D.* (The paper is in press in the Journal of Biological Chemistry.)

966TH MEETING

The 966th meeting was held at the Cosmos Club January 7, 1928.

Program: President J. P. AULT: *Ocean surveys—problems and developments.* (Printed in this JOURNAL for March 4, 1928.)

967TH MEETING

The 967th meeting was a joint meeting with The ACADEMY, held at the Cosmos Club, January 19, 1928.

Program: L. B. TUCKERMAN: *Theoretical principles underlying balloting.*

GEORGE H. HALLETT, Jr.: *An appraisal of election methods.*

968TH MEETING

The 968th meeting was held at the Cosmos Club, January 21, 1928.

Program: E. O. HULBURT: *Ionization of the upper atmosphere.* Using laws, either known or based on apparently reasonable assumptions of the gas pressures in the high atmosphere, the ultra-violet light, the recombination of the electrons and ions and their diffusion, the form of the electron bank in the high atmosphere is calculated and found to be in fair agreement with that required by the data of wireless telegraphy for day and night conditions. For a summer day (North Temperate Zone) the maximum density of the electron bank is about 3×10^5 electrons per cc. at a height of about 200 km; the corresponding values for a winter day are about 2×10^5 and 150 km, and for a summer or winter night about 8×10^4 and 100 to 150 km. There is an ion bank below the electron bank, whose maximum density is probably less than 10^8 ions per cc. (*Author's abstract.*)

W. J. ROONEY: *Earth-resistivity measurements and their bearing on the location of concealed geological discontinuities.* A review of the earth-resistivity investigations of the Department of Terrestrial Magnetism, 1924–1927, shows a consistent relationship between the variations of resistivity with depth and the geological structure of the regions surveyed. The possibility of using resistivity determinations to locate certain types of discontinuity in vertical structure is shown by six specific experiments in Washington and in the copper country of Michigan. Results indicating discontinuities at depths beyond 1000 feet have been secured, but independent determinations to confirm the resistivity indications are seldom available for depths much greater than 100 feet. Hence the depth limit for practical application of the method is uncertain. Given a fairly uniform lateral distribution of material, resistivity measurements made on the surface will disclose quite accurately the distance to underground water and the depth of overburden, and may be used to determine the thickness of rock strata, provided the rocks differ sufficiently one from the other. In general, sedimentary rocks have fairly low resistivities, 5000 to 20,000 ohms per centimeter cube, while the values for the denser igneous rocks run from five to twenty times higher. The resistivity of soils varies widely with composition and with the amount and character of the solutions they contain. (*Author's abstract.*)

H. E. Merwin, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY

598th meeting

The 598th meeting was held in the National Museum, October 11, 1926.
Program: Dr. Aleš Hrdlička, *Explorations in Alaska and northeast Asia.*

599th meeting

The 599th meeting was held in the National Museum, November 16, 1926.
Program: Dr. J. Walter Fewkes, *Elden Pueblo.*

600th meeting

The 600th meeting was held in the National Museum, December 21, 1926.
Program: Wallace Thompson, *Appraising the Mexican.*

601st meeting

The 601st meeting was held in the National Museum, January 18, 1927.
Program: Warren K. Moorehead, *Prehistoric moundbuilders.*

602d meeting

The 602d meeting was held in the National Museum, February 3, 1927.

Program: Mrs. Zelia Nuttall, of Coyoacan, D.F., Mexico.—*New light on ancient American calendars.* The speaker reviewed the evidence for her well-known theory of the origin of the Maya and Aztec calendars, first proposed at the Oxford meeting, 1926, of the British Association for the Advancement of Science. As all the centers of ancient American culture are situated within the tropics, the inhabitants had a simple means at hand for learning the true length of the solar year. The sun itself registered it for them, for within this zone the sun passes twice a year through the zenith, causing the striking phenomenon that, for a moment about noon, all vertical objects are shadowless.

Mrs. Nuttall submitted an array of evidence—historical, documentary, archeological, and photographic—to substantiate her conclusion that Mexicans, Mayas, Ecuadorians, Peruvians, and others inhabiting this zone, observed the strange periodical disappearance of shadows and interpreted it as "a descent of the Sun-God." As this descent is always immediately followed by rains caused by the heat of the vertical solar rays, this momentary descent, which marked the advent of the rainy season, was of transcendental importance to the native agriculturists. After this "descent of the god" they could confidently sow the seeds of maize and other food plants with a certainty of rain. The theory would explain why, as civilization gradually advanced under favorable conditions, this phenomenon, first observed by means of any vertical staff, pole, or stone, led to the erection of pillars, stelae, altars, towers, shrines, and the temples ultimately erected on the summits of pyramidal structures, which were to serve as worthy seats or places of rest for the descending Sun-God and offer constant invitations for him to descend and linger.

603D MEETING

The 603d meeting was held in the National Museum February 24, 1927.

Program: Dr. ALFRED V. KIDDER.—*Cliff-dwellers of Arizona and their predecessors.* The southwestern archaeological field embraces those parts of Arizona, New Mexico, Colorado, and Utah, which contain the remains of the sedentary, agricultural type of Indian, commonly known as Pueblos. The present range of the Pueblo Indian is restricted to the drainage of the Rio Grande and the Little Colorado. Ruins of ancient villages closely similar to those of the historic Pueblos are found throughout a far greater range. They consist of cliff houses, valley towns, and mesa-top dwellings, ranging in size from a half dozen to a thousand rooms. The problem of Southwestern archaeology is the arrangement of these ruins in relative chronological order and the determination of the origin and growth of the culture responsible for them. Until about fifteen years ago the early stages of Pueblo civilization were not recognized. The explorations of the Peabody Museum of Harvard, the Natural History Museum of New York, the National Geographic Society, and other institutions have resulted in the discovery and description of these early stages, the first being the Basket-maker, a phase marked by primitive agriculture, lack of pottery and of stone architecture. This was followed by the Post-basket-maker period which saw the introduction of pottery and the beginnings of masonry construction. The Post-basket-maker was succeeded by the Pre-Pueblo, in which pottery was greatly improved, houses were enlarged and strengthened, and the typical massed type of dwellings first introduced. We are thus now in possession of the outline of the entire growth of the Pueblos from nomadism up.

604TH MEETING

The 604th meeting was held in the National Museum March 17, 1927.

Program: MATTHEW W. STIRLING.—*Recent explorations in Dutch New Guinea.* The interior of the island is largely unknown as it has never been completely mapped or penetrated. The purpose of the expedition under Mr. Stirling's leadership was three-fold: the making of maps; addition to our knowledge of the country; and a study of the peoples inhabiting this region. The expedition was scientifically outfitted, and motor boats and an aeroplane were used as means of transportation. Entrance was effected from the northern coast, thence up the Rouffaer River, to the central range known as the Nassau Mountains, one of the great ranges of the world. The island is inhabited mainly by Papuans, of which three distinct groups were visited: those of the coast, those of the great Lake plain, and those of the Van Reese Mountains. The foothill region, above the Lake plain, is uninhabited for a distance of about thirty miles. After passing this belt, the Negrito pygmy peoples are encountered. The average height of the men is 152 cm, that of the women 145 cm. A permanent camp was established at Tombay, located in the interior of the Nassau Mountains. The peoples have an advanced system of agriculture, of which the staples are: sweet potatoes, sugar cane, taro root, bananas, and lemons. They have a loose type of clan organization. They are polygamists in theory and monogamists in practice. They believe in some form of immortality, but their religious concepts were hard to investigate, as they were very reluctant to discuss anything concerning these matters. The pygmies bury their dead, while the Papuans practise platform burial near the home of the deceased.

605TH MEETING

The 605th meeting was a joint meeting with The ACADEMY and was held in the assembly hall of the Cosmos Club April 21, 1927.

Program: Dr. FREDERICK W. HODGE, of the Museum of the American Indian (Heye Foundation).—*The Zuni Indians of New Mexico.* (To be published in the Proceedings of The ACADEMY, This JOURNAL, vol. 18, 1928.)

606TH MEETING

The 606th meeting was held in the National Museum, October 25, 1927.

Program: Dr. JOHN M. COOPER.—*Field notes on northern Algonkian magic and divination.* In order to determine the limits of western extension of a number of culture traits that are characteristic of the Tête de Boule and Montagnais-Naskapi tribes of Quebec and Labrador, the speaker undertook last summer, 1927, a reconnaissance of the Cree and northern Ojibwa bands of the southern and western James Bay region and of the Albany River area. The belt covered extended about a thousand miles westward of the St. Maurice River to the source of the Albany River and averaged about two hundred miles in breadth. Scapulimancy, or divination by the marks and cracks on flat bones held against the fire, was found to extend continuously from the St. Maurice section to half way up the Albany, and an apparently reliable report was obtained of its occurrence as far west as the country north of Lake of the Woods. Scrying, or divination by peering into water in a dish or into some substitute therefore, was found universally distributed throughout the area studied. Other types of divination, common especially in the eastern half of the area, are those carried out with otter carcasses or otter paws, with beaver haunch bones, with beaver shoulder blades, with bear skulls, and with grouse wishbones. Foetal inclusions are universally used in hunting-magic, as are also singing and drumming for game. The caribou bezoar is used in the eastern section of the area. To bring the north wind, the buzzer, the bull-roarer, and the snow man are resorted to. A number of cradle charms are used, particularly the bit of navel string attached to the cradle bow. The cylindrical or barrel-shaped conjuring tent, that has been reported from various points from northern Labrador to Minnesota, was found of universal extension over the whole belt studied, as was also the whole conjuring complex that is associated with this very distinctive type of tent. In fact, throughout the whole belt is found a culture fundamentally identical in all its features, material and social, with only minor local differences.

607TH MEETING

The 607th meeting was held in the National Museum November 22, 1927.

Program: FRANK H. H. ROBERTS, JR.—*A late Basket-maker village in the Chaco Canyon.* A late Basket-maker village consisting of 18 houses, 48 storage bins and a kiva excavated in the Chaco Canyon, New Mexico, during the summer of 1927, by Mr. Roberts, has given considerable information as to the house-type of the period. In general, the crude, one-room domicile consisted of an oval or rectangular excavation, two and one-half to three feet deep, 12 to 14 feet in diameter, roofed over with a pole, brush, and plaster superstructure. The earth walls of the excavation were lined with large stone slabs which in turn were covered with adobe plaster. Four posts set in the floor a short distance from the walls supported the superstructure. These posts carried a rectangular framework against which the upper ends of small poles, the lower ends of which were embedded in the earth around the periphery of the excavation, were placed. The latter formed the sloping upper walls of the house. The rectangular space at the top probably had a flat roof with an opening in the center to serve as a smoke hole, possibly on occasions as an entrance. The entire wooden structure was then covered with twigs, bark, leaves, earth, and plaster. In the center of the room was an oval or rectangular firepit on the north side of which was a small, circular hole which is probably analogous to the sipapu of kivas. Most of the houses appear to have had an entry way on the south or southeast side. The doorway of the main room gave access into a short passage which in turn opened into a small oval room. The ante-chambers of these domiciles are quite suggestive of the entry-ways into earth lodges built by modern Indians, by the Eskimo, and even by the Palaeo-Asiatic peoples. The kiva was constructed of slabs in much the same fashion as the dwellings. The inner circle, forming the face of the bench was of smaller slabs than the outer or wall of the room. The diameter above the bench was 40 feet and inside the bench 36 feet. There was a central firepit, a deflector on the south side, but no other features in the room. The roof was supported on four large posts. It is quite possible that in this structure is to be seen the predecessor of the great kivas of the Chaco pueblo cultures. Burials were scattered throughout the village. Skeletal remains showed a group of people with long heads, undeformed. There were very few mortuary offerings. Bowls accompanied three of the interments while the other graves had no funerary furniture.

JOHN M. COOPER, *Secretary*

THE GEOLOGICAL SOCIETY

431ST MEETING

The 431st meeting was held in the Auditorium of the Interior Department Building, November 2, 1927, President BUTTS presiding.

Program: Professor D. J. MUSHKETOV, Director of the Russian Geological Survey: *Recent geological investigations in Turkestan.*

432ND MEETING

The 432nd meeting was held at the Cosmos Club, November 23, 1927 President BUTTS presiding.

Program: Professor L. W. COLLET, Geneva University: *The structure of the Alps.*

JOINT MEETING

A joint meeting of the Society and the ACADEMY was held at the Cosmos Club, December 7, 1927, President WETMORE of the ACADEMY presiding.

Program: Captain M. E. ODELL, of Toronto, Canada: *Scientific aspect of the Mount Everest expedition.*

433RD MEETING

The 433rd meeting was held at the Cosmos Club, December 14, 1927, President BUTTS presiding. The Secretary announced the death of MILTON WHITNEY, SAMUEL SANFORD, FRANK SPRINGER, and I. C. WHITE. Vice-president HEWETT took the chair during the presentation of the address of the retiring president.

Presidential Address: *Variations in Appalachian stratigraphy.*

THIRTY-FIFTH ANNUAL MEETING

The thirty-fifth annual meeting was held at the Cosmos Club after the adjournment of the 433rd meeting, President BUTTS presiding.

The annual report of the secretaries was not read. The Treasurer presented his annual report showing an excess of assets over liabilities of $1,139.36 (book value) on December 10, 1927. The auditing committee reported that the books of the Treasurer were correct.

The results of balloting for officers for the ensuing year were as follows: *President:* D. M. HEWETT; *Vice-Presidents:* S. R. CAPPS, G. R. MANSFIELD; *Treasurer:* H. G. FERGUSON; *Secretaries:* W. W. RUBEY, A. A. BAKER; *Members-at-Large-of-the-Council:* W. F. FOSHAG, M. I. GOLDMAN, J. B. MERTIE, JR., C. P. ROSS, W. T. SCHALLER; *Nominee as Vice-President of Washington Academy of Sciences representing the Geological Society:* CHARLES BUTTS.

W. P. WOODRING, W. W. RUBEY, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

C. E. DOBBIN has been transferred from the Fuel Section of the Geologic Branch to the Conservation Branch of the Geological Survey, of which he is to be field representative of the mineral classification division, with office in Denver, Colorado.

The Petrologists' Club met with the Geological Society on February 28 at the National Museum. Special features of the geological, paleontological, and mineralogical collections were shown by Messrs. MERRILL, GILMORE, FOSHAG, BASSLER, and other members of the Museum's staff.

A paper by Miss FRANCES DENSMORE on the music of the North American Indian was presented before the Academy of Athens, Greece, on March 23.

PAUL C. STANDLEY returned to Washington April 2, after spending four months in botanical field work in Honduras. Most of his time was devoted to a survey of the Lancetilla Valley, near Tela, but three weeks were passed in exploration of the pine forests of the interior of the Republic.

The Baltimore-Washington Section of the American Ceramic Society met at the Olmsted Grill on March 31. Program: L. J. TROSTEL, of the General Refractories Company: *The technical control in the manufacture of refractories;* A. N. FINN, of the Bureau of Standards: *The value of the chemist in the ceramic industry.*

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, April 19.	The Academy
Saturday, April 21.	The Helminthological Society
	The Biological Society
Wednesday, April 25.	The Medical Society
	The Geological Society
Saturday, April 28.	The Philosophical Society
Tuesday, May 1.	The Botanical Society
Wednesday, May 2.	The Medical Society

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Vol. 18 May 4, 1928 No. 9

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication. To facilitate the work of both the editors and printers it is suggested that footnotes be numbered serially and submitted on a separate manuscript page.

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JOURNAL

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Vol. 18 May 4, 1928 No. 9

GEOLOGY.—*Again on Pleistocene man at Vero, Florida.*[1] Oliver P. Hay, Washington, D. C.

In a conversation held recently between an anthropological friend and myself about the finding of human remains in supposed Pleistocene deposits, about 11 years ago, at Vero, Florida,[2] he used an expression which implied that the investigations made there, the reports, and the subsequent discussions, proved disastrous for those who affirmed the presence there of Pleistocene man. This remark has prompted the writer to reconsider the case, after having devoted some years previously and the years since that time to the study of the Pleistocene vertebrates and of the Pleistocene geology of North America. I anticipate to say that I regard the investigations as far from having injured the case of Pleistocene man. In the symposium cited above there was no general agreement on the main question and it would be difficult to say who were farther apart in their conclusions, the geologists or the anthropologists.

When the geologists, the anthropologists and the paleontologists arrived on the spot they beheld a low-lying tract composed of thin beds of slightly consolidated materials which looked as if they might have accumulated within a few centuries and which offered for consideration a being almost universally looked upon as a "leitfossil" of the Recent epoch. The lowest stratum in view was a marine shell bed recognized by all as belonging to the Pleistocene, but by most of the company as appertaining to a late time in this epoch—late, because (1) this bed was composed almost wholly of mollusks apparently all of existing species and because (2) it reposed on a terrace,

[1] Received March 8, 1928.

[2] Journ. Geol. **25**: 1–62. 1917.

the youngest of at least three which, according to the prevailing theory, owed their existence to as many successive submergences during the Pleistocene beneath the sea. Overlying this marine marl was a freshwater deposit from 2 to 4 feet thick, composed of sand mingled with a little vegetable matter, some freshwater shells, many bones of land mammals, and a few of reptiles. This bed is known as No. 2. Lying upon this was found a stratum made up mostly of vegetable debris mingled with sand and containing various fossils. It formed a muck bed and was designated No. 3. It, as well as the underlying bed, No. 2, had evidently been deposited by the small stream which had, doubtless for many ages, wandered over the tract.

Now, under the conditions, material and psychological, how was it possible to find room in those thin deposits of sand and muck, for a Pleistocene creature whose skeleton and whose handiwork did not seem to differ from those of a red Indian?

Dr. Rollin T. Chamberlin, of the University of Chicago, made the main reports in opposition to the asserted presence of Pleistocene man.[3] He granted that the human bones found in strata Nos. 2 and 3 had been covered up as those deposits were laid down. "This formation [No. 2] contains human bones essentially *in situ* beyond reasonable doubt, together with the scattered bones of many extinct vertebrates."[4]

One can not be mistaken in saying that Chamberlin's efforts were expended in the endeavor to prove that the deposits containing evidences of man were of comparatively recent time. A feature which he regarded as of high importance was the discovery, in a bog immediately west of the fossiliferous locality, of a stratum from 2 to 4 feet thick, of a dark brown to black sandstone firmly indurated by oxides of iron and manganese. It was thought that the accumulation and induration of this may well have required considerable time. On examining the deposit where remains of man had been found (Sellards' No. 2 and No. 3) Chamberlin found numerous pebbles, "balls" and "cannon balls" of a similar dark sandstone. These he explained as fragments which had been brought down the creek and rolled on their passage into their globular form. He accordingly argued that the deposits holding the fossils and these balls were probably much more recent than the sandstone stratum of the bog. Also in his second report he retained his opinion that the sandstone had furnished the

[3] Journ. Geol. **25**: 25–39; 667–683. 1917.
[4] Journ. Geol. **25**: 27–28. 1917.

rough materials for the balls; hence "the oldest fill in the creek channel is notably younger than the bog deposit." However, one may argue on the other side. As is well known, sandstones saturated with water containing salts of iron and manganese, in the presence of organic materials may harden rapidly. On the west coast of Florida human skulls and skeletons have been found embedded in masses of bog iron, and the bones themselves are sometimes converted into limonite; and yet we are assured that these human remains are of comparatively recent age.[5] Nor is it necessary to suppose that irregular blocks of sandstone were rolled into balls as they were pushed down stream. Round concretionary masses are common occurrences in bog iron deposits and the formation of these may be effected rapidly. Released by erosion they would need no abrasion and would perhaps increase in size while rolling. It is still more probable, however, that the balls observed at Vero were engendered at the spot where they were discovered. At any rate, the bog sandstone and the creek beds may have been laid down in a relatively short, probably simultaneous time.

In his first report Dr. Chamberlin regarded the bog sandstone as also the source of most of the bones which were found in the creek beds. The animals had, he thought, lived, died, and left their skeletons in the sand before it had become consolidated. Later these bones had been eroded out and transported to their final resting place with the balls just described. This conception appeared to relegate the animals back in the Pleistocene to any convenient time and the deposition of the creek beds forward to any required late date. However, when on Dr. Chamberlin's second visit no bones could be found, either in the bog sandstone or in the creek on their way to the fossil-bearing beds, this hypothesis was abandoned. "The solution of the riddle of the mixture of bones of extinct animals with human bones and pottery was therefore sought on other lines." The critical problem was left "still crying for a satisfactory explanation."

In seeking a solution of the problem Dr. Chamberlin fell into various errors. He appeared obliged to assume a late date for the animals and for man. "Both of these deposits [No. 2 and No. 3] were late in the history of the formations of the region, and the oldest of these formations bears both a paleontological and a topographical aspect of recency."[6] In speaking of the marine coquina deposit he says that it does not bear evidence of great age, its shells being all of living species;

[5] Bur. Ethn. Bull. **33**: 64–66.
[6] Journ. Geol. **25**: 673. 1917.

and he cites the assignment, by geologists, of the terrace on which the coquina reposes to the late Pleistocene. It would have been instructive to tell us what Pleistocene deposits of mollusks are not composed of practically all existing species. The Upper Pliocene of England contains from 90 to 95 per cent of living species of mollusks and this Upper Pliocene corresponds to the lower portion of the American Pleistocene. Dr. Ralph Arnold[7] found in the Pleistocene Upper San Pedro beds, near Los Angeles, abundant molluscan species of which only 9.5 per cent were extinct. In Dr. W. C. Mansfield's list of mollusks[8] are recognized 61 species. Of these there are 19 species (exclusive of young and imperfect specimens) which are not indicated as occurring in the recent fauna. Certainly not all of these are extinct; but no one, I think, can affirm that none of them are. If 6 out of this lot are extinct the percentage will be 10; if only 3 are extinct the percentage will be 5. Another piece of evidence in favor of the early Pleistocene age of the Anastasia marl is the discovery in it of a bone of a camel, as reported by Sellards. What stands in the way of referring the Anacostia marl to the lower Pleistocene?

Dr. Chamberlin fell also into the error of accepting without further investigation the view that the terrace was a late Pleistocene marine formation. It may be permitted to call it the youngest terrace, but that does not fix its place in the epoch. Neither it nor the terraces above it are of marine origin. This is demonstrated by the total absence of marine fossils in all of them, except where local sinkings of the coast have occurred since the formation of the last terrace; and these depressions amount to only a few feet. Had those terraces been submerged they would have been filled with mollusks. Similar terraces are common in Europe along the coasts and many rivers, and on our western coast, and they abound in fossils.[9] Our east coast terraces are of river origin and were laid down in probably the earliest Pleistocene when the continent stood at a much higher elevation than now. It was probably at this time when the now submarine channel of Hudson River was excavated and the channels of many of our other great rivers were cut deep, to be refilled at a later time. Drs. T. C. Chamberlin and R. D. Salisbury[10] reject the marine theory of the terraces along our Atlantic coast. The reader ought to peruse, on

[7] Mem. Calif. Acad. Sci. **3**. 1903.

[8] Fla. Geol. Surv., 9th Ann. Rept., p. 78.

[9] See HAUG, *Traité de géologie,* and ARNOLD, Mem. Calif. Acad. Sci. **3**. 1903.

[10] *Text Book of Geology* **3**: 452–454. 1906.

pages 412 to 414 of the 15th volume of the *Journal of Geology,* a review signed T. C. C.,[11] in order to obtain that writer's opinion about the marine origin of the terraces.

Dr. R. T. Chamberlin further assumed that the animal remains were swept by floods into the positions they occupied. No proof can be afforded that a single bone was thus carried into those creek deposits, although this transportation would not involve their belonging to a Pleistocene stage older than that of the deposit No. 2. However, the animals found there probably died not far distant.

In his efforts to prove the recency of the mammalian remains and the deposits at Vero, Dr. Chamberlin hit upon two ideas which have come to other minds since that time, if not before, and which appear to have given them much comfort. These are (1) that the southern climate was better adapted for mammalian life than that of the northern States and (2) that the mammalian fauna existed longer there than it did elsewhere. These notions appear to inspire a sort of poetical feeling, for the conditions are spoken of almost always as "that genial southern clime" and the animals are tenderly mentioned as "lingering longer there."

Doubtless during the Wisconsin glacial stage the mammals of the northern regions were forced southward, even into Florida and Texas. Reindeer reached Kentucky, musk-oxen migrated to Oklahoma, *Elephas boreus* (*E. primigenius,* of authors) probably strayed as far south as Florida and Texas, and so with many other northern species. When, however, the glacier retreated these animals did not remain there, but they kept as near the glacial front as they found it comfortable. Mastodons and certain elephants doubtless lived in Florida during the wane of the Wisconsin stage, but there is not a whit of evidence that they lived there at a later time than they did in New York or Michigan. For a reindeer and a musk-ox the genial climate is the one which furnishes plenty of snow and the kind of food they need.

Now as to the matter of lingering, it is a certainty that many of the mammals found in the Pleistocene beds at Vero, Peace Creek, Melbourne and many other places in Florida did linger there and elsewhere and become extinct only at a later time. *Mylodon,* one or more species of tapirs, the great ox *Bison latifrons,* and *Equus complicatus* appear to have lived on until the Sangamon interglacial. The American mastodon, *Elephas columbi,* and the giant beaver lived long after

[11] Journ. Geol. **15**: 412–414. 1907.

the disappearance of the Wisconsin glacier and left their bones in the deposits overlying the drift. It is also true that many other species, specifically unchanged, are still lingering and they constitute the existing fauna of North America. With the species named above there existed at Vero, Peace Creek, and Melbourne *Megatherium, Chlamytherium, Glyptodon, Elephas imperator*, the Florida saber tooth tiger, and one or more camels. In regions farther west and northwest, as at Frederick, Oklahoma; Rock Creek, Texas; "Hay Springs" (Peters) Nebraska, and in the Aftonian deposits of western Iowa, there are found also numerous species of horses, camels, *Mastodon mirificus* and *Elephas imperator;* and these appear not to have existed anywhere after the first interglacial stage. Had they continued to exist their remains ought to be found in the deposits overlying the Kansan, the Illinoian, or the Wisconsin drifts. Outside of the drift region, in the Appalachian ranges from Lookout Mountain, Tennessee, to Frankstown, Blair County, Pennsylvania, in caves and fissures, have been collected numerous species of mammals of apparently mid-Pleistocene times, but none of those mentioned as being characteristic of the first interglacial stage. In northwestern Arkansas an abundant fauna has been discovered in a fissure, but among these were no *Elephas imperator*, no *Mastodon mirificus*, no camels, no *Glyptodon*, no *Megatherium*, no *Chlamytherium*. In the Mississippi embayment, extending from Cairo, Illinois, to the Gulf and on the south from western Louisiana to western Alabama, a very interesting fauna has been collected, consisting of mastodons, elephants, one or two species of horses, tapirs, megalonyx, mylodon, etc.; but again the forms which are taken to be peculiar to the first interglacial, or Aftonian, stage are not found. We are justified, I maintain, in believing that, instead of a few lingering here and there some hundreds of thousands of years, perhaps to conduct to the happy hunting grounds the spirit of some "mid-Recent" red man, they ceased existence near the close of the first interglacial, or at most did not live beyond the Kansan glacial. Therefore, I hold that the creek bed No. 2, at Vero, and its contents belong in the first, or Aftonian, stage of the Pleistocene.

During his second visit to Vero Dr. Chamberlin was especially engaged in determining, at the localities where human remains had been discovered, the relations of beds Nos. 2 and 3 at their plane of contact. His purpose was to learn whether the human remains were really found in No. 2 or in what he regarded as the very recent No. 3. As to the skeleton No. 1, the first one found, he thought that the 9 inches of brown sand overlying it was too thin to permit a safe conclusion.

At the locality of the second skeleton, where there had occurred more vigorous stream action, Dr. Chamberlin carried the plane of contact nearer the layer of shells. His conclusion was evidently that the human bones belonged in the muck layer or at least might have belonged there. That he proved this he certainly would not assert; nor would he perhaps regard it as necessary. The writer believes for the reasons stated above that it can not be successfully contested that the stratum No. 2 is of early Pleistocene age. In case the muck layer belongs to the Recent epoch we may inquire what was the condition of that little valley during the intervening 200,000 or 300,000 years? I think that no evidence can be furnished that additional deposits were laid down and afterwards removed. It is, as already mentioned, probable that the muck had been accumulating ever since the beginning of the Kansan glacial stage, and I believe that the fossils found testify to this proposition. If, now, this is true what becomes of deductions based by Dr. Chamberlin on the skillful work which he did at Vero?

Dr. Chamberlin[12] emphasizes the importance of the presence of the pottery found at Vero. No pottery was found in stratum No. 2. However, nobody has the knowledge or the authority to say that pottery was not used in America by Pleistocene man. As for myself, I would say that its presence in No. 3 is evidence that early man did use it. Recent revelations indicate that in America in Pleistocene times the art of working flint was far more advanced, in some tribes at least, than had been suspected. The same may be true as regards pottery.

It is the writer's conviction that Dr. Chamberlin erred as respects the age and origin of the coastal terraces, the age of the Anastasia marl, the ages of the creek beds and of the bog sandstone, the origin of the spherical concretions, the manner of accumulation of the bones, the composition and fate of the various elements of the fauna, and the position and age of the human remains. Nor can I give assent to any one of the four conditions set forth at the close of his second report.

The geologists appeared to be in agreement that there had passed between the deposition of stratum No. 2 and No. 3 no considerable lapse of time. In that case the apparent break may mark the begin-

[12] Journ. Geol. **25**: 682. 1917.

ning of the Kansan glacial stage. The change of climate produced a more swampy condition of the little valley and made it a less agreeable resort for such of the larger animals as yet remained and there was a denser growth of plants. The muck accumulated slowly. There appears to be no evidence of either elevation or depression. If the time that has elapsed be taken as 300,000 years and the thickness as 50 inches the amount added would be one inch in six thousand years. The upper layers may be comparatively young; the lower, very old. While it is possible that some bones were washed up from the lower layer there is no necessity for granting it, for they belong to species which continued to live in that stage.

Dr. Aleš Hrdlička's theory of the presence of human bones in the deposits at Vero was short and simple. They were purposely buried there. No claim was made that there was any visible disturbance of the sand, marl, and muck such as would be caused by digging and refilling the grave. There might at first have been some unnatural mingling over the cadaver, but the materials would soon regain their former relations. He reported that evidences of this tendency to reestablish original conditions were observed already on the dump left by the steam excavator.

Dr. George Grant MacCurdy, of Yale University, recorded his conclusions in two papers.[13] In each article he figured three of the flint spalls collected by Dr. Sellards. Two were found in stratum No. 2. One of these was shaped somewhat like the blade of a broad ax. The height was one inch; the length of the thin edge was an inch and five-eighths. Dr. MacCurdy's explanation of its presence in the middle bed was that it had worked its way down by the aid of growing roots or burrowing animals. One may be curious to learn at what point of such a spall a root-cap could strike so as to guide it down through a bed of muck. More spalls were found in No. 2 than in the bed above it. Might not one as well assume that some had been washed up from the lower bed into the upper one? The number of animal burrows that have been dug in our broad land may be just a little short of infinite and arrow heads and spalls might work their way into these; but has any anthropologist ever found a flint weapon in such a situation? In the muck bed at Vero fragments of pottery were abundant. How has it happened that none of these were assisted to reach No. 2 either by roots or rodents? The specious value of such explanations was definitely exposed some years ago by the

[13] Journ. Geol. **25**: 56–62. 1917; Am. Anthr. **19**: 252–261. 1917.

investigations made at Trenton, New Jersey, by the American Museum of Natural History.

Dr. MacCurdy fell into the same error as Dr. R. T. Chamberlin and various other people, that of regarding the "fauna" found at Vero as an integral thing which existed for a while and later disappeared. I have shown already a number of genera which characterized the first interglacial stage as revealed at Vero and numerous localities and which appear at no later stage. Dr. MacCurdy mentions as occurring in the upper stratum (No. 3) at Vero *Elephas columbi, Mammut americanum, Chlamydotherium,* horse, and tapir. *Chlamydotherium* may have lived on for a while in the Kansan stage. It may have possessed some of the vitality of its near relative, the armadillo, which is still living in Texas. As for *Mammut americanum* and *Elephas columbi* and certain peccaries, they continued on probably all over the continent down close to or within the Recent. *Mylodon* and some species of tapirs and one of the horses found at Vero, *Equus complicatus,* and possibly *E. leidyi,* held on until after the Illinoian glacial stage.

After this article had been put in type the annoucement was made by Dr. J. W. Gidley, of the U. S. National Museum, that he had found, in two or three localities in Florida, human bones and artifacts definitely included within stratum No. 2. These discoveries ought to end the dispute about the relationship of man to this important deposit.

PALEONTOLOGY.—*Characters of the brachiopod genus* Lingulidiscina *Whitfield.*[1] GEORGE H. GIRTY, U. S. Geological Survey (Communicated by JOHN B. REESIDE, JR.).

Many years ago, in the course of studying certain faunas from northwestern Arkansas, it became necessary for me to deal with a large series of discinoid shells, and, while discussing the identification of the species I ventured to glance at the generic name that should be used for them. These shells belonged to the group for which Hall and Clarke had revived D'Orbigny's term *Orbiculoidea,* but it appeared to me that on their own showing *Orbiculoidea* was a synonym of *Schizotreta.* Under these circumstances I cast about for some name that was already in the literature rather than propose a new one, and provisionally adopted *Lingulidiscina* Whitfield. Now Whitfield's

[1] Published by permission of the Director of the U. S. Geological Survey. Received March 3, 1928.

description of *Lingulidiscina*, if taken literally, would make that name inapplicable to the orbiculoideas of Hall and Clarke, but I had reasons for believing that the description was in certain respects not accurate. I was led to believe that *Lingulidiscina* could be used to replace *Orbiculoidea*, among other things, by the fact that Schuchert in his bibliography of American fossil Brachiopoda had included under *Lingulidiscina* a shell that I knew to be a characteristic *Orbiculoidea*, and as I had usually found Schuchert well informed and accurate, I concluded, without inquiry, that he must be in possession of some esoteric knowledge regarding those genera. My confidence in this instance now seems ill-judged in view of the singular compilation that passed as the genus *Lingulidiscina*. Thus we have (1) *Orbiculoidea newberryi* in which both valves are in agreement with *Orbiculoidea* as generally understood; (2) *Oehlertella pleurites*, in which the upper valve is like *Orbiculoidea* but the lower valve entirely different, the pedicle aperture being a notch in the margin instead of an oblique tubular perforation; and (3) *Lingulidiscina exilis* itself, in which the lower valve is like *Orbiculoidea*, but the upper valve different.

Some years after my comments on *Orbiculoidea*, in 1912 to be exact, Professor Prosser[2] took a hand in the *Orbiculoidea* question and quoted a letter from Professor Schuchert to the effect that *O. newberryi* was included under *Lingulidiscina* by mistake. This admission was perhaps unfortunate because otherwise Schuchert might lay claim to almost superhuman penetration in an allocation that, on the face of things far astray, now appears to be very close to the truth. Prosser not only made this allegation against my use of the name *Lingulidiscina* but seemed to think that Hall and Clarke were entirely justified in their use of the name *Orbiculoidea*. Though I could not agree with Prosser on this point, and though one of my reasons for substituting *Lingulidiscina* was shown to be fallacious, I continued to use *Lingulidiscina* until very recently, partly because I felt disinclined to reopen the discussion and partly because *Lingulidiscina* still seemed available on fairly good grounds.

Now Professor Schuchert's inclusion of *Orbiculoidea newberryi* under *Lingulidiscina* was not my only reason for thinking that *Lingulidiscina* could properly be employed for these Devonian and Carboniferous shells. Indeed, I found great difficulty in understanding how, as was said to be the case in *Lingulidiscina*, a brachial valve that had essentially the shape and general plan of construction of

[2] C. S. Prosser. Bull. Ohio Geol. Surv. (4) **15**: 203. 1912.

Lingula could be mated with a pedicle valve that had essentially the shape and general plan of *Orbiculoidea* (*Discina*) in view of the fact that these plans are so unlike that the two genera are actually assigned to different orders of brachiopods, *Lingula* to the Atremata and *Orbiculoidea* to the Neotremata. I felt that Whitfield's characterization could hardly be taken literally and that as his figures show the pedicle valve to have typical discinoid characters, the brachial valve was probably of the same type, though possibly having an apex uncommonly near the posterior margin. These considerations appear not to have occurred to either Prosser or Schuchert, and neither of them seemingly tried to ascertain what the characters of *Lingulidiscina* really were. The facts could be ascertained only through an examination of the type specimens, and these, through the unfailing courtesy of the American Museum of Natural History, I have been able to study. My observations in this field seem worth recording even though I now accept *Orbiculoidea* as a valid name in the sense adopted by Hall and Clarke, for they help to establish the relations of *Lingulidiscina* to other genera, relations which Whitfield's diagnosis left more or less doubtful. If his diagnosis were taken without qualifications, *Lingulidiscina* could hardly be of lower standing than the type of a new family. One might even go a little further and say that a brachiopod in which one valve had a terminal beak with shell accretions only at the front and sides while the other valve had a central beak with shell accretions equal all around, could not possibly occur in nature.

The generic description of *Lingulidiscina* reads thus:

"An inarticulate brachiopodous shell, in which the upper valve is linguloid in character, having a marginal or an essentially terminal beak, the accretions by growth being along the lateral and basal margins; lower valve discinoid in character and having its growth lines nearly equal on all sides of the initial point and perforated on the cardinal side by a byssal slit or opening, as in *Discina*. Shell structure as in *Lingula* and *Discina*. Muscular scars yet unknown. Type, *Lingula exilis*, Hall."[3]

The type species of *Lingulidiscina* is commonly quoted as *Lingula exilis* Hall. This is possibly in error. Hall figured two specimens of *L. exilis*, one of which was subsequently figured by Whitfield in illustration of the genus *Lingulidiscina*. Figure 8 of Hall was described as "a specimen with the beak imperfect"; figure 9 as "a more convex individual which may belong to the species." The language here employed clearly implies that Hall was in doubt about the specific

[3] R. P. WHITFIELD. Bull. Am. Mus. Nat. Hist. **3**: 122. 1890.

identity of these two specimens and that the one shown by figure 8 should be considered as the type of *Lingula exilis*. On the other hand, it is the doubtful specimen that was later figured by Whitfield as belonging to *Lingulidiscina*. If Hall's two specimens are really conspecific with each other, and if the doubtful one is in turn really conspecific with the specimens that furnished the generic characters of *Lingulidiscina*, then *Lingula exilis* is in fact the type species of that genus. The doubtful specimen is among those loaned me by the American Museum of Natural History and I feel confident that it is an *Orbiculoidea*. The other and typical specimen of *Lingula exilis*, I have not seen, but the growth lines in Hall's figure suggest that it is really what he believed it to be—a large *Lingula*. If such is the case, *L. exilis* obviously is not the type species of *Lingulidiscina*. I have not thought it necessary to borrow the type specimen of *Lingula exilis* in order to form an opinion upon this point, for my inquiry is addressed at present more particularly to ascertaining the characters of *Lingulidiscina*, and these depend upon Whitfield's specimens and not on Hall's.

To sum up my conclusions regarding *Lingulidiscina* before commenting on the type material in detail: Whitfield's specimens are poorly preserved, probably exfoliated, certainly somewhat crushed, and certainly more or less broken at the margin. Both valves are constructed essentially as in *Orbiculoidea* of Hall and Clarke, though the apex of the upper valve is more excentric than is common in that genus. Whitfield's description is misleading, if taken literally, in saying that the valve is "linguloid in character, having a marginal or an essentially terminal beak, the accretions by growth being along the lateral and basal margins." Let us consider the type specimens in detail, first those representing the brachial valve:

Figures 1, 2, and 3 in Whitfield's description of the genus represent the same specimen, figures 1 and 2 being different views of the brachial valve. These figures, which show a shell shaped like *Lingula* with a beak apparently terminal at the pointed posterior end, are accurate enough in so far as they represent the specimen as it now is, but they are highly misleading in so far as the specimen is decidedly imperfect. The growth lines run out half way up the sides of the brachial valve indicating that the shell was broken in the marginal parts and that the posterior outline was originally much less pointed or at least that the present outline is far from being the true outline. The point represented in Whitfield's figure as a terminal beak appears to be the true apex of the valve, so that the apex must originally have been situated some distance from the margin.

Where discinoids were buried with both valves in conjunction they often suffered a lateral displacement due to compression, one valve projecting on one side, the other on the other. When such specimens are broken from the rock the fracture is likely to occur where the valves are in contact, causing them to be defective along opposite sides. This condition is apparently exemplified by the specimen shown by figures 1, 2, and 3, the brachial valve having slipped backward with the result that the brachial valve projected beyond the line of contact at the posterior end and the pedicle valve projected a corresponding distance at the anterior end. The evidence for this interpretation is as follows: The brachial valve, even in its broken condition extends considerably beyond what appears to be the true posterior margin of the pedicle valve. In addition to the specimen illustrated, however, we have the slab from which it was detached. This slab retains the impression of the pedicle valve and also, projecting downwards from it almost at right angles, a considerable strip of shell, which appears to be the marginal part of the overlapping brachial valve. This strip of shell, which surrounds the pedicle valve from part way up the left side to part way across the posterior end, where it is broken off, may, it is true, be a section of the pedicle valve itself, folded over at a sharp angle, but from the apparently small amount and general direction of the compression suffered this explanation is not so likely. In any event, the brachial valve is undoubtedly imperfect around the posterior margin and the idea conveyed by Whitfield's figures is highly misleading. They represent the specimen as it is, without showing that it is fragmentary, and they seem to bear out the generic diagnosis in a way that is most deceptive. They show, it is true, a shell that at first recalls some of the broader, more spatulate lingulas, but in *Lingula* it is the pedicle valve that projects and is pointed, and the brachial valve that is short and more blunt at the posterior end; here the relation is precisely reversed, the brachial valve is long and pointed, the pedicle valve short and rounded at the posterior margin. This is, to be sure, not at variance with what the description says, though it is at variance with what the description seems to imply—an agreement of some vital sort with *Lingula*. However this may be, the relation between the valves as they now exist in the specimen are in all essentials as they are shown in Whitfield's figure 3, the pedicle valve rounded across the posterior end, the brachial valve pointed and projecting well beyond it. Such, one can say with almost perfect safety, could not possibly be the original condition of any brachiopod shell and the fact affords clear evidence, if only evidence of an abstract character, of serious imperfections in the specimen. It is conceivable that in shells constructed on the discinoid plan the upper valve might be so oblique that its apical point projected beyond the pedicle valve, but the margins of the two valves would of necessity have the same outline.

The original of Whitfield's figures 5 and 6 is a brachial valve which has a depressed convex shape and a nearly circular outline. It is apparently unbroken around the posterior margin. This specimen is not unfairly represented by Whitfield's figure 6, but his figure 5, which is a side view, seems to be faulty. It represents the convexity as too low and the slope to the posterior margin as not sufficiently abrupt. The specimen itself gives indication of having been flattened, for it is dissected by numerous cracks. Whether on account of this, or of other imperfections, the exact location of the beak is hard to determine. It is perhaps more clearly seen if the valve is viewed from the side than if it is viewed from above, and is recognizable more by an abrupt change of direction in the outline from a gentle curve to a straight, steep descent backward than by a pointed prominence on the surface. Thus determined the apex appears to be a little posterior to the point of greatest convexity and to be situated some little distance up from the posterior margin (about 3 mm.). When the valve is viewed from above, however, the beak through foreshortening appears much more marginal.

Whitfield's figure 7 represents the original specimen fairly well, although it fails to allow sufficiently for the breakage that is clearly indicated at the right side, so that the true shape was more nearly circular than it is represented. The beak, as shown in the figure, is probably the true beak, but, as the legend states, the shell is folded inward at the anterior end so that the beak is not marginal as one might infer from the figure, but well up from the margin. Perhaps even more of the infolded shell was originally present than is actually uncovered. At all events in shape this specimen seems to have been very similar to the one last considered, for the convexity was low and the beak situated posterior to the highest point and not very far from the posterior margin, though it was by no means marginal.

Figure 8 of Whitfield represents the specimen that Hall doubtfully referred to *Lingula exilis*. The specimen is too imperfect to yield any facts relative to the genus *Lingulidiscina,* but it is without much doubt a discinoid shell instead of a *Lingula* and it may well belong to the same species as Whitfield's other types.

In addition to the specimens actually figured by Whitfield there was sent to me as part of the typical material another brachial valve whose characters appear to have been essentially like those of the brachial valves already considered. The outline was circular, the convexity low, the beak strongly posterior but not marginal. Finally the borrowed material includes one of the type specimens of *Orbiculoidea doria* (that shown by figure 22 of Plate 2, Hall). The label is inscribed "*Lingulidiscina exilis*, a type of *Discina doria* Hall." Whether this expresses Whitfield's opinion or some other I do not know. In any event according to my conception of the species as derived from Whitfield's specimens, the brachial valve of *Lingulidiscina exilis* must have approximated very closely that of *L. doria*, though on a larger scale, and the specimen of *L. doria* loaned to me may well be a young specimen of *L. exilis*.

Only two pedicle valves are included among Whitfield's typical specimens, both of them figured. One of them is fairly well shown by his figure 3, though as the projecting part of the brachial valve is figured with it, the reader may fail to appreciate that the pedicle valve is broadly rounded at the posterior end and is very nearly symmetrical with a generally elliptical outline, a fact to which allusion has already been made. The major part of the valve is essentially flat; the margins are slightly upturned, producing a gentle concavity, but the parts of the shell adjacent to the pedicle scar are strongly introverted. The details of this scar are obscured. The second pedicle valve (shown by figure 4 as a mold of the exterior) corresponds closely in character with the first one, aside from being more circular in outline. It is gently concave over most of its extent owing to upturned margins, and has a large, deeply introverted pedicle scar. Whether the pedicle had an exit through an oblique tube as in *Orbiculoidea* or through an open fissure as in *Oehlertella* is not clearly shown by either specimen. For my own part I am strongly of the opinion that it issued through an inclosed tube, partly because no marginal slit has been observed, but more especially because an intense deflection of the surface at the locus of the pedicle, such as we have in these shells would more naturally accompany an oblique tube than an open slit. Incidentally, the specimen last described is associated with its fellow valve, which, however, is highly imperfect. Without showing any characters clearly it tends to corroborate the characters ascertained from the more perfect brachial valves already commented on.

The superficial characters of these shells are to some extent a matter of surmise. It is perhaps remarkable that all the brachial valves appear nearly smooth whereas the pedicle valves show the thin, widely spaced, concentric lirae so characteristic of *Orbiculoidea.* All the specimens are more or less macerated or exfoliated, but there is no apparent reason why from this cause the one valve should not be defaced equally with the other. It is possible that the lower or pedicle valve retained these markings while the brachial valve which protected it, but which was itself liable to all the chances of abrading and corroding substances, might have lost them. On the other hand, I recall having seen orbiculoideas which showed a similar variation in sculpture. In both valves the central region was marked in the usual manner by spaced concentric lirae, but these gradually became obsolete toward the margins, deteriorating into feeble rounded striae of growth. The obsolescence of the sculpture was commonly more pronounced on the brachial valve than on the pedicle valve. If among these lingulidiscinas several that retain the upper and lower valves in conjunction have the one almost smooth and the other sharply striated, others, especially Hall's specimen of *Lingula exilis,* are not without suggestion of the characteristic *Orbiculoidea* sculpture in a defaced condition.

To sum up the conclusions that seem to follow from my observations on the typical specimens of *Lingulidiscina:* The outline is as a rule almost circular, though elongated specimens occur in which the length is decidedly greater than the width.

The brachial valve was depressed-convex, with the beak obscure but in position posterior to the highest point and not far from the margin in that part, though obviously by no means marginal. The configuration is in general like that of *Orbiculoidea;* it may be somewhat extreme in the lowness of the arch and in the excentric position of the apex, but it is not without parallel among specimens that seem properly to belong in that genus.

The pedicle valve also appears to be constructed like that of *Orbiculoidea.* My observations do not establish this, although none bears evidence to the contrary. The pedicle slit is here especially in mind; the configuration otherwise is not quite typical, for whereas in *Orbiculoidea* the pedicle valve is gently convex rising to a point in the central part (see Hall and Clarke's figure on p. 125), in these shells the pedicle valve is faintly concave, though it has a strong deflection in the posterior quadrant if the pedicle scar is taken into account. In configuration this type would thus appear to be somewhat intermediate between *Orbiculoidea* and *Roemerella,* though it is much more like *Orbiculoidea.* On the other hand, many recognized orbiculoideas have a pedicle valve that is almost flat, or even faintly concave, whether by nature or by accident it is hard to tell. Few that have come under my observation are so strongly arched as Hall and Clarke's diagrammatic figure.

The sculpture is in a general way that which is common to most Paleozoic discinoids. That of the pedicle valve appears to be perfectly normal but that of the brachial valve, if not defaced, has more or less degenerated from widely spaced sharply elevated concentric lines into relatively inconspicuous fascicles of growth lines.

From the facts as they appear to me I would not hesitate to describe Whitfield's shells as representing a somewhat unusual species of *Orbiculoidea*.

ZOOLOGY.—*A new species of the nemic genus* Syringolaimus*; with a note on the fossorium of nemas.*[1] N. A. COBB, U. S. Department of Agriculture.

The writer's collection of Syringolaims shows them to live on temperate and tropical sea coasts in many parts of the world. Among other places, his Syringolaims (1888–1927) represent the East Indies (Larat), Polynesia (Noumea, Hawaii), the Atlantic and Pacific Coasts of Panama, the Atlantic Coast of the United States, and the English Channel. The manuscript record of these collections contains full descriptions of a number of new but unpublished closely related species.

Our knowledge of this genus has increased but little since de Man described the type species, his *S. striatocaudatus*. The present publication adds information concerning (1) the labial papillae, (2) the amphids, (3) the phasmids (?), (4) the fossorium, (5) the intestine, (6) the male gone, (7) the food habits, and (8) the geographic distribution.

Syringolaimus smarigdus, n.sp. $\frac{6.1}{2.7} \cdots \frac{12.}{\diagup 2.9} \cdots \frac{20.}{\underline{3.2}} \cdots \frac{{}^{15}\text{'}50.\text{'}{}^{15}}{3.9} \cdots \frac{82.}{2.6} > 0.76$ mm
The transparent, colorless cuticle is traversed by plain transverse striae very difficult, or almost impossible, to resolve, which are not altered on the lateral fields. Faint traces of wings occur, beginning near the head and ending on the tail. Longitudinal "striae," due to the attachment of the musculature, are visible in nearly all regions of the body. No series of pores have been seen in the cuticle. Of the highly mobile lips there probably are three, but they are no more than sub-distinct, and are small and somewhat rounded. The pharynx is armed in front with three duplex (somewhat lobster-claw-like), in profile somewhat inverted-comma-shaped, subacute odontia (Fig. 1, *mnd)* having an outward throw of about 180°, a movement seen on more

[1] Embodying investigations made largely at the Laboratories of the U. S. Bureau of Fisheries at Woods Hole, Mass. Received February 25, 1928.

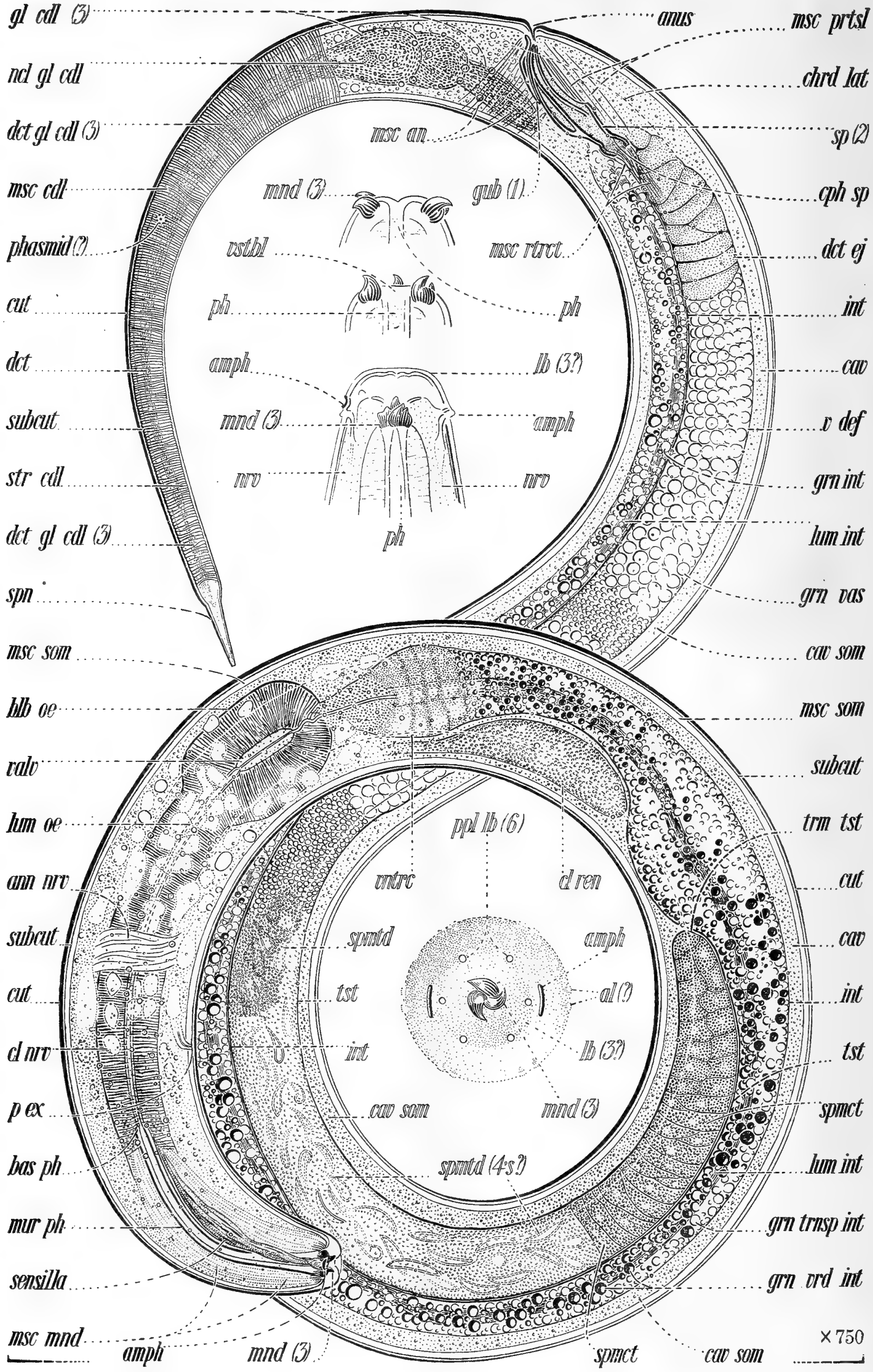
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Fig. 1

than one occasion to occur every second or so when the live nema was placed under the microscope under slight pressure (Fig. 1). The cross-section of the pharynx is round-triquetrous, almost circular, with faint subordinate markings in the middle of each side, indicating on the whole a hexagonal structure. There are no eyespots. The base of the pharynx may be surrounded by a very faint ellipsoidal swelling. There is only a faint pharyngeal muscular swelling, though there are fairly well developed mandibular muscles, lying along the outside of the pharynx (Fig. 1, *msc mnd*). There is a rather distinct but small conoid cardia, one-third as wide as the base of the neck, or less. The ventriculus stains differently from the remainder of the intestine, showing a distinct function to be discharged here; in the living condition however the ventriculus appears somewhat "structureless" (*vntrc*). The granules in the cells of the intestine are of several distinct kinds: some of them are colorless (*grn trnsp int*), others are emerald-green (*grn vrd int*)—hence the specific name *smarigdus;* none are birefringent. The content of the intestine is usually reddish or greenish, and often is derived specifically from an alga belonging to the family Ralfsiae (Fig. 3), among which specimens of *Syringolaimus smarigdus* are often found. There is no prerectum. From the somewhat elevated lips of the anus, of which the anterior lip is the more elevated, the cutinized rectum extends inward and forward a distance about equal to

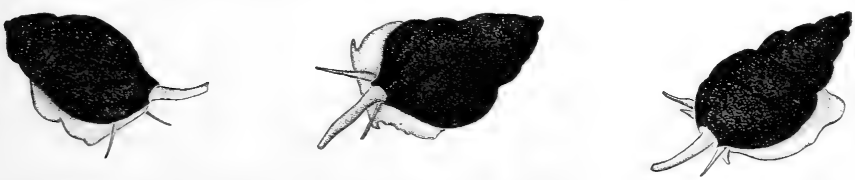


Fig. 2.—Snails, natural size, covered with a very dark green "pile" or "felt" consisting of microscopic algae. The nature of this growth is illustrated in Fig. 3.

two-thirds of the corresponding body diameter. The lateral chords enlarge from one-fifth (terminad) to one-half (mediad) as wide as the body. From the medium-sized continuous vulva, the cutinized vagina leads inward at right angles to the ventral surface three-fifths the way across the body. The uteri contain only one egg at a time, are straight, three to four times as long as the body is wide, and from one-fourth to one-sixth as wide as long. The two opposite, equal, symmetrically arranged ovaries, about half as wide as the body, are reflexed about two-thirds the distance back to the vulva and contain ten to fifteen ova, mostly in single file. The elongate egg may be 3 to 4 body-widths long, appears relatively narrow, and seems to be deposited before segmentation.

$\frac{6.5}{2.8} \cdots \frac{11.}{3.1} \cdots \frac{19.}{3.4} \cdots \frac{47\text{-M}}{3.3} \cdots \frac{81.}{2.7} \rangle 0.85\,\text{mm}$ The single gubernaculum (*gub*) may consist of two arcuate, subslender, parallel, amalgamated pieces, and is rather closely applied to the spicula. Phasmids(?) (Fig. 1) occur on the

Fig. 1.—Male of *Syringolaimus smarigdus*, together with four different views of the head end. Below, a diagrammatic drawing of the front view of the head. Above, three sketches showing different attitudes of the "mandibles" or fossores. The fossores are also shown in both the other illustrations. The lettering of the illustrations consists of self-explanatory abbreviations arranged in the Latin order; *grn vrd int—granulum viride intestinalis*,—green granule of the intestine; etc.

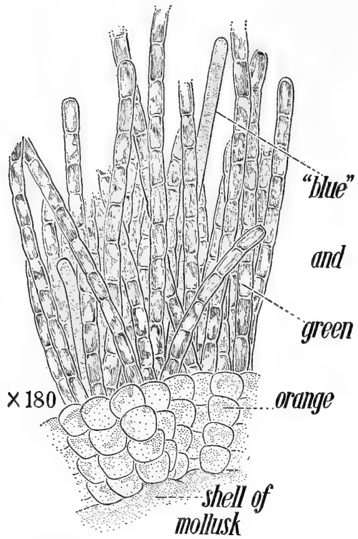


Fig. 3.—Slight portion of the algal growth from the snails shown in Fig. 2, broken or dissected away. Below is the shell of the mollusk. On it an "incrustation," orange in color, consisting of an alga belonging to the family Ralfsiae, probably to the genus *Ralfsia*. On this incrustation there is a thick felt-like growth, consisting of blue-green and yellow-green algae. *Syringolaimus smarigdus* feeds upon the orange-colored alga, which it can reach only by digging through the green algal growth above.

lateral lines near the middle of the tail on both sexes. While there is no distinct bursa, the cuticle is faintly thickened in the submedian region near the anus, possibly a very rudimentary bursa.

Habitat: Common among minute filamentous algae on the surface of marine mollusks, especially the snail *Alectrion obsoleta* (Fig. 2). Also found in sand on beaches, and in sand in several feet of water off shore. Woods Hole region, 1916 to 1927. There is good reason to suppose it ranges both north and south from Woods Hole along the Atlantic Coast. It occurs in beach sand from near Falmouth; and in clear white sand in five feet of water in a cove at the entrance to Buzzard's Bay; also at Waquoit, Mass., among algae on the shell of the living snail, *Alectrion obsoleta* (Nassa); and on the shells of live snails from the Eel Pond at Woods Hole. Its food seems always to be vegetable matter, and in many cases consists entirely of the contents of the cells of a microscopic alga belonging to the genus *Ralfsia* (?).

Outward Acting Nemic "Mandibles"

The writer's study of the attitudes in which the mouth parts became fixed led to the conclusion that in *Axonolaimus* and its relatives, as well as in a large number of other nemas, the onchia (and odontia) had an *outward throw*. If so, it was an obvious deduction that these organs were digging organs, for which the word fossor[2] seems indicated. This deduction led the writer long ago to introduce into generic names of such nemas root words indicating a digging function on the part of the mouth organs, as for instance in the genus names *Scaptrella, Diploscapter*.

It is, however, difficult to observe these organs in operation, and hence of interest to record that such organs have been seen in action in a Syringolaim (Fig. 1), and furthermore that *S. smarigdus* has been observed under conditions constituting strong additional circumstantial evidence that these organs are verily digging organs. *S.*

[2] *Fossor* (plural, *fossores;* collective, *fossorium*); a tool or organ used for digging, usually existing in a plurality and acting symmetrically outward from a plane or axis. Related to "fossorial"—said of animals that dig.

smarigdus is found in algal "incrustations" of the family Ralfsiae, and probably genus *Ralfsia*.[3] It is very apparent that the nema feeds upon the *Ralfsia*, for the color and structure of the contents of the cells of this alga are strikingly characteristic, and the intestinal content of the associated Syringolaims not only has exactly the same color, but frequently is otherwise of such a character that it could be derived *only* from the interior of the *Ralfsia* cells. Often, however, there are scattered foreign birefringent particles (carbonate of lime) mixed with the ingested food; but these birefringent particles are similar to those found *among* the filaments of the *Ralfsia*, and, taking into account the relative size of the mouth parts of the Syringolaim, it is very natural to suppose that some of this foreign matter would be taken in with the food.

No one had previously explained the precise nature of the mouth organs of *Syringolaimus*. They consist of three small, arcuate, more or less acute odontia with a *spirally outward throw*, well adapted to boring and digging (Fig. 1). Now, it so happens that the location and structure of the incrustation formed by the *Ralfsia* would require digging on the part of the nema in order to obtain food from it, for the *Ralfsia* incrustation on the snail shells (*Alectrion*) is usually overgrown with a thick comparatively impenetrable felt of filamentous green algae (Fig. 3); hence the *Ralfsia* can be reached by the *Syringolaimus* *only by digging*.

The snail, *Alectrion obsoleta* (Nassa), lives between tide-marks and hence twice daily is exposed to the air, and on each such occasion any algal growth on it naturally dries up more or less. Here then is an additional complication in the environment of the Syringolaim—a highly and rapidly variable temperature and salinity. It is reasonable to suppose these unusual circumstances might give rise to a peculiar nemic form adapted to the environment. Thus a clue is found to the marked peculiarities of form and structure noted in *Syringolaimus*.

[3] *Ralfsia; fide* Dr. I. F. Lewis.

ARCHEOLOGY.—*Check-stamped pottery from Alaska.*[1] HENRY B. COLLINS, JR., U. S. National Museum (Communicated by D. I. BUSHNELL, JR.)

Check-stamped pottery as an archeological type in America is restricted to the south Atlantic and Gulf region from North Carolina to western Louisiana, and the only modern Indians known to have made it were the Cherokee. It was with some surprise, therefore, that while cataloging the material collected by Dr. Aleš Hrdlička in Alaska in 1926, I found a sherd of otherwise typically Eskimo pottery bearing a check-stamp design. This sherd was picked up on the beach east of Cape Nome on Norton Sound.

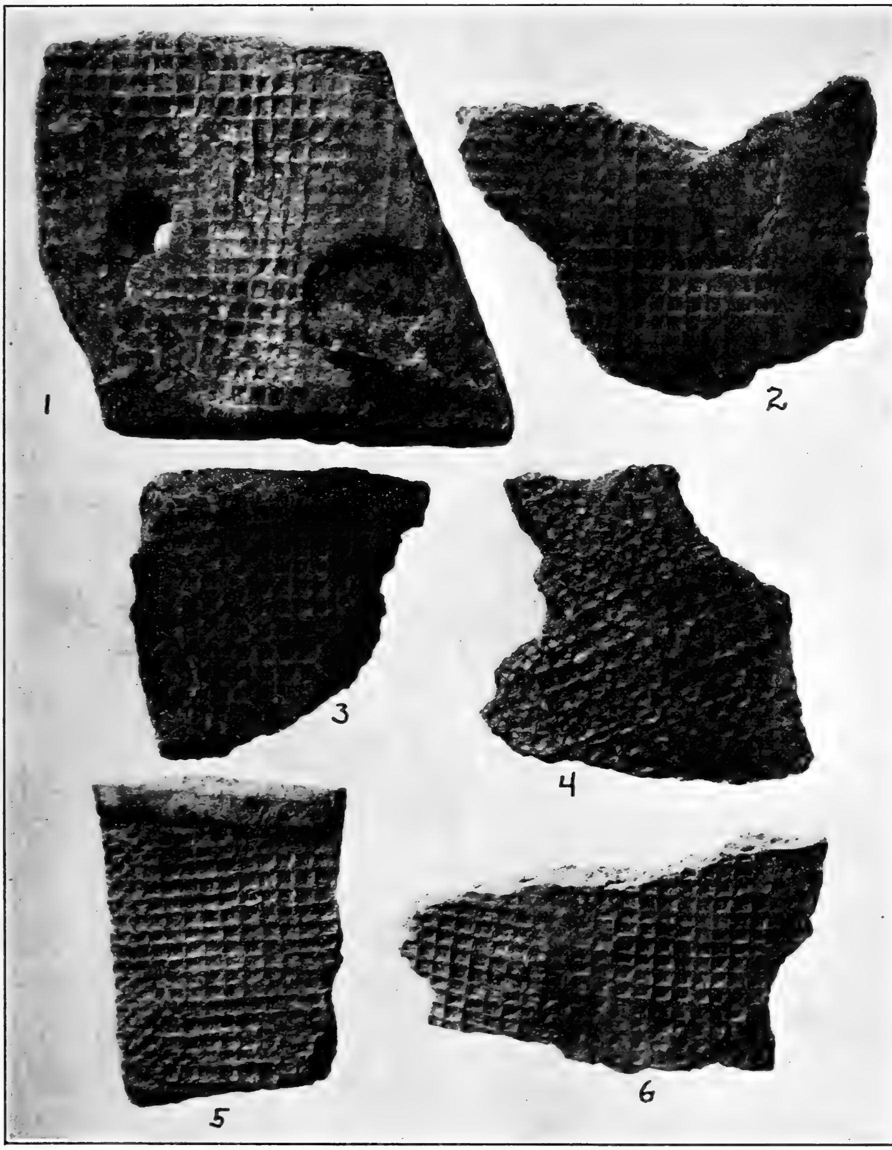
Last summer, while engaged in anthropological work on Nunivak Islands, Alaska, I found more of this pottery. Some three dozen sherds, all apparently fragments of the same vessel, a large flat-bottomed jar, were found together, about a foot below the surface near the ruins of some old houses at the present village of Koot, on the northeastern end of Nunivak Island. A sherd of similar type was obtained from an Eskimo who claimed to have found it while making the excavation for a new house at the same village.

In the accompanying figures are shown three of these sherds, together with the one found by Dr. Hrdlička on Norton Sound, and for comparison, two sherds from southwestern Louisiana. The practical identity of these pieces, as far as ornamentation is concerned, is apparent. The ornamentation was produced by applying to the soft clay a wooden paddle or stamp, on the surface of which was carved a checkered pattern.

Most of the pottery from the Eskimo area is plain except for simple punctate, incised, or corrugated ornamentation about the rim. Sometimes, however, the entire outer surface of the vessel has a rough pitted appearance brought about by the application of a paddle less carefully carved than those which made the impressions on the pottery here illustrated.

The manufacture of pottery is no longer practiced among the Eskimo but the process has been described by Gordon, as related to him by an old eskimo at Cape Nome who had observed it. "A quantity of clay, procured from certain localities on the tundra, was reduced to a smooth paste by mixing with walrus blood and kneading it with the hands. A quantity of sand from the beach was added, together with fine

[1] Received March 7, 1928.



Figs. 1–3, potsherds from Nunivak Island, Alaska. Fig. 4, from Norton Sound, Alaska. Fig. 5–6, from southwestern Louisiana.

feathers from the breast of the ptarmigan. From this material the vessel was built up by means of the hands with the aid of a flat piece of wood shaped like a paddle. Sometimes the exterior was finished smooth and either left plain or decorated with incised lines and dots by means of a pointed stick. Instead of a smooth finish a pitted surface was sometimes produced by means of a roughly carved paddle or by wrapping the unbaked vessel in a piece of grass matting which left its impression. The finished product was then baked in a wood fire. Women, and not men, were engaged in this industry."[2]

More than merely showing the presence of a certain type of ceramic decoration in Alaska, the finding of this pottery, identical in ornamentation with that from a distant region, is believed to be of interest as an example of how two totally unrelated cultures have produced an identical result. The check-stamped pottery of Carolina and Louisiana is obviously related in origin, but the sporadic occurrence of the same decoration among the Eskimo is of no more significance, as an indication of cultural contact, than would be the presence of, for example, an occasional circle and dot design in the Gulf region.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

198TH MEETING

The 198th meeting was held jointly with the Washington Society of Engineers, the Chemical Society of Washington and the American Society for Steel Treating (Washington Chapter) in the Assembly Hall of the Cosmos Club on Thursday, March 19, 1925.

Program: Dr. CARL BENEDICKS, Director of the Metallographic Institute of Stockholm, *The theory of high speed steel.* Three different factors are known to increase the hardness—the resistance against permanent deformation—of a given metal.

1. Deformation at low temperature, or "coldworking." This may be explained, without any assumption of a dubious "amorphous," hard state, by considering the mode of deformation called in crystallography *twin translation;* the increase in hardness is the result of intercrossing twin lamellae.

2. Admixture of substances hard in themselves. Thus the hardness of iron is increased by a content of the hard carbide, cementite, which occurs in carbon steel.

3. The occurrence of a substance in the state of solid solution. In 1901 the speaker pointed out that the solid solutions of the metals are much harder than the metals themselves; Kournakow has since shown this to be true for solid solutions in general. The speaker further, in his thesis of 1904, pointed

[2] G. B. GORDON. *Notes on the western Eskimo.* Trans. Dept. Arch. Univ. Pa. **11 (1)**: 83–84. 1906.

out that a metal is *hardened* if another element is made to occur in it as a supersaturated solid solution.

In every case where the metal—such as iron—possesses two different allotropic states, the gamma and the alpha states, quenching may cause two different solid solutions to occur simultaneously: a *supercooled* solution (as "austenite") and a *supersaturated* solution (as "martensite"). The slow transformation of the first into the second explains a number of hardness problems which otherwise demand special assumptions.

For high speed steel it has been established by X-ray analysis that tungsten possesses the same atomic lattice as alpha iron, differing from that of gamma iron. Hence it was natural that the tungsten is more easily mixed with alpha iron than with gamma iron. According to a general rule of physical chemistry, this implies that the stable region of the alpha iron was raised to much higher temperatures than would otherwise prevail. The alpha iron thus acquired a stability at high temperature that would not otherwise occur. In the case of carbon steel, a supersaturated, hard solid solution is obtained on quenching the high speed steel from a temperature so high that its carbide phase is dissolved. The main difference produced is the raising, due to the presence of the tungsten, of the range of temperature for the existence of alpha iron. (*Author's abstract.*)

199TH MEETING

The 199th meeting was held jointly with the Washington Chapter, American Society of Foresters, in the Assembly Hall of the Cosmos Club on the evening of Thursday, April 16, 1925. The general subject was a *Symposium on Forest Science.* The opening address was given by Col. W. B. GREELEY, Chief of the U. S. Forest Service, after which addresses were given by E. N. MUNNS on *Timber growing and protection from fire,* by H. S. BETTS on *Timber utilization and by-products,* by HAVEN METCALF on *Forest diseases and their control,* and by T. E. SNYDER on *Forest insect pests and their control.*

Col. W. B. GREELEY, *Forest Science in the United States.* Forestry in the United States thus far has largely had the aspect of a crusade, a subject for state or federal legislation, an activity of public agencies, and a field for popular education. These all have their place in a national movement but they represent only a preliminary stage. We are now entering a much broader phase of forestry. The United States has used up two-thirds of its virgin timber supply. Like all the progressive countries of the Old World, which went through an identical process of depleting natural resources, the value of wood in this country is creating a demand for a new source of supply. The force behind the current progress in forestry is becoming more and more largely one of cold economics.

It is perhaps worth while to take the measure of the job cut out for forest science in the United States. We now consume about twenty-two and one-half billion cubic feet of wood annually, or more than two-fifths of all the forest-grown material utilized by the entire world. In no great length of time this enormous volume of raw material must be produced by the practice of forestry. It is equivalent to about 280 million tons of material a year. This is nearly four times the tonnage of iron ore produced in the United States and well over ten times the annual production of cement. The quantity of wood required annually by the United States is over twice the total annual production of all cereal crops.

The size of the forestry problem of the United States is not, however, gauged correctly simply in terms of raw material. Another very important side of it is the effective use of land. About one-fourth of the soil of the United States is now either forest land or land apparently fit only for producing wood. There is small prospect that this area will be materially reduced, at least for many years to come. The profitable employment of land and the rural prosperity that depends upon it loom just as large in our national economy as the problem of providing a sufficient supply of forest-grown materials.

The task of forest science in America is to create the basis of ascertained facts upon which and only upon which this far-reaching economic evolution can be soundly predicated. We often compare forestry with agriculture, and in sketching the field of forest science analogies may readily be drawn with the development of agricultural science. Forestry, like agriculture, involves (1) the protection of crops from destructive agencies, (2) crop culture and the betterment of yields in quantity and quality, (3) the utilization and marketing of crops, with a view particularly to the most effective conversion of raw materials into commodities of commerce, and (4) the economics of crop production and land use which guide sound investments of capital and labor.

The protective phase of forest science deals with the preservation of both old and growing timber from destruction or serious injury by fire, insect pests, and disease. It is not readily appreciated perhaps that there is an important scientific aspect to the protection of forest areas from fire.

Forest insects and tree diseases offer a large field for the expert entomologist and pathologist. Not only are the aggregate losses of forest-grown material enormous; not only must reasonable security from such losses be provided for the capital and labor invested in timber culture; in many instances the productive side of forest science cannot be soundly developed without direct correlation with the prevention or control of destructive pests. And on the other side it seems probable that much of the loss from forest insects or diseases will be effectively reduced only by proper methods of silviculture or timber management.

The second division of forest science, so to speak, is timber culture. In this as in the protective side of forestry there is an immense field for creative work in America. While certain principles and much in the way of practical experience can be borrowed advantageously from the Old World, the silviculture of the United States can only be an outgrowth of its own soil, climatic, and biological factors. Its problems include the more or less distinct growth requirements of at least 100 commercial species of trees.

American foresters have undertaken to develop and apply the art of timber culture in our woodlands from the more obvious facts deduced through superficial observation and the principles of forestry developed by European experience. It has thus far been more a reliance upon faith than upon exact knowledge of the sort which backs up the undertakings of the chemist or the engineer. We cannot yet predict with any close accuracy the yields of timber to be obtained in many portions of the United States under even the simpler and more rudimentary principles of timber culture.

The third phase of forest science deals with the utilization of timber after it has been grown. Wastefulness in the exploitation of American forests and in the manufacture of their products has been engendered by the very abundance and cheapness of our virgin timber. More economical use of wood is just as essential a part of forest conservation as the growing of new crops of timber.

This may appear to be a field for engineering or chemical or physical science rather than forest science. Unquestionably it will call for the expert services of many trained engineers, chemists, and physicists. However you may view it as a field of scientific endeavor, its problems are closely linked with those of forestry.

And finally, forest science will not be complete without a comprehensive understanding of the economics of timber growing, timber transportation, and timber use. The business man wants to know whether forestry will pay, particularly since timber growing enterprises represent investments of capital over such extended periods. Only genuine scientific study can develop the economic background of forestry in the United States.

We are appreciating more and more clearly that no group of scientists lives unto itself; and that no field of scientific work can be marked out by sharp barriers cutting it off from other fields. This is true particularly of forest science. Its lines of work and interest reach out at many points into the fields of pathology, entomology, plant physiology, chemistry, and the engineering sciences. It is fruitless to attempt to say where one domain ends and the other beings. The development of forestry needs the active participation of many scientific groups and agencies, each marching under its own colors. (*Condensed from speaker's manuscript.*)

E. N. MUNNS, *Timber growing and protection from fire.* Timber growing research has been conducted for the most part at the federal forest experiment stations. The whole question of timber production is involved, including such things as nursery and planting practice, development of the best methods of harvesting the mature crop in order to insure the establishment of a new forest in the shortest possible time, and the determination of the yields which can be obtained at different ages and for different types of forest. Investigations have indicated that the Douglas fir regenerates after cutting from the seed which had been stored in the forest litter previous to cutting: that the western white pine seed can be held over in the forest soil up to six years: that it is necessary to save all the advance growth in the western yellow pine forests because climatic conditions are so severe. Investigations have shown that in various forest types the debris resulting from logging must be disposed of in different ways; in one region it can be scattered over the ground, in another it must be piled and burned, in another burned broadcast at certain seasons of the year. Already marked results have been obtained by following the practices indicated by the work of the forest experiment stations. One of the interesting recent developments has been in our knowledge of forest fires, how and why they burn, and how they may be better controlled. Detailed studies have indicated that forest fire weather can be predicted and that there is a close relationship between weather conditions and the spread of fire. As a result, there is now developing a technique of fire protection which is displacing the manual-labor method by one of scientific accuracy, and we are now better able to appraise the damage that fires do. The problem of the forest experiment station is that of how to obtain the maximum forest crop in the shortest possible time. (*Author's abstract.*)

WALTER D. LAMBERT, *Recording Secretary.*

THE GEOLOGICAL SOCIETY

434TH MEETING

The 434th meeting was held at the Cosmos Club, January 11, 1928, President HEWETT presiding.

Program: F. E. MATTHES: *Evidence of three glaciations in the Yosemite region.* In a previous communcation the speaker has set forth the facts which in his judgement prove conclusively that the Yosemite region has been subjected to glaciation twice during the Pleistocene epoch. He now desires to present certain evidences that would seem to point to a third stage of glaciation that antedated the others. These evidences were noted by Frank C. Calkins and himself as early as 1913, but they then seemed hardly conclusive enough to be made the basis of a positive statement. A recent reinspection of certain critical areas, however, leads the speaker to believe that there is warrant for at least a tentative recognition of this third, very early stage.

The evidence found thus far for three stages of glaciation in the Yosemite region may be summed up as follows:

The latest stage, which corresponds in all probability to the Wisconsin stage of the continental ice sheet, is indicated by a series of well preserved, sharp-crested moraines containing a large proportion of unweathered boulders. The rock surfaces that were overridden by the glaciers of this stage have suffered but little from weathering and still retain their polish and striae over considerable areas.

An earlier stage of glaciation that was marked by a much greater extension of the ice streams than was the Wisconsin stage is indicated by another series of moraines of greater volume but less well preserved than those mentioned. They are as a rule inconspicuous and difficult to trace because of the destruction of their crests and the smoothing of their flattened bodies by a surficial layer of sand derived from disintegrated boulders. Most of the boulders within these older moraines are enveloped by a ferruginous coating, and are decomposed and rust stained to a depth of at least half an inch. The rock surfaces that were planed by the glaciers of this earlier stage, far from retaining their polish, have been stripped of disintegrated rock to a depth of several feet. This is shown by the height of residual pedestals preserved under protecting boulders and still better by the height of dikes of resistant aplite that now project above the granite which forms the country rock. Some of the dikes on Moraine Dome stand from 7 to 10 feet high above the granite.

The third and earliest glaciation is believed to be indicated by isolated erratics situated at levels from 100 to 200 feet above the highest of the older moraines, and composed only of the most durable rock types such as quartzite and highly siliceous granite. In some places, as notably on the upland to the east of Mount Starr King, such isolated erratics occur on nearly level tracts where the washing action of rain water can not have been especially vigorous and where in general moraines would have a good chance to be preserved for a long time. They lie, moreover, in places where there is good reason to believe that fairly heavy moraines were once laid down. It is entirely probable, therefore, that these erratics are the sole remnants of moraines of much greater antiquity than those which make up the so-called older series. (*Author's abstract.*)

WILLIAM W. RUBEY: *Possible varves in marine Cretaceous shale in Wyoming.* Microscopic examination reveals laminations about 1/100 of an inch thick in marine shale in many Upper Cretaceous formations in the Black Hills region. These laminations are of different kinds, marked by three types of alternations: (1) coarse and fine particles, (2) much and little organic matter, and (3) $CaCO_3$ and silt. Examples intermediate between (1) and (2) form a gradational series, with those laminations made by alternations of particle size the thicker, and those made by alternations of organic content the thinner. This gradation indicates that at least these two kinds of laminations were formed by the same process and during approximately equal time intervals.

Storms or floods might have caused the alternations of coarse and fine particles but the laminations marked by varying content of organic matter and lime seem to call for recurrent cycles of organic growth or temperature changes. The fact that thin laminations have been preserved indicates that sporadic storms rarely disturbed the sea floor and the regularity of the alternations suggests that the cause, whether storms or not, recurred periodically. Seasonal changes in temperature, rainfall, and food-supply or periodic shifts of marine currents probably afford the simplest explanation of all three kinds of alternations; and, of these two possibilities, seasonal changes appear the more likely.

It is conceivable that annual layers might have formed in the Upper Cretaceous rocks of the Black Hills region, for fossil wood and other evidence indicate that the climate was seasonal; and flocculation, which might possibly prevent the separation of sand and clay into coarse and fine layers, probably would not prevent the formation of layers rich in organic matter and lime. And once formed, thin layers might have been preserved, for the deepest part of the Upper Cretaceous interior sea probably lay near the present Black Hills; also, wave action may not have extended as deep during the widespread equable climates of Upper Cretaceous time as it does today.

The hypothesis that the laminations are annual is tested roughly by comparing the thickness of the observed laminations with the thickness that annual layers might be expected to have. Varves in glacial deposits from other regions are commonly much thicker but many varves in lake deposits and in some marine rocks are of about the same thickness as these laminations. Estimates of the expected thickness of varves in the Upper Cretaceous rocks near the Black Hills also appear to support the hypothesis. Three methods of estimation—(1) The probable area of land draining into the Upper Cretaceous sea and the supposed rate of erosion on the land, (2) the total thickness of Upper Cretaceous rocks in the region divided by Barrell's estimate of the number of years in the Upper Cretaceous, and (3) the rhythmic alternations in Upper Cretaceous rocks in eastern Colorado which Gilbert suggested were formed during precession cycles—all indicate annual layers only slightly thinner than the observed laminations. A modification of the second method (total thickness of Upper Cretaceous rocks divided by old estimates of Upper Cretaceous time based on the amount of salt in the ocean) indicates annual layers somewhat thicker than the observed laminations.

Thus, the laminations are of about the right thickness to be annual; they were not caused by daily variations or by cycles several thousand years long. However, this is no proof that they are annual for they might have formed every few months or years. In fact, more detailed comparisons (*a*) of the length of Upper Cretaceous time indicated by the laminations with that estimated by Barrell and (*b*) of the rate of eastward transgression of the Upper Cretaceous sea (calculated from the number of laminations and the distance of the transgression) with present rates of strand-like movements, suggest this latter possibility. Yet these two relatively small discrepancies might be explained equally well (1) if the average thickness of the observed laminations is not typical of the series in the region, (2) if Barrell's estimate of Upper Cretaceous time is too long, or (3) if there are many inconspicuous unconformities or diastems in the stratigraphic section.

Whether or not the laminations are annual, they suggest some of the conditions of deposition. The degree of preservation of the laminations indicates that the fine grained, organic shales accumulated in deep water or at times of gentle winds. And if the different kinds of laminations formed during equal time intervals, their relative thicknesses indicate that, in general, the sandier shales accumulated more rapidly and the finer grained and more organic shales, more slowly. (*Author's abstract.*)

W. C. ALDEN: *The Gros Ventre (Wyoming) flood of 1927.*

435TH MEETING

The 435th meeting was held at the Cosmos Club, January 25, 1928, President HEWETT presiding.

Informal communications: A. J. COLLIER showed pictures, taken in Montana in 1927, of hailstones one and three-quarters inches in diameter and of the impressions they made on the ground by their impact. He inferred that some so-called fossil raindrop imprints were probably fossil hailstone imprints.

DAVID WHITE discussed the diagrammatic representation of the length of geologic periods and showed a diagram with the geologic time estimates of Holmes and Lawson plotted on a logarithmic spiral. (Diagram and note on pp. 201–203, vol. 18, this JOURNAL).

Program: Dr. E. C. ANDREWS, Government Geologist, New South Wales, Australia: *Geology of the Broken Hill district, Australia.*

436TH MEETING

The 436th meeting was held at the Cosmos Club, February 8, 1928, President HEWETT presiding.

Informal communcations: F. L. HESS described the occurrence near Hebron, Maine, of pollucite, a hydrous caesium aluminum metasilicate ($H_2Cs_4Al_4\ (SiO_3)_9$), associated with albite in pegmatites that contain lithium minerals. The pollucite is one of the last minerals to form in the pegmatites but it is partially replaced by albite. Blocks of pollucite that weigh several hundred pounds have been found at this locality. This abundance and the great resemblance to quartz led Mr. Hess to infer that pollucite may have been mistaken for quartz in pegmatites in other areas. The mineral has been a source of caesium for filaments in radio tubes.

Program: C. WYTHE COOKE and L. W. STEPHENSON: *The Eocene age of the supposed late Upper Cretaceous greensand marls of New Jersey.* The Hornerstown marl, the Vincentown sand, and the Manasquan marl, three formations of the Coast Plain of New Jersey that have heretofore been referred to the Upper Cretaceous series, are now correlated with the Eocene on the basis of a new analysis of their contained fauna and because of the transgressive overlap of the Hornerstown across formations of undoubted Upper Cretaceous age. Together with the overlying Shark River marl, the Eocene age of which has not been questioned, they appear to be approximately equivalent to the Pamunkey group (Eocene) of Maryland, which they resemble both in lithology and fauna. (*Author's abstract.*)

JAMES GILLULY: *Isostasy as a factor in Basin Range faulting in the Oquirrh Range, Utah.* The statement has frequently been made that given an original uplift of a mountain mass above the adjacent country, the resulting transfer of material by erosion from the uplifted mass and deposition upon the adjoining territory will tend to continue the differential movement of the two earth blocks in accordance with the isostatic principle. There is no question that such is the tendency. Quantitative measure of the actual effect of the transfer in continuing the relative movement is, however, rarely available. It is the purpose of the present paper to present some results of a study of this question with respect to the Oquirrh Range, Utah.

The Oquirrh Range is a typical Basin Range, bounded along its western base by normal faults which are demonstrable on structural and stratigraphic as well as physiographic grounds. The recognition of a submature pre-faulting topography permits the reconstruction of the pre-faulting surface, within fairly satisfactory limits. The reconstruction of this pre-faulting topography over the part of the range which is tributary to Rush Valley permits the approximate determination of the volume of rock eroded from the mountain block since the uplift began. This computation reveals the erosion from this part of the range of a rock layer with an average depth of 1100 feet. Assuming that all this material was deposited within part of Rush Valley which now contains fans sloping out from the Oquirrh Range (which assumption is contrary to the exact facts, but tends to favor the efficacy of isostasy) we find that the valley block has sustained loading equivalent to 670 feet of solid rock. The couple set up between the mountain and valley block could not, then, account for more than 1770 feet of the difference in elevation between them, even if we assume that the subcrustal material (which is on the assumption of perfect compensation transferred at depth in the reverse direction) has a density equal to that of the surface rock. If the subcrustal material has a density of 3.3, which is a more probable value, the couple set up by erosion can only account for about 1,550 feet of the observed 3,000 to 5,000 feet difference of elevation of mountain and valley block. Obviously, we must concede that surface transfer of material is of little moment in maintaining the elevation of the Oquirrh Range and that whatever caused the original uplift relative to the valley blocks is still the effective agent in maintaining their relative positions.

Post-Bonneville faulting along the west front of the Oquirrh Range probably averages about 20 feet in displacement. If we estimate 25,000 years as this duration of post-Bonneville time and take Dole and Stabler's figures for the rate of erosion in the Great Basin province (using a factor of 100 per cent to take account of the traction load, neglected by Dole and Stabler) we arrive at a maximum estimate of post-Bonneville erosion of 3 feet. Study of the physiography of the fans reveals that this figure is absurdly high, but even if we accept it, we find it wholly inadequate as a cause of the fault movement which is fully six times as great.

Attention is called to the great work of Gilbert in connection with his study of Lake Bonneville, in which he attacked this problem from several other viewpoints, including particularly the negative evidence afforded by the waterload to which the valley blocks were subjected in Bonneville time. His conclusion that the Basin Ranges are sustained by the strength of the earth's crust seems to be supported by the study of the Oquirrh Range. In conclusion it is pointed out that the limit of load which Bowie concludes from geodetic evidence may be carried by the crust without compensation is large enough to permit this conclusion not only with regard to the Oquirrh Range, but also to practically any other single Basin Range with the exception of the Sierra Nevada and possibly the Wasatch. There is no reason to question the isostatic balance of the province as a whole, but it seems likely that its individual ranges are not compensated by deficiency in density of the rock columns directly beneath them. (*Author's abstract.*)

T. S. LOVERING: *Geology of the Moffat Tunnel, Colorado.* The Moffat Tunnel cuts through the continental divide on D. & S. L. R. R. about 50 miles west of Denver, Colorado. It is a standard railroad tunnel 16 by 24 feet in cross section and over six miles in length. The original estimate of its cost, $5,250,000, was based on the supposition that nothing but hard rock would be encountered. Unfortunately several thousand feet had to be driven through material so soft that costs were increased fourfold.

The writer made a study of the geology of the tunnel in November, 1927. This study showed that a relatively weak schist had been brought against granite and injection gneiss by a profound fault about 2¼ miles east of the West Portal. Substantial support was needed throughout most of the tunnel driven in the schist but in the granite and gneiss on the east of the fault there are long stretches of unsupported rock tunnel. In the pilot tunnel much of the schist is supported by timbering which needs renewal about once a year. Anyone familiar with mining in the nearby schist areas would find nothing unexpected in the character and behavior of the rock encountered in this section of the tunnel.

However, some surprisingly bad ground was encountered near the large fault and soft swelling ground extends about 700 feet to the west and 300 feet to the east of the main break. In this zone the walls, roof, and floor steadily close in at a rate varying up to a maximum of three inches a day. Strongly reinforced concrete is necessary to withstand the pressures developed in this part of the tunnel. Little water was encountered but the rock is slightly moist when opened.

The rocks in this belt have been thoroughly shattered, and chalcedonic quartz and a clay-like mineral have developed as the cementing material of the minutely brecciated rock mass. Experiments on the elasticity of the rock indicate that relief from the rock pressure obtaining in the tunnel could not account for the swelling of the rock by elastic expansion. Experiments on the hydration of the rock indicate that absorption of water even by thoroughly dried samples of the bad ground causes practically no expansion. As the rock in the tunnel is already moist when first opened, swelling can not by caused by hydration. Tests show that although the rock is weak when dry it is even more devoid of strength when wet.

It is probable that the abundant flakes of moist clay in the rock act as a lubricant along the innumerable free surfaces in the brecciated mass. Thus the swelling of the ground probably expresses the integration of minute slippages between the extremely small fragments in the shattered granite and schist. In the fault zone the rock pressure is essentially all-sided or hydrostatic in its nature and causes a uniform inward movement of the bad ground from top, bottom, and sides of the tunnel. In the course of time the rate of swelling grows gradually less. Continued excavation and shaving of the tunnel walls probably relieve the strain in the nearby ground to a marked degree and these factors are chiefly responsible for the gradual improvement in conditions. The strengthening of the rock mass as it dries out is an additional factor working towards the same end. (*Author's abstract.*)

437TH MEETING

The 437th meeting was held at the Cosmos Club, February 22, 1928, President HEWETT presiding.

Informal communications: W. T. SCHALLER described briefly the organization of a sulphur company recently on trial in New Orleans for fraud.

Program: WILLIAM BOWIE: *Changes in geographic position in California as determined by triangulation.*

Discussed by Messrs. FERGUSON, BUTTS, and ALDEN.

C. S. ROSS: *Report on the studies of clays.* An investigation of the clay minerals, under the auspices of the National Research Council, is in progress in the United States Geological Survey laboratories with the coöperation of mineralogists of the National Museum and of Dr. Paul F. Kerr of Columbia University. This work thus far indicates that the important clay forming minerals are not large in number, and that a large proportion of those formerly described are not valid mineral species. The clays may be divided into 3 main groups. The kaolin group includes kaolinite, halloysite and the macroscopically crystalline form of halloysite. These have moderate indices of refraction, low birefringence, and good crystals are not rare.

The montmorillonite group contains montmorillonite, beidellite, nontronite, the iron bearing member of a beidellite-nontronite series; and two unnamed members of the group. The members of this group are hydrous aluminum silicates with variable proportion of MgO and CaO, and of Fe_2O_3 which latter replaces Al_2O_3. The silica ratios are as follows:

Montmorillonite	SiO_2,	Al_2O_3	= 5:1
Unnamed mineral	"	"	= 4:1
Beidellite	"	"	= 3:1
Unnamed mineral	"	"	= 2:1

The part played by MgO in the mineral composition is not fully known and must be further investigated.

A group of potash-bearing clays has been found but their study is in preliminary stages.

Dr. Kerr has studied the clays by means of X-ray diffraction patterns and thus supplemented optical and chemical studies and added important new information. It has been found that the clays, even though very fine grained, can be investigated by the research methods now at the disposal of the mineralogist. (*Author's abstract.*)

Discussed by Messrs. STOSE, MERWIN, RUBEY, and HEWETT.

H. S. WASHINGTON: *Review of Lacroix's paper on the Rocks of the Pacific Islands.* A review of "La Constitution Lithologique des Iles volcaniques de la Polynésie Australe," by A. Lacroix. This is a very important paper, embodying our present knowledge of the petrology and petrography of the lavas of the volcanic islands of the Pacific Ocean. Details cannot be gone into here, but it may be said that the main conclusions of Lacroix—who gives some 75 new and good chemical analyses of the lavas (many of islands hitherto unknown)—are in general agreement with the views of those who have made a study of the Pacific Island volcanoes. The most important conclusion, one that was known before from study of some of the island groups, is that practically all of them, while they are predominantly basaltic and andestic, show trachytic and other alkalic rocks. This connects the rocks of the Pacific volcanoes with those of the Atlantic and the Indian Oceans, and is adverse to the distinction between the "Pacific" and "Atlantic" clans of rocks. (*Author's abstract.*)

Discussed by Mr. BOWIE.

438TH MEETING

The 438th meeting was held at the Cosmos Club, March 14, 1928, President HEWETT presiding.

Informal communication: L. W. STEPHENSON displayed specimens of Upper Cretaceous chalky limestone of about Austin age from Guatemala, in which were closely associated the fossil remains of at least two species of marine shells of the genus *Inoceramus* and two species of very well preserved land plants, one a fertile pinnule of a fern and the other a twig of a coniferous tree.

Program: N. W. BASS: *The origin of the asymmetrical stream valleys of Kansas.* In Kansas, streams that flow eastwardly and those that flow westwardly are eroding their south banks; the north-facing slopes are steeper than the opposite slopes, and the profile of the interstream areas is asymmetrical, the north side being the shorter. Southward trending valleys do not show this asymmetry.

The principle of Ferrel's law that all streams in the northern hemisphere should exert pressure on their right banks does not apply because it is only eastward flowing streams that are eroding their right banks; westward flowing streams are crowding to their left banks and southward flowing streams appear to maintain a neutral course. Regional tilting southward could have caused the condition noted but the scant evidence indicates that it has not.

Certain climatic factors—more direct rays of the sun on southward-facing slopes; prevailing southerly winds, acting more directly on the south-facing slopes; and abundant rainfall during the hot and windy part of the year—are believed to have broken down and removed the rocks on the north side of the streams more rapidly than those on the south side. The nature of the prevailing strata—interbedded limestone and shale, some interbedded sandstone and shale, and loosely cemented very calcareous sand and gravel beds—is no doubt favorable to the operation of these agents. The greater inwash of material from the north sides than from the south is believed to crowd the streams southward. (*Author's abstract.*)

Discussed by Messrs. SEARS, CAPPS, WHITE, RUBEY, BRADLEY, MATTHES, MISER, THOMPSON, and SCHRADER.

H. D. MISER: *Structure of the Ouachita Mountains of Oklahoma and Arkansas.* The Ouachita Mountains, 200 miles in length and 50 to 60 miles in width, extend westward from central Arkansas into southeastern Oklahoma, about half of the mountain region being included in each State. The rocks, which are mostly shale and sandstone, with some chert and novaculite, range in age from Cambrian to Pottsville (Pennsylvanian) and aggregate in thickness 25,000 feet. All the strata were deformed, presumably in late Pennsylvanian time, by folding and faulting that were produced by compressive movements from the direction of Llanoria in Louisiana and eastern Texas.

The crustal shortening in the Ouachita region in Arkansas is about half the original extent of the strata, but in Oklahoma it is apparently greater than half. The shortening in Arkansas is due to close folding and a minor amount of thrust faulting, but the shortening in Oklahoma has been brought about by many long parallel thrust faults, as well as folds. The folds in Arkansas are characteristically isoclinal in large areas, whereas the folds in most of the Oklahoma area are open, though asymmetrical.

Of the several major faults in Oklahoma the two longest, the Choctaw and the Windingstair, reach into Arkansas. They are 125 and 110 miles in length, respectively. The usually accepted idea is that the planes of the major faults have steep dips—between 30° and 90°. The discovery by the writer in 1927 of a window through an overthrust mass in and near Round Prairie in the Potato Hills, west of Talihina, Okla., indicates the presence of low angle thrust planes in the Ouachita Mountains. The actual horizontal displacement by the fault surrounding the window is at least 3 miles. The fault is interpreted to be the cropping edge of the Windingstair fault plane, which comes to the surface at the south base of Windingstair Mountain, 3 miles north of the hills. The total apparent known extent of the fault plane from Windingstair Mountain into the Potato Hills is 6 miles. The actual extent, of course, exceeds this distance. The plane in this distance is somewhat folded, but the folding of the involved rocks took place for the most part before the thrusting. The discovery of the window leads not only to the obvious conclusion that low angle thrusts exist in the Ouachitas, but points toward the conclusion that the major faults there bound thin slices of the earth's crust.

A greater northward movement of the rocks of the Ouachita region of Oklahoma in comparison with that of the rocks of the same region in Arkansas is suggested by the arcuate forms of the structural trends. In Arkansas most of the trends are west and west-southwest, then along and near the west side of the State they bend to a west-northwesterly direction, and next they swing to the southwest in Oklahoma.

The arcuate trends of the folds and faults in Oklahoma, when considered in connection with the considerable crustal shortening of the rock strata in the Ouachita Mountains, indicate that the rocks of the mountains have been moved in a northerly direction past the east end of the Arbuckle Mountains. The east end of the Arbuckles is, in fact, only about 12 miles from the west end of the Ouachita Mountains.

The proximity of the Ouachitas to the Arbuckles, when considered in connection with their strikingly diverse rock facies, suggests, as has been pointed out by C. L. Dake, that the Ouachita rock section in this part of Oklahoma has been thrust northward a long distance over rocks of the Arbuckle facies. How great the distance is we do not know, but it is perhaps at least 20 miles. (*Author's abstract.*)

Discussed by Mr. Ulrich and Miss Jonas.

Clyde P. Ross: *Salient features of the geology of south-central Idaho.* It is now possible to formulate conceptions of the major features of the part of Idaho between 45° 30′ N. latitude and the Snake River Plain. No Archean rocks are known in this region, with the possible exception of some schist near Ivers. There was a great accumulation of marine beds in the Algonkian, at least in Lemhi County, and such beds probably overspread the whole region. These rocks in places are crumpled and overthrust and it appears that much of this deformation is pre-Cambrian. It appears that almost or quite continuously from the late Algonkian or possibly early Paleozoic to the present the region in which the Idaho batholith is now exposed has been above the sea, although in east-central Idaho seas persisted through most of Paleozoic time. Uplift in the part of Idaho where the Idaho batholith outcrops was dominantly a matter of igneous intrusion rather than of folding of strata in a geosyncline.

The Idaho batholith is now exposed over 16,000 square miles and there are numerous exposures of granitic rocks in areas surrounding this large one. Most of the main batholith and its outliers is composed of a characteristic type of quartz monzonite. This rock all came in during one tremendous period of intrusion. It is at least as old as Cretaceous and present data suggest it may be Jurassic. It is younger than Triassic.

Granite on the Middle Fork of Salmon River was intruded as a sill or irregular laccolith in Miocene or Pliocene time. Sedimentary rock on which this mass rests was converted into injection gneiss through the agency of the Idaho batholith and was again injected by the Tertiary granite, in spite of the thin cover the latter must have had.

The region was eroded nearly or quite to a peneplain and then had stream valleys sharply incised in it before Tertiary volcanism started. After the close of Miocene(?) volcanism the region was again eroded, virtually to a peneplain. Since then the history has been essentially one of intermittent uplift and active erosion. The much discussed "lake beds" along Salmon River are largely water-sorted tuff forming an integral part of the Miocene(?) volcanic series, and their influence on the development of the Salmon River drainage appears to have been of minor importance. (*Author's abstract.*)

Discussed by Messrs. LINDGREN and LOUGHLIN.

W. W. RUBEY, A. A. BAKER, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

The four hundredth meeting of the Chemical Society took the form of a dinner in honor of Dr. F. W. CLARKE, Dr. HARVEY W. WILEY, and Prof. CHARLES E. MUNROE, all of whom were early members of the Chemical Society of Washington which later became the Washington Section of the American Chemical Society. About one hundred and sixty members and guests were present.

The Petrologists' Club met at the Geophysical Laboratory on March 20. D. F. HEWETT discussed *Dolomitization as related to ore deposits*, and C. P. ROSS described *Tertiary injection gneisses in Idaho.*

The 9th annual meeting of the American Geophysical Union was held on Thursday and Friday, April 26 and 27, in the National Academy Building. The Sections of Terrestrial Magnetism and Electricity, Seismology, and Geodesy joined on Thursday morning to hear a symposium on *Geophysical methods as applied in the study of geological structure.* The Sections of Meteorology and Oceanography joined on Thursday morning and afternoon to hear a symposium on *Interrelations between the sea and the atmosphere, and the effect of these relations on weather and climate.* This symposium was in three parts: (1) Problems related to solar radiation, (2) Problems related to surface water temperature, and (3) Problems related to atmospheric circulation. The Section of Geodesy met on Friday morning to hear reports on the progress of geodetic work in Mexico, Canada, and the United Stated, and a symposium on *The figure of the earth.* The Section of Volcanology met on Friday morning to hear papers in its field, and the general assembly of the Union was held on Friday afternoon. H. S. WASHINGTON, Chairman, presided over the general meeting, and WILLIAM BOWIE, Geodesy, L. H. ADAMS, Seismology, T. W. VAUGHAN, Oceanography, H. H. KIMBALL, Meteorology, T. A. JAGGAR, JR., Volcanology, presided over the sectional meetings. G. W. LITTLEHALES is Vice-Chairman, and JOHN A. FLEMING General Secretary of the Union.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, May 5.	The Biological Society.
Wednesday, May 9.	The Medical Society.
Thursday, May 10.	The Chemical Society.
	PROGRAM: F. C. WHITMORE, Chairman of the Division of Chemistry and Chemical Technology, National Research Council, *The habits of the atoms*.
Saturday, May 12.	The Philosophical Society.
Tuesday, May 15.	The Historical Society.
Wednesday, May 16.	The Medical Society.
Saturday, May 19.	The Helminthological Society.
	The Biological Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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RADIOGEOLOGY.—*Lead isotopes and the problem of geologic time.*[1]

Charles Snowden Piggot, Geophysical Laboratory, Carnegie Institution of Washington.

This paper seeks to point out a means of experimentally measuring the lead which has been actually produced by the radioactive disintegration of uranium alone, and thereby to provide definite figures for the uranium-lead ratio in its application to the determination of geologic time.

Of the various methods which have been tried or suggested for obtaining a more or less accurate estimate in terms of years of geologic time, that one which uses the uranium-lead ratio is by far the most promising and the most definite. This method is based upon the fact that uranium and thorium are the original elements which produce, by spontaneous disintegration, the long series of radioactive substances which undergo radioactive changes one into the other until finally they produce in each case lead. This lead appears to have no further radioactivity[2] and is assumed to be the final and end product of these radioactive changes.

The time required for these changes to take place has been accurately determined in the case of the uranium series and with much less accuracy for the thorium series, so that we now know just how many years are required for a given amount of uranium to change into its corresponding amount of lead.

It would seem, therefore, that all that is needed to determine the age of a mineral containing considerable amounts of uranium or thorium or both, together with their corresponding lead, would be a careful

[1] Received April 19, 1928.

[2] However, the term "radioactive lead" has come into the literature, and signifies that lead which is known to have been produced by radioactive means.

chemical analysis to determine the amounts of these various constituents, and the substitution of the figures obtained in a suitable formula.

However, as is usually the case, the actual practice is not so simple as the theory would indicate. The necessary chemical analysis is exceedingly difficult and tedious, and the amounts of the significant elements obtained are so small that minute analytical errors have disproportionately great effects upon the ultimate result. The extrapolation in terms of years over vast geologic ages is so great that legitimate analytical errors may cause a difference of hundreds of thousands of years in the indicated age.

This aspect of the problem must depend upon the completeness of the analytical separations and upon the care and skill of the analyst.

But the chemical analysis alone, however satisfactory it may be as a mineral analysis, cannot show whether or not the lead obtained is all of radioactive origin, or whether it came partly from uranium, partly from thorium, or partly from some other source.

The possibility of enrichment by lead from some non-radioactive source must be considered, and also the partial removal of the lead already radioactively produced. These considerations, however, are outside the scope of this paper.

But assuming that the above requirements have all been satisfactorily met, there yet remain two grave uncertainties which make this method unsound and unsatisfactory in its application. They are the most troublesome uncertainties inherent in this procedure and as yet there has been no direct experimental method for dealing with them. They are:

(1) The uncertainty associated with the disintegration of the thorium series—the time required and the amount and origin of the lead produced.

The thorium series of radioactive disintegrations has not yielded to experimental examination as readily as the uranium series has. Consequently there is considerable uncertainty associated with the time required for a given amount of thorium to form its corresponding amount of lead. Also the quantity of lead produced by a given quantity of thorium is not known with satisfactory accuracy.

Therefore the presence of thorium in a mineral to be used for an age determination injects a considerable element of uncertainty into the result, and as some thorium is always present this cannot be avoided. The formula now used contains a corrective factor to take care of the thorium content, but it is admittedly unsatisfactory.

(2) The fact that there is no actual measure of that proportion of the total lead which is known to have been produced from the uranium alone.

If this latter could be determined by actual experimental measurement the thorium uncertainty could be disregarded and the only other uncertainty which would remain inherent and unmeasured in this method would be the existence of possible isotopes of uranium which might have disintegrated more rapidly in the past than the uranium which we know today.

If the lead in any given mineral being studied could be obtained in sufficient quantity and converted into some compound capable of giving lines in the mass-spectrograph, and if the intensity of these lines could be accurately measured, we would then have a direct experimental method for determining the actual amount of uranium lead present. The position of the line would identify it with the uranium-lead isotope and its relative intensity would furnish a measure of its relative amount, and since the actual weights of uranium and lead would be known from the chemical analysis we would then have all the information necessary for a direct comparison of the amounts of uranium and uranium-derived lead. Any other isotopes of lead could be disregarded and no reliance need be placed upon assumed proportions figured from atomic weight determinations of lead associated with uranium and thorium, while any enrichment by ordinary lead would probably be revealed by an abnormally intense "207 line."

It was with these considerations in mind that the author, in October, 1926, wrote to Dr. F. W. Aston, F.R.S., and requested his criticism and coöperation in a proposed plan to convert samples of lead into some volatile organic compound such as lead tetramethyl, lead tetraethyl, lead phenyl, etc., and to endeavor to secure with it the identification and determination of any isotopes by means of the mass-spectrograph. After some correspondence it was decided that lead tetramethyl was the most promising material, and that the first efforts should be directed toward a separation and identification of the isotopes of ordinary laboratory lead.

For this purpose the author took a sample[3] of lead tetramethyl to Dr. Aston in July, 1927, and shortly thereafter Dr. Aston carried out several experiments with this material. The results were most

[3] Prepared for him by Mr. S. C. WITHERSPOON of the U. S. Chemical Warfare Service.

satisfactory and were first published by Dr. Aston in a brief note to *Nature* dated July 30, 1927.[4]

The experiments demonstrated very clearly the existence of the three anticipated isotopes, namely, those of masses 206, 207, and 208 in the approximate ratios of 4, 3, and 7 respectively, and also revealed the existence of other isotopes of lead, present in very small proportions, of which 203, 204, and 205 were indicated, and 209 was reasonably certain.

The isotopes having been thus definitely separated and identified, the next step was to do the same for "radioactive lead," i.e., lead which had been formed mostly or entirely by the radioactive disintegration of uranium and thorium.

For this purpose the author secured some very pure Norwegian bröggerite, a mineral which contains considerable proportions of uranium and lead but a very small proportion of thorium. This material was carefully analyzed[5] for uranium, thorium, and lead and a sufficient quantity "worked up" to yield about 15 grams of "radioactive lead" chloride.

Five grams of this material was converted into lead tetramethyl[6] and sent in a sealed tube to Dr. Aston. Unfortunately, this tube was broken in transit and the material lost, but another quantity of radioactive lead tetramethyl has been prepared and it is proposed to try this in the mass-spectrograph this summer.

Meanwhile Dr. Aston has been developing an instrument for accurately measuring the relative intensities of the lines on the photographic plates from his mass-spectrograph. This will eliminate the personal equation from this determination and render it capable of exact repetition and comparison.

Since there is very little thorium, relative to uranium, in this bröggerite it is anticipated that these next experiments will show a very heavy line at 206, a very light one at 208, and possibly none at all at 207. It will be interesting to see whether any of the other isotopes show up stronger from this radioactive lead than they did with the ordinary lead tetramethyl.

From the data obtained from these two series of lead-isotope measurements we hope to be able:

[4] Nature **120**: 224. 1927.

[5] By Dr. C. N. Fenner of the Geophysical Laboratory.

[6] See note 3.

(1) To determine directly the uranium:uranium-lead ratio for this sample of bröggerite and thereby secure a reliable estimate of its age.
(2) To determine definitely the thorium:thorium-lead relationships.
(3) To throw some light on the other isotopes of lead and their origin.

BOTANY.—*New plants from Central America.*—XIII.[1] PAUL C. STANDLEY, U. S. National Museum.

The Central American plants here proposed as new belong to the family Rubiaceae. Seven of them are representatives of the vast genus *Psychotria*. Formerly it was believed that this group was poorly represented in Central America, but continued exploration suggests that the Central American species may finally equal in number those known from the Antilles.

Psychotria Alfaroana Standl., sp. nov.

Erect shrub 30–60 cm. high, usually simple but sometimes with a few short branches above, the stems terete or obtusely quadrangular, the internodes mostly short, about 1 cm. long, or sometime elongate; stipules deciduous, 8–18 mm. long, often ciliate, the base oblong-ovate, deeply cleft to below the middle, the lobes linear, long-attenuate; leaves opposite, the petioles 1–2 cm. long, stout, often marginate nearly to the base; leaf blades obovate-oblong to elliptic, 11.5–26 cm. long, 3.5–9 cm. wide, acute or abruptly acute, usually long-attenuate to the petiole and decurrent, sometimes merely acutely cuneate at base, thick-membranaceous, deep green above (often glaucescent when dry), glabrous, usually marked on both surfaces with numerous short linear raphids, beneath somewhat paler, often minutely puberulent on the nerves, at least when very young, but soon glabrate, the costa stout, prominent, the lateral nerves slender, about 13 on each side, divergent at a wide angle, arcuate, anastomosing rather remote from the margin, the intermediate nerves inconspicuous; inflorescence terminal, cymose-umbellate, the primary peduncles several, 4–7 mm. long, sordid-puberulent or glabrate, each bearing few or numerous flowers, these borne on stout puberulent pedicels 2–4 mm. long (in fruit); whole inflorescence compact, subglobose, in fruit 2–4.5 cm. broad, borne on a stout erect peduncle 1.5–3.5 cm. long; bracts deciduous; fruit at maturity red, ellipsoid, 8–10 mm. long, 5–6 mm. thick, glabrous; pyrenes 2, sharply 3 or 4-costate dorsally, plane on the inner surface.

Type in the U. S. National Herbarium, no. 1,253,966, collected in wet forest at El Arenal, Province of Guanacaste, Costa Rica, altitude 500 meters,

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January 18, 1926, by Paul C. Standley and Juvenal Valerio (no. 45179). The following collections are referable here:

COSTA RICA: El Arenal, *Valerio* 62, *Standley & Valerio* 45200. El Silencio, Guanacaste, alt. 750 m., *Standley & Valerio* 44585, 44620, 44603, 44771. Los Ayotes, near Tilarán, Guanacaste, alt. 700 m., *Standley & Valerio* 45359. La Tejona, near Tilarán, Guanacaste, alt. 600 m., *Standley & Valerio* 45845, 45855. Pejivalle, Prov. Cartago, alt. 900 m., *Standley & Valerio* 46985.

The species is named for Don Anastasio Alfaro. It is an unusually well marked *Psychotria*, easily recognized by its dwarf habit and condensed globose inflorescence.

Psychotria haematocarpa Standl., sp. nov.

Shrub 1–2.5 m. high, the branches slender, terete or the younger ones obtusely quadrangular, glabrous, the internodes mostly about 1 cm. long but often much longer; stipules persistent, green, united to form a very short sheath, this bicuspidate on each side, the cusps linear-filiform, 3–4 mm. long, glabrous; leaves opposite, the petioles slender or stout, 3–8 mm. long, not sharply differentiated from the blade, glabrous or sparsely puberulent; leaf blades oblong-elliptic, broadest at the middle, 8.5–14 cm. long, 2.5–5 cm. wide, abruptly or gradually long-acuminate, with narrow, often falcate, attenuate-acute acumen, at base gradually or abruptly acute or attenuate and decurrent upon the petiole, membranaceous, glabrous, somewhat lustrous, deep green above, the costa prominent, beneath slightly paler, the costa and lateral nerves slender, prominent, the lateral nerves about 9 on each side, divergent at a very broad angle, slightly curved, irregularly anastomosing remote from margin, pale, the intermediate nerves prominulous, laxly reticulate, the margins plane; inflorescences terminal, capitate, dense, few-flowered, the peduncles 3–4 mm. long, green, puberulent or glabrate; outer bracts lance-linear, acute, green, glabrous, 1.5–2 mm. long; flowers sessile or nearly so; fruit globose, bright red, glabrous, 5 mm. long; pyrenes obtusely 5-costate dorsally, the inner surface plane, not grooved.

Type in the U. S. National Herbarium, no. 1,254,627, collected in moist forest at Naranjos Agrios, near Tilarán, Guanacaste, Costa Rica, altitude 600 to 700 meters, January 29, 1926, by Paul C. Standley and Juvenal Valerio (no. 46407). One other collection is referred here:

COSTA RICA: Pejivalle, Prov. Cartago, alt. 900 m., *Standley & Valerio* 47194.

The relationship of this plant is evidently with *P. involucrata* Swartz, a species widely dispersed in tropical America. The latter differs in the strongly ascending nerves of the leaves, and in the ample, usually branched inflorescence with large bracts.

Psychotria sylvivaga Standl., sp. nov.

Shrub 1–3 m. high, the branches stout, the older ones brownish, obtusely quadrangular, the young branches minutely puberulent or glabrate, 1.5-4 cm. long; stipules distinct, caducous, broadly ovate, 8–10 mm. long, thin, brown, glabrous, marked with numerous short linear raphids; leaves opposite, the petioles slender or stout, 0.8–2.5 cm. long, glabrous; leaf blades oblong-oblanceolate or rarely elliptic-oblong, nearly always broadest above the middle, 9–17 cm. long, 2.5–5.5 cm. wide, usually abruptly acuminate or short-acuminate, with obtuse tip, gradually long-attenuate to the base and decurrent, thick-papyraceous, deep green above, lustrous when fresh, glabrous, narrowly sulcate along the costa, beneath slightly paler, usually sparsely and obscurely short-barbate in the axils of the lateral nerves, the costa and lateral nerves slender, prominent, the lateral nerves 11–16 on each side, divergent at a wide angle, arcuate, irregularly and laxly anastomosing near the margin, the intermediate nerves obscure; inflorescence terminal, cymose-paniculate, lax, many-flowered, the peduncle 5.5–7 cm. long, erect; panicles 4.5–9.5 cm. long, 5.5–11 cm. wide, the primary branches opposite, divaricate, minutely puberulent, the terminal cymes few-flowered, umbelliform, the pedicels in anthesis 1–3 mm. long, puberulent, in fruit sometimes 8 mm. long; bracts minute, triangular, green, brown-ciliate, caducous, their scars brown-pilose; hypanthium globose-turbinate, 1–1.5 mm. long, minutely puberulent; calyx 1 mm. long, shallowly 5-dentate or subtruncate, the teeth broadly triangular, green, obtuse, minutely ciliolate; corolla salverform greenish white, glabrous, the tube 5 mm. long, 1.2 mm. thick, the lobes triangular-ovate, 1.5 mm. long, obtuse; fruit green, globose, 5-6 mm. long, glabrous; pyrenes 2, obtusely 5-costate dorsally, plane on the inner surface, the seeds not grooved.

Type in the U. S. National Herbarium, no. 1,306,274, collected in wet forest at Yerba Buena, northeast of San Isidro, Province of Heredia, Costa Rica, altitude 2,000 meters, February 28, 1926, by Paul C. Standley and Juvenal Valerio (no. 49989). The following collections are conspecific:

COSTA RICA: Wet oak and bamboo forest near Laguna de la Escuadra, northeast of El Copey, Prov. San José, alt. 2,200 m., *Standley* 41974, 41924. Laguna de la Chonta, northeast of Santa María de Dota, Prov. San José, alt. 2,000 m., *Standley* 42212.

Psychotria chiriquina Standl. differs from the present plant in its smaller leaves, glabrous inflorescence, and short corolla. *P. Jimenezii* Standl., which also is related, has nearly sessile leaves, a short corolla, and more evidently pubescent inflorescence.

Psychotria eurycarpa Standl., sp. nov.

Shrub or small tree, 2.5–5 m. high, the branches stout, green, glabrous, the internodes 1–8 cm. long; stipules persistent, green, glabrous, forming an intrapetiolar ring 1–2 mm. long, this cuspidate between the petioles, the cusp subulate, 1–2.5 mm. long; leaves opposite, the petioles stout, 4–18 mm. long, glabrous; leaf blades chiefly elliptic or broadly elliptic, rarely oblong-elliptic, broadest at the middle, 7.5–15.5 cm. long, 2.5–9 cm. wide (averaging about 9.5 by 4.5 cm.), abruptly acuminate or short-acuminate, with acuminate tip, sometimes rounded at apex and short-cuspidate, at base varying from acute to narrowly rounded, sometimes short-decurrent, papyraceous to thin-coriaceous, glabrous, deep green and lustrous above, the costa elevated, beneath paler, lustrous, the costa and lateral nerves rather stout, pale, prominent, the lateral nerves 6 or 7 on each side, divergent at a wide angle, strongly arcuate and directed upward, extending nearly to the margin and there irregularly anastomosing, the intermediate nerves prominulous, pale, coarsely reticulate; inflorescences terminal, cymose-paniculate, the peduncle 0.7–3 cm. long, stout, erect; panicles corymbiform, 2–3 cm. long, usually broader than long, the primary branches green, compressed, glabrous or minutely pulverulent, divaricate or usually ascending, densely few-flowered, the flowers sessile; bracts persistent, green, inconspicuous, linear to triangular, 1–2 mm. long; hypanthium globose-turbinate, 1 mm. long, pulverulent; calyx 0.8 mm. long, shallowly 5-dentate or subtruncate, the teeth broadly triangular, broader than long, green; corolla in bud 4–6 mm. long, pulverulent; fruit at first green, at maturity blue-black, subglobose, 9–12 mm. long, glabrous, shallowly bisulcate; pyrenes 2, sharply 5-sulcate dorsally, deeply and narrowly sulcate on the flat inner surface from base to apex.

Type in the U. S. National Herbarium, no. 1,254,544, collected in moist forest at Quebrada Serena, southeast of Tilarán, Guanacaste, Costa Rica, altitude about 700 meters, January 27, 1926, by Paul C. Standley and Juvenal Valerio (no. 46237). As representative of the species may be listed several other collections:

COSTA RICA: Forests of San Pedro, near San Ramón, alt. 1,300–1,400 m., *Tonduz* 17657. Finca Montecristo, near El Cairo, Prov. Limón, *Standley & Valerio* 48435. El Arenal, Guanacaste, *Valerio* 98.

The species is well marked by the unusually large fruit.

Psychotria orchidearum Standl., sp. nov.

Small erect epiphytic shrub 15–30 cm. high, glabrous throughout; older branches stout, 3–4 mm. thick, ochraceous, rimose, the younger ones quadrangular, ochraceous, lustrous, the internodes mostly 3–6 mm. long; stipules intrastipular, forming an indurate truncate sheath 1–2 mm. long; leaves opposite, the petioles slender, 2–4 mm. long, or often nearly obsolete; leaf blades elliptic or oblong-elliptic, 15–32 mm. long, 6–12 mm. wide, obtuse or acute, apiculate, usually cuneate-acute or attenuate at base, rarely obtuse, thick and fleshy, deep green above, the venation obsolete, beneath paler, the costa evident but the other nerves obsolete; inflorescence terminal, cymose-paniculate, lax, few-flowered, the peduncle slender, 10–13 mm. long, erect, the panicles 1.5 cm. long and broad or smaller, the branches very slender; bracts persistent, greenish, linear or linear-subulate, 1–3 mm. long; pedicels slender, mostly 3–5 mm. long; hypanthium obovoid, 1 mm. long; calyx 1 mm. long, 4-dentate to the middle, the teeth triangular, acute; fruit subglobose, 3 mm. long, red, shallowly bisulcate laterally; pyrenes 2, smooth dorsally, the inner face slightly concave, deeply and narrowly sulcate from base to apex.

Type in the U. S. National Herbarium, no. 1,306,503, collected on tree in wet forest on Cerros de Zurquí, northeast of San Isidro, Province of Heredia, Costa Rica, altitude about 2,200 meters, March 3, 1926, by Paul C. Standley and Juvenal Valerio (no. 50863). No. 50757, from the same locality, represents the same species.

Psychotria orchidearum is closely related to *P. Maxonii* Standl., a common plant of the same region. *P. Maxonii* has long slender branches and is usually a larger plant; its leaves are much narrower than those of *P. orchidearum*, being chiefly linear-lanceolate.

Psychotria grandistipula Standl., sp. nov.

Shrub 3 m. high, the branches slender, subterete, green, very minutely puberulent, the internodes 1.5–4.5 cm. long; stipule one at each node, caducous, forming a sheath about the young leaves, cleft on one side, 3–4.5 cm. long, long-attenuate to a subulate apex, thin, brown, glabrous; leaves opposite, the petioles slender, 1.5–4 cm. long, minutely puberulent; leaf blades lance-oblong to oblong-ovate or elliptic, 5.5–14 cm. long, 2.2–6 cm. wide, abruptly long-acuminate or cuspidate-acuminate, with attentuate acute tip, at base usually very obtuse to truncate but sometimes (even on the same branch) acute, thick-membranaceous, deep green on the upper surface, glabrous, the venation not elevated, beneath scarcely paler, minutely puberulent on the nerves, the costa and lateral nerves slender, elevated, the lateral nerves 9–14 on each side, ascending or the lowest divaricate, slightly arcuate, extending nearly to the margin, there laxly and irregularly anastomosing, the intermediate nerves obsolete; inflorescences terminal, sometimes appearing lateral by the continued growth of the main axis, cymose-paniculate, usually sessile, 4–13 cm. long, lax, many-flowered, the branches slender, minutely puberulent, divaricate or ascending; bracts caducous; pedicels 3–12 mm. long, straight, minutely puberulent; calyx persistent on the fruit, less than 1 mm. long, shallowly and remotely 5-dentate; fruit subglobose, bright red, 7 mm. long, glabrous; pyrenes 2, obtusely 5-costate dorsally; seeds narrowly sulcate on the inner surface from base to apex.

Type in the U. S. National Herbarium, no. 1,253,164, collected in moist forest near Santa María de Dota, Province of San José, Costa Rica, altitude about 1,600 meters, December 26, 1925, by Paul C. Standley and Juvenal Valerio (no. 43268). Additional collections are at hand, as follows:

COSTA RICA: Santa María, *Standley* 42402, 41806; *Standley & Valerio* 43187, 44098. La Colombiana Farm, Prov. Limón, alt. 70 m., *Standley* 36871.

The last specimen cited has no stipules and may not belong here, although it does not appear to differ essentially in other respects from the collections made at Santa María. It is rather unusual to find in the wet coastal forest a species that grows in such a high and comparatively dry region as that of Santa María.

Psychotria grandistipula is unique among the Costa Rican species of the genus in its exceptionally developed stipules.

Palicourea vestita Standl., sp. nov.

Shrub 1.5–2.5 m. high, the branches slender or stout, subterete, densely villous with short slender spreading yellowish many-celled hairs, the internodes 1.5–7.5 cm. long; stipules persistent, green, united to form a sheath 5 mm. long, this truncate, densely short-villous, bicuspidate on each side, the cusps linear, erect, 5–7 mm. long, stiff, attenuate to the apex, puberulent; leaves opposite, the petioles stout, 1.5–3 cm. long, densely short-villous or tomentulose; leaf blades lance-oblong, broadest at or sometimes slightly above the middle, 10–18 cm. long, 2.5–6 cm. wide, rather abruptly acuminate or long-acuminate, with narrow acute tip, narrowed to the acute or obtuse base, thick-membranaceous, bright green above, short-villous along the costa, beneath slightly paler, densely villous on the nerves with short slender yellowish spreading hairs, elsewhere velutinous-pubescent or sometimes glabrate, the costa stout, elevated, the lateral nerves slender, prominent, about 20 on each side, arcuate-divaricate, irregularly anastomosing close to the margin; inflorescence terminal, cymose-paniculate, many-flowered, narrowly pyramidal, 7–9 cm. long, the peduncle stout, 2.5 cm. long, the branches stout, reddish green, divaricate at right angles, densely pubescent; bracts green, linear, 2–4 mm. long; pedicels 2–5 mm. long, stiff, hirtellous; calyx lobes 5, persistent on the fruit, 1 mm. long, triangular, acute, hirtellous;

fruit blue, obovoid-globose, 5 mm. long, slightly compressed laterally and bisulcate, hirtellous; pyrenes 2, each with 3 broad rounded dorsal costae.

Type in the U. S. National Herbarium, no. 1,253,015, collected in wet oak forest near Quebradillas, about 7 km. north of Santa María de Dota, Prov. San José, Costa Rica, altitude about 1,800 meters, December 24, 1925, by Paul C. Standley (no. 42909).

Among the Costa Rican species of *Palicourea* this may be recognized by the copious pubescence of all parts, and by the numerous lateral nerves of the leaves.

Palicourea macrocalyx Standl., sp. nov.

Shrub 2 m. high, glabrous throughout, the young branches green, subterete, the internodes 2.5–4.5 cm. long; stipules green, persistent, 6–9 mm. long, cleft nearly to the base, the lobes triangular-oblong, 2–3 mm. wide, attenuate to the acute apex; petioles slender, 2–2.5 cm. long; leaf blades elliptic-oblong, 8–12 cm. long, 3.3–5 cm. wide, abruptly short-acuminate, with obtuse tip, at base broadly obtuse to acutish, subcoriaceous, somewhat lustrous, the costa and lateral nerves prominent on both surfaces, the costa stout, the lateral nerves about 14 on each side, divaricate, strongly arcuate, extending nearly or quite to the margin, the intermediate nerves prominulous, reticulate; inflorescence terminal, cymose-paniculate, much branched, dense, many-flowered, about 6 cm. long and broad, the peduncle 5 cm. long, the branches dark purplish; bracts oblong to broadly ovate, 4–5 mm. long, green, obtuse or rounded at apex; pedicels 4–6 mm. long, jointed at apex; hypanthium turbinate, 2 mm. long; calyx 5 mm. long, pale yellow, 5-lobate nearly to base, the lobes ovate, narrowed to the obtuse apex, conspicuously 3-nerved; corolla pale yellow, the tube 9 mm. long, 1.5 mm. thick, the 5 lobes broadly triangular-ovate, 2–5 mm. long, obtuse, spreading.

Type in the U. S. National Herbarium, no. 1,306,801, collected in wet forest on Cerro de las Lajas, north of San Isidro, Province of Heredia, Costa Rica, altitude about 2,200 meters, March 7, 1926, by Paul C. Standley and Juvenal Valerio (no. 51611).

Among the Central American species of *Palicourea* this may be recognized easily by the unusual development of the calyx.

Palicourea pauciflora Standl., sp. nov.

Shrub or small tree, the branches green, the older ones terete, the young ones obtusely quadrangular, the internodes 1–3.5 cm. long, densely and minutely puberulous; stipules 4–5 mm. long, green, persistent, distinct or nearly so, bilobate nearly to the base, the lobes narrowly triangular, narrowed to the obtuse apex, minutely puberulous; petioles slender, 5–15 mm. long, puberulent; leaf blades elliptic-oblong, 4–7 cm. long, 1–2.2 cm. wide, abruptly cuspidate-acuminate, the acumen 8–13 mm. long, narrow, acute, at base acute or attenuate, subcoriaceous, deep green above, glabrous, dull, the venation inconspicuous, beneath paler, minutely puberulous, the costa slender, salient, the lateral nerves very slender, prominulous, about 10 on each side, ascending at a wide angle, arcuate, extending nearly or quite to the margin, the intermediate nerves obsolete; inflorescence terminal, cymose-paniculate, open, sparsely branched, few-flowered, short-pedunculate, 4–5 cm. long and broad, the branches puberulent; bracts lance-oblong, green, 3–4 mm. long; pedicels 3–7 mm. long, glabrous, jointed at apex; hypanthium obovoid, 2–2.5 mm. long, glabrous; calyx 4–6 mm. long, 5–lobate nearly to the base, green, glabrous, the lobes ovate-oblong, unequal, acuminate; corolla greenish purple, glabrous, funnelform, the tube 7–8 mm. long, 2 mm. broad at base, 3 mm. broad in the throat, the 5 lobes broadly ovate, obtuse, 4 mm. long, spreading.

Type in the U. S. National Herbarium, no. 677618, collected in humid forest between Alto de las Palmas and top of Cerro de la Horqueta, Chiriquí, Panama, altitude 2,100 to 2,265 meters, March 18, 1911, by H. Pittier (no. 3222). One other collection is at hand:

PANAMA: Top of Cerro de la Horqueta, alt. 2,265 m., *Pittier* 3237.

Palicourea pauciflora is well marked by the large calyx. From *P. macrocalyx* it differs in its small leaves with inconspicuous venation, and in the narrow acute calyx lobes.

Palicourea montivaga Standl., sp. nov.

Slender dense shrub 1.5–2.5 m. high, the branches subterete, green, glabrous, the internodes short, usually 0.5–1.5 cm. long, sometimes longer; stipules green, persistent, connate, 2–2.5 mm. long, bicuspidate, the cusps less than 1 mm. long; leaves opposite, the petioles slender, 7–15 mm. long, glabrous; leaf blades lance-oblong, 5.5–7 cm. long, 1–2 cm. wide, gradually or abruptly very long-acuminate, with acute tip, acute at base, thick-membranaceous, glabrous, deep green above, slightly paler beneath, the costa and lateral nerves slender, prominent, the lateral nerves about 9 on each side, arcuate-ascending, irregularly anastomosing near the margin, the intermediate nerves obscure; inflorescence terminal, cymose-paniculate, many-flowered, about 3 cm. long and broad, the branches ascending, greenish yellow, sparsely and minutely puberulent or glabrous, the peduncle 1.5-3 cm. long; lowest bracts linear, green, 1.5–2 mm. long, the upper ones shorter and broader, green; pedicels 2.5 mm. long or shorter, jointed at apex, some of the flowers sessile; hypanthium broadly turbinate, 1 mm. long, green, glabrous; calyx about 0.6 mm. long, 5-lobate to the base, the lobes broadly triangular, obtuse or acute, erect; corolla yellow or greenish yellow, glabrous, the tube 7 mm. long, slightly curved, enlarged at base, broadened above and 2.5 mm. broad, the 5 lobes broadly triangular, obtuse, 1.5 mm. long, spreading.

Type in the U. S. National Herbarium, no. 1,306,225, collected in wet forest at Yerba Buena, northeast of San Isidro, Province of Heredia, Costa Rica, altitude about 2,000 meters, February 28, 1926, by Paul C. Standley and Juvenal Valerio (no. 49850). The plant is represented by the following collections:

COSTA RICA: Yerba Buena, *Standley & Valerio* 49205, 49874. Cerro de las Caricias, alt. 2,300 m., *Standley & Valerio* 52107, 52226. Cerros de Zurquí, alt. 2,200 m., *Standley & Valerio* 50541, 50551.

From the species of *Palicourea* reported heretofore from Costa Rica, this is distinguished by its small leaves, small inflorescences, and short corolla.

Palicourea adusta Standl., sp. nov.

Weak shrub, 30–90 cm. high, usually decumbent, sparsely branched, the branches slender, subterete, green, the internodes 1–4.5 cm. long, sparsely pilose with short thick spreading hairs or glabrate; stipules persistent, green, short-connate, bicuspidate, the cusps linear, acute, green, 1–2.5 mm. long; leaves opposite, the petioles 6–10 mm. long, glabrous; leaf blades elliptic to elliptic-oblong, 4–6 cm. long, 1.5–2.5 cm. wide, gradually or abruptly acuminate or long-acuminate, with obtuse or acute tip, at base obtuse or acute, firm, deep green above, usually marked with numerous linear pale cystoliths, at first puberulent on the costa but soon glabrate, beneath paler, when young pubescent with short, pale, appressed or spreading hairs, in age glabrate except on the principal nerves, the costa slender, prominent beneath, the lateral nerves very slender, evident, about 9 on each side, arcuate-ascending, extending to the margin; inflorescence terminal, cymose-paniculate, sparsely branched, many-flowered, the panicles 3.5–6 cm. long and nearly or quite as broad, the branches divaricate, sordid-puberulent, violet; bracts green, 2–4 mm. long, linear or subulate, acute; pedicels 1–2 mm. long, puberulent, jointed at apex; hypanthium rounded-turbinate, violet, 1–1.5 mm. long, sparsely puberulent or glabrate; calyx 5-lobate to base, the lobes less than 1 mm. long, unequal, broadly triangular or triangular-ovate, acute to obtuse and apiculate; corolla violet, 8 mm. long, the tube glabrous, enlarged at base, nearly straight, nearly 2 mm. broad, slightly broadened in the throat, the 5 lobes broadly ovate, 1–1.5 mm. long, obtuse or acutish, erect or ascending, obscurely puberulent on the margins.

Type in the U. S. National Herbarium, no. 1,253,350, collected in wet forest on Cerro de las Vueltas, Province of San José, Costa Rica, altitude 3,000 meters, January 1, 1926, by Paul C. Standley and Juvenal Valerio (no. 43666). The following additional collections are referred here:

COSTA RICA: Cerro de las Vueltas, *Standley & Valerio* 43780, 43908. El Páramo, Jan., 1897, *Pittier* 10486.

In general appearance this plant resembles *P. montivaga,* but that is a large shrub with narrower leaves and greenish yellow inflorescence. In habit *P. adusta* is unlike the other Central American species of *Palicourea,* which are tall erect shrubs.

Palicourea salicifolia Standl., sp. nov.

Slender shrub 1.5–3.5 m. high, glabrous throughout, much branched, the branches rather stout, subterete, the older ones ochraceous, the younger ones green, the internodes mostly 1–2 cm. long but often longer; stipules persistent, short-connate, deeply bilobate, the lobes linear, acute, green, 1.5–2.5 mm. long; leaves opposite, the petioles stout, 4–17 mm. long; leaf blades narrowly oblong to elliptic-oblong, 5.5–10 cm. long, 1.3–2.5 cm. wide, long-acuminate, with narrow obtuse acumen, at base acute to long-attenuate, thick and firm, deep green above, somewhat lustrous, beneath paler, the costa prominent beneath, slender, the lateral nerves very slender, about 13 on each side, divaricate at nearly a right angle, arcuate, irregularly anastomosing near the margin, the intermediate nerves obscure; inflorescence terminal, cymose-paniculate, many-flowered, about 4 cm. long and often much broader, the branches usually divaricate, the peduncle usually less than 1 cm. long; bracts green, linear to oblong or spatulate, usually obtuse, mostly 4–7 mm. long, but the upper ones often smaller; pedicels jointed at apex, in fruit sometimes 1 cm. long but usually shorter, bearing 1 or more small green bractlets; hypanthium broadly turbinate, 1.5 mm. long; calyx 1.5–2 mm. long, 5-lobate nearly to the base, the lobes oblong, oval, or broadly spatulate, rounded at apex, green; corolla not seen; fruit bluish green, subglobose, laterally compressed and bisulcate, about 6 mm. broad, the 2 pyrenes sharply 3-costate dorsally.

Type in the U. S. National Herbarium, no. 1,252,646, collected in wet forest at Laguna de la Chonta, northeast of Santa María de Dota, Province of San José, Costa Rica, altitude 2,000 meters, December 18, 1925, by Paul C. Standley (no. 42174). The following additional collections are at hand:

COSTA RICA: Laguna de la Chonta, *Standley* 42178. Near Finca La Cima, above Los Lotes, north of El Copey, alt. 2,100 to 2,400 m., *Standley* 42795, 42806, 42713, 42642.

In foliage characters this plant resembles *P. montivaga*, but it differs from that species in the large bracts of the panicles and in the larger calyx with very different lobes. The corolla has not been seen, and it may be that the plant should be referred rather to the genus *Psychotria*.

Cephaelis latistipula Standl., sp. nov.

Plants simple, 30–100 cm. high, suffrutescent, glabrous throughout, the stems stout, subterete, the upper internodes 2–3 cm. long; stipules distinct, rounded, 14–22 mm. long and nearly or quite as broad, persistent, thick and firm, conspicuously nerved, bilobate at apex, the lobes about 5 mm. long, acutish, undulate or shallowly and irregularly dentate, the sinus closed or nearly so; leaves opposite, the petioles slender, 2–7 cm. long; leaf blades oval-elliptic to broadly elliptic, broadest at or slightly above the middle, 14–21 cm. long, 7–9 cm. wide, rounded or very obtuse at apex and abruptly short-pointed, with acute tip, shortly narrowed to the acute base, chartaceous, deep green above, paler beneath, the costa stout, prominent, the lateral nerves 11 or 12 on each side, divergent at nearly a right angle, arcuate, faintly anastomosing close to the margin, the intermediate nerves obsolete; inflorescences axillary, capitate, dark red, very dense, many-flowered, sessile or nearly so, about 1 cm. long and 2 cm. broad; outer bracts broadly oblong, 7–8 mm. long, 4 mm. broad, obtuse, the inner bracts narrower, irregularly denticulate and ciliolate about the acute apex, the innermost bracts linear; flowers sessile, the hypanthium broadly turbinate, 1.5 mm. long; calyx 2–2.5 mm. long, deeply 5-lobate, the lobes lanceolate, long-acuminate, denticulate; corolla 5 mm. long, funnelform, the lobes spreading, triangular, acute or acutish, much shorter than the tube, short-villous within; anthers exserted.

Type in the U. S. National Herbarium, no. 1,153,168, collected in moist forest at Orosi, Province of Cartago, Costa Rica, March 30, 1924, by Paul C. Standley (no. 39695). One other specimen has been seen:

COSTA RICA: El Muñeco, Prov. Cartago, alt. 1,500 m., *Standley & Torres* 51252.

Cephaelis latistipula is a well-marked species, easily recognizable by its reduced stature, large leaves, broad stipules, and sessile heads.

Coussarea latifolia Standl., sp. nov.

Tree, glabrous throughout, the branchlets stout; stipules (of uppermost leaves) semiorbicular, 5 mm. long, intrapetiolar, short-connate, broadly rounded at apex, soon deciduous; petioles stout, 1.7–2.5 cm. long; leaf blades broadly elliptic-obovate to broadly ovate-elliptic, 16.5–25 cm. long, 9–16.5 cm. wide, rounded at apex and apiculate, acute or obtuse at base, papyraceous, concolorous, pale green when dry, the costa and lateral nerves stout, salient beneath, the lateral nerves about 9 on each side, arcuate-divaricate, irregularly anastomosing close to the margin; inflorescence terminal, cymose-racemose, 6 cm. long, the peduncle 3 cm. long, compressed, the cymes 2 or 3-flowered, borne on ascending secondary peduncles 6–15 mm. long; bracts deciduous; pedicels stout, 1–4 mm. long; hypanthium obovoid, 4 mm. long; calyx tubular-campanulate, 5–7 mm. long, the limb truncate; corolla (in bud) yellowish white, the tube 1 cm. long, the 4 lobes linear-oblong, 13–15 mm. long.

Type in the U. S. National Herbarium, no. 938840, collected in forests of Tsaki, Talamanca, Costa Rica, altitude about 200 meters, April, 1895, by A. Tonduz (no. 9574).

The species is distinguished from other Costa Rican species of *Coussarea* by its large flowers and broad leaves.

Coussarea paniculata (Vahl) Standl.

Froelichia paniculata Vahl, Eclog. Amer. 3. 1796.
Coussarea froelichia A. Rich. Mem. Soc. Hist. Nat. Paris **5**: 177. 1834.

Coussarea enneantha Standl., sp. nov.

Shrub 3 m. high, the trunk 3.5 cm. thick; young branches subterete, slender, the internodes 1–2 cm. long, densely fulvous-hirsute with short spreading hairs; stipules connate, forming a sheath 3 mm. long, hirtellous, tardily deciduous; petioles slender, 12–18 mm. long, densely short-hirsute; leaf blades elliptic-oblong, 9–12.5 cm. long, 3.2–5.3 cm. wide, abruptly acuminate with obtuse tip, at base acute or acutish, membranaceous, when young shortly fulvous-hirsute above along the nerves, glabrate in age, the venation prominulous, beneath green, hirtellous on the nerves, the costa and lateral nerves slender, prominent, the lateral nerves about 10 on each side, divergent at a wide angle, nearly straight, anastomosing toward the margin to form an irregular but distinct collective nerve, the intermediate nerves prominent, coarsely reticulate; inflorescence terminal, sessile, trichotomous, the branches slender, 2.8–3.8 cm. long, densely fulvous-hirsute with short spreading hairs, each branch 3-flowered at apex; pedicels 2–11 mm. long; bracts linear-subulate, 1–2 mm. long, deciduous; hypanthium obovoid, 2–3 mm. long, densely brown-hirtellous; calyx tubular, 8–9 mm. long, 2.5 mm. thick, hirtellous, the 4 lobes ovate-oblong, obtuse, over half as long as the tube; corolla white, the tube slender, 2.5 cm. long, sparsely pilose with slender spreading hairs, the 4 lobes linear, spreading, about 15 mm. long and 2 mm. wide, obtuse, sparsely hirtellous outside; fruit "white," not seen.

Type in the U. S. National Herbarium, no. 678317, collected in the vicinity of Cana, Panama, altitude 600 to 1,950 meters, April to June, 1908, by R. S. Williams (no. 841).

The proper position of this plant is very uncertain, but it seems to agree better with *Coussarea* than with any other group of Rubiaceae known from Central America.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

200TH MEETING

The 200th meeting was held jointly with the Chemical Society and the Philosophical Society in the Assembly Hall of the Cosmos Club on the evening of Thursday, May 28, 1925. Dr. H. FREUNDLICH of the Kaiser Wilhelm Institute at Berlin-Dahlem delivered an address on the *State of aggregation and form of colloid particles.*

201ST MEETING

The 201st meeting was held jointly with the Chemical Society in the Assembly Hall of the Cosmos Club on the evening of Friday, September 25, 1925. Dr. ALEXANDER FINLAY of the University of Aberdeen delivered an address on the *Appeal of science to the community.* The address is published in *Science*, Vol. 62, Oct. 23, 1925.

202D MEETING

The 202d meeting was held jointly with the Geological Society in the Assembly Hall of the Cosmos Club on the evening of Thursday, November 19, 1925.

Program: Dr. WILLIAM H. HOBBS of the University of Michigan, *The poles of the atmospheric circulation.* The two continental glaciers—the ice mantles which overlie the continents of the Antarctic and Greenland—possess each an autocirculation which is anticyclonic in character, but possessed of a vigor which removes it from all comparison with the so-called anticyclones of other areas. The circulations above the continental glaciers—the glacial anticyclones—are to be ascribed to the domed surface of the inland ice and to the excessive irradiation from the snow-ice surface throughout the year. Such irradiation being a function directly of time, a calm is favorable to the development of centrifugal surface movement of the air upon the domed surface. On the other hand, the descent of the air from the high interior of the continent brings about an adiabatic elevation of temperature, and since this is proportional to the vertical component of the air movement, the high velocity that is developed in the outflowing air currents tends to halt the flow with great suddenness and to restore the condition of calm. The weather above the continental glaciers is thus an alternation of calms with blizzards, which latter evolve gradually but terminate abruptly with rapid elevation of temperature—the foehn phenomenon.

The vigor of these powerful circulatory systems over areas that are measured in hundreds of thousands of square miles, is such as to extend the air movement up to near the ceiling of the troposphere and to include the cirrus level. Because of this vigor the central areas of the glacial anticyclones, instead of being dry and characterized by an excess of evaporation over precipitation, as is the case within the central areas of the shallow and inert migrating anticyclones, are regions of high relative humidity and of large precipitation of moisture in the form both of fine ice needles and of minute water droplets. The source of this moisture, amply confirmed by observation, must be ascribed to the water which was locked up in the ice needles of the cirri and of other high-level clouds, this moisture being first melted and later vaporized adiabatically during its descent to the glacier surface.

The two glacial anticyclones of the earth, one centered relatively near, though not over, the southern geographic pole, and the other centered fully nineteen degrees of latitude from the northern pole, are thus the wind poles of our atmospheric circulation. The north polar area itself, as is clearly shown by observations, is an area of monotonously normal barometric pressure, of relatively warm air, of shifting wind direction, and of high humidity.

The continental glaciers with their overlying fixed glacial anticyclones are the two marked refrigerating regions within our atmospheric envelope, and their function in stimulating the circulation is comparable in importance to that of the heating belt of high insolation near the equator. The strong development of climatic zones in the present geological period must be ascribed to the contributory action of the refrigerating engines in developing the present vigor of the atmospheric circulation; for, if we consider the geologic past, the present is an altogether abnormal period, climatically considered, of the earth's history. As has been clearly shown by David White and F. H. Knowlton, the distribution of delicate plant organisms during the geologic past, since at least the early Paleozoic, shows that no strongly developed climatic zones have existed save only during the Permian and Pleistocene periods, with which later period the present is climatically included. It is of the greatest significance, therefore, that these exceptional periods of climate in the earth's history are the only ones of which it is known that continental glaciers existed which, through their refrigerating effect, could have stimulated to unusual vigor the circulation within the atmosphere. (*Author's abstract.*)

203D MEETING

The 203d meeting was held in the Assembly Hall of the Cosmos Club on the evening of Thursday, December 17, 1925. Dr. ERWIN F. SMITH of the Department of Agriculture delivered an address on *Recent views as to the cause of cancer.*

The address dealt with some of the newer researches on cancer and was substantially the same as that prepared for the New Haven Symposium, which appeared in *The American Naturalist*, May-June, 1926. The author was inclined to believe, with Gye and Blumenthal, that cancers are due to one or more parasites, but he also gave quite fully other views as to causation, namely, the irritation hypothesis and the views of Warburg of Berlin and Burrows of St. Louis.

204TH MEETING

The 204th meeting, the 28th Annual Meeting and a joint meeting with the Anthropological Society, was held in the Administration Building of the Carnegie Institute of Washington on Tuesday, January 12, 1926, with President JUDD of the Anthropological Society in the chair. The program consisted of an address by Dr. BYRON CUMMINGS, Director of the State Museum and Professor of Archeology, University of Arizona, on the subject, *Certain metal objects found near Tucson, Arizona.* A brief abstract of his address follows the minutes of the annual business meeting.

A short intermission followed his address, after which the annual business meeting was held.

The minutes of the 27th Annual Meeting were read and approved.

The Corresponding Secretary, F. B. SILSBEE, reported briefly on the activities of the ACADEMY during 1926. During the year 1925, 24 persons were elected to regular membership, 18 of whom had accepted and qualified during the year, and one of whom had declined. Thirty who had been elected before January 1, 1925, also qualified. Six resignations were accepted, and three members were dropped for non-payment of dues. Eleven deaths occurred among the members, as follows: J. C. BRANNER, E. D. CAMPBELL, MITCHELL CARROLL, T. L. CASEY, D. T. DAY, W. F. HILLEBRAND, W. D. HUNTER, W. G. MILLER, B. H. RANSOM, T. L. WATSON, J. B. WOODWORTH.

The Board of Managers held five meetings devoted mainly to routine business. The list of *One hundred popular books on science* was revised, and the biennial directory was issued. The report was ordered accepted and filed.

The report of the Recording Secretary, WALTER D. LAMBERT, was read. There were held during the year ten public meetings, many of them jointly with one or more affiliated societies. The names of the affiliated societies and of the speakers, and the titles of the addresses and additional items of interest, were given. The report was ordered accepted and filed.

The report of the Treasurer, R. L. FARIS, was read. It showed total receipts of $5,485.39 during the year, and total disbursements of $5,970.01. The value of the ACADEMY's investments was $17,036.37, cash on hand was $2,656.18, and the estimated net worth $19,187.83.

The report of the Auditing Committee, consisting of N. H. HECK, V. K. CHESNUT and D. L. HAZARD, was read, verifying the Treasurer's figures. The reports of the Treasurer and the Auditing Committee were then accepted.

The report of the Editors of the Journal was presented by E. P. KILLIP, Senior Editor. It detailed the distribution of the articles in the various fields of science, and noted a slight increase in the cost per page over the preceding year. The effort to obtain articles in as wide as possible a field of scientific interest was continued. The report was ordered accepted and filed.

The report of the Committee of Tellers, F. B. SILSBEE, G. W. VINAL and E. R. WEAVER, was presented by the chairman. In accordance with the report, the following officers were declared elected: *President*, G. K. BURGESS; *Non-resident Vice-Presidents*, RAYMOND PEARL, W. W. CAMPBELL; *Corresponding Secretary*, FRANCIS B. SILSBEE; *Recording Secretary*, W. D. LAMBERT; *Treasurer*, R. L. FARIS; *Manager, Class of 1929*, A. H. CLARK, L. A. ROGERS.

The following Vice-Presidents nominated by the affiliated societies were then elected: *Archeological Society*, WALTER HOUGH; *Society of American Bacteriologists*, W. D. BIGELOW; *Biological Society*, H. C. OBERHOLZER; *Botanical Society*, R. KENT BEATTIE; *Chemical Society*, F. W. SMITHER; *Institute of Electrical Engineers*, A. R. CHEYNEY; *Entomological Society*, A. G. BÖVING; *Society of Foresters*, G. B. SUDWORTH; *Geographic Society*, F. V. COVILLE; *Helminthological Society*, H. C. HALL; *Historical Society*, ALLEN C. CLARK; *Mechanical Engineers*, H. L. WHITTEMORE; *Philosophical Society*, PAUL R. HEYL.

At 10.15 P.M. the meeting adjourned.

Dr. BYRON CUMMINGS, *Certain metal objects found near Tucson, Arizona.* In September, 1924, Mr. Charles E. Manier and his father, while inspecting an old lime-kiln about nine miles northwest of Tucson, noticed a bit of metal projecting from the side of the trench that had been cut through the formation to open an entrance to the bottom of the kiln. On digging away the gravel and caliche in which it was embedded, the object proved to be a cross made of lead alloy. It had been cast in a crude mold on the surface of ground over which were scattered fragments of ore, caliche and gravel. Made in two parts, the inside of each half had been smoothed and engraved with inscriptions in Latin.

Excavations were then made to the right and to the left of this trench by Mr. Thomas Bent, who owns the land, and Mr. Manier. Scattered over considerable area at between two and a half to six feet below the surface have been found four other double and three single crosses. Besides these crosses there have been uncovered three swords and four parts of swords, three spears and two spear heads, and a peculiar paddle-shaped object that may be called a labrum. All of these are more or less engraved with inscriptions in Latin and various symbols and drawings. On the two unusual crosses entwined with serpents are found some Hebrew inscriptions and symbols.

None of this superimposed material shows any evidence of having been disturbed since laid down by natural forces. All of these articles were found embedded in caliche and gravel at practically the same level. This caliche is a lime crust formed irregularly through sand and gravel deposits by the leaching of the calcareous material from the superimposed and surrounding soil and rock. It settles into pockets, spreads out into sheets and cements the sand and gravel together in hard masses that can be broken up only by a sharp pick or a charge of dynamite. Many of these objects were embedded in part or the whole in this solid caliche and could be removed only by vigorous effort with a good pick. Some lay in pockets or thin strata of sand which were overlaid with strata of caliche. Lenses of gravel and sand extend along horizontally above these articles which, if they had been "planted" in recent years and the holes filled up with caliche and gravel, would be broken and the lines of demarcation readily distinguishable.

The articles are made of a lead alloy. Assays show lead and antimony with traces of tin, gold, silver and copper. Ores of this character are mined in the Tucson mountains, a few miles away, and in other mountains further away to the south. The ores have probably been crushed and crudely smelted, the metals puddled and then used in the manufacture of these weapons and emblems. All are crudely fashioned and show such work as you might expect to be produced by men in the desert country of Arizona, with few tools and no mechanical appliances.

The Latin is the capital script that was in common use for records and religious inscriptions up to about the eighth century A.D. The words are separated by dots, and the construction follows that of the classic Latin of Caesar and Vergil. One would judge that they had been carved by one who had a limited knowledge of classical Latin and had woven expressions with which he was familiar into the record he desired to make. The Hebrew inscriptions on the two serpent swords are words and expressions such as "Jehovah," "peace," "mighty empire," etc.

On the face, these evidences would indicate the work of men who, slightly versed in classical Latin, Roman affairs and Jewish history, wished to record this evidence to astonish their contemporaries. But would any people, one or more centuries ago in this remote region, have had time or means or desire either to hoodwink other men by their show of learning or to deceive posterity? The white men who lived in and traversed this region even fifty years ago had very little time for fun or fiction of this elaborate character, if any possessed the ability to manufacture or inscribe these articles. The problem remains unsolved. (*Condensed from author's manuscript.*)

205TH MEETING

The 205th meeting was held jointly with the American Institute of Electrical Engineers (Washington Section) in the Assembly Hall of the Cosmos Club on the evening of Tuesday, March 9, 1926.

Program: Dr. GEORGE C. SOUTHWORTH, of the American Telephone and Telegraph Company, *Some interesting things about radio transmission.* The electromagnetic waves used in radio transmission differ from light only in wave length. Both represent a power transfer, and the intensity of either may be measured by the electric field strength or by the power propagated through a given area. A simple picture of a radio wave may be developed from the Faraday conception of lines of electric and magnetic force. This view is furthermore consistent with other phenomena, such as power flow in a simple battery circuit or an electric light line, or the propagation of speech energy over a telephone circuit.

The power per unit area propagated in a broadcast signal of ordinary strength is so small as to be measured in millionths of a watt per square meter. In addition to propagating power a broadcast wave exerts a pressure on conducting objects on which it happens to fall. This pressure has been computed and is found to be extremely small. Thus the total force due to waves impinging on a tall skyscraper seldom exceeds a millionth of a millionth of a pound.

There is a threshold value below which the human eye will not respond to light. If this value is interpreted in terms of the units used in measuring broadcast signals, we find that the eye is only a hundredth or a thousandth as sensitive as a good radio receiver. The sun sends to us relatively strong electric waves. These are of the order of a million times as intense as those used in radio communication and amount to perhaps 7.5 volts per centimeter.

When radio waves such as employed for transatlantic telephony are propagated over considerable distances, their intensity is impaired on account of both the spreading of the wave energy into greater space and the attenuation caused by the terrain over which they pass. This attenuation is less when the waves pass over water than over land. If the transmission be over relatively great distances, the attenuation undergoes wide changes throughout the 24 hours. At night it is sometimes so little as to permit of transatlantic communication with relatively small amounts of power, but in daylight, it may be so great as to require hundreds of kilowatts of transmitting power. The change in the received signal caused by this varying attenuation is known as its diurnal variation and has been quite thoroughly studied by Bell System engineers in connection with transatlantic telephony.

The utility of radio waves as vehicles of intelligence is determined not only by their intensity but also by the amount of interfering noise, making the ratio of signal-to-noise of great importance. This ratio for transatlantic communication is a maximum during the hours when darkness prevails over the path between England and America, and has a very definite minimum during the late afternoon when the wall of darkness is passing from England to America. On account of the five hours' difference in the standard times used in Europe and in America, the business days overlap but a few hours during our forenoon. If a commercial telephone circuit were to be set up between England and America, probably it would be during these hours that the circuit would have its greatest usefulness. It happens that they come at a time when transmission is neither very good nor very bad.

When radio is used for broadcasting, its interest is frequently a local one, in which case diurnal variation is not of great importance, but there are local effects which are important. For instance, when broadcast waves pass over metropolitan areas, they are sometimes seriously distorted and very definite shadows are produced in which the signal strength is much reduced. Furthermore, in these areas the quality of reproduced speech may be injured, while that just outside the shadow may be excellent. This quality distortion has been improved by stabilizing the transmitter so that only the very smallest frequency changes can result. Although pronounced shadows have been noted in the vicinity of New York City, the transmission over Washington, D. C., seems to be very normal. (*Author's abstract.*)

206TH MEETING

The 206th meeting was held jointly with the Philosophical Society and the Chemical Society in the Assembly Hall of the Cosmos Club on Thursday, March 18, 1926.

Program: Dr. EDWIN E. SLOSSON, Editor of Science Service, *The chemical interpretation of history.* If we can find out the laws of biochemistry we can not only improve the present generation and control the future but interpret the past. The historian in the light of these laws will be able to tell what happened and why. History will then cease to be a mere chronicle and become part of the science of human behavior. Astronomy was for the first five thousand years a mere observational science, but now has become the extra-mundane branch of physics and chemistry.

Historians record the rise and fall of races. They point out that the decline is often due to a lowering of the birthrate and they ascribe this to various causes, moral, financial, political or social. These are plausible surmises, yet it may be that the real cause was a lack of vitamin E. It might happen that a people or clan or class might die out suddenly through a change of diet, while seemingly well nourished and as vigorous as ever. Until this factor is taken into consideration a charge of race suicide must be held not proven in spite of what the moralists may say.

Why does India present such a strange spectacle in the decline of the vigorous races that have successively invaded the country in past centuries? Why does the conquering caste lose its stamina in a few generations? The cause commonly adduced is the climate, the excess of sunshine? Possibly—and possibly the lack of it. We must take into consideration the "purdah disease." The seclusion of the women and children of the aristocratic classes keeps them in the shade. May not one of the causes of racial decay in India be lack of Vitamin D, which is induced by sunshine and is essential for bone formation?

If you belong to the school of historians which holds that the human factor is all important, that history is merely a chain of biographies of the great men of each generation, then here also chemistry may supply the key. For instance, even the historians who lay most stress upon the climatic and economic factors must admit that the course of the world's history was materially affected by the personal peculiarities and temperament of Napoleon Bonaparte. But all histories agree that the Little Corporal at Lodi was a very different person from the Emperor at Waterloo; different in disposition, enterprise and ability. And no wonder, for his chemical composition had changed in the nineteen years between. He was as unlike his former self as carbolic acid is unlike sugar although they are composed of the same elements.

And in science explanation is the first step toward control. The oldest, most stable, most democratic, and within their limitations most efficient commonwealths in the world have adopted chemical methods of political and industrial management. These are the ants and bees, where the workers have been in absolute control for some five million years. They do not choose the head of the state by popular vote from among their own number as is done in representative governments like ours. They get a fit ruler by feeding. When the workers decide by their silent plebiscite that a new queen is needed, they make one to order.

Then there is the climatic theory of history: that the capacities and activities of a people are due to the effects of climate. But what does the climate affect? Obviously the chemical composition and balance of the body through temperature, humidity, pressure, sunshine, diet and mode of life.

The laws of heredity are concerned solely with the combinations of the determinants in the germ plasm. But what determines the determinants? Obviously the difference in their chemical composition. Some day we may find out their chemical structure. Some day we may be able to alter it. Already it has been found possible by means of X-rays to reach the factors of heredity inside the germ cell and so to transform them as to produce strange creatures, such as have never appeared in nature, and this is not only in the first but in the second generation. Such synthetic animals are mostly monsters, but might it not happen that improved species could be produced in some such way? (*Condensed from author's manuscript.*)

207TH MEETING

The 207th meeting was held jointly with the Philosophical Society and the Biological Society in the Assembly Hall of the Cosmos Club on the evening of Thursday, April 15, 1926, with President BURGESS in the chair. On behalf of the New York Geographical Society, Major-General Charles McK. SALZMAN presented the Charles P. Daly medal to Brigadier General DAVID L. BRAINARD, retired, for his Arctic explorations. General Brainard accepted with a few words of thanks. Major General A. W. GREELY, retired, gave some reminiscences of Arctic exploration and of his association with General Brainard.

Acting for the Secretary of the Navy, Capt. W. S. CROSSLEY presented the Cullom Geographical Medal to Dr. HARVEY C. HAYES for his discoveries in acoustic sounding. Dr. Hayes accepted with a short address of thanks.

Program: Dr. PAUL R. HEYL, of the Bureau of Standards, *Visions and dreams of a scientific man.* Contrary to a rather widely current idea, science and scientific men are not purely matter of fact and prosaic. There is a human, even a poetic side to the study of Nature. The visions which Nature presents to us contain the three characteristic features of poetry: the lyric, the epic, and even the tragic. In addition, they contain what is often lacking in the dreams of the poet and the mystic—an element of reality. (*Author's abstract.*)

208TH MEETING

The 208th meeting was held jointly with the Philosophical Society and the Chemical Society in the Assembly Hall of the Cosmos Club on the evening of Saturday, May 29, 1926. Professor ERNST COHEN of the University of Utrecht delivered an address *The metamorphosis of matter and the alleged constancy of our physico-chemical constants.*

209TH MEETING

The 209th meeting was held jointly with the Smithsonian Institution, the Carnegie Institute and the Biological Society in the auditorium of the National Museum at 10th and B Streets on Friday, June 4, 1926. Dr. ALEXANDER WETMORE of the Smithsonian Institution presided. Dr. JOHANNES SCHMIDT of the Carlsberg Laboratories, Copenhagen, delivered an address on *Danish oceanographic expeditions and investigations of the life history of the eel.* After the address President BURGESS of the Academy announced that Dr. Schmidt had been elected an honorary member of the Academy and presented him with a diploma of membership.

210TH MEETING

The 210th meeting was held jointly with the Chemical Society in the Assembly Hall of the Cosmos Club on the evening of Thursday, December 16, 1926. Dr. LOUIS C. HEILAND for the Board of City Trusts of Philadelphia conferred on Dr. HARVEY C. HAYES the John Scott Medal, the actual delivery being made by Mr. E. C. WARNER, Assistant Secretary of the Navy, who made a brief presentation address.

Program: Professor J. N. BRÖNSTED, of the University of Copenhagen, *The metal amines and their significance for the physical chemistry of solutions.* The study of metal amines has played a considerable rôle in the theory of the structure of inorganic compounds. It promises to have a similar significance for the theory of solutions.

Cations as well as anions are known in great numbers in this group. They combine to form salts which have as a rule characteristic and well defined properties, raging in solubility from about 10^{-5} to 1 mol per liter. These salts are very suitable for a study of the solubility laws of electrolytes and have been so used to a large extent. Such data have been of service in verifying the laws of the activity coefficient in dilute solution.

The complex metal amines may contain anions in complex combination with the central metal atom. In many such cases the anion is split off in aqueous solution with measurable speed (aquotation). The reverse reaction is also measurable. These data are very useful in building up the recent theory of the statics and kinetics of ions.

The usefulness and applicability of the definition of acids and bases by the scheme

$$\text{Acid} \rightleftharpoons \text{Base} + H^+$$

is exemplified in a number of cases in this group of compounds. When water instead of ammonia enters the complex ion, the ion becomes an acid, one of the H atoms in the H_2O molecule being partially split off as H^+. The behavior of such metal amine ions verifies the idea of the significance of the electric charge in determining the acidic or basic character of the molecule.

Basic metal amine ions are of highly catalytic effect upon the decomposition of nitramide. The high positive charge of such ions may be expected to throw some light upon this peculiar catalytic reaction.

The aquotation of the various complex ions follows widely different laws. In some cases the velocity is independent of the H^+ concentration, in other cases extremely sensitive toward it. This phenomenon can be explained on the basis of the different acidity of the ions involved in combination with the effect of the electric charge. This explanation may be of value in many similar cases in other fields of investigation, where the presence of small amounts of acid shows a stabilizing effect. (*Author's abstract.*)

WALTER D. LAMBERT, *Recording Secretary.*

PHILOSOPHICAL SOCIETY

969TH MEETING

The 969th meeting was held at the Cosmos Club February 4, 1928.

Program: W. G. BROMBACHER: *Instrument technique in aircraft flights for international records.* Aircraft flights for international records are made under rules and regulations promulgated by the Fédération Aéronautique Internationale (F. A. I.), the United States member of which is the National Aeronautic Association (N. A. A.). Instruments carried in such flights are submitted to the Bureau of Standards for calibration tests, which certifies the results of such tests to the N. A. A. Of the various types of records such as duration flights, greatest speed and highest altitude with and without useful load, the instrumental problems relating to the highest altitude are of the most interest. The rules provide that one or two sealed barographs be carried in order to determine the lowest pressure reached in the flight which is converted to altitude by use of the altitude-pressure relation of the F. A. I. standard altitude. The method of calibration has consisted in subjecting the barograph to a "flight-history" test in which the temperature and pressure are controlled so as to approximate the flight conditions both as to the values and the rates of change. The pressure in the bell jar in which the instrument is placed is controlled so that the pen of the instrument follows the trace made during the flight. Coils in the bell jar through which carbon dioxide is expanded, enable the reduction of the instrument temperature to values as low as −48°C. The pressure when the pen is on the trace at the ground level and at the highest level is measured by means of a mercurial barometer. The difference in these two pressures when subtracted from the pressure at the ground level at the time of the flight gives the lowest pressure attained. This method of calibration, when certain precautions are observed and assuming the use of first quality barographs, enables the lowest pressure to be determined with an accuracy of 1 to 3 millimeters of mercury. The F. A. I. regulations now in force are far from ideal from a scientific point of view. This country through the N. A. A. has submitted modifications which if adopted will insure more satisfactory results. The lack of complete testing facilities in most of the countries has no doubt prevented adoption of these modifications. (*Author's abstract.*)

A. H. BENNETT: *Recent methods for the measurement of aberrations of telescope objectives.* The failure of geometric optics to explain the light distribution in a star disc is pointed out. Physical optics explains the effects at the focus of a telescope objective in a satisfactory manner. Methods of measuring aberrations of a lens system are divided into two classes, geometric and interference methods, with the results expressed in terms of geometric or physical optics, respectively. The Hartmann geometric method and its modifications, by Merland and by Kingslake, are discussed.

The interference methods of Waetzmann and of Twyman, and the modication of the Hartmann method based on interference by Gardner and Bennett are described. The details of an extension of the latter method, as applied by the author to several astronomical objectives, are presented. Some results of this method are shown in the form of phase contours. (*Author's abstract.*)

F. WENNER: *A seismometer employing electromagnetic and optical magnification, and electromagnetic damping.* The seismometer was designed for use with a particular galvanometer of the fluxmeter type; that is, a galvanometer having a fairly long period and very high damping when the externally connected resistance is low. When the average value of the impressed e.m.f. is zero and the rate of change is not excessively high or excessively low, such galvanometers give deflections approximately proportional to the time integral of the e.m.f. The e.m.f. impressed upon the galvanometer is developed in a winding attached to the steady mass of the seismometer and so is proportional to its rate of displacement. Therefore the time integral of the e.m.f. is proportional to the displacement of a steady mass with respect to its support. Consequently the performance of the apparatus approximates that which would be obtained with a direct mechanical connection between the steady mass and the mirror which produced the record photographically. However, for very short period displacements such as are caused by traffic and very long period tilts caused by temperature changes, there is practically no response.

Magnification. Magnification of earth displacements of periods corresponding to the initial phases of distant earthquakes is high, somewhat more than 1000. In the range of periods of earth displacements from 2 1/2 to 30 seconds, the magnification decreases as the period increases as it does with the usual type of seismometer having the same free period and critical damping. Further, the period of earth displacements for which the magnification is a maximum is practically independent of the period of the seismometer and the stiffness of the suspensions of the galvanometer coil.

Damping. The damping both of the seismometer and of the galvanometer is brought about by the use of a single bridge or shunt across the line connecting these two units instead of by the use of additional magnets and a copper plate located on the seismometer, and the use of a suitable resistance in the galvanometer circuit. The period is determined and the damping adjusted from the position of the galvanometer, which normally would be in a room other than that in which the seismometer would be located and might well be in another building. The steady mass is displaced by the momentary passage of a small current through the winding of the seismometer. This current is led to and from the system at two points so selected that the electric circuit constitutes a balanced Wheatstone bridge with the galvanometer in its normal position. If then the bridge or shunt is opened, the electromagnetic damping is practically removed so the period may be observed by noting the time between turning points of the deflection of the galvanometer. If the bridge is not open, it may be adjusted so as to critically damp the entire system, as shown by the deflections of the galvanometer.

Coupling. The electromagnetic coupling between the galvanometer and the seismometer is very close. If the steady mass of the seismometer is held against one of its limiting stops, the damping of the motion of the galvanometer is approximately ten times critical. It is this close coupling or excessive over-damping of the galvanometer which is responsible for operating characteristics differing materially from those of apparatus of the Galitzin design.

Design. In the design an effort was made not only to produce an instrument having improved operating characteristics but one of simple construction requiring but few adjustments of a type easily made.

Records of several earthquakes have been obtained and some of these show both the initial and later phases very nicely. (*Author's abstract.*)

970TH MEETING

The 970th meeting was held in the Cosmos Club February 18, 1928.

Program: H. L. DRYDEN and G. C. HILL: *Wind pressures on cylinders.* The Bureau of Standards has been engaged in the measurement of wind pressures on cylinders in the neighborhood of the critical region in which the field of flow changes character, with a view toward determining coefficients applicable to large chimneys. After a survey of experiments on the flow about cylinders of all sizes and speeds, attention was focused on the critical region and the results of pressure distribution measurements. The principal changes in the pressure distribution at the critical region are as follows:

1. The zonal angle at which the pressure equals the static pressure decreases by several degrees.
2. The maximum value of the decrease in pressure nearly doubles.
3. The mean value of the decrease in pressure over the rear quarter decreases greatly.
4. The resultant force coefficient decreases by more than 50 per cent.

The results of wind tunnel measurements can not safely be applied to large chimneys because of the large extrapolation required. Some preliminary observations on a 10-foot stack in the natural wind were mentioned as indicating the persistence of the low values of the resultant force coefficient. (*Author's abstract.*)

F. W. STEVENS: *The gaseous explosive reaction at constant pressure.* Thermodynamic studies of the gaseous explosive reaction have been made under conditions of constant volume. In these studies a spherical steel bomb with central ignition was found the most effective. The speaker called attention to the advantages of the use of constant pressure methods in the study of gaseous reactions and pointed out the possibility of realizing this condition in the case of gaseous explosive reactions by the use of temporary soap film containers likewise fired from the center. This unusually simple and easily manipulated device is found to function as a bomb of constant pressure (not necessarily atmospheric). It therefore provides the complement to the bomb of constant volume in the relation

$$pv = nRT$$

By either method, the final pressure or the final volume, as the case may be, corresponds to the equilibrium constant of the reaction for that condition.

$$K = \frac{A'^{n'_1} B'^{n'_2} C'^{n'_3} \text{— — — —}}{A^{n_1} B^{n_2} C^{n_3} \text{— — — —}}$$

The deviation from this constant due to the presence of an inert gas in the zone of explosive reaction permits the specific heat of gases to be determined at the temperature of the reaction. Likewise from the final pressure or the final volume corresponding to the equilibrium constant K, the degree of dissociation of the combustion products CO_2 and H_2O may be determined over wide ranges of temperature and pressure.

The application of constant pressure methods to the study of explosive gaseous reactions, made possible by the bubble device, led to the discovery of an interesting kinetic relation connecting the rate of propagation of the zone of explosive reaction within the active gases with the concentrations (partial pressures) of those gases. It was found that the rate of propagation, s, of the zone of reaction measured relative to the active gases, is proportional to the product of the initial concentrations (partial pressures) of those gases:

$$s = k_1 A^{n_1} B^{n_2} C^{n_3}$$

This fundamental kinetic relation found to exist between the rate of propagation of the zone of reaction within the active gases and the concentration of those gases, is further found to bear much the same relation to the kinetics of explosive gaseous reactions as does the fundamental thermodynamic relation expressed by K bear to the thermodynamics of the reaction. That is, the deviations from this kinetic expression due to the presence of an inert gas in the zone of reaction may be analyzed and interpreted by it, as may also the effect of known mixtures of active gases and the effect of pressure. (*Author's abstract.*)

971st MEETING

The 971st meeting was held at the Cosmos Club March 3, 1928.

Program: F. M. Defandorf: *The corona voltmeter.* The definiteness of the voltage at which corona glow appears at the surface of round wires connected to an alternating voltage source led Prof. J. B. Whitehead to utilize this property in the design of a device for measuring the crest value of alternating voltage, that he called the Corona Voltmeter. It consists of a grounded outer cylindrical electrode and a polished concentric inner electrode which is connected to the high voltage source. Aural detection of corona formation was used in preference to visual and ionization methods. Initial corona formation has been shown to be a function of the inner and outer cylinder radii, the temperature of, pressure of, and kind of gas surrounding the electrodes. Dr. H. B. Brooks modified Whitehead's corona voltmeter by providing more accurate control of pressure, temperature, and humidity, previous to its calibration at the Bureau of Standards, where it was found that fouling the corona forming surface with a very small amount of impurity (cylinder oil) altered the corona voltage appreciably. With the surface in an undisturbed "cleaned" condition check readings to within 0.02 per cent could be made. Increase in humidity may raise or lower corona voltage by as much as 3 per cent depending on the size of rod and gas density. The observed data were shown to be in fair agreement with a modified law of corona, and a monogram designed by Brooks for rapid determination of corona voltage from the pressure and temperature measurements for dry air was shown. The apparent superiority in accuracy of the corona voltmeter over the sphere gap was discussed briefly.

W. P. White: *Some surprising adsorption effects.*

Ralph E. Gibson: *The influence of pressure on the high-low inversion of quartz.* The temperature at which quartz inverts from the low to the high form is raised by the application of a uniform hydrostatic pressure. From observations made at pressures from 1 to 3000 megabaryes the rise in the inversion temperature is given as the following function of the pressure:

$$T = -0.3 + 2.1 \times 10^{-2} p + 8.6 \times 10^{-7} p^2$$

From these results the latent heat of inversion and the specific heat of low quartz are calculated.

Underlying the calculation of the specific heat of low quartz are two assumptions which are justified from considerations of the nature of the inversion. (*Author's abstract.*)

H. E. MERWIN, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. E. G. ZIES of the Geophysical Laboratory will spend several months in the Dutch East Indies, in a study of the gases and other volatile products of the volcanoes of that region. Messrs. E. T. ALLEN and C. N. FENNER will spend the summer in a chemical and geological study of the geysers and hot springs of the Yellowstone National Park.

Two lectures supplementary to the annual series of the Carnegie Institution of Washington were given in April. The lecturers and their subjects were: April 18, FRANCIS G. BENEDICT, Director of the Nutrition Laboratory, *Basal metabolism, the modern measure of vital activity;* April 20, CHARLES B. DAVENPORT, Director of the Department of Genetics, *Race crossing in Jamaica.*

The Petrologists' Club met at the Geophysical Laboratory on April 17. H. G. FERGUSON described the *Gold quartz veins of the Allegheny region, California;* G. W. MOREY gave a *Review of the critical phenomena in polycomponent systems.* Officers for the next season were chosen, as follows: *Secretary-Treasurer,* G. TUNELL; *Steering Committee,* D. F. HEWETT, F. C. SCHAIRER, W. T. SCHALLER.

At the April meeting of the Anthropological Society, NEIL M. JUDD, Curator of American Archeology, U. S. National Museum, the retiring president, delivered an address on *The present status of archeology in the United States.*

At the meeting of the National Academy of Sciences on April 23, 24, and 25 the following papers were read by Washington scientists: R. M. LANGER and GERALDINE K. WALKER, *Models of the Schrödinger atom;* E. O. HULBURT, *Ionization in the upper atmosphere of the earth;* FRANK WENNER, *A seismometer employing electromagnetic and optical magnification and electromagnetic damping;* DAVID WHITE, *Algal deposits of Unkar Proterozoic age in the Grand Canyon, Arizona;* HENRY S. WASHINGTON, *The bearing of the Pacific lavas on the question of the Atlantic and Pacific rock clans;* ALEŠ HRDLIČKA, *Traces of prehistoric man in Alaska;* JAMES W. GIDLEY, *Additional evidence on Pleistocene man in Florida;* WALTER T. SWINGLE, *Metazenia in the date palm, possibly a hormone action exerted by the endosperm;* CHARLES F. CRAIG, *Observations upon complement fixation in infections with Endamoeba hystolytica.* ARTHUR KEITH, U. S. Geological Survey, was elected to membership in the Academy.

Dr. J. WALTER FEWKES made the presentation address at the unveiling of the bust of Louis Agassiz at the Hall of Fame in New York, May 10. Dr. Fewkes was a pupil of Agassiz.

Dr. C. POULSEN, Mineralogical Museum, Copenhagen, is spending April and May at the National Museum in connection with his study of the Silurian fossils collected in North Greenland by Dr. Lauge Koch.

A. A. BAKER, U. S. Geological Survey, has left Washington to continue work on the geology of southeastern Utah, and C. H. DANE, of the same organization, is studying the geology of the southeastern part of the San Juan Basin, northwestern New Mexico.

H. W. HOOTS has recently resigned as a geologist in the U. S. Geological Survey to engage in commercial geology.

Obituary

Dr. JOSEPH NELSON ROSE, a member of the Academy, died May 4, 1928. He was born in Union County, Indiana, January 11, 1862, and educated at Wabash College. In 1888 he came to Washington as assistant botanist in the Department of Agriculture, and on the reorganization of the National Herbarium in 1896, and its transfer to the custody of the Smithsonian Institution, became assistant curator, and later associate curator, which position he held at the time of his death. Dr. Rose made extensive botanical explorations in the American tropics and in the Andes, particularly in connection with his monographic study of the cactus family. He is the author of a large number of papers on systematic botany, extending over a period of forty years. Aside from a series of papers on the flora of Mexico, his principal publications have dealt with the Apiaceae and several groups of succulents.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, May 19.	The Helminthological Society.
Wednesday, May 23.	The Medical Society.
Saturday, May 26.	The Philosophical Society.
Wednesday, May 30.	The Medical Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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PHYSICS.—*The thermodynamic characteristic for all bodies.*[1] A. PRESS. (Communicated by E. W. WOOLARD.)

Starting with the fundamental energy equation of thermodynamics we have

$$dQ = dU + pdv = dU + dW \quad \text{.................(1)}$$

In general, of course, dU, representing the internal energy, is a perfect differential—not so pdv. To integrate (1) we require to turn the whole equation into a perfect differential. The common mathematical device of multiplying with a known integrating factor can therefore be resorted to. For generality let this integrating factor be

$$\mu = f(v, \theta) \quad \text{.......................(2)}$$

The energy equation (1) then takes the form

$$\mu\, dQ = \mu \frac{\partial U}{\partial \theta} d\theta + \mu \left(p + \frac{\partial U}{\partial v}\right) dv \quad \text{.............(3)}$$

The usual condition that now needs to be satisfied for a perfect differential is that we have

$$\frac{\partial}{\partial v}\left(\mu \frac{\partial U}{\partial \theta}\right) = \frac{\partial}{\partial \theta}\left\{\mu \left(p + \frac{\partial U}{\partial v}\right)\right\} \quad \text{..............(4)}$$

which reduces to

$$\frac{\partial U}{\partial \theta} \cdot \frac{\partial \mu}{\partial v} - \frac{\partial U}{\partial v} \cdot \frac{\partial \mu}{\partial \theta} = \frac{\partial}{\partial \theta}(\mu\, p) \quad \text{...............(5)}$$

[1] Received March 20, 1928.

It is to be remembered that thermodynamically speaking equation (5) applies to all bodies. No matter what the U may be, as a function of v and θ for a particular body, it nevertheless is true that (5) obtains. Yet the whole of ordinary thermodynamics rests on the basis that the three variables, p, v and θ for example, are sufficient to specify a thermodynamic surface function. In the above, five variables

$$U,\ \mu,\ p,\ v,\ \theta \qquad (6)$$

occur. The question arises, can a surface characteristic function such as

$$p = F\ (v,\ \mu) \qquad (7)$$

be formed in view of (2), (thereby giving $p = F\ (v,\ \theta)$ if desired), that will satisfy (5) and obtain for all bodies. Equation (7) therefore needs to be a very comprehensive, that is, functional type.

Let us therefore postulate the following:

(*a*) That a function $\mu = f\ (v, \theta)$ exists which as an integrating factor will be common to all bodies characterized by the energy equation (1).

(*b*) That for any μ so taken, and a p given, a body can always be found that will enable U to be arbitrarily chosen, making U therefore an independent variable with respect to a given μ and p.

If then the above postulates are accepted, a solution of (5) can be found by the method of separation of variables.

Thus we can take as one independent variable

$$\chi = \frac{\partial}{\partial \theta}\ (\mu p) \qquad (8)$$

On the other hand for the same μ applying to all bodies we can introduce a further independent variable defined by the relation

$$Z = \frac{\partial U}{\partial \theta} \cdot \frac{\partial \mu}{\partial v} - \frac{\partial U}{\partial v} \cdot \frac{\partial \mu}{\partial \theta} \qquad (9)$$

This should appear possible in view of postulate (*b*). We then have by (5) that

$$Z = \chi \qquad (10)$$

In an equation of the type of (10), or its equivalent (5), we are therefore entitled to seek a "particular solution" by setting each side in turn equal to zero.[2] Thus for the right hand term we have

$$\frac{\partial}{\partial \theta}(\mu p) = 0;\ pV = \frac{1}{\mu} \dots\dots\dots\dots (11)$$

Where V is an arbitrary function of v arising as a "constant" of integration. This is a very simple relation for the thermodynamic characteristic for all bodies.

In fact if we wish to determine the integrating factor μ for any characteristic applying to a particular body, equation (11) indicates the method if the V-function is known. This will be exemplified.

An equation such as (11), or its equivalent

$$\frac{\partial U}{\partial \theta}\cdot\frac{\partial \mu}{\partial v} - \frac{\partial U}{\partial v}\cdot\frac{\partial \mu}{\partial \theta} = 0 \dots\dots\dots\dots (12)$$

has other important consequences, for we have that

$$\frac{\dfrac{\partial U}{\partial \theta}}{\dfrac{\partial U}{\partial v}} = \frac{\dfrac{\partial \mu}{\partial \theta}}{\dfrac{\partial \mu}{\partial v}} \dots\dots\dots\dots (13)$$

showing that we must also have

$$\mu = \Phi(U) \dots\dots\dots\dots (14)$$

The integrating factor is then a function of the internal energy U. For the perfect gas we would thus have

$$\mu = \frac{1}{\theta} = \Phi(U) \dots\dots\dots\dots (15)$$

Of course having found the "particular solution" given by (11) we can attempt to find a more "complete solution." Let us then write

$$\mu = M\,\mu_0 \dots\dots\dots\dots (15a)$$

where

$$\left.\begin{aligned} M &= \phi(U)\cdot\psi(v, \theta) + 1 \\ \mu &= \mu_0 + F(v, \theta) \end{aligned}\right\} \dots\dots\dots\dots (16)$$

giving (second line of (16))

and

$$\mu_0 = \Phi(U) \dots\dots\dots\dots (14)$$

[2] Or to a constant. The latter alternative does not check with the requirements for an ideal gas.

Taking note of (12) and (15a) we have

$$\left.\begin{aligned} \left(\frac{\partial \mu}{\partial v}\right)_\theta &= M\left(\frac{\partial \mu_0}{\partial v}\right)_\theta + \mu_0\left(\frac{\partial M}{\partial v}\right)_\theta \\ \left(\frac{\partial \mu}{\partial \theta}\right)_v &= M\left(\frac{\partial \mu_0}{\partial \theta}\right)_v + \mu_0\left(\frac{\partial M}{\partial \theta}\right)_v \\ \frac{\partial}{\partial \theta}(\mu_0\, p) &= M\frac{\partial}{\partial \theta}(\mu_0\, p) + \mu_0\, p\left(\frac{\partial M}{\partial \theta}\right)_v \end{aligned}\right\} \qquad (17)$$

Substituting back it follows that

$$M\frac{\partial U}{\partial \theta}\cdot\frac{\partial \mu_0}{\partial v} - M\frac{\partial U}{\partial v}\cdot\frac{\partial \mu_0}{\partial \theta} - M\frac{\partial}{\partial \theta}(\mu_0\, p)$$

$$+\mu_0\left(\frac{\partial M}{\partial v}\right)_\theta\cdot\frac{\partial U}{\partial \theta} - \mu_0\left(\frac{\partial M}{\partial \theta}\right)_v\cdot\frac{\partial U}{\partial v} = \mu_0\, p\left(\frac{\partial M}{\partial \theta}\right)_v \qquad (18)$$

The first line of (18) then vanishes because by (14) μ_0 is already the particular integrating factor. That is to say, (18) must reduce to the following

$$\frac{\partial U}{\partial \theta}\cdot\left(\frac{\partial M}{\partial v}\right)_\theta = \left(p + \frac{\partial U}{\partial v}\right)\left(\frac{\partial M}{\partial \theta}\right)_v \qquad (19)$$

A simplification of (19) is in order because by definition in (16), M is assumed a function of v and θ so that

$$\frac{\left(\frac{\partial M}{\partial v}\right)_\theta}{\left(\frac{\partial M}{\partial \theta}\right)_v} = -\left(\frac{\partial \theta}{\partial v}\right)_M \qquad (20)$$

That is to say, we can write (19) in the following manner

$$p + \frac{\partial U}{\partial v} = \left(-\frac{\partial \theta}{\partial v}\right)_M\cdot\frac{\partial U}{\partial \theta} \qquad (21)$$

The function M then does exist, for thermodynamically speaking the latent heat function $p + \frac{\partial U}{\partial v} = l$ must be in some manner related to the specific heat at constant volume, $\frac{\partial U}{\partial \theta} = C_v$.

Applying the above to the equation of a perfect gas by way of example, let

$$pv = R\theta \quad \text{.......} (22)$$

Then for the integrating factor μ_0 we can set according to equation (11) that

$$\frac{1}{\mu_0} = R\theta;\ \mu_0 = \frac{1}{R\theta} \quad \text{.......} (23)$$

Again, knowing that for a perfect gas $\frac{\partial U}{\partial v}$ in (21) would be equal to zero we have

$$\frac{\partial U}{\partial v} = 0;\ \frac{\partial U}{\partial \theta} = C_v = \alpha \quad \text{.......} (24)$$

Therefore by (21) and (22)

$$-\alpha \cdot \left(\frac{\partial \theta}{\partial v}\right)_M = \frac{R\theta}{v} \quad \text{.......} (25)$$

The integral of (25) is consequently

$$\theta \cdot v^{\frac{R}{\alpha}} = f(M) \quad \text{.......} (26)$$

and for the simplest form of $f(M) = M$ we have

$$\mu = \theta \cdot v^{\frac{R}{\alpha}} \cdot \frac{1}{R\theta} = \frac{1}{R} \cdot v^{\frac{R}{\alpha}} \quad \text{.......} (27)$$

In other words a further integrating factor is a function of v only whereas the original one was $\mu = \frac{1}{\theta}$.

Multiplying the Energy Equation with the μ of (27) we have for an ideal gas in view of (24) and (22) that

$$R_\mu\, dQ = v^{\frac{R}{\alpha}} \cdot \frac{\partial U}{\partial \theta} \cdot d\theta + v^{\frac{R}{\alpha}} \cdot p \cdot dv$$

$$= v^{\frac{R}{\alpha}} \cdot \alpha \cdot d\theta + R\theta \cdot v^{\frac{R}{\alpha} - 1} \cdot dv \quad \text{.......} (28)$$

The latter is a perfect differential since we have

$$\frac{\partial}{\partial v}\left(\alpha\, v^{\frac{R}{\alpha}}\right) = \frac{\partial}{\partial \theta}\left(R\theta\, v^{\frac{R}{\alpha} - 1}\right) \quad \text{.......} (29)$$

Elsewhere I have shown that the particular integrating factor given by

$$\left.\begin{aligned} pV &= \frac{1}{\mu} \\ \text{with } \mu &= f(U) \end{aligned}\right\} \qquad (30)$$

leads to a consideration of a new type of cycle analogous to that of Carnot. The new cycle comprises two adiabatics and two iso-U curves instead of two isothermals.

CRYSTALLOGRAPHY.—*The crystallography and optical properties of β-lactose.*[1] EDGAR T. WHERRY, Bureau of Chemistry and Soils.

Although the crystallographic features of ordinary α-lactose have been fully described, there appear to be no data on the β-form. In the study of the development of minute crystals of sugars in ice cream, the Bureau of Dairy Industry of the United States Department of Agriculture found it desirable to have means for distinguishing these two forms of lactose from one another as well as from sucrose, and the examination of the grains by the immersion method under the polarizing microscope seems well adapted to the purpose. Accordingly O. E. Williams of that Bureau prepared and turned over to the writer a sample of crystallized β-lactose, in order that its properties might be determined and contrasted with those of other sugars. The crystals were obtained by holding a concentrated lactose solution at a temperature of about 94°C. They were then washed several times with hot glycerol and hot ethanol. The melting point was found to be 252.4°C.; since the melting point given in the literature is 252.2°, their identity was thus confirmed.

The crystals, which range from 1 to 5 mm. in diameter, are transparent and colorless. They have a pronounced polar development, and the distribution of their faces show that they belong to the holoaxial-polar (sphenoidal) class of the monoclinic system. Measurements of 10 crystals were made on the two-circle goniometer, with the results presented in Table 1.

[1] Received March 19, 1928.

TABLE 1.—ANGLES OF β-LACTOSE

Monoclinic, holoaxial-polar; $a : b : c = 0.817 : 1 : 0.377$; $\mu = 88° 15'$

No., letter	Symbols		Description	Angles			
				Measured		Calculated	
	Goldschmidt	Miller		φ	ρ	φ	ρ
1.*c*	0	001	Prominent but distorted	80°–85°	1° 45′	90°00′	1°45′
2.*m*	∞	110	Dominant, reflecting well	50° 45′	90° 00′	50°45′	90°00′
3.*L*	−2 ∞	$2\bar{1}0$	Prominent, much curved	65°–75°	90° 00′	67°46′	90°00′
4.*X*	$-1-\frac{2}{3}$	$\bar{3}23$	Moderately curved	58°–60°	25°–27°	59°44′	26°29′

For the most part the faces are more or less rounded, but the angles could be measured with sufficient precision to make the second decimal place certain, so that the axial ratios are stated to the third place. The form having the most nearly perfect faces was taken as the positive unit prism, and used for orienting the crystals on the goniometer. The value of the acute monoclinic angle μ (often called β by American crystallographers, although this symbol more properly belongs to the obtuse angle) was then obtained by measuring the ρ angle of the principal terminal plane, which was taken as the basal pinacoid. To obtain the axial ratio c it was necessary to use measurements on a distinctly curved form, so that the value of this axis is especially uncertain. That form was taken to be a negative back pyramid, and the symbol for it which gave the most reasonable value for c was found by trial to be ($\bar{3}23$). Figure 1 shows the habit, the plan at the top having been drawn with straight edges in the theoretical positions, the parallel-perspective elevation below with the edges in part curved as they are in reality.

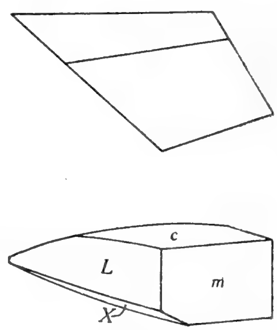


Fig. 1

When examined by the immersion method under the polarizing microscope, the substance appears in irregular fragments, showing between crossed nicols first to third order colors, and yielding on trial with successive liquids the refractive index values: $\alpha = 1.542$, $\beta = 1.572$, $\gamma = 1.585$. As the positions of the grains are random, means of these values are usually exhibited, although it is not difficult to find grains with the different index directions lying horizontally, so that matching with the corresponding liquids can be obtained. In convergent polarized light negative biaxial interference figures having a rather large axial angle, 2E = 120°, are occasionally obtained, the axial plane lying in the ortho-zone, and the acute bisectrix lying in angle μ about 30° from axis *c*. Table 2 shows these values, contrasted with those of α-lactose and sucrose.

TABLE 2.—OPTICAL CONSTANTS OF THREE SUGARS

Substance	α	β	γ	$2E$
α-lactose	1.517	1.553	1.555	$33\frac{1}{2}$°
β-lactose	1.542	1.572	1.585	120°
Sucrose	1.540	1.567	1.572	79°

The reason that the refractive indices of the β-lactose are so much higher than the corresponding ones of the α-form is that the former is anhydrous, whereas the latter is a monohydrate. The value of β given for α-lactose represents a redetermination, and accords with the small axial angle better than the value usually ascribed to this substance. In all three cases, however, β is less certain than are the other two indices, because of the random positions assumed by the grains.

For distinguishing these three sugars in practice the procedure given in Table 3 may be used. Oily immersion liquids of refractive indices 1.520, 1.540, 1.555, 1.570, and 1.585 are required. All observations should be made on grains brought to an extinction position by rotating the stage until the grain attains its maximum darkness as viewed between crossed nicols, and then removing the upper nicol (analyzer). The rule for ascertaining the relative values of the refractive indices is simply that on *raising* the microscope-tube slightly a band of light is seen to pass into that substance—crystal or liquid—having the *higher* index in the direction of the vibration plane of the polarizing nicol. In making such observations in white or yellowish light, the ordinary eye is unable to distinguish differences in refractive index between two substances in contact less than about $\pm$ 0.003; apparent matching means, then, that the index of crystal and liquid agree with this degree of approximation.

TABLE 3.—DIRECTIONS FOR DISTINGUISHING α-LACTOSE, β-LACTOSE, AND SUCROSE

Immerse in liquid 1.520. If the boundaries of numerous grains disappear, repeat with liquid 1.555; if this is also matched by a number of grains the substance is .... α-lactose.

In case the refractive indices of the grains are all decidedly higher than the first liquid, try liquid 1.540. If this matches the lowest index of some grains, repeat with liquid 1.570; if some grains match this and none show a higher value, the substance is .... sucrose.

If one refractive index on many grains proves to be distinctly higher than the last liquid tried, immerse next in liquid 1.585. If this matches the highest refractive index of any of the grains, the substance is .... β-lactose.

Should none of these requirements be fulfilled, the substance under examination is neither lactose nor sucrose.

GEOLOGY.—*A new locality for Fox Hills fossils in Colorado.*[1] J. HARLAN JOHNSON, Colorado School of Mines (Communicated by JOHN B. REESIDE, JR.).

In August, 1926, the writer discovered a new and rather prolific locality for Fox Hills fossils that seems worth recording because of the fine preservation and unusual variety of forms present. It is located in secs. 21 and 22, T. 11 N., R. 68 W., southeast of Round Butte and about 12 miles north of the town of Wellington in Larimer County, Colorado.

The fossils occur in a relatively thin zone at about the base of the Millikin sandstone member, as defined by Henderson.[2] The stratigraphic section at the locality is as follows:

SECTION OF PART OF THE FOX HILLS SANDSTONE IN SECS. 21 AND 22, T. 11 N., R. 68 W., LARIMER COUNTY, COLORADO.

Bed		Feet
8.	Sandstone, greenish yellow, massive though rather soft	25
7.	Sandstone, white, containing many small limonite concretions	9
6.	Sandstone, soft, massive, white with light brown streaks; some buff concretions near base	18
5.	Sandstone, hard, dark brown	1
4.	Sandstone soft, massive, white; contains irregularly scattered concretions as much as 4 feet in diameter	12
3.	Sandstone, soft, buff; contains brown concretions of varying size	15
2.	Shale, brown, sandy, with much concretionary limonite in small masses	4
1.	Shale, dark gray to black, slightly sandy	?

Most of the fossils collected came from beds 5 and 6. There were also, in bed 4 and bed 6, sandstone casts of pelecypods, sometimes showing remnants of the shell, but usually in a poor state of preservation. No fossils were noted in beds 1, 2, or those below the measured section. The best preserved specimens came from concretions in bed 4, though a number of well preserved fossils came from other concretions at the base of bed 6.

The fauna of the locality, as determined by John B. Reeside, Jr., of the U. S. Geological Survey, is as follows:

Pelecypoda: *Callista nebraskensis* Meek and Hayden, *Cardium speciosum* Meek and Hayden, *Gervillia subtortuosa* Meek and Hayden, *Mactra formosa* Meek and Hayden, *Modiola meeki* Evans and Shumard,

[1] Received March 13, 1928.

[2] JUNIUS HENDERSON. Colo. Geol. Surv. Bull. **19**: 22. 1920.

Nucula larimerensis Reeside,[3] *N. weldensis* Reeside,[3] *Ostrea gillulyi* Reeside,[3] *Ostrea* sp.?, *Protocardia subquadrata* Evans and Shumard, *Pteria nebrascana* Evans and Shumard, *Teredo?* tubes, *Veniella humilis* Meek and Hayden.

Scaphopoda: *Dentalium gracile* Hall and Meek.

Gastropoda: *Anchura americana* Evans and Shumard, *Cylichna volvaria* Meek and Hayden, *Fasciolaria* (*Piestocheilus*) *scarboroughi* Meek and Hayden, *Fasciolaria* sp., *Fusus* (*Serrifusus*) *dakotensis* Meek and Hayden, *Fusus?* sp., *Gyrodes johnsoni* Reeside,[3] *Haminea subcylindrica* Meek and Hayden, *Lunatia occidentalis* Meek and Hayden, *L. subcrassa* Meek and Hayden, *Pyropsis bairdi* Meek and Hayden?, *Pyropsis* sp., *Trachytriton vinculum* Hall and Meek.

Cephalopoda: *Discoscaphites conradi* Morton.

Associated with the invertebrates were shark teeth, small vertebrae of fish, and silicified wood, in part showing the effects of attack by boring mollusks.

PALEONTOLOGY.—*New Cretaceous mollusks from Colorado and Utah.*[1] JOHN B. REESIDE, JR., U. S. Geological Survey.

This paper describes three species of pelecypods and a gastropod from the Fox Hills sandstone (Maestrichtian) of northeastern Colorado and a gastropod from the base of the Colorado group (lower Turonian) of Utah. The geographic location, stratigraphic position, and faunal association of the Fox Hills species are described above by Professor J. Harlan Johnson (pages 305–306).

Genus NUCULA Lamarck

Nucula larimerensis Reeside, n. sp.

Figures 7–9

A single specimen from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, is the basis of this species.

Shell moderately large, heavy; broadly subelliptical, moderately gibbous; proportion of length to height about as 5 to 3. Beaks blunt, subcentral. Lunule and escutcheon but little differentiated. Posterior margin narrowly rounded, anterior margin a little broader; basal margin gently convex, crenate inside. Dorsum declining with very slight convexity both before and behind the beaks; gross angle formed by the dorsum at the beak of the valve 130°.

[3] See pages 306–312 for description of these species.

[1] Published by permission of the Director of the U. S. Geological Survey. Received March 13, 1928.

Sculpture consists of fine, irregularly spaced concentric lines of growth; and very faint radial lines scarcely visible without the assistance of a hand lens, 2 per millimeter at the posterior margin and 3 in 2 millimeters at the anterior margin.

Hinge and other internal characters not seen.

Length, 35 millimeters; height, 22 millimeters; convexity of a valve, 8 millimeters.

This species is characterized by its medium size, broadly subelliptical outline, and very faint radial sculpture. No other species from the Western Interior is close enough to it to deserve comparison. *N. percrassa* Conrad[2] in the Ripley fauna of the Coastal Plain resembles *N. larimerensis* but the latter has much fainter radial sculpture, is less gibbous and more evenly subelliptical in outline, and has the beaks lower and placed farther forward. *N. larimerensis* also resembles *N. slackiana* Gabb[3] but has again much fainter radial sculpture, lower and more anteriorly placed beaks, and subelliptical outline.

The type is in the U. S. National Museum (Cat. No. 73454).

Nucula weldensis Reeside, n. sp.

Figures 16–18

Five specimens collected by Prof. Johnson from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, are the basis of this species.

Shell small, moderately heavy; subtrigonal, rather inflated; proportion of length to height about as 4 to 3. Beaks not very prominent, posterior, opisthogyrate. Lunule elongate, ill-defined, bordered by an indistinct angulation of the valve; escutcheon nearly smooth, cordate, of moderate size, sharply defined by an angular shoulder. Anterior and posterior margins rounded, basal margin semielliptic in outline, apparently smooth inside. Dorsum declining with moderate convexity anterior to the beaks and with slight concavity behind; gross angle formed by the dorsum at the beaks about 75°.

Sculpture of fine concentric growth lines and only the faintest suggestion here and there of radial sculpture.

Internal characters unknown in type. Cross-section of another specimen indicates a series of 20 teeth before the beak and one of 9 behind, diverging at an angle of 90°.

Length of type, 20 millimeters; height, 15 millimeters; convexity of a valve, 6 millimeters.

This species is characterized by small size; relatively high, subtrigonal, inflated shell; distinct escutcheon; smooth inner margins; and lack of radial

[2] T. A. CONRAD. *Observations on a group of Cretaceous fossil shells found in Tippah County, Miss.* Journ. Acad. Nat. Sci. Phila. (2) **3**: 327. *pl. 35, f. 4*. 1856; BRUCE WADE. *The fauna of the Ripley formation on Coon Creek, Tenn.* U. S. Geol. Surv. Prof. Paper **137**: 39. *pl. 8, f. 1–4*. 1926.

[3] W. M. GABB. *Descriptions of new species of American Tertiary and Cretaceous fossils.* Journ. Acad. Nat. Sci. Phila. (2) **4**: 397. *pl. 48, f. 37*. 1860; JULIA GARDNER. *Md. Geol. Surv. Rept., Upper Cret.,* p. 511. *pl. 19, f. 1–4*. 1916.

sculpture. It differs from the nearest forms of the Western Interior as follows: from *N. planimarginata* Meek and Hayden[4] in its smaller, stouter shell, higher subtrigonal outline, and lack of radial sculpture; from *N. cancellata* Meek and Hayden[5] in smaller size, higher subtrigonal shell, and lack of radial sculpture; from *N. coloradoensis* Stanton[6] in its larger, stouter shell and lack of radial sculpture; from an unnamed species in the Eagle sandstone of Montana in its lack of radial sculpture and smaller escutcheon. *N. weldensis* differs from similar species of the Coastal Plain as follows: from *N. stantoni* Stephenson[7] in its lack of radial sculpture, lesser height, stouter shell, and greater umbonal angle; from *N. amica* Gardner[8] in its lack of radial and strong, regular concentric sculpture; from *N. microconcentrica* Wade[9] in its subtrigonal form.

The type is in the U. S. National Museum (Cat. No. 73455); four paratypes are at the Colorado School of Mines, Golden, Colorado.

Genus Ostrea Linnaeus

Ostrea gillulyi Reeside, n. sp.

Figures 1–6, 10, 11

This species is represented by 6 individuals from 6 localities and a somewhat doubtful lot of 10 specimens from a seventh locality.

Shell of medium size, subovate to subtriangular, more or less arcuate. Shell thin in most specimens, moderately thick in some. Beaks narrow to pointed, slightly twisted, and turned posteriorly. Left valve swollen, rather evenly rounded; right valve flat to slightly concave, fitting within the margins of the left valve.

Hinge high, triangular, sharply inclined posteriorly. Ligament area crossed by fine growth lines and in the right valve by fine longitudinal lines also; groove well-defined, deep. Margins of right valve near the hinge coarsely dentate; of the left valve pitted to correspond with the denticles of the right valve. Muscle scar large, oval, situated toward the middle posterior of the valves. Margins of the lower part of both valves smooth.

Surface of left valve covered by irregular, rounded radial ribs, 2 to 4 millimeters wide, which bifurcate and are variable in height; and by sharp concentric lamellae. Surface of right valve with sharp concentric lamellae and obscure, irregular radial ribs or striae.

The height of the type is 75 millimeters; length, 40 millimeters; convexity of the left valve, 15 millimeters.

[4] F. B. Meek. *Invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country.* Rept. U. S. Geol. Surv. Terr. **9**: 101. *pl. 15, f. 8; pl. 28, f. 16.* 1876.

[5] F. B. Meek. *Op. cit.*, p. 102. *pl. 28, f. 13.*

[6] T. W. Stanton. *The Colorado group and its invertebrate fauna.* U. S. Geol. Surv. Bull. **106**: 94. *pl. 21, f. 9.* 1893.

[7] L. W. Stephenson. *Cretaceous formations of North Carolina.* Rept. N. Car. Geol. Econ. Surv. **5(1)**: 79. *pl. 11, f. 1–6.* 1923.

[8] Julia Gardner. *Op. cit.*, p. 514. *pl. 19, f. 5–6.*

[9] Bruce Wade. *Op. cit.*, p. 40. *pl. 8, f. 7–8.*

This species is characterized by its strong radial sculpture, somewhat arcuate form, and its size. No species now known in the Western Interior is very close to it. In the Coastal Plain *O. tecticosta* Gabb[10] is similar but seems a consistently smaller, less arcuate, and more coarsely ribbed shell. Some Tertiary species also are similar to *O. gillulyi* but hardly enter into consideration here.

The type specimen (U. S. Nat. Mus. Cat. No. 73457) was collected by James Gilluly from the Fox Hills sandstone in the NW 1/4 sec. 7, T. 9 N., R. 67 W., Weld County, Colorado. Other specimens (U. S. Nat. Mus. Cat. No. 73456) from the Fox Hills of Colorado were collected by Prof. Johnson in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County. It is also represented in a collection made by V. H. Barnett from the top of the Lewis shale in the SW 1/4 sec. 34, T. 34 N., R. 77 W., Converse County, Wyoming; in a collection made by C. E. Dobbin from the lower part of the Lewis shale in NW 1/4 sec. 8, T. 21 N., R. 78 W., Carbon County, Wyoming. A collection made by T. W. Stanton from the Mesaverde formation at James Lake, Laramie Plains, Albany County, Wyoming, contains a number of specimens of an oyster that appears to be this species, though all the individuals are small and none are especially well preserved. The range of *O. gillulyi* would appear to be through the upper half of the Montana group.

Genus Gyrodes Conrad

Gyrodes johnsoni Reeside, n. sp.

Figures 12–15

Three specimens from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, are the basis of this species.

Shell small for the genus, very much depressed, approaching a thick disk in general form. Volutions about 3 in number, the outer one constituting perhaps three-fourths of the bulk of the shell; well rounded in cross-section, showing neither shoulder nor umbilical carina. Surface of the shell in part preserved in the type and showing only lines of growth parallel to the aperture. Suture impressed. Aperture obliquely ovate; outer lip thin, sharp; inner lip thin, nearly straight. Umbilicus deep, open.

Maximum diameter of shell, 21 millimeters; altitude, 14 millimeters.

This species is distinguished from most species of *Gyrodes* by the lack of shoulder and umbilical carination, from others by the great depression of the whorls. *G. petrosa* Morton[11] and *G. depressa* Meek[12] are perhaps the nearest species but both have an umbilical carina and are relatively higher shells.

[10] W. M. Gabb. *Op. cit.*, p. 403. *pl. 68, f. 47–48;* L. W. Stephenson. *Op. cit.*, p. 143. *pl. 38, f. 1–9.*

[11] Stuart Weller. *Cretaceous paleontology of New Jersey.* N. J. Geol. Surv., Pal. ser. **4**: 689. *pl. 77, f. 13–18.* 1907.

[12] T. W. Stanton. *Op. cit.*, p. 135, *pl. 29, f. 11–14.*

This type is in the U. S. National Museum (Cat. No. 73458), and two paratypes are at the Colorado School of Mines, Golden, Colorado.

Genus ANCHURA Conrad

Anchura? forresteri Reeside, n. sp.

Figure 19

The scar of attachment of a large lower valve of *Exogyra olisiponensis* Sharpe var. *oxyntas* Coquand, from the basal part of the beds of Colorado age at Black Bluff, Utah, constitutes a fairly sharp mould of a gastropod not at present known by any other specimen.

Parts of three whorls and the exterior of much of the wing-like extension of the outer lip are shown. The species is high-spired, the volutions of the spire moderately convex with numerous longitudinal, somewhat inclined, rounded ribs and only faintly visible spiral sculpture. The body-whorl shows both axial and spiral sculpture and is cancellated. The expanded outer lip bears a distinct, rounded keel, curved posteriorly into the sharp tip of the wing. The suture of the body whorl near the outer lip extends posteriorly across the preceding whorl but there is no clear evidence in the specimen of a posterior extension of the lip along the spire.

The writer knows no American species very close to *Anchura? forresteri* and though the type is somewhat indefinite believes it worthy of a name. It is best characterized by the size, the form of the extension of the outer lip, and the sculpture. It is strikingly like *Aporrhais* ("*Chenopus*") *olisiponensis* Choffat[13] from the lower Turonian of Portugal, though on the basis of the single specimen available it seems better to keep the two under separate names. It is difficult to tell from either Choffat's figures or the present specimen whether the two species belong to *Anchura* or *Aporrhais*, though they are in some respects more like certain species definitely assignable to *Anchura*.

The type is in the U. S. National Museum (Cat. No. 73459).

ILLUSTRATIONS

Figures 1–6. *Ostrea gillulyi* Reeside, n. sp., outer, inner and anterior views of the two valves of the type, a complete shell from the Fox Hills sandstone in the NW 1/4 sec. 7, T. 9 N., R. 67 W., Weld County, Colorado. (p. 308.)

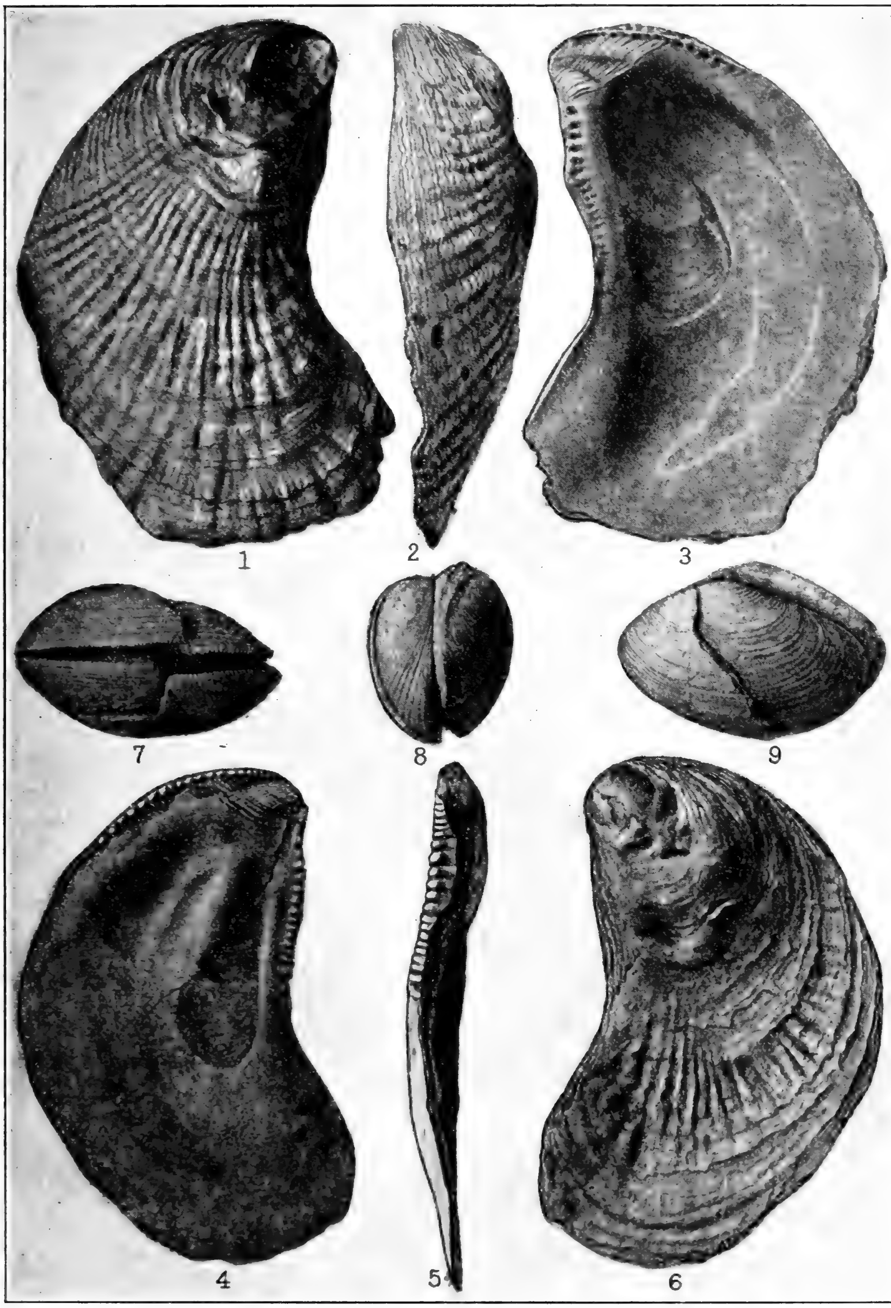
Figures 7–9. *Nucula larimerensis* Reeside, n. sp., basal, anterior, and right views of the type, a complete shell from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado. (p. 306.)

Figure 10. *Ostrea gillulyi* Reeside, n. sp., a left valve with strong radial sculpture. Same locality as Figs. 1–6. (p. 308.)

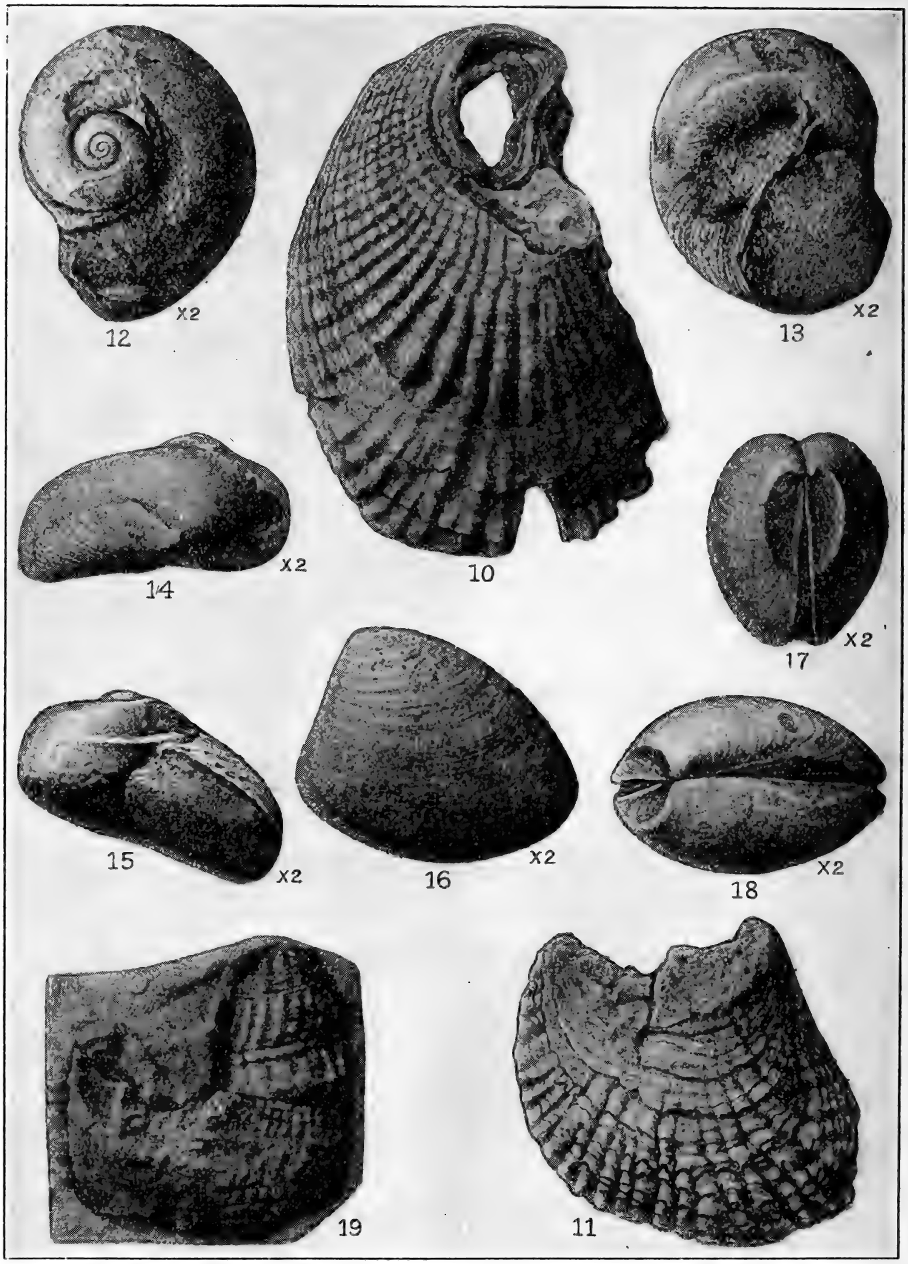
Figure 11. *Ostrea gillulyi* Reeside, n. sp., a left valve with strong concentric sculpture. Same locality as Figs. 7–9. (p. 308.)

Figures 12–15. *Gyrodes johnsoni* Reeside, n. sp., apical, umbilical, dorsal, and apertural views (×2) of the type, a cast retaining parts of the shell. Same locality as Figs. 7–9. (p. 309.)

[13] PAUL CHOFFAT. *Faune crétacique du Portugal* **1(1)**: 12. *Prosobranches pl. 2, f. 8–9.* 1886; **1(4)**. *Prosobranches pl. 5, f. 1–2.* 1902.



Figures 1–9. 1–6, *Ostrea gillulyi;* 7–9, *Nucula larimerensis*



Figures 10–19. 10–11, *Ostrea gillulyi;* 12–15, *Gyrodes johnsoni;* 16–18, *Nucula weldensis:* 19, *Anchura? forresteri*

Figures 16–18. *Nucula weldensis* Reeside, n. sp., right, posterior, and top views (×2) of the type, a complete shell. Same locality as Figs. 7–9. (p. 307.)
Figure 19. *Anchura? forresteri* Reeside, n. sp., plaster cast from the type, a mould from the basal part of the beds of Colorado age at Black Bluff, Utah. (p. 310.)

RADIOGEOLOGY.—*The radium content of Stone Mountain granite.*[1] CHARLES SNOWDEN PIGGOT, Geophysical Laboratory, Carnegie Institution of Washington.

This paper refers to the first measurements by the author, of what is intended to be a comprehensive study of the radium content of the various classes of rocks of the Earth's structure. It is of a preliminary and introductory nature only. A paper describing in detail the apparatus and technique used and the results obtained from a study of several rocks will be published shortly.

DESCRIPTIVE

The sample used was a gray biotite-muscovite granite from Stone Mountain, Georgia, and was a part of the same block as used by Day, Sosman and Hostetter[2] in their determination of densities at high temperatures.

The density of this material at 25° is 2.633 and the chemical composition as determined by Packard[3] is as follows:

ANALYSIS, NORM, AND MODE OF STONE MOUNTAIN GRANITE

SiO_2	71.66
Al_2O_3	16.05
Fe_2O_3	0.86
FeO	Not determined
MgO	0.17
CaO	1.07
Na_2O	4.66
K_2O	4.92
H_2O+	1.00

NORM[3]		MODE[4]	
Quartz	22.80	Quartz	20
Orthoclase	28.91	Microcline	40
Albite	39.30	Plagioclase $Ab_{85}An_{15}$	30
Anorthite	5.28	Mica, nearly all muscovite	10
Corundum	1.12		
Hypersthene	1.72		

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[1] Received March 14, 1928.

[2] ARTHUR L. DAY, R. B. SOSMAN and J. C. HOSTETTER. Am. Journ. Sci. **37**: 1–39. 1914. Also Neues Jahrb. Beil. Bd. **40**: 119–162. 1915.

[3] H. S. WASHINGTON. *Chemical analyses of igneous rocks.* U. S. Geol. Survey, Prof. Paper **99**: Analysis No. 51, p. 173. 1917.

[4] L. H. ADAMS and E. D. WILLIAMSON. *The compressibility of minerals and rocks at high pressures.* Journ. Frank. Inst. **195**: 483. 1923.

The rock was crushed, and ground to a fine powder in a ball mill. A 25-gram sample was mixed with 100 grams of a flux, consisting of equal parts by weight of anhydrous sodium and potassium carbonates, and the mixture was fused in a furnace of special design, in a slow stream of pure carbon dioxide gas. Any radium and thorium emanation was carried out of the melt by the carbon dioxide produced by the fusion and was swept along in the stream of CO_2. This latter was absorbed by hot sodium hydroxide solution, and the unabsorbed gases, consisting of air (adsorbed on the mix), helium, and minute quantities of other gases from the rock, and containing the radium and thorium emanations, were collected over mercury, which was regulated by a leveling bulb. From there they were subsequently drawn into an evacuated emanation chamber and the remaining vacuum relieved by drawing CO_2-free air through the entire apparatus and thereby insuring the assembly of all emanation within the emanation chamber.

This chamber[5] is a closed cylinder of brass of one liter capacity with a brass rod projecting down the center through insulation of pure amber. After allowing the chamber to stand under a static charge of 650 volts potential difference for three hours, to permit of the elimination of any thorium emanation, an alpha-ray determination was made in the usual way with a gold-leaf electroscope of the detachable Lind type.[5]

Calibration was effected by making a number of runs with the granite alone, and then making another series, identical in every respect except that a known amount of radium, in equilibrium with its disintegration products, was added.

This added radium was secured by pipetting a standard radium solution into small thin-walled glass bulbs, evaporating slowly to dryness and then sealing the bulbs. These were allowed to stand for more than thirty days, after which time the radium was again in equilibrium with its emanation, and the bulbs could be used. Bulbs containing 1 and 3 cubic centimeters of solution, respectively, were used. A bulb would be embedded in the mix and the fusion carried out in the usual way.

The standard radium solution used was such that 1 cubic centimeter contained 32.2×10^{-12} grams radium element.

The flux alone was found to have some radioactivity. That this

[5] A development of the detachable electroscope and chamber of S. C. Lind. Vide, Bull. **212,** Bureau of Mines. Also Journ. Ind. and Eng. Chem. **7:** 406. 1915; **7:** 1024–29; **12:** 469–72. 1920.

was a true effect is indicated by the fact that a run made on 100 grams of flux gave an electroscope reading of 0.0014 divisions per second, while a 200-gram sample of the same material gave a reading of 0.0029 divisions. A number of runs were made which confirmed these figures.

The "natural leak" of the electroscope assembly was always taken before each measurement and applied as a subtractive correction to all readings. In every case the apparatus remained under charge long enough for the insulation to take up any "electrical soak" and come to a condition of stable equilibrium. After each measurement the emanation chamber was blown out for several hours with dry, CO_2-free air drawn from outside the laboratory building.

Experimental

The effect on the electroscope of the granite alone was determined by a series of sixteen fusions, the results constituting the following table. The numbers represent divisions of the scale, as seen in the telescope, which were passed over, per second, by the gold leaf of the electroscope.

No.	*Divisions per second*	*No.*	*Divisions per second*
1	0.0100	9	0.0115
2	.0110	10	.0096
3	.0100	11	.0119
4	.0133	12	.0102
5	.0106	13	.0093
6	.0127	14	.0127
7	.0102	15	.0097
8	.0111	16	.0105

These give an average of 0.01089. If the effect of the flux (0.0014) is subtracted from this the reading for the granite alone is 0.0095.

The addition of a 1-cubic-centimeter bulb of radium to an otherwise normal run produced the following effect:

	0.0137	divisions per second
	.0137	" " "
	.0131	" " "
Average	.01350	" " "
Less the effect of the flux and rock	.01089	" " "
1 cc. Ra solution	.00261	" " "

On adding a 3-cubic-centimeter bulb to a normal run the readings were:

	0.0179	divisions per second
	.0176	" " "
	.0197	" " "
	.0197	" " "
	.0179	" " "
Average	.01856	" " "
Less the effect of the flux and rock	.01089	" " "
3 cc. Ra solution	.00767	" " "

One-third of which is 0.00256 divisions per second.

The average effect of 1 cubic centimeter of standard radium solution as obtained from the two series of experiments is therefore 0.00259.

Since 1 cubic centimeter of radium solution is equivalent to 32.2×10^{-12} grams radium element, 0.00259 divisions per second fall of the electroscope leaf is equivalent to 32.2×10^{-12} grams, or

$$1 \text{ div. per second} = \frac{32.2 \times 10^{-12}}{0.00259} = 12702 \times 10^{-12} \text{ grams Ra.}$$

So that:

$$\frac{\text{Electroscope reading} \times 12702}{25} = \text{grams} \times 10^{-12} \text{ of Ra per gram rock.}$$

Conclusion

According to the experiments described above the sixteen measurements of the radium content of Stone Mountain granite vary from a low of 4.013×10^{-12} to a high of 6.757×10^{-12}; with an average for the series of 4.826×10^{-12} grams of radium per gram of granite.

BOTANY.—*A new tree fern from Haiti.*[1] William R. Maxon, U. S. National Museum.

Among a number of critical pteridophyta from Haiti recently submitted to the writer by Dr. Carl Christensen for identification is the following undescribed tree fern:

Hemitelia minuscula Maxon, sp. nov.

Fronds small, about 1 meter long, spreading, the stipe (incomplete) about 30 cm. long, slender, arcuate, pale buff from a darker, finely brownish-fur-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 21, 1928.

furaceous base, freely aculeate, the spines narrowly conical, blunt, nearly straight, 1.5–2 mm. long; scales not collected. Blade of an oblong-ovate type, about 70 cm. long, 35 cm. broad, bipinnate-pinnatifid, the rachis pale buff, 3–5 mm. thick, minutely subfurfuraceous above, glabrate beneath, unarmed; pinnae alternate, spreading or slightly decurved, oblong, abruptly short-acuminate, about 18 cm. long, 8–10 cm. broad, short-stalked, the distal basal pinnule distant 5–8 mm. from primary rachis, the proximal one as much as 1.5 cm.; secondary rachis densely substrigose above with curved yellowish-gray hairs, subpersistently paleaceous beneath, the scales pale rufous-brown, thin, lustrous, minute, deeply bullate, mostly with an attenuate flexuous tip (hairs wanting); pinnules 13–15 pairs, spreading (the basal ones often decurved or reflexed), nearly sessile (stalked about 1 mm.), narrowly oblong, 4–5 cm. long, 9–12 mm. broad, attenuate in the outer third, pinnatisect at base, pinnatifid beyond to 0.5–1 mm. from the costa, obliquely crenate at the subcaudate apex, the costa clothed like the secondary rachis; segments 10–12 pairs, oblong, 3 mm. broad at base, slightly curved, rounded-obtuse, rather close, the strongly revolute margins lightly crenate, the costule sometimes with 1 or 2 short weak hairs above, beneath conspicuously bullate-paleaceous throughout; veins 5 or 6 pairs, impressed above, forked just below the middle; sori 5 or 6 pairs, the receptacle strongly elevated, subcapitate, freely septate-paraphysate; indusium a minute, delicately membranous, rufous proximal scale, incised, the divisions lacerate. Leaf tissue thick-herbaceous, dull yellowish-green, discoloring, glabrous.

Type in the Copenhagen Botanical Museum, from Massif du Nord, Anse-à-Toleur, Morne Colombeau, Haiti, alt. 900 meters, June 20, 1925, *E. L. Ekman* H 4365; co-type in the U. S. National Herbarium.

The present species is referable technically to the genus *Hemitelia* because of the presence of a proximal indusial scale, which, though small, is only partially concealed and on account of its divided or deeply cleft form approaches the usual condition found in *Eu-hemitelia.* Of the West Indian tree ferns *H. minuscula* resembles in a general way *Alsophila aquilina* Christ, but that species differs rather widely in its strongly coriaceous leaf tissue, its conspicuously stalked pinnae and pinnules, its non-furfuraceous vascular parts, and its very few, larger, and widely scattered bullate scales of the under surfaces, these usually solitary on the costules. A very minute vestigial indusium scale is usually present in *A. aquilina,* as in a few other species of *Alsophila,* but it is dark colored, distinctly chitinous, closely appressed, and subentire, wholly lacking the filamentous processes seen in *H. minuscula* and several other *Eu-hemitelia* species of tropical America.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES.

THE ACADEMY

211TH MEETING

The 211th meeting, the 29th Annual Meeting, was held in the lecture room, East Building, of the Bureau of Standards on Tuesday, January 11, 1927, with President BURGESS in the chair. President Burgess gave a brief talk illustrated by lantern slides descriptive of various phases of work of the Bureau of Standards. This was followed by an intermission during which guests of the ACADEMY left the room to begin an inspection of the laboratories. After this the annual business meeting was held. It was voted to dispense with the reading of the minutes of the 28th Annual Meeting.

The Corresponding Secretary, F. B. SILSBEE, reported briefly on the activites of the ACADEMY during 1926. His report showed that 20 regular members and one honorary member had been elected and had qualified during the year, 4 had resigned, and 9 had died, showing a net gain of 8. Those who died were: G. N. ACKER, F. H. BIGELOW, C. K. WEAD, F. C. CUMMING, E. W. SAFFORD, C. V. PIPER, W. T. LEE, C. W. ELIOT, F. H. KNOWLTON. The report was ordered accepted and filed.

The report of the Recording Secretary, W. D. LAMBERT, was read. There were held during the year several public meetings, all of them jointly with one or more affiliated societies. The names of the affiliated societies, speakers, and the details of the addresses, and additional items of interest were given. The report was ordered accepted and filed.

The report of the Treasurer, R. L. FARIS, was read. It showed total receipts, $5,647.27; total disbursements, $6,094.72; academy's investments, $18,000.37; cash on hand, $2,208.73; estimated net worth, $20,433.32.

The report of the Auditing Committee, Messrs. AVERS, WHERRY, and PEFFER was read, verifying the Treasurer's figures. The reports of the Treasurer and the Auditing Committee were then accepted.

The report of the Editors of the Journal was presented by AGNES CHASE. It detailed the distribution of the articles in the various fields of science and gave statistics concerning Volume No. 16 of the Journal. The report was ordered accepted and filed.

The report of the Committee of Tellers, Messrs. SILSBEE, GARDNER, and LOMBARD, was presented by the Chairman. In accordance with the report the following officers were declared elected: *President,* A. WETMORE; *Corresponding Secretary,* L. B. TUCKERMAN; *Recording Secretary,* W. D. LAMBERT; *Treasurer,* R. L. FARIS; *Non-resident Vice-Presidents,* T. LYMAN, H. F. PITTIER; *Managers,* R. S. BASSLER; F. B. SILSBEE.

The following Vice-Presidents nominated by the affiliated societies were then elected: *Archaeological,* WALTER HOUGH; *Bacteriological,* W. D. BIGELOW; *Biological,* H. C. OBERHOLSER; *Chemical,* E. T. WHERRY; *Entomological,* A. G. BÖVING; *Geographic,* F. V. COVILLE; *Geological,* N. H. DARTON; *Helminthological,* M. C. HALL; *Historical,* A. C. CLARK; *Mechanical Engineers,* H. L. WHITTEMORE; *Philosophical,* J. P. AULT.

The meeting adjourned at 9.15 and was followed by an inspection of the laboratories in the East and Industrial Buildings at the Bureau of Standards and a social hour.

212TH MEETING

The 212th meeting, a joint meeting with the Philosophical Society, was held on Thursday, February 17, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. ARTHUR HAAS, of the University of Vienna, *The atom as a source of energy.* The Bohr theory of the atom was first discussed and attention called to the enormous amount of energy available both in the planetary system of the atom and in the nucleus. The possibility was presented that by collision of electrons and protons matter might be entirely transformed into energy. The reverse phenomenon, the generation of matter out of radiation, would only be possible for rays of a very high frequency. This frequency ought at least to be so high that one light-quantum of the rays would possess the same amount of energy as would be liberated by the annihilation of a single hydrogen atom. One possible way in which it could occur seems to be suggested by the Compton effect. If atoms or nuclei colliding with light-quanta were in enormously rapid motion, the frequency could be raised in a considerable degree. Collisions with rapidly moving material particles thus might impart to a light-quantum that critical frequency which qualifies it for a transmutation into a hydrogen atom. (*Author's abstract.*)

213TH MEETING

The 213th meeting, a joint meeting with the Anthropological Society, was held on Thursday, February 24, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. ALFRED V. KIDDER, Chairman of the Division of Anthropology and Psychology of the National Research Council, *The Cliff Dwellers of Arizona and their predecessors.* The Southwestern archaeological field embraces those parts of Arizona, New Mexico, Colorado, and Utah, which contain the remains of the sedentary, agricultural type of Indian, commonly known as Pueblos. The present range of the Pueblo Indians is restricted to the drainage of the Rio Grande and the Little Colorado. Ruins of ancient villages closely similar to those of the historic Pueblos are found throughout an infinitely greater range. They consist of cliff houses, valley towns, and mesa-top dwellings, ranging in size from a half dozen to a thousand rooms.

The problem of Southwestern archaeology is the arrangement of these ruins in relative chronological order and the determination of the origin and growth of the culture responsible for them. Until about fifteen years ago the early stages of Pueblo civilization were not recognized. The explorations of the Peabody Museum of Harvard, the Natural History Museum of New York, the National Geographic Society, and other institutions have resulted in the discovery and description of these early stages, the first being the Basket-maker, a phase marked by primitive agriculture, lack of pottery and of stone architecture. This was followed by the post-Basket-maker period which saw the introduction of pottery and the beginnings of masonry construction. The post-Basket-maker was succeeded by the pre-Pueblo, in which pottery was greatly improved, houses were enlarged and strengthened, and the typical massed type of dwelling first introduced. We are thus now in possession of the outline of the entire growth of the Pueblos from nomadism up. (*Author's abstract.*)

214TH MEETING

The 214th meeting, a joint meeting with the American Chemical Society (Washington Section) and the American Society for Steel Treating (Washington-Baltimore Section), was held on Friday, March 4, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. CECIL DESCH, of the University of Sheffield, *The growth of crystals.* (Given in full in a paper entitled *The growth of metallic crystals* presented at a meeting of the American Institute of Mining and Metallurgical Engineers in February, 1927 and published in the proceedings of that Institute.) Geometrical crystallography, which has reached a state of such remarkable perfection since its beginnings a century and a half ago, is concerned with the conditions of symmetry in crystals and with their possible faces, but it attaches little importance to the relative development of those faces, so that variations of habit, of such interest to the mineralogist, are mostly ignored. Since crystals of strikingly different habit, such as the many varieties of calcite, may all be derived from the same primitive crystal, their peculiarities must be due to variations in the conditions during growth, and this fact gives to the study of the growth of crystals a special importance. A simple crystal immersed in a solution of the right degree of supersaturation may continue to grow whilst retaining its original shape unimpaired, as in the perfect octahedra of the alums which have been prepared by some manufacturing firms. Such crystals may grow to a large size without change of shape, and when an octahedron of chrome alum, for instance, is allowed to grow in a solution of the isomorphous common alum, the regularity of growth is obvious from the uniformity of the colourless sheath enveloping the coloured nucleus. The increase in size has been brought about by the deposition of a uniform layer of new material on each face. On the other hand, faces may disappear or new faces may make their appearance in the course of growth, and an explanation has to be sought in the external conditions and in the internal structure of the crystal, both factors being concerned in producing the result.

It has long been known, certainly since the eighteenth century, that the presence of small quantities of foreign matter will sometimes produce a change of crystalline form. Common salt, which usually crystallises in cubes, forms octahedra if grown in a solution containing urea. When the quantity of urea is small, crystals with the faces of both the cube and the octahedron are produced. The crystals of organic compounds often vary very greatly according to the solvent which has been used. Such facts as these give the first clue to the problem of growth.

The use of X-rays in the study of crystal structure has placed crystallography on an entirely new footing. All modern studies of crystals start from the idea of the space lattice. The atoms, whether occurring singly or grouped to form molecules, are so arranged in space that a single unit is exactly repeated at regular intervals in three dimensions. Through such an assemblage planes may be drawn in any direction. Certain planes so drawn will contain a greater number of atoms in a given area than any planes drawn in a different direction, and it is these closely packed planes which play the principal part in crystal structure. Moreover, in crystals in which the atoms are of more than one kind, different planes may contain the atoms in different relative proportions, so that they may be assumed not to be chemically identical. Any plane may be imagined as a possible face of the crystal, although only a few of them are realisable in practice. The several planes must have different chemical properties. This follows from our conception of the space lattice. The forces which hold the atoms in position are electrical in character, and depend on the number and arrangement of the electrons in each atom. The chemical behavior is dependent on the same conditions, and the chemical properties of a crystalline surface must vary with the grouping of the atoms within it. What chemists often call residual affinity must vary with the denseness of packing of the atoms in a plane, so that each set of similar faces must have its own chemical characteristics. This supposition is confirmed by the action of chemical agents on crystals. In the etching of metals by acids, it is easily seen that the reagent penetrates more readily along certain planes than in any other direction, as clear facets, of cubes or octahedra in most instances, make their appearance and give the characteristic lustre to the etched surface.

It has been shown by Johnsen, Gross and others that the faces which survive during growth are those which have the lowest velocity of growth in a normal direction, and that these are in general the most closely packed planes. More openly packed planes have a higher velocity of growth, but their relative area diminishes as the crystal increases in size, and they ultimately disappear. The experiments of Nacken on salol and benzophenone are instructive. By attaching a small crystal of salol to a copper hemisphere immersed in the molten substance maintained at a constant temperature, and withdrawing heat by cooling a copper rod attached to the hemisphere, the rate of cooling could be varied, and it was found that when this was very slow, the liberation of latent heat by the solidification of the salol and its removal by conduction kept pace with one another, and the surface of the growing crystal was spherical or nearly so, being determined only by the thermal conductivity, which varies only slightly in the direction of the different crystallographic axes. As the rate of cooling is increased, the growth perpendicular to certain directions fails to keep pace with the rest, and faces having a low velocity of perpendicular growth begin to make their appearance, at first with oval outlines. As the crystal increases in size, the area of such faces increases until their boundaries meet, and the crystal at last assumes its typical form, with plane faces and straight edges.

The experiments of Volmer and others on the formation of crystals of zinc and mercury in an evacuated vessel, by the impact of a stream of molecules of the metal on a plane surface, have thrown much light on the process. Nuclei are at first formed, and those grow which have the basal plane (the crystals being hexagonal) perpendicular to the direction of the stream. This plane has the lowest velocity of growth in a direction normal to itself. With mercury at $-60°C$ thin leaflets result, the thickness of which is only one ten-thousandth of the diameter. A quantitative interpretation of these experiments, together with those of Marcelin, which proved growth to be a discontinuous process, occurring by the formation of successive thin sheets, leads to the conclusion that atoms or molecules are first adsorbed as a layer of unit thickness, the atoms or molecules in which have a certain freedom of movement. In the course of such movement, groupings which may be regarded as two-dimensional crystal nuclei may arise, and the whole layer then assumes an orderly arrangement, in conformity with the underlying space lattice. Since adsorption plays so large a part in growth, it is not surprising that an alteration of habit may be produced by the presence of impurities. The observations of Gaubert on lead nitrate are particularly instructive. This salt separates from water in octahedra, but when methylene blue is added cubic faces appear, these faces being stained blue while the octahedral faces remain colourless. As the quantity of the dye is increased, the crystals become completely cubic, with blue faces. Evidently adsorption of the colouring matter by the cube face has lessened its rate of growth, so that it survives at the expense of the more rapidly growing octahedral face. It is probable that differences of habit in naturally occurring minerals are largely due to the influence of small quantities of foreign matter, but a very small quantity may suffice, so that the impurity responsible for the result may not have been detected in the course of an analysis.

Well developed crystals are usually formed by comparatively slow growth, so that as material is withdrawn from the solution, or as heat is given out by the solidification of a melt, there is ample time for readjustment. Miers has shown that the solution in immediate contact with the growing face of a crystal of a salt is actually denser than the bulk of the solution, suggesting that the dissolved molecules undergo a preliminary rearrangement in the liquid before separation as a solid. For this view there is some evidence, notably from the fact, observed by Nasini and others, that solutions which are undercooled through the freezing point show small discontinuities in properties, although no solid separates. It will be of interest to examine this point by means of the X-ray method. On the other hand, when growth is very rapid, the supply of material by diffusion may not keep pace with it, and the conditions are disturbed. Simple geometrical considerations show that the sharp angles of the crystal are more favourably placed for the reception of material by diffusion than the middle parts of faces, so that growth occurs at the angles by preference. The effect is cumulative, so that the crystal assumes a star shape, which in course of time undergoes branching, the process being repeated at each branch. This is the origin of dendritic crystals, which are so common in nature. They are most easily obtained by allowing crystallisation to take place rapidly, as when a solution of a salt is evaporated quickly on a glass slide. The internal symmetry of the crystal is not destroyed, and most such crystals may be regarded as parallel growths, one axis being usually favoured. Thus native copper branches in the direction of the octahedral axis, whilst common salt forms growths parallel with the trigonal axes. Diffusion may be hindered, and dendritic growth encouraged, by making the solution more viscous, as by adding gum. In highly viscous materials, such as glasses, slags, and pitchstones, very beautiful dendritic growths are frequently present. The "trees" formed by the electrolysis of solutions of metallic salts have a similar structure.

Periodic crystallisation is an interesting phenomenon, which again has a bearing on the origin of naturally occurring mineral structures. It was observed more than 70 years ago by Brewster in ancient glass which had undergone a process of decay. It may arise from several different causes in different substances. The effect is very simply observed in molten salol. When a thin layer is melted on a slide and allowed to cool, slender needles are seen to radiate from each centre. The advancing point of each needle withdraws material from the liquid, and a gap is left, the molten salol standing up as a wall in front of the crystal edge. Owing to its viscosity, an appreciable time is required for the liquid to flow until it is again in contact with the crystal, when growth is resumed. This process is repeated, so that the advance of the needle is intermittent, and the crystal when complete is marked by transverse lines indicating the stages of growth. The process may be followed under the microscope with ease. Some salts crystallise from water with a very definite periodicity, the best example being potassium dichromate, a thin layer of a solution of which, if rapidly evaporated, will yield concentric rings of minute crystals with very regular intervals. The effect is here no doubt one of supersaturation, the solution being impoverished by the separation of one ring of crystals, so that the process is interrupted until the right concentration is again reached by diffusion, and so on. Similar structures are seen in glazes on porcelain and, although more rarely, in slags. They are closely connected with the phenomenon of periodic precipitation in jellies, the formation of Liesegang's rings. The study of periodic crystallisation throws light on some natural structures, especially of agates, which are in all probability formed by the periodic crystallisation of silica from the gelatinous contents of a cavity in a rock. Ruskin maintained that the banding in agates was due, not to periodic infiltration of a liquid, but to segregation, and his view is confirmed by modern work. In particular, the so-called canals which have been supposed to represent the passages by which liquid entered and left the cavity are seen, by laboratory experiments on periodic crystallisation, to be merely geometrical effects produced by the meeting of different systems of advancing bands.

Dendritic and periodic crystallisation depend on more complex causes than change of habit, and are correspondingly more difficult to study in a quantitative manner, but there can be little doubt that the examination of the chemical properties of the several planes in crystals will throw much light on these as on other problems of crystallisation. (*Author's abstract.*)

215TH MEETING

The 215th meeting, a joint meeting with the Anthropological Society, was held on Thursday, April 21, 1927, in the Assembly Hall of the Cosmos Club.

Program: Dr. FREDERICK W. HODGE, *The Zuñi Indians of New Mexico.* (Illustrated by lantern slides and moving pictures.) The speaker reviewed briefly the history of the Zuñi Indians during the Spanish regime, commencing with the year 1539, when their pueblos first became known to civilization as the "Seven Cities of Cibola." A glimpse of Zuñiland, together with views of the salt-gathering ceremony at the sacred Salt Lake, was offered in motion-pictures. Other pictures illustrated the process of pottery-making from the preparation of the clay, through the fashioning and painting of water-jars and food-bowls, to the finished receptacles. The grinding of corn and the manufacture of wafer-bread, one of the most ancient and still the most important food staple of Zuñi, was illustrated as further showing a part of the domestic life of a people whose primitive customs have been little changed.

Still retaining most of their ceremonies of old, the Zuñi perform rites at their sacred Rainbow Spring for the purpose of bringing rain, the ceremony shown in the picture being in the native belief the direct cause of the first showers for nine months. Following this rite, on the next day, a masked rain-dance was performed at the main pueblo of Zuñi, views of which, showing the dance-steps and the costumes of the participants, together with the antics of the "mud-head" clowns, were presented as affording an impression of religious ceremonies that probably have been practised unaltered for many centuries. (*From notes supplied by the speaker.*)

W. D. LAMBERT, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Paul C. Standley, formerly of the U. S. National Museum, has been appointed Associate Curator of the Herbarium in Field Museum of Natural History, Chicago. He began work in his new position the first of June.

Dr. E. O. Ulrich, of the U. S. Geological Survey, is spending four weeks in May and June in field work in Missouri, Arkansas, and Oklahoma. Dr. T. W. Stanton, will spend the latter half of June and the month of July in a continuance of his studies on the Cretaceous of western Texas. Drs. Edwin Kirk and G. H. Girty will spend several months in examination of the Paleozoic rocks of the Eureka district and other parts of Nevada. Dr. John B. Reeside, Jr., will visit Geological Survey parties in connection with work on the Mesozoic formations of the Rocky Mountain region.

Dr. Julia Gardner is spending the summer in Louisiana and Texas in a continuation of her studies on the Tertiary formations of the Gulf Coastal region.

Professor A. S. Hitchcock, of the Bureau of Plant Industry, and Custodian of Grasses in the U. S. National Herbarium, has left Washington for a collecting trip to Newfoundland. He will first visit the New York Botanical Garden and the Gray Herbarium of Harvard University to study the grass collections of these institutions. The months of July and August will be spent in Newfoundland and Labrador studying and collecting grasses. Many species of grasses have been described from Newfoundland the identity of which is uncertain. It is hoped that some of these species may be found. The work is in connection with the preparation of a Manual of the grasses of the United States.

To select a successor to Dr. Fewkes recently retired from the position of Chief of theBureau of American Ethnology, Smithsonian Institution, a special board of examiners, composed of Secretary Abbot, Dr. A. V. Kidder, Carnegie Institution, and Frederick W. Brown, Assistant Chief of the Examining Division of the U. S. Civil Service Commission has been formed, in view of the importance of the position. The examination will consist solely of the consideration of qualifications by the special board. The minimum qualifications are recognized eminence in American ethnological research, experience in the direction and prosecution of ethnological research, administrative capacity, and familiarity with the literature of American ethnology and archaeology, and with the activities of scientific and professional organizations and institutions concerned with the subject.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, June 7. The Entomological Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Proceedings

This Journal is indexed in the International Index to Periodicals, to be found in public libraries.

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Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication. To facilitate the work of both the editors and printers it is suggested that footnotes be numbered serially and submitted on a separate manuscript page.

Illustrations in limited amount will be accepted, drawings that may be reproduced by zinc etchings being preferable.

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SPECTROSCOPY.—*Multiplets in the Co* II *spectrum.*[1] WILLIAM F. MEGGERS, Bureau of Standards.

A study of the absorption spectra of iron, cobalt, and nickel[2] as produced by condensed sparks between metallic electrodes under water revealed for each metal several hundred lines characterizing the neutral atoms and a much smaller number ascribed to ionized atoms. Extensive classifications of the lines from neutral atoms showed that practically all of the absorbed lines involved low-energy states of the respective atoms. A similar interpretation for the absorbed lines due to ionized atoms was indicated by Russell's[3] analysis of the Fe II spectrum, and the observations were useful in the cases of nickel and cobalt for detecting the first regularities among their spark lines. The Ni II spectrum has since been more fully analysed by Shenstone;[4] the purpose of the present note is to give some preliminary results for the Co II spectrum.

A portion of the spectrum (2150–5000 A) has been remeasured, relative intensities have been estimated on an expanded scale and several classes of spark lines have been recognized by comparison of their behavior in the spark and arc. Thus certain groups of lines in the spark spectrum appear with almost equal intensity in the arc spectrum while others are much weaker in the second case, and still others show very weak or not at all in the arc but strong and usually more or less diffuse and unsymmetrical in the spark. The first class includes all the lines observed in the absorption experiments referred

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Received May 8, 1928.

[2] MEGGERS and WALTERS. Sci. Pap. Bur. Stand. (551) **22**: 205. 1927.

[3] RUSSELL. Astrophys. Journ. **64**: 194. 1926.

[4] SHENSTONE. Phys. Rev. **30**: 255. 1927.

to above, and some of them have been observed partially self-reversed in the spark in air. Such a group lies between the wave length limits 2249 A and 2449 A; it has been arranged as a trio of multiplets $^5F'$-$^5(D', F, G')$. This is the most prominent feature of the entire spectrum interval thus far examined. A somewhat weaker group of lines extending from 2192 A to 2339 A, overlaps the other group: it has been arranged on the basis of line intensities as a second trio of multiplets, ^3D - $^3(P, D', F)$. The triplet-D term was recognized in a strong group of lines between 3353 A and 3621 A constituting the intersystem combinations ^3D - $^5(D', F)$. These three sets of combinations are presented in Table 1. Term symbols and relative term values appear at the top and left margin, the term values being relative to $^5F_5' = 0.0$. Each combination of levels is represented by the observed wave length and estimated intensity (in parenthesis) of the spectrum line, and by the wave number in vacuum. The interval ratios for levels of the $^5F'$ term are 254.1:389.3:531.9:678.5 = 1.9:2.9:3.9:5.0 while the theoretical ratios are 2:3:4:5. When the interval ratios are in such good agreement with the theoretical values it is a good indication that the term either represents the normal state or a very low metastable one.

Although neutral cobalt is fairly strongly represented by absorption lines in the solar spectrum no spectroscopic evidence for the presence of ionized cobalt in the solar atmosphere has been put forward. In this connection it is interesting to note that the intersystem combinations ^3D - $^5(D', F)$ between 3353 A and 3621 A appear to be the only set of strong Co II lines lying within the range of solar spectrum transmitted by the earth's atmosphere, practically all of the other strong lines being less than 2900 A in wave length. The presence or absence of ionized cobalt in the solar spectrum must therefore rest with this group of spectral lines. Comparison of the wave lengths and intensities of these lines with absorption lines in Rowland's *Preliminary table of solar spectrum wave lengths,* is shown in Table 2. My wave length data for the Co II lines appear in the second column and Rowland's values for solar lines (the original and the reduced value on the International Ångstrom scale) are given in the fourth column. My intensity estimates are in the third column and Rowland's in the fifth. The last column indicates special reasons for regarding the coincidence of five of the Co II lines as doubtful. For the remaining nine lines the mean difference between my values and the corrected Rowland wave lengths is ±0.02 A, which is the average probable

TABLE 1.—MULTIPLETS IN THE Co II SPECTRUM

	$^5F_5'$ 0.0	$^5F_4'$ 678.5	$^5F_3'$ 1210.4	$^5F_2'$ 1599.7	$^5F_1'$ 1854.2
$^5D_4'$ 42028.3	2378.62(100) 42028.3	2417.66(40) 41349.7	2449.15(10) 40818.1		
$^5D_3'$ 42621.7		2383.45(80) 41943.2	2414.06(40) 41411.4	2436.98(10) 41021.9	
$^5D_2'$ 43102.3			2386.37(50) 41891.9	2408.76(25) 41502.5	2423.61(10) 41248.2
$^5D_1'$ 43436.0				2389.54(40) 41836.3	2404.17(20) 41581.7
$^5D_0'$ 43739.6					2386.74(25) 41885.4
$^5F_5$ 41847.4	2388.90(100) 41847.5	2428.29(10) 41168.7			
$^5F_4$ 42970.4	2326.48(25) 42970.2	2363.79(80) 42292.0	2393.91(10) 41759.9		
$^5F_3$ 43688.8		2324.30(40) 43010.5	2353.43(60) 42478.2	2375.19(15) 42089.0	
$^5F_2$ 44187.0			2326.12(30) 43976.8	2347.40(30) 42587.3	2361.52(10) 42332.7
$^5F_1$ 44498.5				2330.35(30) 42898.8	2344.26(25) 42644.3
$^5G_6'$ 43728.0	2286.16(100) 43728.0				
$^5G_5'$ 43995.6	2272.26(8) 43995.4	2307.84(75) 43317.2			
$^5G_4'$ 44457.1	2248.66(2) 44457.1	2283.52(15) 43778.5	2311.60(50) 43246.8		
$^5G_3'$ 44800.6		2265.74(3) 44122.0	2293.39(20) 43590.1	2314.04(40) 43201.2	
$^5G_2'$ 45038.0			2280.96(4) 43827.6	2301.40(15) 43438.4	2314.97(30) 43183.8

TABLE 1—*Continued*

	$^3D_3$ 14421.2	$^3D_2$ 14681.2	$^3D_1$ 14988.5
$^3P_2$ 59994.4	2193.58(15) 45573.3	2206.18(12) 45313.0	2221.22(5) 45006.2
$^3P_1$ 60315.4		2190.65(10) 45634.2	2205.50(5) 45327.0
$^3P_0$ 60420.6			2200.40(6) 45432.1
$^3D_3'$ 57890.8	2299.76(20) 43469.4	2313.58(8) 43209.7	
$^3D_2'$ 57910.2	2298.73(8) 43488.9	2312.54(10) 43229.2	2329.11(10) 42921.7
$^3D_1'$ 57734.2		2322.01(5) 43052.9	2338.69(6) 42745.9
$^3F_4$ 58037.8	2291.98(40) 43616.6		
$^3F_3$ 59208.8	2232.05(15) 44787.9	2245.11(30) 44527.4	
$^3F_2$ 60017.2	2192.48(10) 45596.1	2205.06(3) 45336.0	2220.11(15) 45028.8
$^5D_4'$ 42028.3	3621.22(100) 27607.2		
$^5D_3'$ 42621.7	3545.03(25) 28200.5	3578.03(30) 27940.4	
$^5D_2'$ 43102.3	? 28681.0	3517.48(10) 28421.3	3555.93(10) 28114.0
$^5D_1'$ 43436.0		? 28754.8	3514.21(5) 28447.8
$^5D_0'$ 43739.6			? 28751.1

TABLE 1—*Concluded*

	$^3D_3$ 14421.2	$^3D_2$ 14681.2	$^3D_1$ 14988.5
$^5F_5$ 41847.4			
$^5F_4$ 42970.4	3501.73(200) 28549.2		
$^5F_3$ 43688.8	3415.78(75) 29267.5	3446.40(100) 29007.5	
$^5F_2$ 44187.0	3358.59(10) 29765.9	3388.2(50?) 29505.8	3423.84(75) 29198.6
$^5F_1$ 44498.5		3352.80(30) 29817.3	3387.72(60) 29509.9

TABLE 2.—Co II LINES IN THE SOLAR SPECTRUM

Terms	λ *I.A.*	*Intensity*	*Row.* λ *I.A.*	*Intensity*	*Notes*
$^3D_2$-$^5F_1$	3352.80	30	3352.908 0.771	000	
$^3D_3$-$^5F_2$	3358.59	10	58.771 0.634	00	Doubtful
$^3D_1$-$^5F_1$	3387.72	60	87.854 0.715	00	
$^3D_2$-$^5F_2$	3388.2	50 ?	88.311 0.172	3	Co I coincident
$^3D_3$-$^5F_3$	3415.78	75	15.922 0.782	00 N	
$^3D_1$-$^5F_2$	3423.84	75	23.972 0.832	0 N	
$^3D_2$-$^5F_3$	3446.40	100	46.536 0.395	1 Nd?	Double in sun?
$^3D_3$-$^5F_4$	3501.73	200	01.841 0.700	0	
$^3D_1$-$^5D_1'$	3514.21	5	14.382 0.240	0000 N	
$^3D_2$-$^5D_2'$	3517.48	10	17.653 0.511	000 N	
$^3D_3$-$^5D_3'$	3545.03	25	45.194 0.053	0000	
$^3D_1$-$^5D_2'$	3555.93	10	56.088 5.947	000 Nd?	Double in sun?
$^3D_2$-$^5D_3'$	3578.03	30	78.138 7.997	0000	
$^3D_3$-$^5D_4'$	3621.22	100	21.340 0.200	2	Masked

error of my determinations. The systematic difference for the same nine lines is only +0.002 A, and the intensities are roughly parallel. In other words, the lines are coincident and the presence of ionized cobalt atoms in the reversing layer of the sun is thus established.

It is noticed that the intensities of these Co II lines are very low in the sun, but it should be remembered that the lines in question involve excited states of the ionized cobalt atoms. The lines involving lower metastable states or the normal state should be considerably stronger in the solar spectrum but unfortunately these are all in the ultra-violet which is shut off by the earth's atmosphere. The strong lines of the $^5F'$ - $^5(D', F, G')$ multiplets which were absorbed in the under-water spark are also assumed to end with a metastable state. This quintet F′ term is ascribed to the electron configuration $s\ d^7$ to which the metastable ^3D probably also belongs, but the true normal state is thought to be a triplet-F′ term from the configuration d^8. According to the method which Laporte[5] outlined for predicting the relative positions of such terms the low $^3F'$ (d^8) term is expected to lie about 3500 cm^{-1} lower than $^5F'$ $(s\ d^7)$ in the energy diagram of the Co^+ atom. This term has not yet been found but before its existence can be denied the spectrum must be more carefully studied in the ultra violet between 1800 A and 2200 A. However, Shenstone's[6] failure to find similar predicted low terms in the Ni II and Cu II spectra makes it appear probable that the explanation required for the apparent absence or low intensity of certain expected combinations will apply also to the Co II spectrum.

Note added in proof.—Lang (Phys. Rev. **31**: 773. 1928) has recently identified the lowest terms in the Ni II and Cu II spectra from wave length measurements in the ultra violet below 1900 A.

PHYSICAL CHEMISTRY.—*The diameter of the CH_2 chain in aliphatic acids.*[1] CHARLES SNOWDEN PIGGOT, Geophysical Laboratory, Carnegie Institution of Washington.

This paper gives a brief account of some of the earlier measurements in this particular field of investigation. They were made in the spring of 1923 at the laboratory of Sir William Bragg, at University College, London, and were part of a more comprehensive investigation

[5] LAPORTE. Zeitschr. Phys. **39**: 127. 1926.
[6] SHENSTONE. Phys. Rev. **30**: 264. 1927.
[1] Received May 2, 1928.

being carried out by Dr. Alexander Müller, to whom acknowledgment is hereby made for guidance and assistance in the work. Their earlier publication was delayed by the pressure of other duties.

When ordinary paraffin wax was exposed to a beam of X-rays, in a suitable apparatus, it gave lines similar to those produced by substances generally recognized as crystalline. This was rather an unexpected result, since paraffin wax had been regarded by many as an excellent example of an "amorphous" substance. This observation, however, indicated that it was either actually crystalline in the ordinary sense, or else possessed regularly recurring units which had the property of reflecting X-rays in a manner analogous to that of a substance possessing a recognized crystalline structure. It raised the question whether or not there might be crystalline compounds in paraffin wax which were similar to the higher aliphatic acids. These considerations led to an X-ray investigation of these substances.

Preliminary experiments showed that paraffin wax and stearic acid gave very similar lines on the photographic plate, and, furthermore, that there were two principal lines, of the first order, which seemed to be identical in the two substances.

Since paraffin wax must consist of a large number of chemical compounds, the above observation would indicate that some fundamental unit must be common to them all and have at least one dimension the same, or nearly the same, in each. Also that this dimension is the same, or nearly the same, in stearic acid.

In an homologous series such as must exist in paraffin wax, or such as is the series of aliphatic acids, the length of the molecules must obviously vary with the number of carbon atoms in the chain. This variation in length should reveal itself by varying distances between similar lines on the X-ray plate. Paraffin wax gave the two principal lines mentioned above, and also a great many other lines, some of which were extremely indistinct. The lines of varying distances might correspond to the varying lengths of different molecules and the apparently fixed lines to the cross-sectional dimension of their chains.

The above is briefly the sequence of reasoning, based on the first unexpected results obtained from exposing paraffin wax to a beam of X-rays.

The conclusion was reasonably obvious that a great number of organic compounds had one dimension in common, capable of influencing X-rays; also, that this dimension was most likely the cross-section of the aliphatic carbon chain; and that this same dimension, or one very close to it, occurred in stearic acid.

The suggestion was therefore obvious to measure this dimension in a number of pure aliphatic organic compounds. The aliphatic acids, because they could be crystallized, and so obtained in a state of great purity, were selected.

A further consideration which influenced their selection was the speculation regarding the possible influence of the -COOH, or carboxyl group which is attached to one end of the chain, whether or not this heavy group would influence the close packing and thereby the diameter of the chain. If it should, then its influence would probably be greater in the short chain molecules than in the long chain ones.

Experimental

Since the equipment available did not permit of studying the acids which are liquid at ordinary temperatures (formic, acetic, etc.)[2] there was prepared[3] a number of the higher acids which are solids at ordinary temperatures. These were: pentadecylic, $C_{14}H_{29}COOH$; palmitic, $C_{15}H_{31}COOH$; stearic, $C_{17}H_{35}COOH$; and behenic, $C_{21}H_{43}COOH$ acids and they were recrystallized to a high degree of purity. They were studied by the "powder method" using copper rays. The results are tabulated below.

TABLE 1

Name of acid	*Formula*	*Distance between lines*	*d in Ångstrom units*
Pentadecylic	$C_{14}H_{29}COOH$	3.898	4.26
Palmitic	$C_{15}H_{31}COOH$	3.931	4.22
Stearic	$C_{17}H_{35}COOH$	3.930	4.22
Behenic	$C_{21}H_{43}COOH$	3.943	4.24
Average			4.235

Conclusion

It is apparent that, within the limits of experimental error, the short dimension of all the acids studied is the same, i.e., 4.235×10^{-8} cm.

This would indicate that the chains of all the aliphatic acids have the same diameter. Apparently this diameter of the chain, which is really a measure of the close-packing[4] of the atoms making up the

[2] Apparatus enabling the sample to be cooled by liquid air is now in process of development.

[3] By Mr. N. K. Adam, of London.

[4] See Alex. Müller and G. Shearer. Trans. Chem. Soc. **123**: 3160. 1923.

chain, is not influenced by the carboxyl group. However, the shortest chain here investigated was comparatively long, possibly too long to be influenced by the carboxyl group, and it may be that the difference between fourteen and twenty-one carbon atoms is not sufficient to reveal any influence.

The indications are that all organic CH_2 chains are of the same diameter and that this is about 4.235 Å.

BOTANY.—*Studies of Venezuelan Bignoniaceae.—III. New species of the genus* Arrabidaea.[1] H. PITTIER, Caracas, Venezuela.

The study of the materials of the genus *Arrabidaea* collected in Venezuela by the author and his coworkers has resulted in almost doubling the number of species known in that country. As before, the author is indebted to Mr. T. A. Sprague of the Royal Gardens at Kew for the preliminary examination of the specimens and for many useful indications. Besides, this well known authority on the Bignoniaceae has described recently under the name of *Arrabidaea calodyctios*, one of our most interesting discoveries in the family. The best thanks are here extended to him.

1. ARRABIDAEA P. DC., Rev. Bign. 10. 1838 (ex parte)

CLAVIS SPECIERUM VENEZUELENSIUM USQUE ADHUC COGNITARUM

Ovula pro loculo 4-seriatim affixa; folia nonnulla saltem biternata, plerumque ternata; foliola plus minusve oblonga, breviter obtuso-acuminata, mucronulata, glaberrima; corolla extus subtomentosa; ovarium lepidotum (Sect. 1. PARACARPAEA) **1. A. inaequalis**

Ovula pro loculo biseriatim affixa
- Ovula pro loculo 6–8; flores parvi; paniculae multiflores (Sect. 2. MICROCARPAEA) **2. A. carabobensis**
- Ovula pro loculo plura vel plurima; flores pro rata generis magnis; capsula magna; calyx pro rata brevis, campanulatus, raro breviter tubulosus vulgo truncatus vel denticulatus (Sect. 3. MACROCARPAEA)
  - Folia stirpium adultarum praeter lepides probabiliter ubique etiamsi interdum parcissime obvias glabra i.e., pilis simplicibus destituta (Ser. 1. *Glabrae*)
    - Inflorescentia praecox; folia 3-foliolata; calyx bilabiatus; ovarium puberulum **3. A. acuminata**
    - Inflorescentia coaetana, paniculata, terminalis, amplia; foliola concolora
      - Folia simplicia (?) vel raro binata rarissime ternata, coriacea **4. A. platyphylla**

[1] *Studies of Venezuelan Bignoniaceae.*—II appeared in this JOURNAL 18: 170–172. 1928. Received May 2, 1928.

Folia ternata vel conjugata cirrho simplici clausa
Calyx subturbinatus, herbaceus, truncato vel minute denticulato, 9–10 mm. longus, corolla 3.5 cm. longa 5. **A. corymbifera**
Calyx truncato-campanulatus, integerrimus vel denticulatus, subtomentosus
Foliola obtusiuscula vel obtuse acuminata, sicca castaneo-viridia vel obscure ferruginea 6. **A. florida**
Foliola lata, obtusa vel plus minusve acuminata, sicca nigra vel purpurea; flores color rubro abundantes
Corolla 3.5–3.7 cm. longa; foliola plus minusve acuminata, venis primariis vulgo 5–6 7. **A. Chica**
Corolla 1.4–1.8 cm. longa; foliola lata, obtusa, venis primariis vulgo 6–7 8. **A. larensis**
Folia stirpium adultarum praeter lepides pilos simplices vel raro ramosos gerentia, ulteriores interdum ope microscopii tantum conspicui (Ser. 2. *Indutae*)
Foliola concolora (nec colore nec textura nec indumento discolora (Subser. 1. *Concolores*)
Rami novelli pilis divaricatis instructi; folia supra opaca, rigida, herbacea; calyx 4–5 mm. longus; corolla 4–4.5 cm. longa; ovula pro loculo 16–18 9. **A. guaricensis**
Rami novelli pilis appresis haud divaricatis induti; ovula pro loculo 20
Foliola apice rotundata supra glaberrima, subtus in axillis venarum conspicue pilosula, demum glaberrima; calyx 7–9 mm. longus; capsula parce lepidota, 1.8–2 cm. lata 10. **A. ovalifolia**
Foliola supra subtusque plus minusve tomentosa
Foliola apice acuminata, olivaceo nigra, subtus dense et molliter induta; calyx 4 mm. longus; corolla 4–4.2 cm. longa; capsula dense mollissimeque tomentosa 1 cm.l ata 11. **A. mollissima**
Foliola apice obtusa, cinerea vel ferruginea; calyx 8 mm. longus; corolla 4.5–5 cm. longa; capsula puberula vel glabrata, 1.2–1.7 cm. lata 12. **A. rotundata**
Foliola discolora, subtus indumento interdum minuto vel brevissimo non raro canescenti-tomentella (Subser. 2. *Discolores*)
Ovula pro loculo 10–16
Folia summa saltem simplicia parva; foliola supra minutissime lepidota, sicca atro-purpurea, subtus tomentella, incana vel subviolacea; corolla circa 1.6 cm. longa 13. **A. carichanensis**
Folia omnia ternata vel conjugata
Foliola utrinque ovali-rotundata, apice saepe emarginata, supra glabrata, venis subtus in axillis barbata, demum puberula vel glabrata; corolla 3.7–3.8 mm. longa 14. **A. Spraguei**
Foliola ovalia vel elliptico-oblonga, acutata vel acuminata, supra glabra, subtus canescentia; corolla 3.2 cm. longa 15. **A. barquisimetensis**
Ovula pro loculo 18–22
Folia subtus obsolete reticulata, late ovata, supra nitentia in sicco nigrescentia, subtus minute sericea, plus minusve roseorubescentia 16. **A. calodyctios**
Foliola subtus conspicuiter reticulata
Foliola basi plerumque leviter emarginata
Corolla 5.5 cm. longa; foliola supra costa venaeque exceptis glabra subtus parce pilosula 17. **A. lenticellosa**

Corolla 2.7–3 cm. longa; foliola supra submollia, subtus utrinque tomentella 18. **A. Sieberi**

Foliola basi rotundata vel sub-truncata, haud emarginata, supra glaberrima

Foliola supra in sicco nigrescentia, subtus canescentia, minute sericea; corolla 2.5 cm. longa; ovarium muricatulum 19. **A. zuliaensis**

Foliola supra in sicco plus minusve cupreocolorata, subtus in nervis nervulisque crispulo-hirtella demum glaberrima; corolla 2.2–2.4 cm. longa; ovarium lepidotum 20. **A. cuprea**

1. ARRABIDAEA INAEQUALIS (P. DC.) Baill. Hist. Pl. **10**: 28. 1891.

AMAZONAS TERRITORY (BRAZIL): Ríos Cassiquiare, Vasiva y Pacimoni (*Spruce* 3272). The type from Dutch Guiana.

2. **Arrabidaea carabobensis** Pittier, sp. nov.

Frutex scandens, ramulis parce verruculosis, petiolis, petiolulis, rhachide inflorescentiarumque minute et dense tomentello-pubescentibus; foliis discoloribus, ternatis conjugatisve cirrho simplici clausis, modice petiolatis, petiolo tereto, supra applanato, foliolis (in specimine utrinque conjugatis) submembranaceis, petiolulis teretibus, laminis ovatis vel ovato-lanceolatis basi rotundatis, plerumque complicatis, apicem versus attenuatis, subacutis vel breviter acuteque acuminatis, marginibus leviter revolutis, supra minute pilosulis costa venisque inconspicuis impressis, subtus canescentibus dense tomentellis, costa venisque primariis 7–8 prominentibus venulis prominulis; cirrho plus minusve fulvovel cano-pubescente; paniculis floribundis, elongatis, terminalibus, ramis inferioribus e foliis summis axillaribus; bracteis bracteolisque ovatis ovato-oblongisve, obtusis; calyce pariter cano-tomentello, tubuliformi, minute penicillo-denticulato, purpurascente; corolla infundibulitubulosa, lobis late ovatis, acuminatis, subaequalibus, extus puberula vel minutissime pubescente, intus prope insertionem staminum villosa, lobulis puberulis; staminibus inclusis, glabris, thecis antherarum divergentibus, connectivo apice inconspicuo; disco breve, cupulato; ovario dense lepidoto, ovula pro loculo 6–8, biseriatis; stylo glabro; stigma bilobulato, lobulis lanceolatis, acutis; capsula deest.

Petiolus 1.8–2.4 cm. longus; petioluli 1–1.5 cm. longi; laminae 4.5–9.5 cm. longae, 2.5–4 cm. latae. Paniculae 15–30 cm. longae. Pedicelli 1.3 mm longi. Calyx 3–3.5 mm. longus. Corolla 8–10 mm. longa. lobulis circa 2.5 mm. longis, 2.5–3.5 mm. latis. Stamina circa 2 mm. supra basin aequialte insidentia, 3.2–4 mm. longa; staminodium 1.5 mm. longum. Discus 0.6–0.7 mm. altus. Ovarium 1.7 mm. longum; stylus 6 mm. longus.

CARABOBO: Hacienda de Cura near San Joaquín, in bushes, flowers July 8, 1919 (*Pittier* 7915, type).

The only species of section *Microcarpaea* met with in Venezuela up to the present, it is evidently related to *Arrabidae Agnus-castus* P. D.C. but differs in the indument of the flowers, the shape of the corolla lobes, the hairy insertion of the stamens, the connective equalling the parallel thecae of the anthers, the ovules twice more numerous in each cell, etc.

3. ARRABIDAEA ACUMINATA (Johnston) Urban, Rep. Nov. Sp. Fedde **14:** 306. 1916.

ISLA MARGARITA: El Valle (*Johnston* 345, type).

4. ARRABIDAEA PLATYPHYLLA (Cham.) Bur. & K. Schum. in Mart Fl. Bras. **8**^{2}**:** 38. 1896.

PORTUGUESA: Guanare, Calvario hill (*Pittier* 12048). The type from Brasil.

5. ARRABIDAEA CORYMBIFERA (Vahl) Bur. in Engl. & Prantl., Pflanzenfam. **4**^{3b}**:** 213. 1895.

LARA: Vicinity of Barquisimeto (*J. Saer d' Héguert* 252). The type from State of Rio Grande, Brazil.

6. ARRABIDAEA FLORIDA DC. Prodr. **9:** 184. 1845.

FEDERAL DISTRICT: San Andrés de Caruao (*Pittier* 11937). Type from Japura Valley, Río Negro basin, Brazil.

7. ARRABIDAEA CHICA (Humb. & Bonpl.) Verlot, Rev. Hortic. **1864:** 154. 1864.

Margins of the Orinoco and Casiquiare rivers near Maypures, Esmeralda and Mandavaca (*Humboldt & Bonpland*, type); Maypures, on the Orinoco margin (*Spruce* 3618, var. *thyrsoidea*).

8. **Arrabidaea larensis** Pittier, sp. nov.

Frutex scandens, ramulis verruculosis, petiolis, petiolulis rhachideque inflorescentiarum minute puberulis et parce lepidotis; foliis vix discoloribus ternatis conjugatisve cirrho simplici clausis, breviter petiolatis, juveniis subtus molliter pubescentibus; petiolo valido, supra canaliculato; petiolulis petiolo brevioribus supra anguste canaliculatis; laminis oblongis, interdum ovato-oblongis, basi rotundatis, utrinque insigniter reticulato-venosis, supra nitidissimis atro-purpureis, costa prominula plus minusve pilosula, subtus opacis cupreo-purpureis, costa interdum pilosula venisque 6–7 primariis subprominentibus; panicula terminali, angusta, floribus pedicellatis, apice ramulorum congestis; bracteis bracteolisque parvis ovato-lanceolatis, acutis, minute pubescentibus; pedicellis modice longis; calyce tubuloso-campanulato, tomentoso, parte superiore distincte nigro-glanduloso denticulis 5 interdum glandulosis insidentibus; corolla tubuloso-campanulata, tubo basilari angusto apice abrupte expanso, lobulis late ovatis, basi constrictis apice obtusis, extus minutissime tomentella, intus minute puberula, circa insertionem staminum glanduloso-villosula, lobulis tomentellis; staminibus glabris, thecis divaricatis, staminodio apice capitellato; ovario glaberrimo, ovulis pro loculo circa 22, biseriatis; stigmatibus obtusis; capsula deest.

Petioli 0.7–1.2 cm. longi; petioluli 0.5–1 cm.; laminae 4.8 cm. longae, 1.5–3.2 cm. latae, Panicula 12 cm. longa. Pedicelli 2–3 mm. longi. Calyx 4–5 mm. longus. Corolla 1.4–1.8 cm. longa, lobulis 3–3.5 mm. longis, 2.7–3.5 mm. latis. Stamina circa 3 mm. supra basin corollae aequialte insidentia, majora 8 mm., minora circa 6 mm. longa; staminodium 3 mm. longum. Discus 0.8–1 mm. altus. Ovarium circa 2.5 mm. longum; stylus plus minusve 9 mm. longus.

LARA: Near El Tocuyo, flowers September 25, 1922. (*Dr. A. Jahn* 1186, type).

Closely allied to *A. Chica* Verlot, but differs in the minute indument of the stems, petioles and panicles, the distinct shape and size of the leaflets which are but seldom entirely glabrous, in the dense short glandular pubescence of the insertion of the stamens and in the capitellate staminode and glabrous ovary.

9. **Arrabidaea guaricensis** Pittier, sp. nov.

Frutex deciduus, altissime scandens, basi crassus, ramis teretibus, striatis, glabris, cortice griseo hinc inde lenticellato tectis, ramulis novellis plus minusve tomentello-pubescentibus, pilis divaricatis; foliis subconcoloribus, membranaceis, ternatis conjugatisve, cirrho simplici clausis, longe petiolatis, petiolo tereto anguste canaliculato petiolulisque brevibus supra applanatis tomentoso-pubescentibus; laminis foliolorum late ovatis basi rotundatis subtruncatis subemarginatisve, apicem versus rotundatis et abrupte angusteque acuminatis, acumine fere mucronulato, supra opacis, minutissime reticulatis, costa venisque primariis 6–7 impressis minute pubescentibus, demum glaberrimis, subtus reticulatis, parce pubescentibus, costa venis venulisque prominentibus, marginibus ciliatis; cirrho gracili, pubescente, apice unguiculato; paniculis praecocibus, elongatis, angustis, terminalibus, pedunculis pedicellisque hirtello-pubescentibus; bracteis bracteolisque minutis, pubescentibus; calyce brevi, campanulato, extus pubescente, parcissime glanduloso, distincte 5-denticulato; corolla elongata, tubuloso-campanulata, lobulis late ovatis, obtusis, extus tubo basilari glabrato excepto dense pubescente, pilis retroflexis, intus insertionem, staminum pilis albis glandulosis interspersis vestita excepta, lobulisque glabra; staminibus glabris, thecis antherarum valde divaricatis; disco annulari, pulvinato, glabro; ovario apice minutissime hirtello-puberulo, utrinque lepidoto, ovulis biseriatis pro loculo 16–17; stylo glabro, stigmate acuto; capsula lineari, apice obtusa, plus minusve fulvo-pubescente; seminibus pro loculo 11–12.

Frutex basi 10 cm. crassus. Petioli 3–6 cm. longi; petioluli laterales 0.5 cm., terminales 1–5 cm. longi; laminae 5–12 cm. longae, 3.5–8 cm. latae. Panicula 15–30 cm. longa; bracteae et bracteolae plus minusve 0.5 cm. longae. Pedunculi et pedicelli 0.8–1 cm. longi. Calyx 4.5 mm. longus. Corolla 4–4.3 cm. longa, lobulis 1 cm. longis et latis. Stamina minora 0.9–1 cm., majora 1.3–1.4 cm. longa, subaequialte 6 mm. supra basin tubo corollae innixa; thecae antherarum circa 2 mm. longae. Discus 0.8–1 mm. altus. Ovarium 4 mm. longum; stylus 4–4.2 cm. longus. Capsula 14–17 cm. longa, 1.3 cm. lata, fulvescente; semina 0.9–1.1 cm. longa, 2.5–3 cm. lata.

GUÁRICO: Alrededores de Ortíz, in dry forests, flowers December 27, 1923 (*Pittier* 11308, type); same locality, fruits February 18, 1924 (*Pittier* 11432, type of the capsules); vicinity of El Sombrero, flowers and fruits February 19, 1924 (*Pittier* 11436).

This species occurs frequently in the deciduous forests along the tributaries of the Guárico river, between Ortíz and El Sombrero. It is a high climber, reaching the top of the tallest trees, where it spreads at flowering time like a brilliant crown of pale pink. Its affinities seem to be with *A. arthrerion* Bur., from which, however, it differs somewhat in most of its characters. The plant is distinctly deciduous and the bloom is always precocious.

10. **Arrabidaea ovalifolia** Pittier, sp. nov.

Frutex alte scandens, ramis glabris cortice griseo plus minusve lenticelloso tectis, ramulis virgatis petiolis petiolulis pedunculis pedicellisque puberulo-pubescentibus; stipulis desunt; foliis ut videtur plerumque ternatis, ecirrhosis, longiuscule petiolatis, petiolis teretibus indistincte canaliculatis; foliolis petiolulatis, petioluli saepe longiusculis, supra vix applanatis, laminis ovalibus, basi rotundatis, lateralibus vix obliquis, apice rotundatis, anguste emarginatis, supra glaberrimis, reticulatis, costa venisque 5–6 prominulis, subtus in axillis venarum conspicue pilosulis, demum glaberrimis, laxe reticulatis, costa venisque subprominentibus; paniculis ex apice ramulorum axillarium auctis, elongatis; pedunculis longiusculis, dichotomis; pedicellis gracilibus; calyce campanulato, apice parce ciliato, 5-dentato (basi indistincte glanduloso, glandulis magnis?), extus dense lepidoto; corolla infundibuli-campanulata, extus minute furfuracea intus circa staminum insertionem, piloso-hispida, pilis canescentibus, demum parce furfuracea, tubo basin angustato, lobulis late ovatis apicem rotundatis; staminibus glabris, thecis divaricatis; disco crasso, glabro, pulvinato; ovario minutissime muricatulo, ovulis pro loculo 20, biseriatis; stylo glabro; capsula linearis, basi angustata, apicem mucronata, marginibus incrassatis; valvis applanatis, parce lepidotis, plus minusve impresso-punctatis; seminibus crassiusculis, alis hyalinis.

Petioli 3.5–7.5 cm. longi; petioluli 1.5–2.5 cm. longi; laminae 7–10 cm. longae, 4–6.5 cm. latae. Racemi usque ad 30 cm. longi; pedunculi I 2–4.5 cm., II 1–2 cm., pedicelli 0.8–1 cm. longi. Calyx 7–9 mm. longus. Corolla 4 cm. longa, lobulis 0.9–1 cm. longis, 0.9–1.1 latis. Stamina minora 0.9 cm., majora 1.3 cm. longa; staminodium 4 mm. longum. Discus 2 mm. altus. Ovarium 3 mm. longum; stylus 1.6 cm. longus. Capsula 27–33 cm. longa, 1.8 cm. lata; semina 1.5 cm. longa, 4 cm. lata.

ARAGUA: Banks of river near San Juan de los Morros, flowers and fruits April 9, 1927 (*Pittier* 12311, type, in Herb. Mus. Comm., Caracas, cotype in U. S. National Herbarium, Washington); between Parapara and Uberito, Guárico, fruits May 7, 1925 (*Pittier* 11799).

I have not been able to match this species with any described. It evidently should be placed very near *Bignonia glabrata* H.B.K. and *Arrabidaea rotundata* Bur. From the first it differs in having longer and pubescent petioles and petiolules, barbulate nerve axils and dull, distinctly emarginate leaflets (Kunth's diagnosis of *B. glabrata,* does not, however, extend to all important details and he did not see the flowers, which in our specimens were of a dark pink color). *Arrabidaea rotundata,* on the other hand, is described as having almost tomentose leaves, pubescent calyx, and a corolla tomentose without and papillose at the insertion of the stamens within; the capsules are shorter than in our specimens and slightly narrower; only the seeds do not seem to differ except in the greater width.

11. ARRABIDAEA MOLLISSIMA (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. 8^2: 46. 1896.

Valleys of Aragua (*Humboldt & Bonpland,* type).

12. ARRABIDAEA ROTUNDATA (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. 8^2: 48. 1896.

CARABOBO: Isla de las Aves, Valencia Lake (*Humboldt & Bonpland,* type).

13. ARRABIDAEA CARICHANENSIS (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. 8^2: 62. 1896.

BOLIVAR: Between Carichana and Encaramada, on the Orinoco margins (*Humboldt & Bonpland,* type).

14. **Arrabidaea Spraguei** Pittier, sp. nov.

Frutex alte scandens, ramis crassis longitudinaliter striatis minute parceque lenticellatis, ramulis teretibus minute pubescentibus mox glabris; foliis coriaceis, discoloribus, ternatis conjugatisve, petiolis validissimis teretibus petiolulisque 2–3–ve brevioribus superne canaliculatis, laminis basi truncatis, leviter emarginatis, vel juveniis in petiolum distincte breviterque attenuatis, apice obtusis vel saepe emarginatis, supra glabratis, in aetate sublucidis, reticulatis, costa venisque primariis circa 8 impressis, subtus in axillis barbatis, demum puberulis glabratisve, costa venisque prominentibus; cirrhis vulgo validissimis; paniculis axillaribus terminalibusque, rachi ramulisque minute pubescentibus, pedunculis pedicellisque divaricatis trichotomis; bracteis bracteolisque caducissimis vel subnullis; calyce campunulato, 5-nervato mucronatoque, plus minusve fissi-lobato, extus minutissime puberulo marginibus plus minusve ciliatis; corolla campanulato-infundibuliformi, purpureo-rosea, tubo basilari angusto, lobulis late ovatis, marginibus sinuatis, extus papilloso-puberula, intus insertionem staminum villoso-glandulosam excepta parce papillosa vel glabrata lobulis puberulis; staminibus glabris, inclusis, filamentis tenuibus, thecae valde divaricatis; staminodio elongato, apiculato; disco toruloso, laevi, glabro; ovario oblongo, minutissime lepidoto, ovulis pro loculo circa 15–16; stylo plus minusve pilosulo; stigmatibus puberulis, oblongis, apice obtusis; capsula lineari, basi apiceque cuneata, valvis coriaceis, extus rugulosis, glabris, nervo mediano tenui percursis; seminibus 12–14.

Petioli 2.5–4.2 cm.; petioluli 1.2–3.5 cm.; laminae 5.5–13 cm. longae, 3.5–9 cm. latae. Paniculae 10–35 cm. longae, 10–25 cm. latae; pedicelli 5–12 mm. longi. Calyx 0.9 cm. longus. Corolla 3.7–3.8 cm. longa, lobulis 1.1–1.2 cm. longis latisque. Filamenta 5 mm. supra tubi basilari basin inserta, 1–1.3 cm. longa; thecae 2.5–3 mm. longae; staminodium circa 4 mm. longum. Discus 1 mm. altus. Ovarium 2 mm. longum; stylus 1.5 cm. longus; stigma circa 2 mm. longum. Capsula 19–20 cm. longa, 1.7 cm. lata; semina 1.3 cm. longa, usque ad 4.5 cm. lata.

ARAGUA: San Juan de los Morros, in bushes, flowers February 22, 1924 (*Pittier* 11476, type).

GUÁRICO: Between Guarumen and Caimana bridges, road El Sombrero to Ortíz, flowers February 21, 1924 (*Pittier* 11469).

LARA: Banks of La Ruesga near Barquisimeto, flowers and fruits September 1923 (*J. Saer d'Héguert*, 1922).

The leaves of this species are distinctly paler underneath than above, hence there would be no mistake in placing it in subsection *Discolores*, near *A. tuberculata* and *A. subincana* P. DC. If, however, it should be assigned to the *Concolores*, its place should be with *A. rotundata* Bur. Its characters agree well enough with the description of *Bignonia balbisiana* P. DC., but not at all with that of *A. rotundata* Bur., as given in the *Flora Brasiliensis*.[2] It is more than likely that we really have here a new species, which we take pleasure in naming for Mr. T. A. Sprague, the learned authority on Bignoniaceae.

15. **Arrabidaea barquisimetensis** Pittier, sp. nov.

Frutex scandens, caule ramisque cortice griseo verruculoso tectis, ramulis annotinis et praecipue novellis hirtellis vel dense villosis; foliis ternatis

[2] **8**[2]: 48. 1896.

conjugatisve cirrho crasso simplici apice valde incrassato interdum clausis, petiolis modice longis, gracilibus, teretibus, supra vix applanatis petiolulisque brevibus dense villosis; laminis ovatis, ovato-oblongis oblongo-ellipticisve, basi rotundatis plerumque complicatis apice sensim acutatis acuminatisve acumine nunc angusto et acuto, nunc lato obtusoque, supra nitentibus in sicco nigrescentibus, glabris, minute reticulatis, costa venisque impressis, subtus canescentibus primum dense villoso-tomentosis, in aetate glabrescentibus costa venisque 5–7 prominentibus villoso-hirtellis; paniculis terminalibus, brevibus, paucifloribus, pedicellis petiolulis multo longioribus pedunculoque brevi tomentoso-villosis; calyce campanulato, bilabiato, eglanduloso, extus parce villoso, lobulis subacutis; corolla infundibulari-campanulata, extus dense canescente furfuraceo-villosula, intus prope insertionem staminum glanduloso-villosula, lobulis villosulis, demum glaberrima, tubo basilari brevi, lobulis ovato-rotundatis, apice plus minusve denticulatis; staminibus glabris thecis valde divaricatis, connectivo vix prominente; staminodio subulato, apice vix incrassato; disco tubuloso, pulvinato, extus sulcato; ovario parce tuberculato, lepidoto, ovulis pro loculo 10–12, biseriatis, stylo glabro, stigmatis ovato-lanceolatis; capsula elongata, lata, basi cuneata, apice acutato-attenuata, glaberrima, seminibus pro loculo 6–8.

Petioli 1–5.5 cm. longi; petioluli 0.4–1.5 longi; laminae 4.5–11 cm. longae, 2–5.7 cm. latae. Paniculae 5–8 cm. longae. Pedicelli 0.8–1.5 cm. longi. Calyx circa 8 mm. longus, lobulis 2 mm. longis. Corolla 3.2 cm. longa, tubo basali 2.5–3 mm. longo, lobulis 0.7–1 cm. longis, 0.8 cm. latis. Filamenta 1.2–1.5 cm. long, 4 mm. supra basin corollae aequialte insidentia; thecae circa 3 mm. longae; staminodium 5 mm. longum. Discus circa 1.5 mm. altus. Ovarium 4 mm. longum; stylus circa 2 cm. longus. Capsula 27–31 cm. longa, 2 cm. lata; semina 1.6–1.7 cm. longa, circa 5.5 cm. lata.

LARA: La Ruesga near Barquisimeto, flowers and fruits May 1925 (*J. Saer d' Héguert* 214, type).

Open land species, growing in arid savannas and at times simply frutescent, and other times a climber. On account of its glandular and distinctly bilabiate calyx it may be questioned whether it really belongs in *Arrabidaea.* If so it may be placed in series *Indutae*, subseries *Discolores*, near *A. cinerea*, from which, besides in the already mentioned peculiarities of the calyx, it departs in the number of ovules, the shape of the disc and the indumentatum. Could it be identical with *A. mollissima* (H. B. K.) Bur. & K. Schum.?

16. ARRABIDAEA CALODYCTIOS Sprague, Bull. Misc. Inf. Kew **1927:** 358. 1927.

FEDERAL DISTRICT: On the road from La Guaira to Caracas, 900 m., in thickets, flowers September 6, 1925 (*Pittier* 11883, type); same locality, flowers June 23, 1922 (*Pittier* 10377).

MÉRIDA: Lagunillas, 700 m., flowers April 3, 1922 (*Dr. A. Jahn* 1077).

17. **Arrabidaea lenticellosa** Pittier, sp. nov.

Frutex scandens, caulibus ramisque creberrime lenticellatis, glabris, ramulis modice crassis, subvirgatis, striatis, juveniis dense tomentellis, vestutioribus glabrescentibus; foliis leviter discoloribus ternatis conjugatisve cirrho simplici primum puberulo clausis, breviter petiolatis; petiolo canaliculato, plus minusve tomentello vel pubescente; foliolis modice petiolulatis, petiolulis canaliculatis pubescentibus glabratisve, laminis ovalibus basi obtusis vel leviter emarginatis apice abrupte breviterque acuminatis acumine obtuso, supra costa venisque impressis, breviter villosulis exceptis glabris, subtus reticulatis, costa venis primariis 6–7 prominentibus venulisque prominulis parce pilosulis; inflorescentiis ad nodos supremos ramulorum defoliatorum paniculariformibus insertis; bracteis bracteolisque minutis, deciduis; pedunculis pedicellisque tenuibus villosulis; calyce membranaceo, violaceo, campanulato, insigniter 5-denticulato, lateraliter plus minusve fisso, extus praecipue basin cano-puberulo; corolla tubuloso-campanulata, tubo basilari angusto, lobulis magnis, ovato-oblongis, extus puberula, intus circa insertionem staminum villosa, lobulis puberulis; staminibus glabris apice corollae tubo basilari inserta, thecae valde divaricatis; staminodio filiformi, apice apiculato plus minusve spiraliter convoluto; disco cupulari, extus laevi; ovario minutissime denseque cano-lepidoto, ovulis pro loculo 18–24; stylo glabro, stigmatibus elongatis anguste lanceolato-apiculatis; capsular elongata, basi cuneata, apice longiuscule acuminata, marginibus incrassatis, valvis planis, glaberrimis nervo mediano prominulo percursis; seminibus pro loculo 18–24.

Caules ut videtur 4–6 m. longa, 2–3 cm. diam. Petioli 2–3 cm. longi; petioluli 1.2–1.5 cm. longi; laminae foliolorum 8–10 cm. longae, 5–6.5 cm. latae. Pedunculi I 5–7 cm., II 1–2 cm. longi; pedicelli 0.7–1 cm. longi. Calyx 0.8–1 cm. longus. Corolla 5.5 cm. longa, lobulis 1.3–2 cm. longis, 1.5 cm. latis. Filamenta 5–11 mm. longa; thecae circa 2.5 mm. longae. Discus 1.5 cm. altus. Pistillum circa 2.3 cm. longum; stigmata circiter 4 mm. longa. Capsula 20–33 cm. longa, 1.6–1.8 cm. lata; semina 1.3 cm. longa, 4–4.2 cm. lata.

GUÁRICO: Mesa of El Sombrero, in clusters of low bushes scattered over the savanna, flowers April 17, fruits and leaves September 10, 1927 (*Pittier* 12370, 12481, type).

This species has to be placed in subseries *Discolores* of the *Indutae*, near the Brazilian *A. tuberculata* and *A. subincana* P. DC. It is the first species reported from Venezuela of a group characterized by the peculiar pubescence of the leaves. The name refers to the appearance of the stems, densely covered with whitish lenticels.

18. ARRABIDAEA SIEBERI P. DC. Prodr. **9**: 186. 1845.

FEDERAL DISTRICT: Hills above La Guaira (*Pittier* 9852).

MIRANDA: Cerros de los Mariches (*Pittier* 12449). Guárico: Mesa de El Sombrero (*Pittier* 12494).

19. **Arrabidaea zuliaensis** Pittier, sp. nov.

Frutex alte scandens, ramis floriferis pendulosis, striatis, parce verruculosis minutissime puberulis; foliis coriaceis, basi ramulorum verosimiliter 3-foliolatis, superioribus 2-foliolatis cirrho simplici clausis; petiolis petiolulisque modice longis, canaliculatis, minutissime puberulis, laminis oblongo-ellipticis, basi rotundatis subcuneatisve saepe complicatis, apice sensim attenuatis, acuminatis, mucronulatis, supra opacis parcissime puberulis costa venisque circa 7 subprominentibus, subtus laxe reticulatis, minute velutinis, costa venisque prominentibus; paniculis amplis basi longe ramulosis, multifloribus, rhachi anguloso, pedunculis pedicellisque minute puberulis; floribus pedicellatis, in cymis umbelliformibus 3–8 dispositis, bracteis bracteolisque minutissimis, caducis suffultis; calyce tubuloso apice versus sensim et leviter ampliato, truncato, edentulato, extus velutino-canescente; corolla violaceo-rosea vel purpurea, infundibulari-tubulosa, extus dense et minute, tomentello-puberula, intus prope staminum insertionem villosula lobulis tomentello-villosis, tubo basi angustissimo, calyce subduplo longiore, lobulis orbicularibus; staminibus glaberrimis, filamentis filiformibus, thecis valde divaricatis, arcuatis; staminodio filiformi, apice leviter expanso; disco tubuloso-annulari; ovario muricatulo; ovulis circiter 22 pro loculo, biseriatis; stylo glabro, stigmatibus ovatis, acutis; capsula deest.

Petioli 1.5–3.5 cm. longis, petioluli 1–1.5 cm.; laminae 5–12.5 cm. longae, 2–7 cm. latae. Pedunculi 0.5 mm., pedicelli 2–4 mm. longi. Calyx 4 mm. longus. Corolla 2.5 cm. longa, tubo basilari 7 mm. longo, lobulis 5 mm. longis et latis. Stamina circa 7 mm. supra basin corollae insidentia; filamenta 1.2–1.5 cm. longa; thecae circa 2 mm. longae. Discus 0.6 mm. altus. Ovarium 2 mm. longum; stylus circa 1.2 cm. longus.

ZULIA: Banks of Lora and Santa Ana rivers, in semihumid forests, flowers December 19, 1922 (*Pittier* 10992, type).

TRUJILLO: El Dividive, in savanna bushes, flowers November 28, 1922 (*Pittier* 10827).

Arrabidaea zuliaensis is a very near relative of *A. Schomburgkii* Klotzsch, of British Guiana, but it has larger flowers, a distinctive indumentatum leaves with more numerous primary veins, and the ovules in each cell constantly 22 instead of 18–20.

20. **Arrabidaea cuprea** Pittier, sp. nov.

Frutex sarmentosus, ramulis floriferis minutissime puberulis, striatis, foliis coriaceis, ternatis conjugatisve, cirrho simplici clausis, petiolis elongatis, angulosis striatisque, ecanaliculatis, petiolulisque canaliculatis plus minusve hirtellis, pilis crispulis; petiolulo terminale lateralibus 2–3-plo longiore; laminis ovalibus, basi rotundatis, apice breviter obtuso-acuminatis, mucronulatis, lateralibus valde obliquis semirotundatis semicuneatis, terminale basi rotundato supra plus minusve cupreo-coloratis, glaberrimis, minute reticulatis, costa venisque primariis circa 7 profunde impressis, subtus pallide viridibus, reticulatis, costa venis venulisque prominentissimis parce crispulo-hirtellis exceptis glaberrimis; paniculis terminalibus ramulosis, multifloribus, ramulis basilaribus ex axillis foliorum superiorum auctis, rhachide pedunculis pedicellisque brevibus minutissime furfuraceo-puberulis; bracteis bracteolisque parvis, ovatis, pariter pedicellis vestitis; calyce campanulato, apice truncato hinc inde denticulato, violaceo, extus plus minusve fulvescente puberulo; corolla infundibulari-tubulosa, tubo basilari brevi angusto, lobulis inaequalibus, late ovatis suborbicularibusve, extus minute furfuraceo-puberula, intus prope staminum insertionem villosula, lobulis puberulis, demum glabra; staminibus glabris, filamentis tenuibus; thecis divaricatis, connectivo vix conspicuo; staminodio filiformi, apice capitellato; disco cupulato, glabro, lateraliter sulcato; ovario utrinque lepidoto, ovulis pro loculo 18–20 biseriatis; stylo glabro, stigmatibus lanceolato-acutis.

Petioli 5–8.5 cm. longi; petiolulus terminalis 1.7–2.5 cm. longus; petioluli laterales 0.4–1 cm. longi; laminae 8–12 cm. longae, 4.5–7.5 cm. latae. Pedunculi 0.5–1.2 cm., pedicelli 1–2 mm. longi. Calyx 4–5 mm. longus. Corolla 2.2–2.4 cm. longa, tubo basilari 4 mm. longo, lobulis 5–7 mm. longis, 6–8 mm. latis. Stamina circa 4 mm. supra basin corollae insidentia; filamenta 9–13 mm. longa; thecae 2.8 mm. longae. Discus 0.8–1 mm. altus. Ovarium 2.3 mm. longum, stylus 12–13 mm. longus.

MIRANDA: Vicinity of Petare in low bushes in savannas, flowers September 11, 1927 (*Pittier* 9791, type).

Distinguished from the other species of the *Discolores* group by its glabrous leaves tinged above with purplish-red, the veins all deeply impressed, and covered with curly hairs on the opposite face. The thecae of the anthers show on their anterior side diminutive scars which correspond to the line of dehiscence.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

216TH MEETING

The 216th meeting, a joint meeting with the Geological Society, was held on Wednesday, December 7, 1927, in the Assembly Hall of the Cosmos Club.

Program: Captain N. E. ODELL, F.G.S., of Toronto, *Scientific aspects of the Mount Everest Expeditions.* The three Expeditions to Mount Everest—of 1921, 1922, and 1924—though having primarily for their object the attainment of the summit of the world's highest mountain, have nevertheless yielded important scientific data from a region previously unexplored by white men. The results obtained relate to physiology, zoology, botany, geology, glaciology, as well as, in a more limited degree to meteorology and ethnography. In addition, an area of Southern Tibet amounting to more than 10,000 square miles was surveyed topographically, and upwards of 8000 square miles was mapped geologically.

Although the expeditions were at the outset equipped, as recommended by physiologists, with an apparatus providing oxygen for the high climbing parties, yet on the third expedition it was definitely ascertained that such a degree of natural acclimatisation can be attained that it would appear possible to achieve the summit of the mountain (trigonometrically determined first in 1849, and later found to be approximately 29,141 feet in altitude) without the aid of an artificial supply of oxygen. An elevation greater than 28,000 feet was reached entirely without its use.

New and interesting species of insects were discovered; bees, moths, and butterflies were found at 21,000 feet, and attid spiders occurred living in an environment solely of rocks and ice at 22,000 feet, while the alpine chough was seen manoeuvring easily and gracefully at 27,000 feet.

Lichens have been found to grow at higher Arctic latitudes, as well as at higher altitudes, than any other plants, but *Arenaria muscosa* was collected at 20,400 ft., and the common alpine edelweiss at 17,500 feet in the Everest region. However in 1905 *Delphinium glaciale* had been found at 20,600 feet on Kangchenjunga by Dr. Jules Jacot Guillarmod.

The southern portion of Tibet traversed consists predominantly of Mesozoic rocks, principally Jurassic shales and quartzites but moderately folded. The southern border of these are steeply upturned, together with a limited calcareous series in a subjacent position, against the gneisses of the main

Himalayan axis. The above calcareous series is of probable Permo-Trias age, at least in part, and would appear to compose as highly metamorphosed outliers the upper part of Everest itself and the neighboring mountains. Below this calcareous facies occur extensive biotite gneisses, which in turn rest on other calcareous metamorphics, of doubtful, though possibly Palaeozoic, age. The whole formation has been intruded by extensive granite-pegmatite veins and sills. There is evidence that a good deal of horizontal thrust has taken place, but the last movements in this region have been predominantly radial or vertical. The incoming of the Himalayan ortho-gneiss, found deep down in the range, has been accompanied by the uplift of the superimposed para-gneisses, which now form in many localities immense fault-scarp features overlooking the younger sediments of the Tibetan Plateau. The latter are cut locally by granitic and dioritic differentiation phases of the ortho-gneiss, and also by basic dyke-rocks of younger age.

There is evidence on all hands in the Mount Everest massif of waning glaciation. Old morainic terraces are to be seen bordering the valleys, and these extend far out on the plains to the north. Moreover there is evidence that during the maximum phase of the glacial cycle the ice mass accumulated in the area between the Great Himalayan Range and the Trans-Himalayan Ranges was sufficient to reverse tме present direcfion of drainage and to have its outflow over many of the lower passes on to the southern slopes of the Great Range. This condition, especially during the wane of the maximum stage, would have a decided effect upon the trend of the subsequent of drainage of the region, and be a contributing cause no doubt to the astounding course taken by the Arun River in its upper reaches of the Yaru Chu.

On account of the unique combination of physical conditions of this region the existing glaciers hold many unusual features and structures. Of particular interest was a significant developement of the "vein structure" in part of the East Rongbuk Glacier. This phenomenon here gave rise to a remarkable feature called the "Trough," extending for more than 3 miles longitudinally down the glacier. Another interesting feature was the immense ice-pinnacles, often as much as 100 feet in height.

On the first expedition it was definitely ascertained that the Tibetan name for Mt. Everest is "Chomolungma," signifying "Goddess Mother of the Mountain Snows." This poetic name will in future be applied to the whole group, Mount Everest (named after Sir George Everest of the Indian Trigonometrical Survey, during whose regime the mountain was first measured) being retained for the highest point of the group. (*Author's abstract.*)

217TH MEETING

The 217th meeting, the 30th Annual Meeting, was held in the lecture room of the Carnegie Institution Building at 16th and P Sts., on Tuesday, January 10, 1928. The meeting was called to order at 8:15 P.M. by Vice-President AULT. The retiring President, ALEXANDER WETMORE, delivered an illustrated address entitled *Prehistoric Ornithology in North America.* (This JOURNAL **18:** 145–157. 1928.)

At the conclusion of the address there was a brief intermission, after which President WETMORE took the chair and called the annual business meeting to order. The minutes of the 29th annual meeting, held January 11, 1927, were read by the Recording Secretary and approved.

The report of the Corresponding Secretary, L. B. TUCKERMAN, was presented. He reported the election of F. A. VENING MEINESZ to honorary membership and the death of the following members: LÉON PIERRE MANOUVRIER, Honorary Member, CHARLES D. WALCOTT, Past President, WILLIAM H. DALL, CARL H. EIGENMANN, JAMES F. KEMP, CHARLES G. NUTTING, FREDERICK B. POWER, IRA REMSEN, CHARLES S. SARGENT, ERWIN F. SMITH, GEORGE B. SUDWORTH, ISRAEL C. WHITE, MILTON WHITNEY, WILLIAM P. WILSON.

On January 1, 1928, the membership consisted of 15 honorary members, three patrons, and 576 members, one of whom was a life member. The total membership was 594, of whom 384 reside in or near the District of Columbia, 178 in other parts of the continental United States, and 32 in foreign countries.

The Board of Managers held five meetings which were devoted mainly to routine business. The average attendance was thirteen members.

During the year the Washington Post of the Society of American Military Engineers was added to the societies affiliated with the ACADEMY. There are now eighteen affiliated societies.

The report of the Corresponding Secretary was ordered accepted.

The report of the Recording Secretary was presented by him. It showed that during 1927, in addition to the annual meeting, five meetings had been held, all in connection with affiliated societies. The subjects of the addresses at these meetings and the names of the speakers were given. The report was ordered accepted.

The report of the Treasurer, R. L. FARIS, was presented by him. Among other items of interest it showed the following: Total receipts during 1927, $5,936.33; Total disbursements, 1927, $5,205.65; Cash on hand, January 1, 1928, $2,939.41; Value of Academy's investments, $17,536.37; Estimated net worth, $19,884.74.

The report of the Auditing Committee, PAUL BARTSCH, Chairman, S. F. BLAKE and H. C. FULLER, was presented by the Chairman. The Committee found the Treasurer's report and records to be correct in every detail. The reports of the Treasurer and of the Auditing Committee were ordered accepted.

The report of the Board of Editors was presented by W. J. PETERS. The seventeenth annual volume of the Journal contained 564 pages and 72 principal articles, the distribution of which in various fields of science was indicated. The average cost per page was $6.53. In accordance with the recommendation of the Editors approved by the Board of Managers, no charge to authors was made for illustrations. The report of the Editors was ordered accepted.

The report of the Committee of Tellers, consisting of L. B. TUCKERMAN, Chairman, L. V. JUDSON and H. E. MERWIN, was presented by the Chairman. In accordance with the report the following were declared elected: *President*, R. B. SOSMAN; *Corresponding Secretary*, L. B. TUCKERMAN; *Recording Secretary*, W. D. LAMBERT; *Treasurer*, R. L. FARIS; *Non-resident Vice-Presidents*, B. W. EVERMANN, J. G. LIPMAN; *Managers*, WILLIAM BOWIE, F. E. WRIGHT.

The newly elected President was escorted to the Chair by Vice-President AULT. After taking the chair he announced the appointment of E. W. WOOLARD as Editor and of L. H. ADAMS as Chairman of the Committee on Membership.

The Corresponding Secretary reported that the following members of the Academy had been nominated for Vice-Presidents by the affiliated societies: WALTER HOUGH, *Archaeological;* E. A. GOLDMAN, *Biological;* G. W. MOREY, *Chemical;* A. G. BÖVING, *Entomological;* PAUL G. REDINGTON, *Foresters;*

E. V. Coville, *Geographic;* Benjamin Schwartz, *Helminthological;* Allen C. Clark, *Historical;* H. L. Whittemore, *Mechanical Engineers;* P. R. Heyl, *Philosophical.*.

The members so nominated were unanimously elected Vice Presidents.

No new business being presented, at 9.40 P.M. the meeting adjourned.

Walter D. Lambert, *Recording Secretary.*

THE GEOLOGICAL SOCIETY

439th meeting

The 439th meeting was held at the Cosmos Club, March 28, 1928, President Hewett presiding.

Informal communication: C. S. Ross presented evidence that the St. Francis dam near Los Angeles, California, failed because the foundation rocks were weak. Investigations have shown that the part of the dam which failed rested on a pebbly clay known as "red conglomerate" and the part which remained standing rested on schist. Mr. Ross' microscopic examinations indicate that a band of clay two feet thick between the pebbly clay and the schist may be fault gouge. The failure of this weak clay (perhaps further weakened by water leakage along a fault) probably started the undermining of the dam. Discussed by Messrs. Hoots and Sears.

Program: C. W. Washburne, New York City: *The origin of normal faults.* Which is the more active side of a normal fault? Equal activity of both walls is impossible if the resulting regional tilt toward the direction of upthrow results from curvature of the fault-surface. Tilt of this prevailing type requires that the fault-surface be concave toward the more active side, toward the downthrow of gravity faults and toward the upthrow of upthrust normal faults. That the rotation of blocks occurred generally against curved surfaces is deduced from the indications that the action was one of rather high rigidity, the associated bending of the rock being in most cases wholly inadequate to permit the observed tilt to occur against a plane surface of fracture. Systematic curvature thus becomes a logical requirement, but it is difficult to detect because generally the curve is too gentle, having a radius of many miles.

Faults of short radius of tilt, especially if the angle of tilt be high, should have the sharpest curvature. Such are the faults across the Elk Basin anticline, Wyoming. Here the close spacing of oil-wells permits the determination of the curvature of a few faults, all concave in section toward the upthrown side.

Study of the tilt and form of simple lone normal faults, so fully isolated from other coeval structures that the stresses making the latter did not interfere with those making the faults, leads to the conclusion that nearly all their activity lay on the upthrow sides. Examples are the Sierra Nevada; the fault-line of the main Mexican oil fields running from Dos Bocas through Huasteca, Naranjos, Cerro Azul and El Alamo; also the Kurrajong fault, west of Sydney, Australia; the Jackson Fault, Alabama, etc. Definite examples of gravity faults are unknown to the writer, except a few small examples that are better regarded as superficial land-slide settling.

The driving upward of a foot-wall could arise from the upbending of compressive shears. In fact it would increase the regional compression, if the radius of curvature of the fault be greater than the width of the tilted block.

On the other hand the gravitative subsidence of hanging walls could occur only under regional tension, and would make nearly vertical striae. Regional tension would create breccia along countless steep fissures wherever the hanging wall could not subside, which would occur more commonly than would the ability to subside. Brecciated fissures should be more common than normal faults, instead of being comparatively rare. Tension would create types of intersection of rock joints, such as dropped wedges, which the writer cannot find among the joints exposed in faulted regions, nor elsewhere. Rock is too weak to transmit effective tension, in fact one joint across a line of tension would suffice to nullify its power beyond that joint. Except as a weak superficial and local phenomenon, there is probably no tension in the earth's crust.

There seems to be ground for questioning the existence of tension even on the upper surface of growing anticlines. No evidence of it can be seen in the folded Pleistocene sea-beaches of New Zealand, nor in anticlines of the Columbia River basalt, which probably had little cover when folded. No breaks are visible over the tops of these folds, and none are present on the steep limbs of many of them but where faults occur on the limbs they fail to satisfy the probable effects of tension and permit a better interpretation. In these anticlines apparently each layer crept over the underlying layer far enough up the limbs to prevent any visible cracking of the top of the arch, as would have happened had their bending been like that of a rigid beam. Other anticlines, however, may be found whose outer surfaces display tension.

In a region subject to compression in one direction there could be no tension in another direction, because joints inclined at various angles to the main line of compression would transfer some of the pressure laterally, as would also any weak masses that could be mashed or squeezed. The intimate association of normal faults with many anticlines, with which they grew concomitantly, the inclination of their striae, the associated bending of the rock, and other phenomena, indicate that many normal faults were formed when the rock was under compression in all directions. General considerations make it probable that most normal faults were formed under compression.

A foot-wall under compression could not rise slowly without lifting the hanging wall with it. The motion must have been so rapid that the momentum of the active foot-wall made it slip upward beneath the relatively inactive hanging wall, which was held by inertia, or which more likely had a relatively small elastic rebound downward, equal movement being improbable because a subsiding hanging wall would have to displace a continuous solid mass below it, while the rising foot-wall need only lift the weight of overlying rock.

The velocity required to bring into play the elements of momentum and inertia is unknown, but according to Harry Fielding Reid, in a personal communication, it is much less than the writer had thought. Velocities of 10 feet per second probably will suffice to create these effects. The slip during a single earthquake may amount to 20 and possibly to 50 feet, but the seismograms suggest that these slips occur in two or more stages, so that each slip amounts to only a few feet. Microscopic study of a few slickensides indicates that the heat generated did not melt quartz, but theoretically it must have been appreciable.

Great significance is attached to faults intimately associated with anticlines. There are: (1) faults nearly normal (60° to 90°) to the anticlinal axes; and (2) faults parallel to the axes. (1) The cross-faults of anticlines run nearly parallel to the line of greatest stress that made the anticline and are thought to have originated as *blätter* from the shear created by local difference in the horizontal stress. A break would dip away from the side receiving the more intense stress and moreover the foot-wall side presented greater area across the line of main stress. This made it thicken and rise more than the hanging wall side, which rose less. The striae now remaining on these faults are nearly vertical at their points of maximum throw high on the anticline but have low inclination where the faults die out, low on the two limbs. That the growth of the faults was at least slightly aided by pressure also at right angles to this, or along the axis, is indicated by the fact that the faults at Elk Basin, Wyo., that have observable curvature are concave in section toward the upthrown sides. At Elk Basin the cross-faults upthrown on their northwest sides are older, smaller and less numerous than those upthrown on the southeast. The comparatively rare first type of normal fault is formed during the main stages of folding, while the more common second type, mentioned below, appears to form during its last stages and to continue into stages wherein the rock-bending can hardly be detected. (2) Faults parallel to the axis of anticlines are especially characteristic of the steeper limb of asymmetric folds, where they invariably help to uplift the structure, pointing to the common origin of fault and fold. Such structures are called "fault-folds." In many cases, as at Casper Mountain, Wyoming, they are steep reversed faults near their termini, but are normal faults along the central parts of their courses, judging usually from the inclination of the main joints and minor slips which are there visible. Because of talus the inclination of the main fault rarely is determinable at such places, but at Mexia, Texas, an incipient or very small fault-fold is characterized by normal (N. W.) dip of the fault along the higher part of the structure and by reversed (S. E.) dip along the low southern part of the structure. In fault-folds the greatest displacement occurs in front of the highest part of the structure where both axis and fault generally have a small bend or bulge toward the "downthrown" area. Sharp "capes" and similar projections toward the "downthrown" area generally result from irregularities in the original fault fracture, rather than from later cross-faults. This class of faults generally has steep striae.

The second class of faults is thought to be analogous to the prevailing type of normal fault, which is thought to break nearly at right angles to the direction of main stress. Such breaks parallel to the main lines of folding characterize the great faulted regions of the earth, such as the late Tertiary faults of western North America. Horizontal motion along them, as along the San Andreas rift, California, arises probably from a later shift in the direction of stress.

The intersection of little faults in several regions, most thoroughly studied at Elk Basin, Wyo., and in several parts of New Zealand, shows a persistent relation in the relative age of parallel faults of opposite dip, those dipping one way being invariably older than those dipping the other way. It shows also a persistent relation in the relative age of faults of different trend. In other words there was no movement of "blocks" between little parallel faults of opposite dip, leading to the presumption that such movement probably did not occur in the large "blocks" within which many of the small observations were made. The same relation seems to hold between faults of different trend, except where those of one trend have low striae. Certainly many thrust-faults terminate in cross-faults with nearly horizontal striae, and isolated normal faults that can be followed to their termini bend strongly toward the direction of upthrow. Where a fault is not isolated, its course will be affected by the concomitant strain of neighboring coeval breaks, as in a group of *en echelon* faults, each of which trend with typical concavity toward the upthrow, except at one end where with relatively small displacement it bends the other way to connect with the next *en echelon* fault. This relation is reported personally by Leon Pepperburg to hold for at least some members of the Mexia zone of faults. On the other hand the course of normal faults seems rarely to be affected by older breaks, which they cross at sharp angles without visible deviation. The course of the new break is more often affected by an old line of weakness nearly at right angles to it, which may make a sharp "cape" in the scarp, but usually a new fault cuts nearly straight across all older breaks, as though they did not exist.

These age relations between normal faults are readily explainable under the hypothesis that they arose from compressive shear, but not under the tensional theory, because there is no conceivable cause of systematic pull across a region in one direction during the first period of faulting, in the opposite direction during the next period, and in another opposing pair of directions during the next two periods of faulting. This is the problem presented for solution by the intersection of little faults at Elk Basin, Wyo., in various parts of New Zealand, and probably at other places where studies are less complete. It is explicable if we assume that the main stress across the area was exerted first in one direction and later in another, and that each of the two periods be divided in two parts, in the first of which the greater yielding to compression occurred to one side of the district in question, and in the second part of which the greater yielding occurred on the other side. Each period of faulting was too long to let us explain this alternation of stress through the operation of elastic rebound or other yielding to elastic stress. The elastic relief of compression, thought by some to create tensional faults, would tend merely to maintain compression.

Displacement is thought to arise generally from movements widely distributed through the rock, largely in its softer and more yielding parts, and originally inclined at low angles, but bending upward toward faults. Local thickening and bending of the more yielding rocks is thought to make an incipient fault-fold at right angles to the line of principal stress, the growth of which cracked the harder layers. Such a crack is thought to concentrate the movements distributed in the more yielding rock, the distributed movements bending gently upward toward the break that relieves them, and so feeding displacement to the fault. The distributed movements in the more yielding rock may be minute over-thrusts or pseudo-flowage. Where they have been most concentrated either through greater intensity or through longer application, the displacement is greatest, as viewed either in plan or in cross-section. Thus the systematic cross-faults of Elk Basin and other Wyoming anticlines seem to gather their displacement within the Cretaceous shales. The distributed movements that feed displacement to the trunk-fault may be regarded as its roots. Where the reverse action occurs, in the parts of a fault that lose displacement upward, even where part of the loss goes into monoclinal bending and where there are no visible branches, the phenomena correspond, except that they are reversed, displacement there being scattered into disseminated movements, instead of being gathered from the former.

The concentration of the disseminated movements in space would in itself cause their concentration in time, or greater velocity, but the high velocity of slipping is due mainly to the operation of elastic rebound, as explained by Harry Fielding Reid. The disseminated movements press with increasing force against a line of fracture until the accumulated force exceeds the resistance, when a slip occurs. At that moment the rock is bent and compressed elastically and the relief of this condition is a sudden fling forward along the fault. The possible velocities are much higher than those required to create effects of momentum.

Under this theory, normal faults not only gather their displacement largely below, but they also start at depth and crack their way upward. On the other hand, under the theory of gravity faults, the force is applied from above, where the faults originate, cracking their way downward. Definite test of the two theories can be found in the character of the offsets of little faults wherever a district can be found in which there has been a second reversal of stress back to its original direction. So far the writer has been unable to find such a place, but some field doubtless will furnish the required proof.

These opinions arise from studies in broad sheets of sedimentary rock. Many of them do not apply to areas of igneous activity, although the broader principles probably hold true. (*Author's abstract.*)

Discussed by Messrs. SEARS, CAPPS, GILLULY, HESS, FERGUSON, LOVERING, BASS, BOWIE, HEWETT, GREIG, and RUBEY.

440TH MEETING

The 440th meeting was held at the Cosmos Club, April 11, 1928, President HEWETT presiding.

Informal communication: DAVID WHITE exhibited two small vertebrate fossils, a salamander and a fish, collected at Mazon Creek in the northeastern part of the Illinois coal field. The fossils are in ironstone nodules from rocks equivalent to the Allegheny (Pennsylvanian) formation. The Mazon Creek locality is noted for the fossil plants that have been collected there.

Program: Dr. CHRISTIAN POULSEN, Mineralogical Museum, Copenhagen: *The Danian formation.* The Danian formation consists almost exclusively of organic sediments which form a series of strata 30–40 feet thick. Three different main facies are found: Bryozoan limestone, Coccolite limestone and Coral limestone. The Bryozoan and Coccolite limestones are widely distributed in Denmark and found both in the lower and upper Danian, whereas the third important type of rock, the Coral limestone, is confined to the upper Danian and known only from a few localities, where the conditions were favorable to these animals.

The lower Bryozoan limestone and the base of the Danian outcrop in the famous Stevns Cliff section: This section shows the white chalk of the *Belemnitella mucronata* zone the uppermost part of which contains a little terrigenous material and numerous Bryozoa; the chalk is overlain by a thin layer of clay, the so-called Fish clay, which forms basins in the surface of the White chalk. Then follows a layer of limestone 2–3 feet thick, the Cyclaster limestone, which is overlain unconformably by the Bryzoan limestone.

Dr. A. ROSENKRANTZ,[1] who has recently studied the Stevns Cliff section and especially the strata between the White chalk and the Bryzoan limestone, outlines the geological history as follows: At the end of Senonian time the sea bottom on which the White chalk had been deposited was elevated to about sea-level. It is uncertain whether the basins in which the Fish clay was deposited existed at that time or were formed by erosion after emergence of the Senonian strata. Following this emergence the Fish clay was deposited.

[1] Meddelelser fra Dansk geologisk Forening **6.** 1924.

Gradually the waters became clearer, resulting in a transition from the Fish clay to the pure Cyclaster limestone. This limestone was probably formed by material derived from the White chalk. After the deposition of the Cyclaster limestone the sea bottom rose above sea level. Frosion then leveled the land surface, leaving some of the Cyclaster limestone in the Fish clay basins. Weathering of the very flat and presumably low land hardened the surface layers so that the Cyclaster limestone as well as the White chalk in the spaces between the Fish clay basins was considerably hardened. At the same time the numerous sponges found in these sediments were decomposed, leaving more or less dendritic holes in the surface. After this land period the Danian sea swept in and covered the area. The holes in the sediments beneath were filled with Bryozoan limestone and thus Senonian and Danian species are found apparently in the same bed, as, macroscopically, there is not much difference between the limestone varieties in question.

The contact line between the Cyclaster limestone and the Bryozoan limestone is the lower limit of the Danian formation.

The fauna of the Bryozoan limestone is not greatly different from that of the Coccolite limestone, except for the presence of the Bryozoa. The only facies that shows essential faunal differences is the Coral limestone at Faxe. The Coral limestone at this famous locality contains, in addition to species known from the other facies, a very rich fauna of corals, lamellibranchs, gastropods, cephalopods and crustaceans. The corals are closely related to the forms now living on the bottom of the rather deep sea west of northern Norway.

Lithologically the Coccolite limestone shows a striking resemblance to the White chalk, but its fauna has the normal Danian aspect.

It is possible to divide the Danian into two subdivisions which, however, differ little in fauna or lithology. In the upper Danian the fauna contains a few characteristic species which are unknown in the lower Danian, such as *Crania tuberculata* Nilsson, *Terebratula lens* Nilsson and *Ditrupa schlotheimi* Rosenkrantz.

Toward the end of the Danian the sea became shallower as shown by intraformational conglomerates at some localities.

The Danian is overlain by greensand and glauconitic marls containing a typical Paleocene fauna.

Originally the Danian was regarded as the youngest subdivision of the Cretaceous system, but now several Danish geologists accept the opinion of De Grossouvre, that this formation should be considered the lowermost Tertiary. The position of the Danian, however, is still a matter of discussion. The fact that ammonites are not found above the Cyclaster limestone ought to be taken in consideration. On the other hand, the Danian fauna contains a very great number of persistent Senonian species, whereas only a few Danian species are found in the lowermost Paleocene; in other words the break beneath the Danian represents only a relatively short space of time, whereas the upper break must have been of long duration. These last mentioned facts are strong evidence that the Danian is the youngest subdivision of the Cretaceous system.

Typical Danian, or formations which can be correlated with it, are probably not to be found outside Scandinavia, perhaps with the exception of the Calcaire à Lithothamnium at Vigny, France, which contains *Hercoglossa danica* (Schlotheim), and *Nautilus Bellerophon* Lundgren; in addition to these species a certain number of Montian species are found in the Vigny fauna. E. Haug[2] therefore regarded the Calcaire à Lithothamnium as passage beds. The Calcaire à Lithothamnium probably corresponds to the lacuna above the Danian in Denmark as suggested by J. P. J. Ravn.[3] (*Author's abstract.*)

Discussed by Messrs. CAPPS, STANTON, SCHALLER, RESSER, GOLDMAN, and Miss GARDNER.

H. W. HOOTS: *The structural history and unusual rock types of the Santa Monica Mountains, southern California.* The Santa Monica Mountains are one of the prominent structural features which adjoin the Los Angeles Basin in southern California, one of the most prolific oil producing districts known. Even though the eastern part of the Santa Monica Mountains will themselves probably yield no oil, the importance to the petroleum industry of knowledge concerning the rock types and detailed geologic history of this area is apparent. The area contains many striking geologic features and, inasmuch as it adjoins a thickly populated educational center and is easily accessible by automobile, it provides an interesting field for the trained geologist and for student classes from the several universities of southern California.

The eastern part of the Santa Monica Mountains, east of Topanga Canyon, presents a section of varied rock types including coarsely crystalline plutonics, "basic" and "acidic" intrusives and pyroclastics, metamorphic strata consisting of slate and schist, and a wide assortment of sedimentary rocks. The stratigraphic record is far from complete; the presence of Paleozoic rocks is very doubtful and there is a gap in the early Tertiary record representing much of middle and late Eocene and Oligocene times. The Mesozoic appears to be fairly well represented although Jurassic deposits may not be present and the age of the Triassic (?) rocks is not established beyond dispute. Except for a fragmentary exposed Pliocene record and a gap representing an important but unknown thickness of middle Miocene rocks, the late Tertiary and Quaternary, beginning with lower Miocene, is fairly complete.

The accompanying table gives a list of the rock formations exposed in the eastern part of the Santa Monica Mountains and information regarding their probable ages and general characteristics.

Structurally, the eastern part of the Santa Monica Mountains is a broad open anticline, the axis of which lies in the extensive central area of Santa Monica slate and plunges westward from the major granitic intrusive mass just north of Hollywood. The attitudes of younger rocks, particularly those of Miocene age which cover so much of the north and south flanks of the mountains, conform in a general way to this anticlinal structure. It is apparent from the presence of several pronounced unconformities, however, that this major fold has experienced several stages of growth and deformation. The anticlinal structure is still clearly obvious in the central part of the district, but in the eastern and western parts the original fold has been so intricately deformed by block faulting and igneous intrusion that much of the fold is either difficult to recognize as such, or is down faulted and entirely concealed beneath alluvium. Pre-Modelo diastrophism produced an anticline which, judging from the westward plunge of the fold, was complete in the district east of Topanga Canyon, although similar major uplifts of this age no doubt occurred farther west; post-Modelo diastrophism, however, was responsible for anticlinal uplift which affected a larger area as a unit, an area which included the district west of Topanga Canyon as well.

[2] *Traité de Géologie* **2**: 1406. Paris, 1908–11.

[3] Danmarks geologiske Undersøgelse, 2 Række, No. 43, p. 40.

From the distribution of spotted slate and the known relation of this slate to the major exposed granitic intrusion, it is believed that much of the area along and north of the anticlinal axis is underlain by a much larger intrusive body of granitic rock. The broad open character of the fold, a unique structural feature for the Coast Ranges of California, is that which might be expected to result from bodily uplift by a large deep-seated intrusion. However, since most of the folding occurred during and since Miocene time, and since there are no known granitic rocks of Tertiary age on the west coast, it seems improbable that intrusion of granite has itself produced this fold. It does seem probable, however, that the character of the fold produced by late Tertiary uplift was controlled in some measure by the presence of a large, much older body of granitic rock beneath the folded area.

The structural features of this district are particularly striking. One is the post-Topanga (Middle Miocene), pre-Modelo (Upper Miocene) unconformity which represents the only period of folding (see table on pp. 354–355), which contests in importance that deformation which occurred near the close of the Pliocene. The other is the remarkably close association between faults and intrusions of basalt in the pre-Modelo rocks of the Topanga and Santa Ynez Canyon district, an association which forces the conclusion that faulting and intrusions of basalt had a close genetic relation during the period of post-Topanga, pre-Modelo diastrophism.

Several types of rock occur in this area which, judging from the literature, are not common in California. Some of them are known elsewhere but have not yet been described in detail. The spotted slate, a contact metamorphic facies of the Santa Monica slate, is worthy of additional study and is to be described in a paper now in preparation.

In the Martinez formation (lower Eocene), and possibly also in the Chico formation (Upper Cretaceous) of some areas, occur prominent reefs of white limestone from a few feet to 50–60 feet thick. These reefs commonly extend for not more than a few hundred feet and terminate in an abrupt wall; the largest reef is approximately 500 feet long. This limestone is distinctly nodular, has irregular bedding, and is characteristically spotted, due to the abundance of nearly white irregularly shaped algae and algal colonies imbedded in a limestone or argillaceous matrix of light brown or gray color. The algae are of the lithothamnion type but have not as yet been studied in detail.

The Modelo formation contains several rock types of unusual interest. A massive bed at the base, lying directly upon the Santa Monica slate, has a typical dark gray color due to the abundance of slate fragments. According to the terminology of some geologists this slate-fragment sandstone may be classified under the group name graywacke. Locally it is very fossiliferous; in other places it is absent and its stratigraphic position is occupied by a 4 to 6 inch bed of oolitic phosphate, another type of rock which does not appear to be common in the California Tertiary.

The siliceous shale of the Modelo is not in the least unusual for the Miocene of California but its siliceous character and association with beds of volcanic ash and bentonite, its micro-fossil content, and its remarkable banding provide ample material for a number of interesting speculations. (*Author's abstract.*)

Discussed by Messrs. HEWETT, RUBEY, BUTTS, and STANTON.

W. W. RUBEY, A. A. BAKER, *Secretaries.*

Table of Rock Formations and Unconformities in Santa Monica Mountains, California

Geologic age	*Formation*	*Character and approximate thickness*	*Feet*
Recent	Alluvium	Breccia-conglomerate, sandstone, and silt.	0–100±
Pleistocene	Alluvial plain now uplifted and deeply dissected	Poorly sorted reddish brown breccia-conglomerate and sandstone with earthy matrix and indistinct bedding. This alluvial plain, now far above present level of drainage, has been given the name Santa Monica Plain.	0–300±
	Marine Pleistocene	Fossiliferous soft gray sandstone and sandy clay.	5–50±
Unconformity (Horizontal Pleistocene rests directly upon Pliocene, dipping as much as 60°)			
Pliocene	Pico formation	Soft dark gray clay and sandstone with lenses and concretions of yellowish gray limestone. Exposed only in coastal belt northwest of Santa Monica.	1,000±
Unconformity (Some folding and erosion but importance uncertain because of limited distribution of Pliocene)			
Miocene			
Upper Miocene	Modelo[a] formation		
	Upper member	White punky diatomaceous and foraminiferal shale and fine sandstone grading laterally into clay-shale and sandstone.	2,300±
	Lower member	Soft light gray to brown well-bedded shale, banded hard platy siliceous shale, thin and thick massive beds of sandstone and conglomeratic sandstone, and volcanic ash. Much of shale is foraminiferal.	2,250±
Unconformity (Represents the most pronounced pre-Pliocene deformation, which, in this case included folding, faulting, and basalt intrusion)			
Middle Miocene	Topanga formation	Massive fossiliferous sandstone and conglomerate and thinly bedded shale and sandstone intercalated with intrusive and extrusive basalt and pyroclastics of lower and upper Topanga age. Basal 1,000 feet of conglomerate west of Cahuenga Avenue may be Vaqueros.	4,500–7,500±
Lower Miocene and Oligocene(?)	Sespe(?)-Vaqueros(?) formation	Light gray and red conglomerate and conglomeratic sandstone. Unfossiliferous.	3,500–4,000±
Unconformity (An important stratigraphic gap produced by some folding and erosion of uncertain magnitude)			

Eocene			
Lower Eocene	Martinez formation	Soft brown shale, sandy shale, and sandstone, with hard limestone concretions containing fossils. Prominent discontinuous reefs of white algal limestone are conspicuous.	250+(?)
Cretaceous (Upper)	Chico formation	Massive brown and gray conglomerate and sandstone and dark gray shale. Fossiliferous. May also contain reefs of white algal limestone.	8,000±
Unconformity (Not exposed, but unquestionably present because of striking difference in metamorphism of Cretaceous rocks and older slates, exposed contacts of which are faults)			
Jurassic(?)	Granitic intrusion	Granite and granodiorite. May be of Paleozoic age.	
Triassic(?)	Santa Monica slate	Black slate, much of which has undergone contact, as well as regional, metamorphism and is locally altered to mica schist. Base not exposed.	5,000–7,000±

[a] The rocks herein called the Modelo formation appear to be entirely of upper Miocene age and are not, therefore, the exact equivalent of the Modelo in the type district of the Santa Clara Valley which is believed by W.S.W. Kew to include rocks of both middle and upper Miocene age.

SCIENTIFIC NOTES AND NEWS

Mr. H. W. Hoots has resigned from the U. S. Geological Survey to engage in petroleum engineering with the Union Oil Company, Los Angeles, California.

The offer of the Smithsonian Institute to take over and maintain the Mycological Collection of the late C. G. Lloyd of Cincinnati, which had been without a curator since the death of the founder in 1926, has been accepted by the trustees of the Lloyd Library and Museum; and the collection has been moved to Washington and is now in process of installation. This outstanding collection of the larger fungi, gathered together during the life time of Curtis Gates Lloyd, contains a number of specimens variously estimated at 50,000 to 100,000, nearly 10,000 negatives of fungus subjects, hundreds of photographic prints, half-tones of all the illustrations issued in Mr. Lloyd's numerous publications, voluminous correspondence with practically all the mycologists of the world active during his life time, many notebooks, and a great mass of manuscript records pertaining to the specimens. The collection will be maintained as a separate unit by the Office of Mycology and Disease Survey, in the Bureau of Plant Industry, under the immediate supervision of a custodian to be named by the Smithsonian Institution. It will be housed in steel herbarium cases and in a fire-proof building. The cataloging of the herbarium and the arranging and indexing of the other materials constituting the collection will be commenced shortly, and it is expected that this work will be completed within two years. The herbarium and supporting collections will then be available for the use of all interested mycological workers.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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JOURNAL

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Vol. 18 July 19, 1928 No. 13

GEOLOGY.—*Variations in Appalachian stratigraphy*.[1] Charles Butts, U. S. Geological Survey.

The truly scientific investigation of the stratigraphy of the Appalachian Valley may be said to have begun in the period 1835–1842 with the work of W. B. Rogers in Virginia and H. D. Rogers in Pennsylvania. They recognized the broad outlines of the stratigraphic succession and reached a substantially correct understanding of the general geologic structure. In the period 1855–1869 Safford studied and described the geology of Tennessee, making finer subdivisions than the Rogers brothers had done and introducing the British and New York classification and systemic names. Still later, from 1875 to 1885, the Second Geological Survey of Pennsylvania made still finer subdivisions of the stratigraphic column and followed still more closely the New York classification. In 1894 the report on the Paleozoic rocks of Alabama, prepared mainly by Henry McCalley under the direction of E. A. Smith, the State Geologist, was published. Here also the general British, Canadian and New York classifications were followed. In both the Alabama and Pennsylvania reports the stratigraphic subdivisions were in part of a broad, inclusive character. For example, it has been found possible to break up formation No. II of the Second Survey of Pennsylvania into 14 mappable units, ranging from Middle Cambrian to Trenton in age, and in Alabama the "Pelham limestone" included rocks from middle Beekmantown to rocks of upper Richmond age and was thus nearly synonymous with Ordovician in the broadest sense.

Subsequent to 1880 large areas of the Valley were mapped in greater detail than ever before by the geologists of the U. S. Geological

[1] Address of the retiring president of the Geological Society of Washington, delivered December 14, 1927. Received May 8, 1928. Published by permission of the Director of the U. S. Geological Survey.

Survey, Hayes, Keith, Campbell, and Darton. They had the aid of fair topographic maps, which were wanting to their predecessors. Their work consisted mainly in mapping the various lithologic units, and their discrimination of the map units was in general satisfactory and the mapping carried out consistently. Owing, however, to the almost complete neglect of paleontology, various errors were made in correlation and identification of formations in different belts of outcrop within the Valley. For example, the shale of Martinsburg age of the northwestern belts in Tennessee and Virginia (Trenton to Maysville ages), was identified with the much older Sevier shale (of upper Chazy age) of the southeastern belts. The lower part of the Sevier really corresponds to the Ottosee limestone of the northwestern belts, which is separated from the younger Martinsburg shale by the Moccasin limestone. In like manner the essential equivalency of that part of the Chickamauga limestone corresponding to the Lowville limestone in the most northwestern belts adjacent to the coal fields with the Moccasin limestone of the middle belts and the Bays sandstone of the southeastern belts was not recognized.

It remained for one who through years of intensive paleontologic and stratigraphic studies had become a master of the criteria by which alone correct stratigraphic correlation is possible to point out such errors as I have mentioned and put the systematic stratigraphy of the Valley on a sound basis. I refer, of course, to Ulrich, who began work in the southern Appalachians in 1896, and in 1902, after a few seasons' work zigzagging back and forth across the Valley, published in collaboration with Schuchert, the paper on *Paleozoic Seas and Barriers* (Bulletin 52 of the New York State Museum). In this paper the basic concepts of the authors regarding the history of Appalachian deposition as suggested by the distribution of the deposits were set forth. Briefly their thesis was that the Appalachian geosyncline was occupied by a number of subordinate, relatively long and narrow troughs of deposition, having in part separate oceanic connections, and separated by long narrow barriers. They thought that at times the geosyncline was almost entirely submerged and contemporaneous deposition extended clear across it and along nearly its whole length. Ulrich continued work in the Valley and in 1911 his great work, the *Revision of the Paleozoic Systems,* was published. In this he elaborated or modified the ideas set forth in *Paleozoic Seas and Barriers,* and applied them to the revision of the classification of the Paleozoic strata up to the top of the Beekmantown, which he included in his

Canadian system. The idea of long, narrow barriers was largely abandoned and the idea of continental tilting and shifting of troughs of deposition was stressed.

My own connection with this work has been mainly in detailed mapping for folios and State maps all along the Valley from Pennsylvania to Alabama, and in this I have, of necessity, had to depend upon Ulrich for precise stratigraphic correlation. I have had opportunity to check to a large extent Ulrich's determination of stratigraphic equivalency and it is my purpose in the rest of this address to present some concrete examples of stratigraphic variations that have come under my own observation, point out their possible causes, and show their possible bearing upon Ulrich's general hypothesis of local warping and shifting troughs in the Appalachian geosyncline.

The variations of which I shall speak are of two kinds—variations in the sequence of formations from place to place and variations in the character of the same formation in different parts of the Valley, or facies variations.

I will first take up the variation in sequence and afterwards the variations in facies.

General Sequence of Formations

The general formational sequence in the Valley is fairly well displayed in the group of sections shown in Figure 1.

At the base of the Paleozoic succession a group of quartzites and shales of Lower Cambrian age rests upon the Archean rocks of the Appalachian Mountains or on those of the Piedmont plateau. These Cambrian rocks border the Appalachian Valley on the southeast from Pennsylvania to Alabama. They make the Blue Ridge for much of the distance from Potomac River to Roanoke, Virginia. They are variously subdivided and named but in general may be appropriately designated by Safford's name Chilhowee sandstones and shales or, more briefly, the Chilhowee group. (See Figure 1, section 6.)

The overlying Shady limestone, mainly dolomite, is persistent and fairly uniform in character throughout the length of the Valley. The same is true of the next overlying Watauga shale, to which other names have been given in different areas, as Rome in parts of Georgia, Alabama, and Tennessee, Waynesboro in Pennsylvania, "Russell" on the northwest side in Virginia, and "Buena Vista" in the vicinity of Lexington, Virginia. Recently the U. S. Geological Survey has adopted the name Watauga shale for the southeast side of the Valley in Virginia and the name Rome formation for the belts on the northwest side in which the name "Russell" has formerly been used. The writer would prefer to abandon all other names as synonyms and apply the prior name Rome throughout, for the unit is generally acknowledged to be substantially the same from end to end of the Appalachian Valley. The next overlying unit, Honaker limestone, is persistent but of variable facies, as will be shown later. The Nolichucky shale, succeeding the Honaker, is well-defined in northern Tennessee and southern Virginia but loses its identity north and south of that general region.

Next above the Nolichucky is the Jonesboro limestone in the southeastern belts of outcrop and the Copper Ridge dolomite in the northwestern belts. The relationship of these will be discussed farther on.

Succeeding the Jonesboro (as here redefined), or the Copper Ridge, according to locality, is the Nittany dolomite, containing the *Lecanospira* zone—one of the great persistent units, extending in faunal and lithologic integrity throughout the Valley. This general zone is known to persist from the northwest highlands of Scotland (Durness limestone, in part) via Newfoundland, Quebec, Lake Champlain and the Appalachian Valley to southern Missouri, where it is represented by the Roubidoux formation. The zone is everywhere marked by its characteristic genus of gastropods, of which Ulrich recognizes several species, the genotype being "*Ophileta*" *compacta* Salter. The genus is, however, quite distinct from *Ophileta,* and Ulrich has given to it the name *Lecanospira.*

The Nittany is overlain by 50 to 200 feet of beds containing the gastropod genus *Ceratopea,* which are in turn succeeded by the Mosheim limestone, and that by the Lenoir limestone. The Lenoir limestone represents the middle Chazyan Crown Point limestone of the Lake Champlain region and contains the well known *Maclurea magna* zone. The Lenoir is represented in the northwestern belts in the Stones River limestone shown in Figure 1, section 2.

The Lenoir is followed by coarse limestone or marble named Holston marble in Tennessee and Holston limestone in southwestern Virginia. This unit has also been called Murat limestone in Rockbridge County and neighboring parts of Virginia.

Next in upward sequence is the Athens shale, carrying the Normanskill graptolite fauna. At Knoxville, Tennessee, the Athens is absent and the Holston marble is directly succeeded by the Tellico sandstone. The Tellico is succeeded in turn by the Sevier shale, the lower part of

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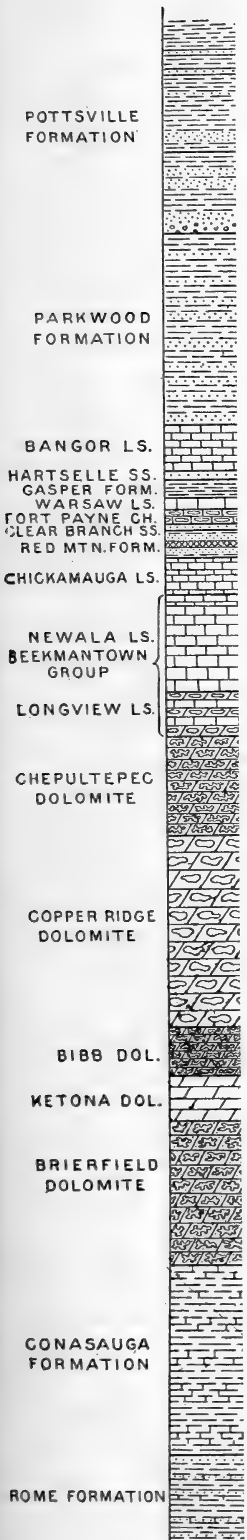

Figure 1.—Se
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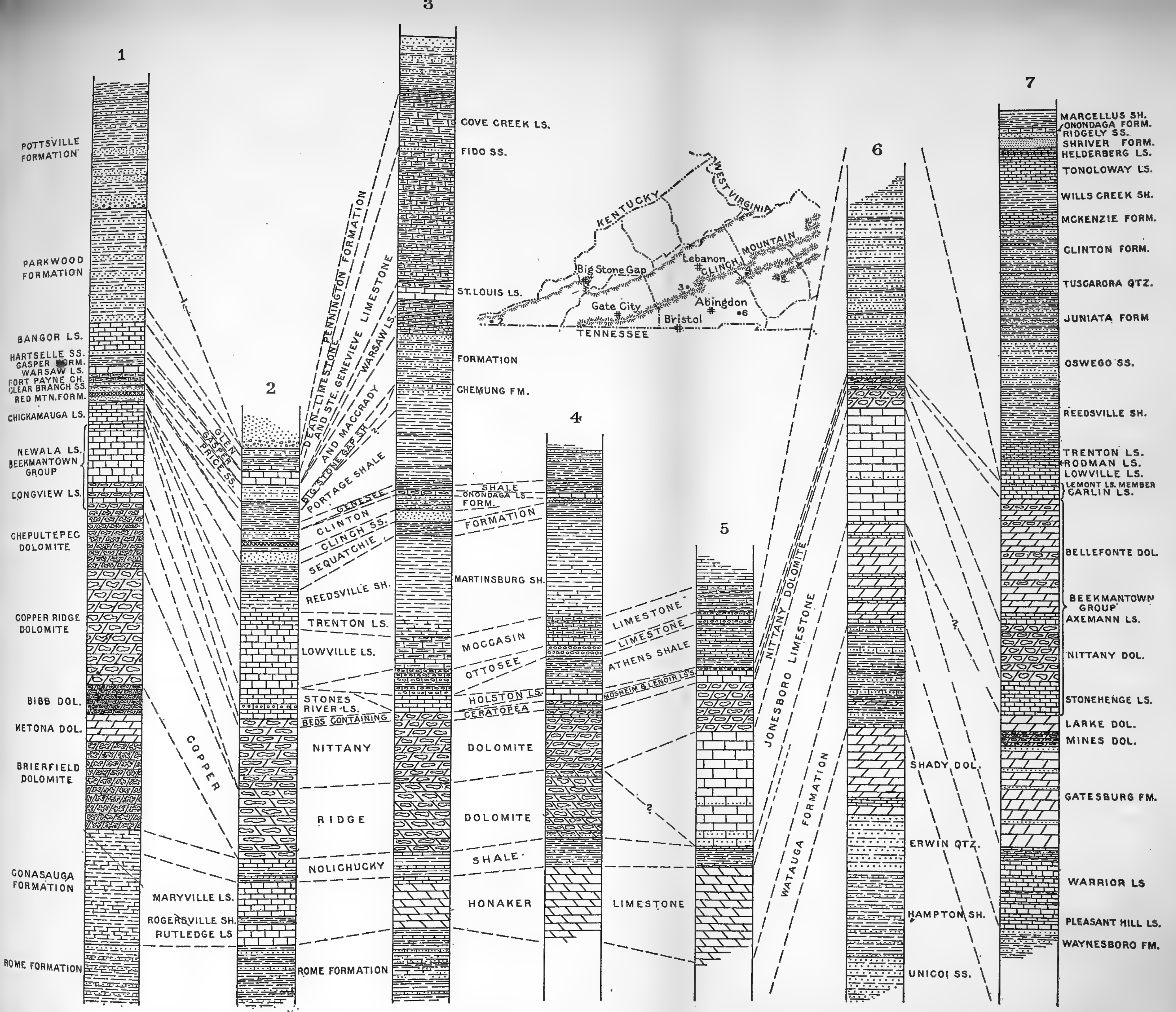

Figure 1.—Sections showing stratigraphic sequence in Alabama, Virginia, and Pennsylvania. Section No. 1 is in the Birmingham District, Alabama, the part above the Chickamauga limestone in Birmingham Valley, the part below the Chickamauga in Cahaba Valley; sections Nos. 2 to 6 in southwestern Virginia, as shown in key map; section No. 7 in Center, Huntingdon, and Blair counties, central Pennsylvania. Scale of sections 1 inch = 2,000 feet.

which is represented in the northwestern belts in Tennessee and throughout southwestern Virginia by the Ottosee limestone. This new name was given by Ulrich to a smaller unit of a very different facies in the northwest part of the Valley. Northwest of Clinch Mountain in Tennessee and throughout the areas covered by folios in southwestern Virginia, the Martinsburg shale was erroneously identified and mapped as Sevier shale, whereas the actual representative of the typical Sevier (with its basal calcareous part now called Ottosee) was included in the Chickamauga limestone.

Next above the Ottosee in the middle belts is the Moccasin limestone, which is approximately the same as the Lowville limestone of the northwestern belts, as shown in section 2, Figure 1. The Moccasin is succeeded in the middle belts by the Martinsburg shale, which includes in its lower part the equivalent of the true Trenton limestone. In the northwestern belts the Trenton becomes recognizable as a limestone and the post-Trenton part of the Martinsburg, composed largely of shale, is made a separate formation, named the Reedsville shale.

Overlying the Reedsville or Martinsburg, according to locality, a formation composed mainly of red shale and sandstone extends throughout most of the Valley from Pennsylvania to southwestern Virginia. In Pennsylvania it is named the Juniata formation, but in southwestern Virginia, where marine fossiliferous limestone comes into it, it is named the Sequatchie formation. This unit was wrongly called Bays sandstone in the southwestern Virginia folios, the typical Bays, as said before, being equivalent to the older Lowville or Moccasin limestone.

The Sequatchie or Juniata is succeeded throughout the Valley and southward to central eastern Tennessee by a ridge-making quartzite called Tuscarora in Pennsylvania and Clinch in Virginia. It makes the crest of Clinch Mountain. The Clinch or Tuscarora is followed by the Clinton formation, so well known through the Valley from New York to Alabama on account of its deposits of stratified iron ore.

Next above the Clinton in Pennsylvania, Maryland, and northern Virginia, lie shale and limestone of Cayuga age, followed in turn by the Helderberg limestone. The Helderberg, however, does not extend southward in Virginia to the region covered by the sections, although in the extreme northwestern belts adjacent to the coal fields, as in the vicinity of Big Stone Gap, both Cayuga and late Helderberg are represented. In southern Virginia, in the middle belts, the Clinton is overlain by a thin representative of the Oriskany sandstone and that by limestone and chert of Onondaga age. This is followed in turn by black shale of Marcellus and Genesee age, and the latter by a varying thickness of Upper Devonian shale and sandstone in the main representing the Portage and Chemung formations of western New York.

Next above the Chemung comes the basal Mississippian Price formation, of New Providence (Burlington, Pocono) age, and this is followed by later formations of Mississippian (Meramec and Chester) ages up to the Pennington formation. Southeast of Clinch Mountain there is a hiatus due to the absence of beds of Keokuk age, and on the northwestern side of the Valley this hiatus is increased by the additional absence of the Warsaw and most of the St. Louis limestones.

Variations in Sequence

Intercalation of the Blount Group of Ulrich.—I have selected a few of the more clear-cut and extreme variations for presentation. The first is the intercalation of the Blount group of Ulrich along the strike between Pennsylvania and Alabama, as illustrated in Figure 2. In this figure the photograph on the right, turned a quarter way around to facilitate drawing the correlation lines, is a view in one of the quarries at Bellefonte, central Pennsylvania. The strata dip 50° northwest. At the top, above the junction of the correlation lines, is the Lowville limestone; just below the junction of the lines is the Lemont member of the Carlim limestone, of Chazy age.

The Lemont here is only 10–15 feet thick and at both its top and bottom is a bed of clayey composition not more than 1 foot thick, identified by Ross and others as volcanic ash or what has recently been identified by them as bentonite, which occurs at several horizons and which has been found at many places in the Appalachian valley and the more interior parts of the eastern United States.

The limestone above the Lemont is known to be Lowville from the presence of its guide fossils, *Tetradium cellulosum*, and *Cryptophragmus antiquatus* (*Beatricea* of Ulrich). The Lemont is known to be of middle Chazy age by the presence in it in some localities in central Pennsylvania of the well known guide fossil *Maclurea magna* as well as the occurrence of other equally good middle Chazy fossils.

Going south to the general region marked by Knoxville, Tennessee, the Lemont limestone is represented by the Lenoir limestone, with *Maclurea magna* and a profusion of other fossils, and the Lowville limestone is represented southeast of Knoxville by the Bays sandstone. This is proven by the occurrence of *Tetradium cellulosum* in limestone

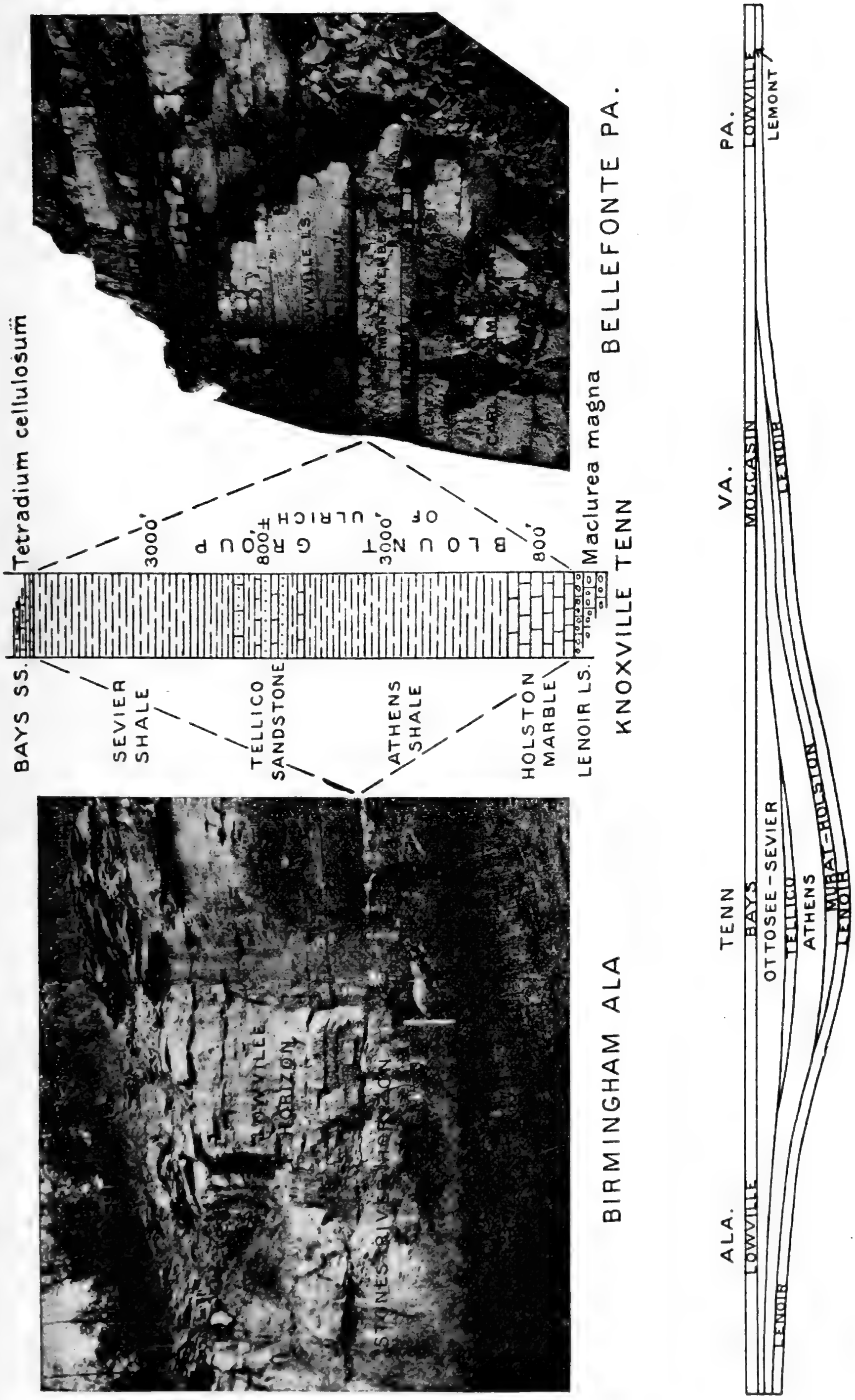

Figure 2.—Photographs and sections to show the stratigraphic relations and geographic distribution of the Blount group of Ulrich. Note the parallelism of the bedding at the unconformities shown in the photographs.

in the base of the Bays in that locality, as shown in the section between the photographs. The significance of this fossil will be discussed further on. However, as shown in Figure 2, the Lenoir limestone in the Knoxville region is separated from the beds of Lowville age by a group of formations which aggregate 7,500 feet in thickness and which are absent in central Pennsylvania. This thickness is obtained by taking the maximum well-determined thicknesses of the several units in different parts of the Knoxville region. These thicknesses are used for the purpose of emphasizing the time interval between the Lemont and Lowville, or between their equivalents, Lenoir and Bays. The left hand photograph of Figure 2 is a view of a quarry in Birmingham, Alabama. The situation is here nearly the same as in central Pennsylvania. As will be shown a little further on, the limestone above the prominent parting at the level of the man's head is of Lowville age; the limestone below the parting contains a characteristic fossil, *Plectambonites subcarinatus* and represents the Lebanon limestone, the top formation of the Stones River group of the Nashville Basin, Tennessee. Ulrich, from the fossils present, believes the Ridley limestone also to be represented in the section at Birmingham by beds below those representing the Lebanon. Now Ulrich assigns the Ridley, which in the Nashville Basin lies immediately beneath the Lebanon, to about the same stratigraphic level as the Lenoir limestone, which in turn is approximately the same as the Lemont limestone, with the result that the Lowville horizon at Birmingham is separated from the Ridley horizon (possibly Lenoir or Lemont) by only 50 feet of beds of Lebanon age not present in the eastern and northern parts of the Appalachian valley.

Proof of the Lowville age of the limestone above the parting in the quarry at Birmingham is found at a quarry on the same outcrop just northeast of Gate City, 4 miles northeast of Birmingham. The same prominent parting as that shown in the left hand photograph is present as a rubbly bed reaching a thickness of possibly a foot and on which is a reef-like accumulation of fossils, *Solenopora*, *Columnaria*, Bryozoa, and brachiopods. Ten feet above the parting at this place *Tetradium cellulosum* and *Cryptophragmus antiquatus* (*Beatricea gracilis* Ulrich), the two principal guide fossils of the Lowville limestone, occur and extend 20 feet higher. The specimens of *Cryptophragmus* and *Tetradium* collected here have been figured by the writer.[2] The sequence below the break is the same as that shown in the photograph of the quarry at Birmingham.

[2] *Geology of Alabama.* Alabama Geol. Surv. Spec. Rept. **14.** *pl. 32, f. 1–5.* 1926.

Cryptophragmus is a unique fossil; nothing like it is known from any other horizon in the Appalachians. It occurs together with *Tetradium* in an identical faunal and stratigraphic sequence from Canada to Alabama, and the two mark a continuous zone in the Lowville limestone along the northwest margin of the Appalachian Valley and in the lower part of the Moccasin limestone in the middle belts of the Valley. The *Tetradium* occurs in the limestone at the base of the Bays sandstone and just above the typical Sevier shale southeast of Knoxville, Tennessee.

A most remarkable feature of this great hiatus at the base of the Lowville limestone is the perfect parallelism of the bedding above and below the unconformity and the absence of any physical evidence that the time that elapsed between the deposition of the Lemont and the beginning of the deposition of the Lowville was long enough for the deposition of 7,500 feet of beds in northeastern Tennessee and Virginia. This concordance of bedding and perfect appearance of continuous deposition is not an occasional phenomenon but is manifested in every exposure of the sequence.

The intercalation of the Blount group of Ulrich into the general Appalachian sequence is illustrated by the diagramatic section at the bottom of Figure 2. The Athens shale is recognized in the vicinity of Strasburg, Virginia, 20 miles southwest of Winchester. It extends in one syncline or another into northeastern Alabama and was originally a continuous deposit. The Holston limestone is known as far north as Staunton, Virginia and extends 50 miles or more southwest of Knoxville, Tennessee. The Tellico sandstone seems to be restricted to the Knoxville region in a broad sense. The Ottosee limestone is known as far north in Virginia as Tazewell and Wytheville, some 40 miles north of the Tennessee line, and the typical Sevier shale, including the Ottosee in its lower part, reaches its maximum development southeast of Knoxville. It may be represented in part in Alabama by the Little Oak limestone, which in Cahaba Valley lies between the Lowville-Moccasin-Bays horizon above and the Athens shale below. At any rate, the Little Oak, as determined by Ulrich from its fossils, is of Chazy age, and this conclusion is corroborated by its stratigraphic relations. It certainly falls within the same limits as the Tellico sandstone and Sevier shale.

No actual superposition of rock units such as that shown in the diagram beneath the word Tennessee (Figure 2, bottom) is known. The diagram only represents the chronological sequence of the units and roughly indicates their distribution along the strike of the Valley and at the same time shows the extent of the time that elapsed between the deposition of the Lowville and Lemont in Pennsylvania and between the deposition of the equivalent formations in Alabama.

Other variations along the Valley.—There are other great variations in the sequence of formations along the length of the valley. As shown in Figure 1, section 1, in Alabama there wedges in between the Copper Ridge dolomite and the Conasauga limestone, the upper part of which is equivalent to the Nolichucky shale, 2,000 to 2,500 feet of dolomite (Brierfield, Ketona, and Bibb dolomites) not present in Virginia and most of Tennessee. In Alabama also the Chepultepec dolomite, 1,000 feet thick, intervenes between the Copper Ridge dolomite and the Longview limestone, which is equivalent to the Nittany dolomite. In central Pennsylvania, as shown in Figure 1, section 7, there is the Stonehenge limestone, 600 feet thick, between the Nittany and the horizon of the Chepultepec. In Pennsylvania too, there is the Gatesburg formation, 1,750 feet thick, in the central part and the Conococheague limestone in the southeast belts of the Valley that appear to be about equivalent to the dolomite between the Nolichucky and Copper Ridge in Alabama. In the intermediate regions of Virginia and Tennessee there is therefore an important hiatus between the Nolichucky and Copper Ridge and between the Copper Ridge and Nittany. Between the Nittany and Mosheim there is a great hiatus due to the absence of a large part of the Bellefonte dolomite of central Pennsylvania, 2,000 feet thick and of the still younger St. Peter sandstone and associated formations of the Mississippi Valley. There are also great differences in the Silurian and Devonian systems that I will not touch upon.

Variations across the Valley.—Taking up now a transverse section of the Valley rocks in southwestern Virginia, about midway between Pennsylvania and Alabama, it appears that the sequence of the lower formations up to the top of the Nolichucky shale is constant. However, nothing is known of the Shady dolomite or the Chilhowee group on the northwestern side of the Valley where their horizons are not exposed. The Rome ("Russell") formation of the northwestern side is substantially equivalent to the Watauga shale of the southeast side, the Honaker limestone is about the same as the Rutledge, Rogersville, and Maryville combined of the northwestern side and the Nolichucky probably extends clear across, and is represented in the upper part of the undivided mass of dolomite and limestone in the southeastern belts included in the Honaker in Figure 1, section 6. In the case of the Rutledge, Maryville, and Honaker, and in that of the Nolichucky, there are marked changes of facies in the different belts as will be described subsequently. At the horizon of the Copper Ridge dolomite, however, the section on opposite sides of the Valley is strikingly different. The sequence in the northwesternmost belts, as shown in sections 2, 3, and 4 of Figure 1, holds in all the belts southeastward across the strike to that part of the Valley southeast of the line of the great Pulaski overthrust. Southeast of that line the place of the Copper Ridge, namely, the space between the Nolichucky shale and the Nittany dolomite, is occupied by 2,000 feet of rock which is predominantly limestone and which in 1911 was included by Ulrich in his Jonesboro limestone. As defined by Ulrich, the Jonesboro was made to include beds corresponding to the Nittany dolomite and still higher beds to the base of the Mosheim. However, it is agreed now that the Nittany is a distinct and easily separable unit in southwestern Virginia, and the name Jonesboro limestone is here redefined and restricted to the limestone which near Jonesboro, Tennessee, underlies the Nittany dolomite and rests on the Nolichucky shale.

The change from the 1,200 feet of cherty dolomite of the Copper Ridge to the 2,000 feet of banded limestone of the Jonesboro in the distance of a mile across the strike is startlingly abrupt. In the Copper Ridge of most of the northwestern belts no limestone has been observed, but in the belt next northwest of Abingdon extending northeast along Rich Valley between Clinch and Walker Mountains—the belt nearest to the Jonesboro limestone—layers of limestone appear scattered through the main mass of Copper Ridge and there seems to be rather more limestone at the top. On the other hand, in one place or another, heavy dolomite 50 to 300 feet thick occurs between the fossiliferous limestone in the top of the Nolichucky and the limestone of the Jonesboro. On the evidence of fossils, mainly gastropods of "Canadian" (Beekmantown) types which, so far as I have observed, occur only in about the upper 1,000 feet of the Jonesboro and mainly in the upper 500 feet, as I am here restricting it, Ulrich has classed the whole formation as "Canadian" (Beekmantown). If that is correct it must be in part equivalent to the Stonehenge limestone of Pennsylvania, which it resembles lithologically. The Stonehenge underlies the Nittany, as does the Jonesboro. If too, this interpretation is correct, the difference in southwestern Virginia at this general horizon between the succession shown in sections 2 to 4 and that shown in sections 5 and 6, Figure 1, is a difference in sequence. So, although Ulrich regards the Jonesboro as all "Canadian" (Beekmantown) yet, in view of the occurrence of limestone layers in the nearest northwest belt of Copper Ridge dolomite and a considerable thickness of dolomite in the base of the Jonesboro in places, and in view of the facts, first, that no identifiable fossils have yet been obtained from the lower 1,000 feet of the Jonesboro to prove its age, and, second, that in some cases formations of dolomite to the northwest change to limestone to the southeast side of the Valley, the possibility that the lower two-thirds or so of the Jonesboro is a limestone facies of the Copper Ridge or possibly of Copper Ridge and Chepultepec, should not be excluded from consideration. This subject will be touched upon again.

The Nittany dolomite is one of the persistent units extending both the length and breadth of the valley, and marked throughout by *Lecanospira*.

Above the Nittany and immediately succeeding *Ceratopea* zone in the middle and southeastern belts of the valley, the Mosheim and Lenoir limestones and the Blount group of Ulrich are present but in the northwest belt represented in section 2, Figure 1, they are not present. Except possibly in Mosheim time the northwest side of the Valley seems to have been separated by a barrier from the middle and southeastern sides so that the Stones River group on the northwest and the Lenoir limestone on the southeast were deposited in separate troughs, as shown by the almost complete difference of their fossils. No species, or very few, are common to the Stones River and Lenoir, although the Lenoir and Stones River seas were in part contemporaneous.

The Holston limestone occurs in the first two belts northwest of Clinch Mountain but no farther northwest. This formation has been proved to be the same as the Murat limestone, occurring in the vicinity of Lexington, Virginia, but Holston is the older name. The Athens shale nowhere extends northwest of Clinch Mountain, which indicates that that region was land in Athens time. The Ottosee limestone extends farthest northwest, being present in Rye Cove, 8 miles northwest of Gate City, and at the southeast base of Big A Mountain in Russell County. The land that existed northwest of the line of Clinch Mountain during Athens time was submerged in Ottosee time. The Ottosee extends southeastward to the belt next southeast

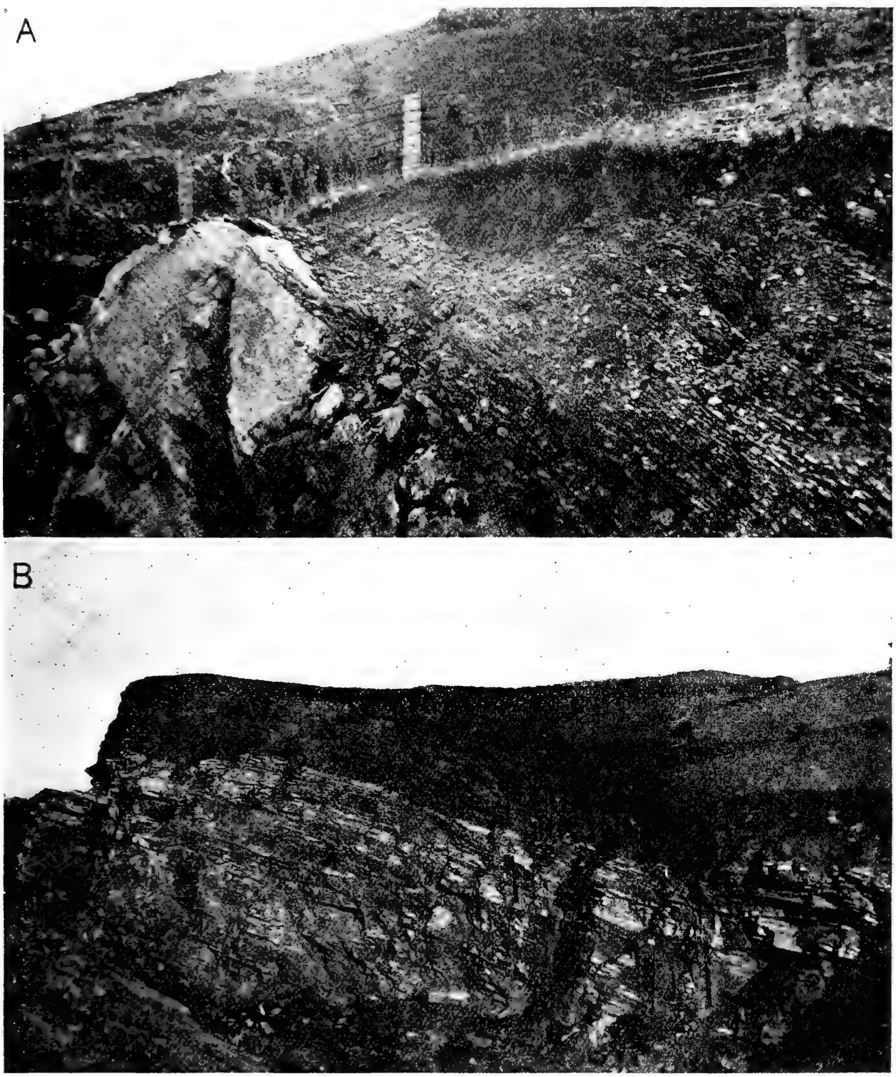

Figure 3.—A. Nodular Ottosee limestone unconformably overlying massive Holston limestone. The Athens shale, which normally follows the Holston, as shown in B, is absent. Highway cut on Little Indian Creek near the boundary between Russell and Tazewell counties, Va., looking southwest.

B. View of an abandoned quarry of the Mathieson Alkali Works, 2 miles southeast of Saltville, Va., looking east and showing the Athens shale immediately overlying the Holston limestone. The Ottosee limestone follows the Athens here, but its outcrop is hidden by the high ground above the quarry. This locality is southeast of Clinch Mountain and about 12 miles southeast across the strike from the locality of A.

of Little Walker Mountain. Southeast of that belt the Athens shale is the youngest formation present.

The differences in sequence within the Blount Group of Ulrich between the belts northwest and southeast of Clinch Mountain are shown on Figure 1, sections 3 and 4 and also in the photographs of Figure 3. In Figure 3A, the characteristic nodular limestone of the Ottosee is shown resting directly upon the thick bedded Holston limestone, the normally intervening Athens and Tellico being absent. This photo was taken on the road between Lebanon and Tazewell, near the line between Russell and Tazewell counties and northwest of Clinch Mountain. In Figure 3B the Athens is shown in contact with the Holston limestone near Saltville, southeast of Clinch Mountain, at the location 4 on the map, Figure 1. There is about 600 feet of Athens here, with characteristic Normanskill graptolites and other fossils peculiar to the graptolite zone. The Ottosee, 300 feet thick, is present here above the Athens and beneath the Moccasin limestone, both Ottosee and Moccasin cropping out on the slope beyond the quarry, not shown in the photograph.

The next notable example of variation in sequence selected for particular description is in the Birmingham district, Alabama. Here, as shown in Figure 4, there is a very great difference between the section in Cahaba Valley as shown in the right hand section from that of the Birmingham Valley shown on left hand section. The two belts are barely 8 miles apart across the strike and the distance from the southeast side of Cahaba Valley to the northwest side of Birmingham Valley is about 15 miles. The Conasauga limestone, 2,000 feet thick in Birmingham Valley, is not present on the northwest side of Cahaba Valley in the vicinity of Helena 14 miles south of Birmingham. Limestone and shale referred to the Conasauga are present in the south end of Cahaba Valley but, so far as known, it is of Middle Cambrian age and older than the Conasauga of Birmingham Valley. The Bibb and Brierfield dolomites of the south end of Cahaba Valley are absent farther north in that belt and also are absent from Birmingham Valley. The Ketona and Copper Ridge dolomites extend clear across both belts. The Chepultepec dolomite and Longview and Newala limestones, aggregating a thickness of 2,500 feet, occur only in Cahaba Valley, leaving a large erosional unconformity between the Copper Ridge dolomite and Chickamauga limestone of Birmingham Valley. The Longview is the same as the Nittany dolomite (*Lecanospira* zone) of Virginia and Pennsylvania, while the Newala includes the upper

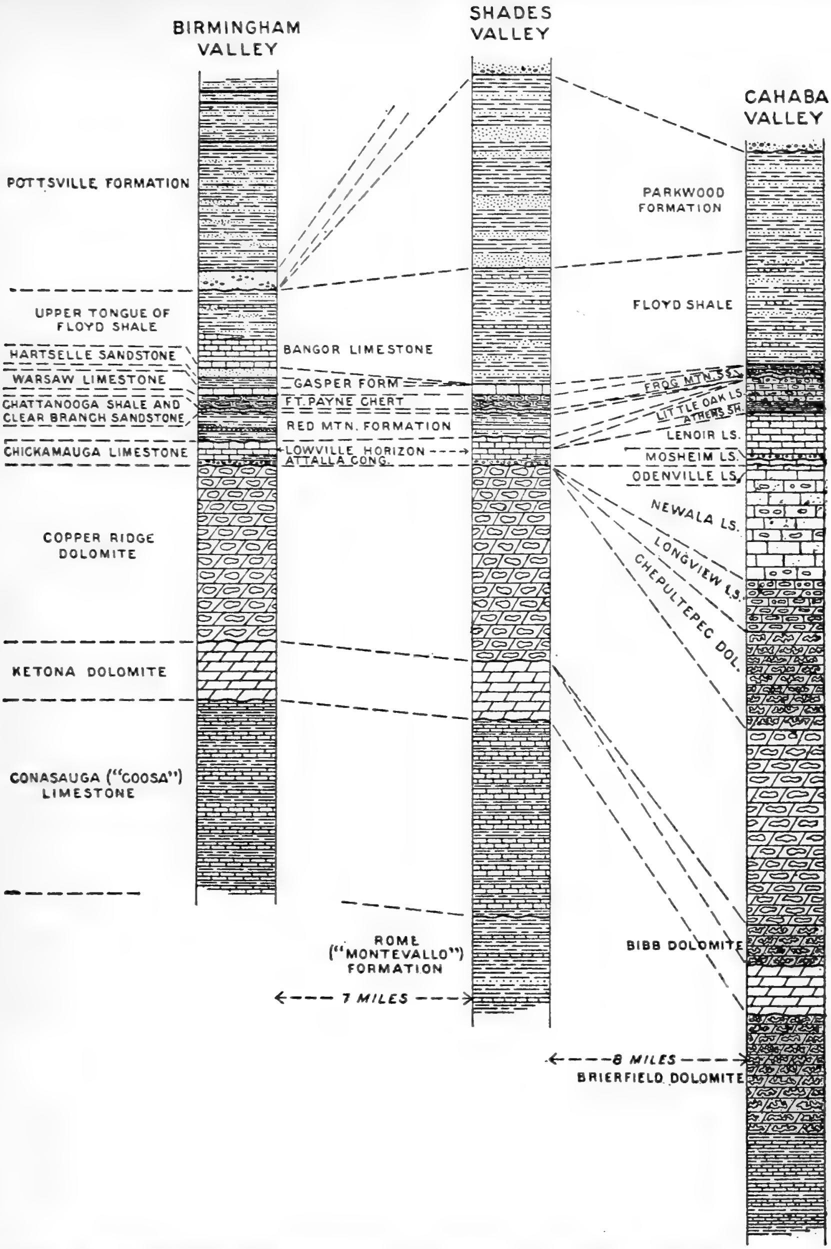

Figure 4.—Sections in the Birmingham District, Alabama, to show differences in sequence between Cahaba and Birmingham valleys. Reproduced from the Bessemer-Vandiver folio with change in the lower part of Cahaba Valley section. The formations below the Fort Payne chert are not exposed in Shades Valley but, except the Rome, crop out on the northwest of Red Mountain (which bounds Shades Valley on the northwest). They, and the Rome also, crop out southeast of the Cahaba coal field, which bounds Shades Valley on the southeast, so there is no reasonable doubt of their presence beneath Shades Valley. The part of the Cahaba Valley section from the Bibb dolomite down represents the sequence in the southern part of Cahaba Valley in the Montevallo region. In the part of Cahaba Valley beginning about 10 miles north of Montevallo and extending a considerable distance farther northeast, the Bibb and Brierfield dolomites, and the Conasauga limestone are absent and the Ketona underlies the Copper Ridge and rests upon the Rome formation. Scale, 1 inch = 2000 feet.

Beekmantown (*Ceratopea* zones), not well represented in southwest Virginia but strongly developed in Pennsylvania and Alabama. Its distribution is another example of variation along the length of the Appalachian Valley. The Chickamauga includes representatives of the Stones River, Black River (including Lowville), and Trenton limestones. The Lenoir limestone, 500 feet thick in Cahaba Valley, is represented by a much smaller thickness in the midst of the Stones River part of the Chickamauga, as indicated by the correlation lines. While regarded as approximately contemporaneous, as noted above, the Lenoir and its representative in the Stones River, both fairly fossiliferous, have almost no fossils in common, from which fact it is believed that they must have been deposited in separated troughs. These troughs of deposition were probably farther apart than the belts of the formations at present for there is a fault between the belts along which the horizontal movement may have been several miles. Above the Lenoir in Cahaba Valley are the Athens shale and the Little Oak limestone, both entirely absent in Birmingham Valley and their horizons represented by the extensive hiatus between the Lowville and Stones River limestones shown in the photographs of Figure 2. It is to be noted, too, that the ore-bearing Red Mountain formation does not occur in Cahaba Valley, as shown on the right hand section. The Fort Payne chert, lower Mississippian, however, spread over the whole region and far to the southeast of Cahaba Valley. It marks a period of wide transgression of the sea.

It is believed that these differences in stratigraphic sequence between Cahaba and Birmingham Valleys were caused by a longitudinal barrier, effective intermittently, the location of which is now marked by the Helena fault along the southeast side of the Cahaba coal field.

Higher in the Alabama section the Parkwood formation is a most notable case of extreme variation. Along the northwest side of the Cahaba coal field, as shown in the Shades Valley section, the Parkwood is over 2,000 feet thick; on the northwest side of the Coosa coal field 10 miles to the southeast, its thickness is about 1,000 feet, while on the southeast side of the Warrior coal field, northwest of Birmingham Valley, as exhibited in the Birmingham Valley section, the Parkwood and, it is believed, the Shades sandstone member and overlying shale, also of the basal coal measures (Pottsville formation) of the Cahaba field, aggregating a thickness of about 3,000 feet, are entirely absent. The northwest side of the Cahaba field and the southeast side of the Warrior field are now only 6 to 7 miles apart with a thrust fault between.

VARIATIONS IN FACIES

Honaker limestone.—Passing now to variations in facies, I take up first the Honaker limestone, which is mainly dolomite, and equivalent formations in southwestern Virginia. In the northwestern belts of the Appalachian Valley there are three recognizable divisions, in ascending order, Rutledge limestone, Rogersville shale, and Maryville limestone. In the middle belts there is no Rogersville shale and the corresponding rocks are nearly all heavy-bedded dolomite hardly to be distinguished lithologically from the Copper Ridge and Nittany dolomites. In the extreme southeastern belts, where the Rogersville is also absent and the Nolichucky not a distinct unit, the mass is made up of a variable succession of thick-bedded or shaly dolomite with many intercalated layers of pure light gray limestone. In a belt a mile or two wide lying, in general, northwest of a line connecting Marion, Abingdon, and Bristol and extending from the State line northeastward to Marion, still another facies of this unit is developed. Thick portions of it are largely mixed with insoluble clastic material so that on weathering and leaching only a soft, mealy, yellowish brown mass remains, preserving plainly the original bedding. Interbedded with such material is laminated or shaly dolomite; thick-bedded dolomite weathering down to a dark pulverulent mass; and toward the top relatively pure, banded, limestone, lithologically so similar to the overlying Jonesboro that I found myself unable to separate the two until I discovered that, as described in the Greenville folio, a section 100 to 200 or more feet thick, which I refer to the base of the Jonesboro, carries a number of layers of sandstone. This sandy zone persists for miles in the region, and as it can be easily recognized by its abundant sandstone debris on the surface of a predominantly limestone area, it constitutes a guide to the boundary between the Jonesboro and the limestone facies of the immediately underlying Nolichucky (which in the southeastern belts, as shown in Section 6, is included in the Honaker). Owing to the difficulty of making the separation of the Jonesboro and the underlying Upper Cambrian limestone, and owing to the fact that the Copper Ridge dolomite, at least in the usual facies that gives the characteristic expression of the Knox dolomite, did not exist in this broad belt between Bristol and Abingdon, the entire succession from the Rome ("Russell") formation to the Athens shale was, in the Bristol folio, thrown together as the Shenandoah limestone. Within this mass it is possible to discriminate: first, the *Honaker* limestone, or perhaps a new unit which will include the Honaker and the limestone equivalent of the Nolichucky shale; second, the Jonesboro limestone; third, the Nittany dolomite, overlain by a thin representative of the post-Nittany *Ceratopea* zone; fourth, the Mosheim limestone; and fifth, the Lenoir limestone.

Jonesboro limestone.—As I have already pointed out, the Jonesboro limestone may be in part a limestone facies of the Copper Ridge dolomite—that is a question that may be definitely decided in the future. Trilobites occur in the lower part of the Jonesboro and will afford an answer if ever found in a matrix from which they can be extracted. The facts next to be presented may have a bearing upon the formation of opinion in the matter.

On the northwest side of the Valley from Pennsylvania to Alabama, the Beekmantown formations (Canadian of Ulrich) are, with the exception of the Stonehenge and Axemann limestones in Pennsylvania, all dolomite. Along the southeast side of the Valley the corresponding formations are nearly all limestone. In Center County, Pennsylvania, the Beekmantown formations are 4000 feet thick, all dolomite except 650 feet of Stonehenge at bottom and 100 to 200 feet of Axemann limestone in the midst. In the Mercersburg-Chambersburg area, Pennsylvania, a belt which, across the strike, is 40 miles southeast of the Center County area, the Beekmantown is described by Stose as limestone. In Tuckaleeche Cove, on the extreme southeast side of the Appalachian Valley southeast of Knoxville, Tennessee, are deposits of Beekmantown age according to Ulrich, which, according to both Keith and Ulrich, are also limestone. The same is true in Alabama where, in Cahaba Valley, southeast of Birmingham and along that strike into Georgia, rocks of Beekmantown age are predominantly a very pure limestone above and include a large proportion of limestone in the lower 500 feet (the Longview limestone or *Lecanospira* zone). There seems thus to be a decided tendency for the Beekmantown rocks to consist of limestone to the southeast and dolomite to the northwest. It would be in accordance with this tendency for the Jonesboro limestone to be in part a southeastern facies of the Copper Ridge dolomite. On the other hand, the Jonesboro is a lithologic unit, the upper 500 feet of which at least seem to be clearly of Beekmantown age and Ulrich thinks it very probably is all Beekmantown.

Athens shale.—Another striking example of facies differences is found in the Athens shale. In the middle belts of the Valley from Lexington, Virginia, to Marion, Virginia, the Athens is composed largely of thin-bedded, dark limestone and of black shale in varying proportion. At Lexington practically the whole thickness is limestone, which has been named the Liberty Hall limestone. At Marion and in the vicinity of Wytheville there is an alternating succession of beds of shale and limestone. In great contrast with the limestone facies is a sandstone facies in the belts along the southeast side of the Valley in the Wytheville-Bristol region. The Athens here includes black shale several hundred or perhaps 1000 feet thick at bottom and an unknown but great thickness of thick-bedded, coarse-grained, loosely cemented, arkosic sandstone above. This sandstone facies extends to the top of the Athens throughout these southeastern belts, no younger beds being present. The total thickness of the sandstone and of the entire Athens in these belts is therefore unknown but, from the great width of the area, which southeast of Bristol is about five miles, and the steep dips, one gets the impression of a very great thickness—several thousand feet at least. The sandstone in the Athens has been mapped here as Tellico, but its Athens (Normanskill) age is proven by characteristic genera and species of graptolites occurring in the shale partings high up in the sandstone part of the formation.

An interesting fact is disclosed by the distribution of the sandstone and limestone facies of the Athens. A narrow syncline immediately southwest of Wytheville occupied by the sandstone facies, is exactly like the synclinal belts southeast of Bristol and Abingdon. Not a layer of limestone is present in a thickness of a thousand feet or more in this strip. On the other hand, at Marion, in a small fenster, 2 to 3 miles east of Wytheville, and in Crockett Cove about 4 miles north of Wytheville, the limestone facies of the Athens is well developed and contains not a layer of sandstone. This apparent anomaly, namely the presence of the sandstone facies of the Athens southwest of Wytheville lying directly in the strike between the limestone facies at Marion and that of the fenster 2 miles east of Wytheville, is explained by the fact that the elongated area west of Wytheville has been shoved several miles northwest from its position at the time of deposition by the movement on the great Pulaski fault. It belongs in the strike of the belts southeast of Bristol and Abingdon, while the areas of the limestone facies are in their normal places. They belong to the part of the crust beneath the Pulaski thrust that has not been displaced.

Lowville, Moccasin, and Bays formations.—The next example of facies difference is the Lowville-Moccasin-Bays unit. On the northwest side of the Valley from Pennsylvania to Alabama and west over the Nashville Basin, only the typical Lowville blue or dove limestone facies occurs. In places as along the northwestern slope of Wallen Ridge in southwestern Virginia, however, layers of greenish, argillaceous crumbling limestone or calcareous mudrock occur in the formation. This mudrock is lithologically identical with such rock in the Moccasin facies except that the latter is red. In the middle belts of the Valley in southwestern Virginia, as shown in sections 3, 4, and 5, Figure 1, and through Tennessee and northwestern Georgia to the northern part of Cahaba Valley, Alabama, the Lowville is represented by the Moccasin limestone, distinguished by the red shale, or mudrock, and the red argillaceous limestone, which make the bulk of the formation. In northwestern Georgia, as at Rocky Face, a few miles northwest of Dalton, a formation of red mudrock estimated to be as much as 1000 feet thick is believed to be the representative of Moccasin. In northeastern Alabama, in Colvin and Beaver Creek Mountains, between Calhoun and Etowah counties, and in St. Clair County, extending southwest to Odenville and in strike with the area at Rocky Face this lithology, although not so thick as at Rocky Face, is changed still more by the introduction of fossiliferous sandstone. In eastern Tennessee, along the southeastern side of the Valley, the beds of Lowville age also carry much sandstone as well as red shale and some limestone. This is the Bays facies, the formation in these southeastern belts being named the Bays sandstone. That these regional developments are but different expressions of contemporaneous deposition is proved by the all but universal occurrence of the Lowville guide fossils somewhere in the mass in all these areas except that at Rocky Face, where if present, they have not yet been discovered. In all areas of the Moccasin and Bays facies in Virginia, gray limestone in the lower part of the formation contains either *Tetradium cellulosum* or *Cryptophragmus antiquatus*, or both. In northeastern Alabama *Tetradium cellulosum* has been found in limestone at both top and bottom of the formation, and characteristic Lowville species of ostracods also occur. In contrast to the clastic or impure limestone (Moccasin or Bays) facies of the southeastern or middle belts, the Lowville of the northwestern side of the Valley is in large part very pure. Twenty-one samples from the quarries at Bellefonte, Center County, Pennsylvania, show an average content of about 97 per cent calcium carbonate, 1 per cent magnesium carbonate, and 2 per cent insoluble matter.

Like the Lowville, the next overlying limestone, of Trenton age, is, in the northwestern belts and in the Cincinnati and Nashville regions, a relatively pure limestone, easily enough recognized as a distinct group of minor units by its lithology and fossils. In the middle belts of the Valley, and in Pennsylvania also in the country to the southeast of the Valley proper, the Trenton, as determined by its fossils, is represented by the lower part of the Martinsburg shale, as shown in sections 3 to 5, Figure 1.

Formations of Richmond age.—If identifications of fossils and correlations of formations are correct, one of the most noteworthy examples of facies differences is found in the Medina group of the New York classification and its equivalents elsewhere. In Pennsylvania the Juniata formation is non-marine red shale and red sandstone. In southwestern Virginia it is red shale with layers of impure limestone carrying marine fossils, the Sequatchie formation. On the escarpment south of Lake Ontario its equivalent is the red Queenston shale. Going from Queenston through Ontario, Canada, to the northern end of Lake Huron and thence southward into southeastern Indiana, this non-marine red shale of Pennsylvania and New York can be traced step by step into the highly fossiliferous limestone of the Richmond group of southern Indiana and southwestern Ohio. From Indiana and southwestern Ohio, the Richmond, still fossiliferous, can be traced into northwestern Alabama and unmistakably identified in Sequatchie and Big Wills Valleys in Tennessee and Alabama, where, however, red color begins to appear in the argillaceous limestone. From Big Wills Valley it can be traced far into Tennessee and probably into southwestern Virginia where, as noted above, the unit is red shale with layers of impure limestone. The upper part of the old Medina group, now named Albion sandstone, so fully displayed in the Niagara gorge and containing in its lower part a few marine fossils, is almost certainly the same as the non-marine Tuscarora quartzite of Pennsylvania and the Clinch sandstone of Virginia. The stratigraphic position of the Albion, Tuscarora, and Clinch is identical—between the Queenston-Juniata-Sequatchie below and the Clinton above. Northwestward through Ontario the Albion, in part at least, is the same as the fossiliferous, partly limestone Cataract formation, and this in turn is correlated through its fossils with the fossiliferous marine Brassfield limestone of Ohio and Kentucky. The Brassfield through its fossils is identified by Ulrich with part of the iron ore-bearing Rockwood formation at Rockwood, Tennessee, and at Jasper, Sequatchie Valley, Tennessee, and with the part of the Red Mountain formation of Alabama below the "Big Seam" of iron ore. The part of the Red Mountain formation overlying and including the "Big Seam" is of Clinton age. At Cumberland Gap, Virginia-Tennessee, the Brassfield fauna is found in beds that are limy at the top and gritty at the bottom and which, like the Clinch sandstone of Virginia and the Tuscarora quartzite of Pennsylvania, lie between the Clinton above and the Sequatchie or Juniata below. There seems no considerable doubt that the Albion, Cataract, Brassfield, Clinch, and Tuscarora are all different facies and names for essentially one time unit.

Mississippian formation.—As a last example of facies change, I will mention that which takes place in the Mississippian formations of southwestern Virginia. At Cumberland Gap the Keokuk and St. Louis are very thinly represented and the intervening Warsaw is absent. All the other Mississippian formations at Cumberland Gap are relatively thin, aggregating barely 1000 feet. In the trough southeast of Clinch Mountain (Figure 1, section 3), the Keokuk is absent, but the Warsaw and St. Louis are well represented and the total thickness of the Mississippian is around 6000 feet. It is one of the thickest Mississippian sections known. Except for the Price and Pennington formations, which are clastic in both regions, there is a marked difference in composition of the formations in the two regions. The change in thickness and composition is particularly striking in the Ste. Genevieve and Gasper formations. At Cumberland Gap they are composed of thick-bedded oolitic limestone of high purity and their combined thickness is about 200 feet. Southeast of Clinch Mountain, on the other hand, these formations are predominantly highly argillaceous, thinly laminated limestone which weathers to a soft material much like a shale and their thickness is over 2300 feet as against 200 feet at Cumberland Gap. This difference is probably due to the proximity of the southeastern area to the sources of the clastic sediment which is mixed with the calcareous constituents of the formation.

Conclusions

The most important conclusion to be drawn from the distribution of the various formational units of the Appalachian Valley is that the Appalachian Geosyncline and a great area to the west were in a state of intermittent warping. At a given time one part was above water and another part below. At a later time the conditions were reversed. Sometimes, as in Nittany and Lowville times, submergence was certainly widespread if not universal; at other times, as in the time when the Tellico sandstone was laid down in the Knoxville region, emergence prevailed Through all of upper Chazy ("Blount"), time the distribution of formations and faunas indicate that the middle part of the Valley in the Virginia-Tennessee region, especially on the southeast side, was depressed while the north and south ends, and especially the northwest side, were elevated. This elevation also affected a great area extending far to the westward over the present sites of the Nashville and Cincinnati domes, where deposits equivalent to Ulrich's Blount group are unknown and where the Carters limestone, equivalent to the Lowville limestone, rests upon the Stones River limestone with so strong an appearance of conformity that Ulrich was for a long time puzzled as to their relations, in fact, until he had discovered the existence of the beds which he called the Blount group intervening in time between them and had established the Lowville age of the Carters through its fossils.

Contemporaneous local warping occurred and controlled the distribution of the members of the group itself. First the deposition of the Holston limestone extended westward for 10 miles or more beyond the northwest limit of the Athens shale. Emergence of the trough progressed, as proved by the restricted distribution of the Athens toward the northwest as compared with that of the Holston, though the apparent shrinkage was possibly of the nature of an uplift in the northwest and depression in the southeast side of the trough, causing a southeastward shift of the trough in Athens time. But emergence and shrinkage of the area of deposition continued some time, as attested by the small area of the Tellico as compared with that of the Athens or Holston. After Tellico time, however, a downward warping set in, as witnessed by the northwestward extension of the Ottosee limestone beyond the limits of the earlier Holston. This movement continued until in the succeeding Lowville-Moccasin-Bays time the entire geosyncline and the area westward beyond the present location of the Mississippi River, where the Lowville is represented in the Plattin limestone of Arkansas and Missouri, was submerged.

As to the matter of barriers—in only one case does a relatively narrow longitudinal barrier separating two troughs within the geosyncline seem to be needed to explain the facts. I refer to the apparently contemporaneous Lenoir limestone and the Ridley limestone of the Stones River group. In Alabama these two formations occur within less than 10 miles of each other across the strike. Both are fossiliferous, yet so far as known, there are no species, or at most only very few, in common and these were of cosmopolitan oceanic distribution.

The Lenoir fauna is of Atlantic origin and has closer affinity with the Ordovician faunas of Scotland and Scandinavia than with the fauna of the Ridley, 10 miles away, which on the other hand, carries a fauna of the interior Nashville basin. However, as there is a great overthrust between the two areas, the Lenoir was doubtless deposited at a distance from the Ridley greater than that by which they are now separated. At that, however, it is difficult to understand how animals with free swimming larvae and other means of distribution did not commingle if there were open water connections between the areas in which they lived or, in other words, if they had been deposited in the same sea.

Finally, it seems to me that these variations in stratigraphy, of which a few examples have been given, are a record of a constantly and gently oscillating crust or exterior shell of the earth which caused a continual shifting of the areas of land and sea within the Appalachian geosyncline throughout Paleozoic time. That the oscillations or pulsations were gentle is proved by the absence, throughout the entire Paleozoic sequence of the Appalachian Valley, of strong angular unconformities between deposits separated by long periods of time, the physical relations between such deposits, as revealed within the limits of actual exposures, very closely simulating continuity of deposition even where the breaks are greatest. See the photographs of Figure 2. As a matter of fact, it is only through tracing certainly identifiable formations over large areas and finding that they become separated by thick intervening deposits absent at the place of starting, or through the determination of the age of contiguous formations or contiguous parts of a seeming lithologic unit by means of fossils, that the existence of many great stratigraphic gaps or unconformities can be detected at all. The causes of the earth movements involved in these geologic phenomena are a fascinating and tantalizing subject of speculation but their investigation falls within the province of the geophysicists.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

394TH MEETING

The 394th regular meeting was held June 2, 1927, in Room 43 of the National Museum. In absence of the president, the corresponding secretary-treasurer presided. The entire evening was devoted to brief notes and exhibition of specimens.

Dr. T. E. SNYDER spoke of the genus *Coptotermes* which was established in 1896 by Wasmann, the oriental species *gastroi* Wasmann being the genotype. There are approximately 43 species, 21 oriental, 9 Australian, 9 Ethiopian, and 4 neo-tropical. The status of some of the species is as yet in doubt. The genus *Coptotermes* is in the family Rhinotermitidae, the intermediate family between the higher and lower termites. Most of these termites are subterranean in habit; a few of them make hard carton true nests, but most of them burrow in soil and wood with diffused nests. Soldiers of species of *Coptotermes* have a frontal gland which exudes an acidulous secretion coagulating and hardening in the air which is used as defense against ants. With this secretion it is possible to dissolve lime mortar in stone and brick foundations. The Japanese Government has prohibited the use of lime mortar in consequence. Species of *Coptotermes* attack buildings, bridges, telephone poles, and various growing crops. They are a serious enemy in rubber plantations. About 1913 a *Coptotermes*, at first supposed to be the Australian species *C. lacteus* Froggatt, was discovered on the Island of Oahu at Honolulu. In 1920 the Japanese entomologist, M. Oshima, described it as a new species, *C. introdens*, close to but distinct from *C. formosanus* Shiraki. In 1924 it was found on the Island of Hawaii at Hilo. In 1926 American entomologists decided that *intrudens* is a synonym of *formosanus* of southern Japan, Formosa and the south China coast. Another species of *Coptotermes*, a new species doing 95 per cent of the damage to buildings done in the Philippines, was intercepted in Hawaii and has not become established. Owing to the fact that *Coptotermes formosanus* has been found infesting floating dry docks, coal barges, and other vessels in the harbors of the Hawaiian Islands, it is quite possible that it may be introduced into continental United States, especially California. Every effort will be made by the Federal Horticultural Board, the State Board of Agriculture of California, and officials at Hawaii, to prevent this. The insect builds a concentrated nest, hence fumigation is an effective control measure. A photograph was shown of such a nest found in the hold of a floating dry dock from which nest earthlike shelter tubes went down on timbers below the water level, i.e., were submerged in salt water. This ability of the insect to live below the water line is a strong point in its life history.

Dr. SNYDER also discussed *Insect damage to yellow and white pine timbers in the roof of the White House.* During May 1927 an examination was made of the timbers from the roof of the White House which were being removed in repair work. The supporting timber trusses had been pulled out of place so that they no longer structurally served as trusses but carried the heavy load as beams. This caused the roof to sag to a dangerous degree. It was found that the white and yellow pine timbers had become infested by *Hexarthrum ulkei* Horn, one of the Cossind beetles in the family of weevils Curculionidae.

This insect is one of the so-called powder-post beetles which reduce the wood fiber to a powder-like condition. There are several earlier records of similar damage to the woodwork of buildings and flooring, caused by this insect, some of these records occurring in Washington, D. C. The ends of heavy timbers were badly weakened where they had been eaten by these insects—some were even broken off. The insect also invaded sound lathing attached to the infested timbers. There was no decay in some of the timbers infested by this beetle nor in the lathing. However, decay was present in the ends of some of the timbers supporting the roof of the tall portico in front of the White House. These powder-post beetles usually lay their eggs in joists or crevices of timber under conditions of darkness and poor ventilation. Impregnation treatments of timbers with zinc chloride would prevent such infestation and even coats of varnish would probably be effective. Frequent inspection of untreated timbers is advisable, especially in old buildings. Where timbers are not structurally weakened the insects infesting them can be killed by thoroughly saturating the wood with orthodichlorobenzene, applying the liquid with a saturated rag or mop, or as a spray. Several applications may be necessary to kill the insects. If this chemical is used as a spray it is advisable to open the building, as the odor of the chemical may prove disagreeable in a closed room. In spraying timbers overhead, care should be taken not to let the liquid drip down as it might slightly burn the face and hands and would be especially injurious to the eyes.

Dr. H. Morrison discussed briefly the Cockerell types of Coccidae in the U. S. National Museum. According to most recent lists there are now over 3000 described species of Coccidae, of which 512, or approximately one sixth, have been described by Dr. Cockerell. The National Collection of Coccidae, according to a preliminary check, contains types or co-types of all but 81 of the species described by Dr. Cockerell. Mr. Rohwer spoke briefly of Dr. Cockerell's 19-month fossil collecting trip now in progress.

Dr. Morrison also reported arrival of two shipments of scale insects sent for identification over a year ago by Mr. Kincaid from Seattle, Washington. These proved to be *Lecanium coryli* (Linn.), a species reported once from Nova Scotia many years ago, though there is no certainty that the identification was correct. It was introduced some 15 years ago into British Columbia and has recently attained importance as a pest of shade trees. It is a general feeder on shade, ornamental and rosaceous fruit trees, and occurs in considerable numbers in Stanley Park, Vancouver, and in Seattle and adjacent territory. Some efforts have been made to obtain an appropriation from Congress for work on it. Material was exhibited by Dr. Morrison.

Dr. Schauss reported the recent gift by Jordan of a paratype of *Sthenauge parasitus* Jord. He discussed briefly its larval habits, especially its rather curious feeding habits. He also read a paragraph from Novitates Zoologicae (vol. 33, 1926) containing additional very interesting information regarding it.

Mr. Barber exhibited local forms of Lampyridae and spoke of the contrast between "species" as they have been recognized by taxonomic study and "species" as they occur in nature. He thinks of a species as a living population, reproducing its kind, but isolated from other species by specialized habits or adaptations. These may be evident in distinctive mating instincts, in peculiar ecological habitat, in time of appearance, etc., as well as (more fortunately from our standpoint) in differences in structure. The Lampyridae differ from their near relatives the Lycidae and the Cantharidae (Telephoridae) in the almost universal persistence of the photogenic function which so far as known remains in the larval stages of even those forms whose adults have lost their lights by becoming diurnal in their activities. Those retaining their crepuscular or nocturnal flight period have modified the photogenic organs for use in courtship signals, and the light emissions have become so distinctive in species maturing concurrently as to constitute a barrier against hybridization. About 30 species have been found in the vicinity of Washington but the taxonomy of the group is so confused that but few can be identified. The differential characters are usually not recorded in descriptions, most of the types are inaccessible, the recorded synonymy is based almost entirely on opinions formed from superficial resemblances of poorly preserved and unauthentic samples. Of the 69 species of the family listed from the United States in the Leng Catalogue about 14 appear to be known from the vicinity of Washington but this number will rise to more than the 30 species thus far encountered when the incorrectly suppressed species, and the new forms are untangled and elucidated.

Mr. Barber cited *Phanaeus carnifex* as an example of specific misidentification which has been so consistently overlooked that almost 170 years have passed without a single correct application of this name to the species described in Linnaeus' 10th edition. He exhibited specimens of the three well-known species confused by Linnaeus under the name *Scarabaeus carnifex* and showed that the original description was probably not based upon specimens but upon two figures. One of the latter is the Jamaican species well known as *sulcatus* Drury 1770, the other became *Scarabaeus festivus* Linn. 1767. On the latter date Linnaeus applied the name *carnifex* to our well-known tumblebug of the Atlantic Coast. The three species involved being merely collectors' prizes, the name not as yet entering economic, medical, or popular literature, the case seems one for simple adjustment in conformity with nomenclatorial rules rather than for recourse to the International Commission on Zoological Nomenclature which has plenary power and might set the rules aside to validate the established usage in this case. Thus *carnifex* Linn. 1758 would suppress *sulcatus* Drury 1770 (a coal-black species from Jamaica), *carnifex* Linn. 1767 (being a homonym) would be rejected in the synonymy of the next available name, and our brilliant Carolinian species would be known henceforth as *vindex* Macleay 1819, while the glorious red Venezuelan *Oxysternon festivum* (Linn. 1767) remains unchanged.

C. T. Greene spoke of two species of Diptera which were external parasites on aquatic hosts. He exhibited two pamphlets as follows: (1) "The Larva of a Chironomid (*Trissocladius equitans* n. sp.) which is parasitic upon a May-fly Nymph (*Rithrogena* sp.)" by P. W. Claassen. The larval and pupal stages of this fly are passed under the wingpads of the host. (2) "Le Cycle Évolutif de *Dactylocladius commensalis* sp. nov. Chironomide à larve commensale d'une larve de Blepharoceride (Diptera)" by A. Tonnoi. This larval parasite lives on the under side of the Blepharocerid larva passing both the larval and pupal stage there.

Dr. Mann narrated an incident of one of his collecting trips some time ago in Honduras in which his curiosity had been considerably aroused by rumours of a mysterious tree called by the natives the "rain-tree," and which he supposed would prove to be one bearing some form of Cercopid drip. When at last he had opportunity, however, to examine the tree he found that there indeed came from it tiny spurts of water as reported, but instead of Cercopids being the cause of this he found the trouble was caused by an infestation in considerable numbers by a large species of *Cicada*, specimens of which he duly collected for the National Museum.

Dr. G. F. White reported briefly on studies he is making on a protozoan (*sporozoan*) and a bacterial disease of the Mediterranean flour moth (*Ephestia Kuehniella* Zeller). The protozoan disease is particularly infectious in cultures of this insect and has proven to be a very troublesome factor to different workers using this species in their studies. Infection takes place through the food ingested. Death may occur at any stage of the insect following infection. The disease is not limited to *Ephestia*. A bacterial disease of this species was first described in Germany and its causal organism determined and named. This infection has been encountered in cultures of the insect in Washington. Death takes place during the larval stage, the mortality sometimes reaching 100 per cent. The possible use of these maladies in the control of this insect pest was suggested. A further discussion of these diseases will be given at a later time.

Mr. Rohwer called attention to a circular letter which was being distributed by Dr. C. W. Stiles asking for the opinion of American zoologists regarding the objections of Dr. Franz Poche, of Vienna, to certain rules and procedures of the Commission on Zoological Nomenclature. Dr. Poche has circulated a letter requesting zoologists to petition the Commission to make certain radical changes in the Code, and also to make a radical change in the method of handling matters of nomenclature. These circular letters by Dr. Poche have received the approval of a great many zoologists, but some of them have probably not had sufficient opportunity to study the question from all angles. Hence Dr. Stiles has felt it desirable to bring the matter to the attention of the American zoologists. In discussing Dr. Stiles' circular letter, Mr. Rohwer touched briefly on two of Dr. Poche's propositions. The first proposes that problems of nomenclature be brought before the General Congress for discussion by a majority vote of members of the Commission instead of by a unanimous vote. He stated that this would not be fair to the countries which have only one representative on the Commission, as sometimes this representative cannot be reached promptly and a matter might be presented to the General Congress without his having even considered it. Another objection to the majority vote is that the attendance at the meetings of the General Congress is always predominantly from the country in which the meetings are held; therefore if a proposition should be presented without the unanimous approval of the Commission, it is fairly certain that the ideas of the country in which the meetings are being held would prevail. This is obviously unfair to the other countries, and would destroy the international unity which now prevails in settling nomenclatural problems. The second proposition of Poche discussed by Mr. Rohwer deals with the reversion to the principle of elimination in fixing genotypes. Mr. Rohwer pointed out that a controversy had taken place a number of years ago between the school which advocated the fixation of types by the elimination principle and those who wished to adopt the first species rule. A compromise was reached in which both methods were adopted, and in addition the principle of priority was introduced and certain machinery for the selection of genotypes was set up by the International Commission in Article 30. The adoption of Poche's proposition of fixing genotypes only by the method of elimination would break faith with those people who agreed to the compromise which was reached in 1907, and would create chaos, inasmuch as it would set aside many designations which have been made on the recommendations of Article 30.

Mr. ROHWER stated that the Committee on Nomenclature of the Society had already replied to Dr. Stiles' circular, and as individuals had opposed all of the propositions advanced by Dr. Poche. He urged each member of the Society to study the matter carefully and to sign the circular submitted by Dr. STILES so that he could have a complete record of the opinions of American biologists.

395TH MEETING

The 395th regular meeting was held October 6, 1927, in Room 43 of the National Museum. President J. A. HYSLOP presided.

In commenting on the minutes of the previous meeting, Dr. HOWARD stated that he had recently met in Prague a Mr. C. Blattney who informed him that *Lecanium coryli* (Linn.) and *L. cornei* were very heavily parasitized there, and that he would be glad to furnish us with material if needed here.

The Corresponding Secretary-Treasurer read a letter from the Honorary President, Dr. E. A. SCHWARZ, presenting to him for the society one thousand dollars in securities of the American Building Association of this city, the income of which is to be used year by year to augment the printing fund. An enthusiastic and unanimous vote of thanks was tendered to Dr. SCHWARZ for this gift, the characteristic generosity and thoughtfulness of which are very deeply appreciated by every member.

Dr. S. B. FRACKER, formerly of Madison, Wisconsin, now of this city, was elected to membership. Upon request, Dr. FRACKER made a few remarks and discussed briefly the lack of opportunity for research in administrative work.

Greetings and felicitations were extended to Dr. HOWARD upon his safe return from Europe. He will discuss his recent trip in some detail at a later meeting.

Mr. GREEN reported the death of Mr. H. S. HARBECK at Philadelphia, October 2. Mr. HARBECK's interest had been in collecting Diptera.

Program: F. L. CAMPBELL: *The toxicology of arsenic as an insecticide.* Methods and apparatus for the determination of acute and chronic minimum lethal doses of arsenic for individual insects were described. The M. L. D. of arsenic for insects from the data now available appears to range from 0.003 to 0.03 mg. of arsenic per gram of insect, the dose varying with the species of insect, its age, and the compound of arsenic employed. The M. L. D. of arsenic for insects and mammals is of the same order of magnitude.

Discussed by McINDOO, HOWARD, RICHARDSON and BRIDWELL.

Dr. W. H. LARRIMER: *Results of the ten-million-dollar European corn borer campaign.* A summary of the results of the campaign and opinions thereon were given under three subdivisions: (1) *United States Department of Agriculture:* Surveys of 743 townships in the heavily-infested states indicate that the ten-million-dollar spring campaign against the European corn borer has retarded the insect's rate of increase. Census of the borer population, as determined by actual count in the field during the past two months in Michigan, Ohio, New York, and Pennsylvania, shows that there is now an average of fourteen borers per one hundred stalks in the campaign area, as compared with an average of nine borers per one hundred stalks last year. In 1925 the borer population in the area was two borers per one hundred stalks. Though this means an increase of fifty percent in borer population this year, it compares favorably with the increase of over three hundred percent in borer population registered in 1926 when there was no control campaign. Had there been no campaign this spring, judging by the increase in 1926, we might now find about thirty-two instead of fourteen borers per one hundred stalks. The increase from nine to fourteen borers per one hundred stalks came this year despite a clean-up that destroyed ninety-five percent of the borers. Five borers left of an original population of one hundred will produce on an average one hundred fifty mature borers. The clean-up this spring was even more effective than the Department had expected. (2) *Executive Committee of the International Corn Borer Organization:* After due consideration of the data presented, and after observing conditions, it is the judgment of the Committee that the campaign has been successful as far as humanly possible. (3) *Joint Committee of the American Association of Economic Entomologists, the American Society of Agronomy, and the American Society of Agricultural Engineers:* The committee of entomologists, agronomists, and agricultural engineers cooperating, endorse the efforts to control the corn borer and commend those engaged in directing the research, regulatory and extension activities designed for its control. Especial commendation is given to the multitude of farmers who cooperated in the clean-up campaign. It is believed that the compulsory clean-up of 1927 not only greatly reduced the rate of infestation increase, but has been successful in preventing serious commercial losses, and that the expenditure of large funds for this purpose has been completely justified.

Discussed by WEBB, MCINDOO, HOWARD, HYSLOP, BISHOP and MORRISON.

Mr. ROHWER discussed the recent generous gift by will of the late Dr. C. F. BAKER to the U. S. National Museum of his insect collection, and of Mr. CUSHMAN's trip to the Philippines to procure it. He gave a brief outline of Dr. BAKER's career, and spoke appreciatively of his arduous labors in the advancement of entomology. This gift is a very notable addition to our national collection, and doubtless will be worked over by investigators for many years to come. A committee, consisting of HOWARD, GRAF and ROHWER, was appointed to draw up appropriate notice of Dr. BAKER's death.

396TH MEETING

The 396th regular meeting was held November 3, 1927, in Room 43 of the National Museum. President J. A. HYSLOP presided.

Dr. F. L. CAMPBELL, Mr. H. H. SHEPARD and Mr. R. S. FILMER were elected to membership.

Resolutions regarding the death of Dr. C. F. BAKER were read by Dr. HOWARD, and incorporated into the minutes as follows: "The Entomological Society of Washington, by formal and unanimous action, not only expresses its great sorrow on learning of the death of its long-time member, CARL F. BAKER, but here records its very high esteem for the man and its admiration of the very wonderful work that he accomplished in his comparatively short life. The Society considers that his life efforts to increase our knowledge of insects have been of the very greatest importance to science, and believes that his achievements are almost unparalleled in the history of entomology. The Society is deeply gratified to know that Dean Baker held Washington entomologists in such high esteem that in his will he arranged to have his extraordinary collections in entomology brought to Washington and deposited in the U. S. National Museum." It was recommended that copies of this minute be sent to the family of Dean BAKER.

Dr. STANISLOW MINKIEWICZ of Pulawy, Poland, gave a brief summary of his tour the past summer over various parts of the United States and Canada. During this trip he was able to visit and review entomological work at Ithaca and Geneva, New York; portions of Canada and Nova Scotia; Melrose Highlands and Arlington, Massachusetts; Riverton, New Jersey; Columbus and Wooster, Ohio; West Lafayette, Indiana; Urbana, Illinois; Manhattan, Kansas; Salt Lake City, Utah; various places in central and southern California; Portland, Oregon; Seattle, Washington; Vancouver, British Columbia; Madison, Wisconsin; and East Lansing, Michigan. He also touched briefly on some of the agricultural and entomological problems in Europe, and contrasted conditions there with those in this country, dwelling especially on the lack of parasites here for control of the imported injurious insects. He expressed his thanks to Washington entomologists for courtesies extended to him.

Dr. H. T. FERNALD, Massachusetts Agricultural College, Amherst, Mass., discussed the value of professional contacts offered by the entomological organization in Washington and deplored the comparative isolation in which many entomologists like himself were obliged to work.

Prof. R. A. COOLEY, Agricultural Experiment Station, Bozeman, Montana, discussed a parasite (*Ixodiphagus texanus* Howard) of the spotted-fever tick.

Dr. C. F. DOUCETTE, of Santa Cruz, California, described some recent bulb work on the West Coast.

Mr. C. H. HADLEY, of Toledo, Ohio, and Dr. F. W. Poos, of the Norfolk (Va.) Truck Experiment Station, also spoke briefly.

The first address on the regular program was given by Dr. HOWARD, who, with the help of lantern slides, told about some of the entomological highlights of his summer in Europe. During the trip he visited England, France, Germany, Poland, Czechoslovakia, Austria, Hungary and Jugoslavia. He showed portraits of a number of entomologists known to the members of the Society by reputation but who never have been in this country. Excellent work is being done at the newly instituted parasite laboratory of the Imperial Bureau of Entomology at Farnham Royal, England, by S. A. Neave, J. F. Myers and R. Stenton, and also at the Biologischen Reichs-Anstalt, in Berlin, under Dr. A. Haase. Active work is being carried on in Poland and Czechoslovakia. An exact description of the entomological material which has been brought together in great quantity by Dr. J. Obenberger in the National Museum at Prague since the conclusion of the great war had been placed in Mr. Rohwer's hands by the speaker. Two young Russian refugees, S. Novicki at Skierniewice, Poland, and L. Oglobin at the Prague Museum, are intensely interested in the parasitic Hymenoptera. A brief account of the Tenth International Zoological Congress at Budapest the first week in September was given, illustrated by portraits of most of the entomologists in attendance, including especially striking pictures of Dr. S. Bodenheimer of Palestine and Dr. L. Biro of Budapest.

Dr. E. A. BACK: *Some facts regarding moth proofing solutions.* The speaker renewed the investigations to date, and by means of lantern slides and actual samples of injured materials brought out details of much interest. Tests made in the Bureau of Entomology indicate that no solution now on the market will permanently and absolutely protect fabrics from attack by fabric pests, though it appears to be true that the better solutions when applied properly do impart a protection that is worth considering. Solutions that impart a real degree of resistance to moth attack when properly applied have been found to be worthless when merely sprayed over the fabric in a casual manner. It is believed that the present use of so-called moth proofing solutions by certain fabric manufacturers will either automatically stop moth damage or will force the manufacturers of the solutions to withdraw their extravagantly worded advertisements.

Discussed by SIEGLER and GRAF.

J. S. WADE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. ROBERT B. SOSMAN has resigned from the Geophysical Laboratory, Carnegie Institution of Washington, to join the staff of the newly established Department of Research and Technology of the U. S. Steel Corporation, with headquarters at the plant of the Federal Shipbuilding and Dry Dock Co., Kearny, New Jersey.

WILLIAM R. MAXON Associate Curator, Division of Plants, National Museum, left for Europe on July 4, to study the fern collections of several of the larger European herbaria. Mr. Maxon's principal investigations will be carried on at the British Museum and at the Royal Botanic Gardens, Kew, in connection with the preparation of the fern volume of the Flora of Jamaica, a work now in course of publication by the British Museum. From England Mr. Maxon expects to go to Stockholm, Copenhagen, Berlin, and Paris, and will return to Washington in October.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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MATHEMATICS.—*On Fermat's Last Theorem.*[1] VAL. MAR. SPUNAR, Chicago, Ill. (Communicated by PAUL R. HEYL.[2])

It is well known that the equation

$$x^n + y^n = z^n \quad \ldots\ldots\ldots\ldots (1)$$

n being any positive integer, cannot be solved in integers if n be a multiple of 4. If, therefore the equation (1) has integral solutions for any n this exponent must contain an odd prime, say λ, where $\lambda \geq 3$. If then the equation (1) has an integral solution (x, y, z) the equation

$$x^\lambda + y^\lambda = z^\lambda \quad \ldots\ldots\ldots\ldots (2)$$

will have the solution (x^m, y^m, z^m) where $m = n/\lambda$.

If the equation (2) has a solution, it evidently has one in which x, y, z are relatively prime. We shall suppose that one of these solutions is that we are considering: Then, since

[1] Received May 10, 1928.

[2] *Note.*—In the Mathematical Gazette for October, 1923, the undersigned showed that in Fermat's equation (2), for a given value of z, there is a critical value of the exponent λ above which no integral solution is possible. But since this critical value of λ is an increasing function of z, this result leads to no general proof of Fermat's Theorem. In the following article Mr. Spunar shows that no integral solution of Fermat's equation is possible unless z is greater than a certain function of λ, or conversely unless λ is less than a critical value, which is also an increasing function of z. Mr. Spunar's critical limit is far more stringent than that of the writer, and is thus a contribution to the literature of this subject along an almost unworked line.—*P. R. Heyl.*

$$\frac{z^\lambda - y^\lambda}{z - y} = z^{\lambda-1} + yz^{\lambda-2} + \ldots\ldots + y^{\lambda-2}z + y^{\lambda-1}$$

$$= y^{\lambda-1}\left[1 + \frac{z}{y} + \frac{z^2}{y^2} + \ldots\ldots + \frac{z^{\lambda-1}}{y^{\lambda-1}}\right]$$

$$= y^{\lambda-1}\left[1 + 1 + \frac{z-y}{y} + 1 + \frac{z^2-y^2}{y^2} + \ldots\ldots + 1 + \frac{z^{\lambda-1} - y^{\lambda-1}}{y^{\lambda-1}}\right]$$

$$= y^{\lambda-1}\left[\lambda + \frac{z-y}{y} + \frac{z^2-y^2}{y^2} + \ldots\ldots + \frac{z^{\lambda-1} - y^{\lambda-1}}{y^{\lambda-1}}\right]$$

$$= \lambda y^{\lambda-1} + (z-y)y^{\lambda-2} + (z^2-y^2)y^{\lambda-3} + \ldots\ldots + (z^{\lambda-1} - y^{\lambda-1})$$

$$= \lambda y^{\lambda-1} + (z-y)\,U$$

$$= I$$

where U is an integral function of y and z, I and $z - y$ can have no common factor except λ. If then

$$x^\lambda = z^\lambda - y^\lambda = (z-y)\,I$$

any factor of $z - y$ other than λ must divide x^λ, and there must be λ such factors if there is one; whence it follows that $z - y$ is a perfect λth power, unless $z - y \equiv 0 \pmod{\lambda}$.

If then (still excluding the λ factor), $z - y = \alpha^\lambda$ it follows that $x = \alpha\,\xi$.

Since the same reasoning applies whether x, y, or z be taken, we may set

$$x = \alpha\xi \quad \alpha^\lambda = z - y \quad \xi^\lambda = \frac{z^\lambda - y^\lambda}{z - y} \ldots\ldots\ldots\ldots (3)$$

$$y = \beta\eta \quad \beta^\lambda = z - x \quad \eta^\lambda = \frac{z^\lambda - x^\lambda}{z - y} \ldots\ldots\ldots\ldots (4)$$

$$z = \gamma\zeta \quad \gamma^\lambda = x + y \quad \zeta^\lambda = \frac{x^\lambda + y^\lambda}{x + y} \ldots\ldots\ldots\ldots (5)$$

where α, β, γ, ξ, η, ζ, and λ are all relative primes.

It follows, then, that

$$2z = \gamma^{\lambda} + \beta^{\lambda} + \alpha^{\lambda} \quad \text{(6)}$$

$$2y = \gamma^{\lambda} + \beta^{\lambda} - \alpha^{\lambda} \quad \text{(7)}$$

$$2x = \gamma^{\lambda} - \beta^{\lambda} + \alpha^{\lambda} \quad \text{(8)}$$

$$2d = \gamma^{\lambda} - \beta^{\lambda} - \alpha^{\lambda} \quad \text{(9)}$$

where

$$d = x + y - z = \alpha(\xi - \alpha^{\lambda-1}) = \beta(\eta - \beta^{\lambda-1}) = \gamma(\gamma^{\lambda-1} - z). \quad (9\ bis)$$

and

$$d = \alpha\beta\gamma\Delta \quad \text{(10)}$$

Since

$$\xi^{\lambda} = \frac{(z - y + y)^{\lambda} - y^{\lambda}}{z - y} = (z - y)^{\lambda-1} + \lambda P$$

where P is an integer, and by Fermat's minor theorem

$$(z - y)^{\lambda-1} \equiv 1 \pmod{\lambda}$$

it follows that

$$\xi^{\lambda} \equiv 1 \pmod{\lambda}$$

Moreover, $(h\lambda + 1)^{\lambda-1} \equiv 1 \pmod{\lambda^2}$ by Fürtwangler's theorem. Multiply both members by $h\lambda + 1$ and apply $(h\lambda + 1)^{\lambda} \equiv 1 \pmod{\lambda^2}$ and we find that $h \equiv 0 \pmod{\lambda}$ and $\xi = h_1\lambda^2 + 1$.

Similar results can be found for η and ζ. Hence:

$$\xi = 2h_1\lambda^2 + 1 \quad \text{(11)}$$

$$\eta = 2h_2\lambda^2 + 1 \quad \text{(12)}$$

$$\zeta = 2h_3\lambda^2 + 1 \quad \text{(13)}$$

Substituting these values of ξ, η, and ζ in equation (2) and developing by the binomial theorem, we obtain:

$$\gamma^{\lambda} - \alpha^{\lambda} - \beta^{\lambda} \equiv 0 \pmod{\lambda^3} \quad \text{(14)}$$

and by (9), (10), and (14)

$$d = \alpha \beta \gamma M \lambda^{3+e} \qquad \text{(15)}$$

where α, β, γ, M and λ are relatively prime.

Employing equation (2) in the form

$$(z - y)\left(\frac{z^\lambda - y^\lambda}{z - y}\right) + (z - x)\left(\frac{z^\lambda - x^\lambda}{z - x}\right) = (x + y)\left(\frac{x^\lambda + y^\lambda}{x + y}\right) \qquad \text{(2 bis)}$$

and applying (3), (4), (5), (11), (12), (13), we obtain

$$(z - y)\,(2\,h_1\,\lambda^2 + 1)^\lambda + (z - x)\,(2\,h_2\,\lambda^2 + 1)^\lambda = (x + y)\,(2\,h_3\,\lambda^2 + 1)^\lambda$$

Expanding and reducing, we have

$$(z - y) + (z - x) \equiv (x + y) \pmod{\lambda^3}$$

or

$$\alpha^\lambda + \beta^\lambda \equiv \gamma^\lambda \pmod{\lambda^3}$$

Therefore

$$x + y \equiv z \pmod{\lambda^3} \qquad \text{(I)}$$

Employing (3) in the form

$$x^\lambda = (z - y)\,\xi^\lambda = (z - y)\,(2\,h_1\,\lambda^2 + 1)^\lambda$$

$$\equiv (z - y) \pmod{\lambda^3} \qquad \text{(II)}$$

and subtracting (II) from (I) we get $x^\lambda \equiv x \pmod{\lambda^3}$. Doing similarly for y and z, we obtain

$$x^{\lambda - 1} \equiv y^{\lambda - 1} \equiv z^{\lambda - 1} \equiv 1 \pmod{\lambda^3} \qquad \text{(16)}$$

$$\alpha^{\lambda - 1} \equiv \beta^{\lambda - 1} \equiv \gamma^{\lambda - 1} \equiv 1 \pmod{\lambda^2} \qquad \text{(17)}$$

Again, substituting the values of ξ, η and ζ from (11), (12), and (13) into (9 *bis*), viz.,

$$x + y = z + d \qquad \text{(18)}$$

we obtain, after an easy reduction

$$\gamma = \alpha + \beta \pm 2\,\lambda^2\left(h_1\,\alpha + h_2\,\beta - h_3\,\gamma - \frac{\alpha\,\beta\,\gamma\,\Delta\,\lambda^{1+e}}{2}\right) \qquad \text{(19)}$$

whence $\alpha + \beta = \gamma \pm \delta$, where δ is any positive integer greater than zero; for if $\delta = 0$, then, by (19), $\gamma = \alpha + \beta$. Equations (6), (7), and (8) give

$$2\alpha\xi = (\alpha+\beta)^{\lambda} - \beta^{\lambda} + \alpha^{\lambda} = 2\alpha^{\lambda} + \lambda\alpha^{\lambda-1}\beta + \ldots + \lambda\alpha\beta^{\lambda-1} \ldots (20)$$

$$2\beta\eta = (\alpha+\beta)^{\lambda} + \beta^{\lambda} - \alpha^{\lambda} = 2\beta^{\lambda} + \lambda\alpha\beta^{\lambda-1} + \ldots + \lambda\alpha^{\lambda-1}\beta \ldots (21)$$

$$2\gamma\zeta = (\alpha+\beta)^{\lambda} + \beta^{\lambda} + \alpha^{\lambda} = 2(\alpha+\beta)^{\lambda} - \lambda\beta(\alpha+\beta)^{\lambda-1} + \ldots + \lambda(\alpha+\beta)\beta^{\lambda-1} \ldots (22)$$

whence

$$\xi = A + \frac{\lambda\beta^{\lambda-1}}{2}, \; \alpha \textit{ even} \ldots (20 \textit{ bis})$$

$$\eta = B + \frac{\lambda\alpha^{\lambda-1}}{2}, \; \beta \textit{ even} \ldots (21 \textit{ bis})$$

$$\zeta = C + \frac{\lambda\beta^{\lambda-1}}{2}, \; \gamma = \alpha + \beta \textit{ even} \ldots (22 \textit{ bis})$$

where A, B, and C are any integers whatsoever. This is, however, contrary to the hypothesis.

If we suppose

$$\alpha + \beta = \gamma + \delta \ldots (23)$$

then, obviously, we have

$$\delta < \alpha < \beta < \gamma \ldots (24)$$

If, however, we assume

$$\alpha + \beta + \delta = \gamma \ldots (25)$$

then it is easy to show that (24) holds good here also. For this purpose we add the following two series of inequalities where $x < y < z$:

$$1 > \frac{x}{z} > \left(\frac{x}{z}\right)^2 > \ldots > \left(\frac{x}{z}\right)^{\lambda-1} > \left(\frac{x}{z}\right)^{\lambda} > \left(\frac{x}{z}\right)^{\lambda+1} > \ldots > 0 \; (26)$$

$$1 > \frac{y}{z} > \left(\frac{y}{z}\right)^2 > \ldots > \left(\frac{y}{z}\right)^{\lambda-1} > \left(\frac{y}{z}\right)^{\lambda} > \left(\frac{y}{z}\right)^{\lambda+1} > \ldots > 0 \; (27)$$

Therefore

$$2 > \frac{x + y}{z} > \frac{x^2 + y^2}{z^2} > \dots . > \frac{x^{\lambda - 1} + y^{\lambda - 1}}{z^{\lambda - 1}}$$

$$> 1 > \frac{x^{\lambda + 1} + y^{\lambda + 1}}{z^{\lambda + 1}} > \dots > 0 \qquad (28)$$

Hence

$$z^{\lambda - 1} < x^{\lambda - 1} + y^{\lambda - 1} \qquad (29)$$

By (3_3) and the last equation

$$\xi^{\lambda} < \lambda\, z^{\lambda - 1} < \lambda\, (x^{\lambda - 1} + y^{\lambda - 1}) \qquad (30)$$

Hence

$$\xi < \lambda\, (\alpha^{\lambda - 1} + \beta^{\lambda - 1} H^{\lambda - 1}) \qquad (31)$$

where $H = n/\xi$. Thus

$$x < \lambda\, \alpha^{\lambda} + \lambda\, \alpha\, \beta^{\lambda - 1} H^{\lambda - 1}$$

$$\alpha^{\lambda} + d < \lambda\, \alpha^{\lambda} + \lambda\, \alpha\, \beta^{\lambda - 1} H^{\lambda - 1}$$

or

$$d < (\lambda - 1)\, \alpha^{\lambda} + \lambda\, \alpha\, \beta^{\lambda - 1} H^{\lambda - 1} \qquad (32)$$

Therefore

$$\gamma^{\lambda} - \alpha^{\lambda} - \beta^{\lambda} = 2\, d < 2\, (\lambda - 1)\, \alpha^{\lambda} + 2\, \lambda\, \alpha\, \beta^{\lambda - 1} H^{\lambda - 1}$$

Substituting for γ its value from (25), and developing it by the binomial theorem and reducing, we obtain

$$\lambda\, \beta^{\lambda - 1} (\alpha + \delta) + \binom{\lambda}{2} \beta^{\lambda - 2} (\alpha + \delta)^2 + \dots . < 2\, \lambda\, \alpha\, \beta^{\lambda - 1} H^{\lambda - 1}$$

$$\alpha + \delta < 2\, \alpha\, H^{\lambda - 1} < 2\, \alpha$$

Therefore, as $\xi < \eta < \zeta$ by (3_3), (4_3), and (5_3), and the general assumptions $x < y < z$, $H < 1$,

$$\delta < \alpha \qquad (24)$$

We remember here that $\delta \equiv 0 \pmod{\lambda^2}$ from (19), and note that from (3_3)

$$\lambda x^{\lambda-1} < \lambda y^{\lambda-1} < \xi^{\lambda}$$

Therefore

$$\lambda \alpha^{\lambda} < x \quad \text{(25)}$$

By (19) we see that δ always contains the factors 2 and λ^2. Hence by (24) and (25),

$$2^{\lambda} \lambda^{2\lambda+1} < \lambda \delta^{\lambda} < \lambda \alpha^{\lambda} < x < y < z \quad \text{(26)}$$

[*Note.*—Mr. Spunar furnishes also a proof that δ always contains in addition the factor 3, which gives the still more stringent condition

$$6^{\lambda} \lambda^{2\lambda+1} < x < y < z$$

The proof of this is rather too long to be added here, but the fact is worthy of mention.—*P. R. Heyl.*]

In conclusion, I wish to give my best thanks to Dr. Paul R. Heyl for the great interest he has taken in preparing my paper for publication.

ETHNOLOGY.—*Some results of the study of American Indian music.*[1] FRANCES DENSMORE, Bureau of American Ethnology, Smithsonian Institution.

First of all, let me express my high appreciation of the honor of the invitation from M. Const. Maltezos, asking that I send him a note upon my study of Indian music, for transmission to the Academy of Athens. I am aware of M. Maltezos' deep and extended research in the music of ancient peoples, in both the old and new worlds. To that research he has brought the scholarly attainments of the physicist. My own work is done from the standpoint of a musician and an observer of human nature. Music is essentially a vital and human expression, especially in a primitive race like the American Indian. It has been said that "the North American Indians give us a fuller knowledge than any other existing race affords of the manner of

[1] Paper prepared by request and submitted at the sitting of the Academy of Athens, Greece, on March 22, 1928. The paper was translated by Professor Const. Maltezos and is being published by the Academy of Athens. Received May 4, 1928.

working of the primitive creative mind." The study of Indian music has, therefore, a relation to the general subject of primitive music in all races.

The Indians living in North America did not share the high development of those living in Central America and in certain parts of South America. There are no records in stone to tell us of their early art. The minds of the old men were the repositories of the wisdom and experience of the tribe, and it was the duty of the old men to transmit this orally to the next generation, each man instructing his oldest son. In development of memory the Indian excelled, but in logic and deductions from facts he did not excel. His culture and mental habit were not such as to produce a musical system comparable, for example, to that of the Hindu or the Chinese. The Indians are not a homogeneous people or nation but consist of many tribes which differ in language and important customs.

The following incident shows the manner of reasoning by a Sioux Indian who was highly respected among his people. He found a globular stone on top of a hill, similar to stones that were abundant in a river not far distant. On being asked how he explained the peculiar shape of the stone he said it had become globular by looking at the sun since "things that look at each other for a long time will come to have a resemblance." He carried this stone on his person and attributed the good health of himself and his family to its presence. In order to stimulate the supposedly magic power of the stone he sang a song, according to an Indian custom which will be described in this paper.

Agassiz, the great naturalist, said that "the function of science is to strive to interpret what actually exists." In the study of Indian music the facts are the vocal sounds produced by the Indians and recorded by means of the phonograph. The interpretation must concern itself with the life and customs of the Indian, and with his mental attitude. If we were to try to understand Indian songs without taking all these into consideration we would become involved in a maze of speculation. Although we admit the kinship of all humanity, the Indian belongs to a different race from our own. His habit of thought and his standard of beauty are not like ours, and even more different is his idea of the function of music in his daily life. Music, to the American Indian, was not primarily an art to be cultivated for pleasure. It was part of the means by which he exercised magic, and it lay, in part, in the field of religion.

In the oldest times of which we have any knowledge, the Indians believed that songs were received in dreams, and this continues to the present time among many old Indians. The "dream" of the Indian is a trance-like condition induced by abstinence from food and intense concentration of the mind. While in this condition the Indian imagines himself visited by a supernatural being which promises its aid in any difficulties that may befall him. The mysterious visitant usually sings a song which the dreamer learns and is told to sing when asking for the promised aid. On awaking, he remembers the song and it becomes his most valued possession. It can hardly be supposed that such songs are based upon an intelligent musical system. The profound students and thinkers among the Indians were concerned with means of obtaining supernatural help, not with calculations nor material facts. They were mystics and their old songs can not be separated from their mysticism.

A type of song which is probably as old as the "dream song" is that connected with folk-tales, many of which were of cosmic significance and intended for the instruction of the people. Melodies were introduced at intervals during a long story and were sung by the narrator. In the most primitive tribe under observation the melody was sung only once, after which the narrator resumed his story. It appears that the song broke the monotony of the narrative in an agreeable, rhythmic manner, and it usually represented the expression of some character in the story, either human or otherwise. For example, one story recorded by the writer was concerning a contest between a beaver and a plant called "fox-tail" as to which could cause rain to fall. Each sang his own magic song and the beaver produced the heavier downpour of rain. In explanation it was said that the beaver had a stronger supernatural helper than the flower. Can we expect to find in such material a consciously evolved musical system?

I began my study of Indian music in 1893, and have conducted that research for the Bureau of American Ethnology of the Smithsonian Institution since 1907. In the pursuit of this study I have visited many Indian reservations and recorded songs on the phonograph, transcribing and analysing about 1700 of such records. For transcriptions, I use the ordinary musical notation with only a few additional signs. If a tone is sung less than a quarter-tone higher than the indicated pitch I place a plus sign above the note, and if a tone is sung less than a quarter-tone below the indicated pitch a minus sign is placed above the note. A slight extending or diminishing of the length of the tone is indicated by a sign for a "hold," placed vertically above the note, the opening of the curve being toward the left if the tone is shortened and toward the right if it is prolonged. By this simple and familiar notation it is possible to present a large amount of material in a form convenient for observation. A more elaborate graphic representation would make it necessary for students to master a new medium of expression and, if accurate and adequate, would require the services of a large staff of workers. The writer has no assistants and the opportunity to secure genuine Indian songs is rapidly passing away. These are among the circumstances which justify the use of ordinary musical notation in the transcription of Indian songs. It is not claimed that Indians sing all the tones of the diatonic scale with accuracy but it will be shown that the upper partials (overtones) of a fundamental tone constitute the framework of many Indian songs. These tones are usually sung with a degree of accuracy that would be considered acceptable in a cultured singer.

The Indian produces his tone in the back of his throat, holding the lips and teeth motionless and separating the tones by a peculiar action of the throat muscles. This tone is unfocused and frequently resembles the vocal sound produced by an animal. There is a multiplicity of by-tones which suggests that the song is progressing by minute intervals of pitch, and one of the first decisions that must be made by a student of Indian music is concerning the degree of importance to be attached to these small gradations of pitch.

It may safely be assumed that if exceedingly small intervals or gradations of pitch are consciously produced, the Indian must have an ability to discriminate such intervals when hearing them. In order to test the pitch-discrimination of Indians the writer took with her, to Indian reservations, a set of eleven standardized tuning forks, one of which gave the fundamental tone of the series (a′, 435 vibrations, international pitch) while the other forks produced tones respectively 1/2, 2, 3, 4, 5, 8, 12, 17, 23 and 30 vibrations above the fundamental. These forks were lent by Dr. C. E. Seashore, Dean of the Graduate College, University of Iowa, who kindly examined the tabulated report of the result of the test. He expressed the opinion that "the abilities here shown are about as good as one would find among the average American whites under similar conditions." The ear of the Indian is trained to hear sounds which we do not notice but this test does not indicate that he has a superior perception of differences in the pitch of tones. A practical experience with Indians has convinced me that, among uncultured people, small variations in the pitch of vocal sounds are not directed by an intelligence which would entitle them to serious consideration. I do not think that a voluminous study of them would reveal any underlying system or laws. Lacking that definite purpose, the undertaking does not seem justified.

During the first year of my work with the recording phonograph I made an experiment which has an important bearing on this subject. Two phonographs were placed opposite each other in such a position that the ends of the recording horns were together. Selecting a typical record of an Indian song, I played it on one phonograph and recorded it on the other. A duplicate was made from this record and so on until I had the sixth duplication of the original record. This was much softer than the original but the tones were those of the diatonic scale, sung with reasonable accuracy. The duplications had eliminated the by-tones, leaving the kernel of tone which had been obscured by the Indian's manner of rendition. As so much depended upon the accuracy of my hearing I underwent a test by Dr. C. E. Seashore in his laboratory, the result being entirely satisfactory. This may be regarded as a standardizing of the human ear in order that it may safely be used as an instrument of measurement.

An Indian seldom strikes the drum or shakes his rattle precisely with the corresponding tone of his song. Through the courtesy of Dr. Dayton C. Miller, head of the department of physics, Case School of Applied Science, Cleveland, Ohio, this peculiarity of Indian music was given a graphic proof. The writer's phonograph was installed in Dr. Miller's laboratory, portions of two records were played by the phonograph and the sound recorded graphically by the phonodeik, an instrument of Dr. Miller's invention. In one of the songs thus studied, the portion photographed by the phonodeik was of about 23 seconds' duration, as reproduced by the phonograph, and made a film record about 38 feet in length. In a detailed report on this test Dr. Miller stated that "the first beat of the pair of drumbeats follows the beginning of an accented voice tone with great regularity. Of 25 such instances identified on the photograph the drumbeat follows the voice by 0.12 second in 12 cases and in no instance does the interval differ from this by more than 0.02 second." Other interesting results of this test are apart from our present consideration.

In order to determine whether Indian music resembles that of a European people, a comparison was made between the structure of Indian and Slovak songs, the latter being analysed by the same method employed in analysing Indian songs. The material used in this comparison consisted of 710 Indian songs from widely separated tribes and 10 typical Slovak songs selected for the purpose by Mr.

Ivan Daxner, secretary of the Slovanian League of America, whose co-operation is gratefully acknowledged. The Slovak songs included the Slovak national anthem, a song concerning Janosik, a very ancient melody entitled "In praise of song," a "dialogue on melody," several love songs, and folk-songs concerning the plowboy and the girl who watched the geese. On comparing the structural analyses it was found that the resemblances were fewer than the differences. The Indian and Slovak songs under analysis differed in trend and in the principal interval of progression; it also appeared that the Slovak songs had more directness in beginning and more simplicity of rhythm.

In order to obtain representative material it is necessary to exercise great care in the selection of Indian singers and interpreters. To this phase of the work one must bring a knowledge of Indians which can be gained only by experience. The Indians have their standards of good singing and recognise only one correct version of a song. This version must be obtained if the work is to be reliable. One of the requirements of a good singer among the Indians is that he shall repeat a song with absolute accuracy. To the credit of the Indians it may be said that repetitions after a period of weeks, months or (in one instance) after the expiration of two years have been found identical in tempo, pitch and note-values. Similarly, it is not unusual for as many as ten renditions of a song to be recorded on one phonograph cylinder without the slightest differences in the renditions. This accuracy appears in ceremonial songs and in records made by the best singers. There are other instances in which we find slight and unimportant variations in the renditions. The first is usually the best rendition in such cases but transcription is made from the clearest, wherever it occurs on the cylinder.

Mention has been made of a system of analysis devised and used by the writer. This consists at present of 18 tables of classification. Four additional tables were used in the analysis of 710 songs and the results were so similar in the tribes under analysis that these bases of classification were discontinued as being no longer necessary. The discontinued tables concerned the metronome tempo of voice and drum, a comparison of these tempi, and the pitch of the keynote of the song. The tables now in use are as follows:

1. Tonality (determined by the interval between the keynote and its third and sixth). 2. First note of song—its relation to keynote. 3. Last note of song—its relation to keynote. 4. Last note of song—its relation to compass of song. 5. Number of tones comprising compass of song. 6. Tone material. 7. Accidentals. 8. Structure (melodic or harmonic). 9. First progression—

downward and upward. 10. Total number of progressions—downward and upward. 11. Intervals in downward progression. 12. Intervals in upward progression. 13. Average number of semitones in an interval. 14. Part of measure on which song begins. 15. Rhythm (meter) of first measure. 16. Change of time (measure-lengths). 17. Rhythmic unit. 18. Rhythm of drum or rattle.

Each song is analysed according to these tables as soon as it is transcribed. These analyses are combined into a tribal group, and the tribal groups are, in turn, combined in a large total which shows the characteristics of all the songs under consideration. About 1700 songs have been transcribed and analysed but only 1073 have been combined in the large total. The data to be presented are based upon this group of 1073 songs, comprising songs of the Chippewa, Sioux, Ute, Mandan, Hidatsa, Papago, and Pawnee tribes. The songs analysed singly but not included in this total are those of the Yuma, Cocopa, Yaqui, Makah, Menominee, Winnebago, Tule Indians of Panama, and the Salish and Tsimshian songs recorded in British Columbia. A large number of Indian songs have been heard at tribal gatherings and not recorded phonographically. In all the tribes an effort has been made to obtain the oldest songs, recorded by the most reliable singers. Special attention has been given to songs connected with magic or with the treatment of the sick. A limited number of comparatively modern songs have been recorded for purposes of comparison.

The tables of analysis which chiefly interest us at present are Nos. 2, 3 and 6 from which the problem of scale in Indian music may be discussed. The term "keynote" is applied to the tone which, by the test of the ear, appears to be the fundamental tone in the series of tones comprising the song. This does not present a claim that the Indian regards it in this manner. The term is used for convenience, similarly to the ordinary notation in which the songs are transcribed. Having decided upon the tone to be designated as the keynote, the analysis of the song proceeds upon that basis. In a limited number of songs there is no apparent feeling for a keynote, such songs being pure melody without tonality. These occur chiefly in the songs of tribes which are not included in the present total. They are classified as irregular in tonality and await further study.

On examining Table 2 we find that 216 songs (20 percent) begin on the octave above the keynote, 150 songs (14 percent) begin on the twelfth, and 285 songs (27 percent) begin on the fifth above the keynote. The ratios of these intervals are respectively 2/1, 3/1, and

3/2. On examining Table 3 we find that the keynote is the final tone in 597 songs (56 per cent), and the fifth is the final tone in 342 songs (32 percent). The data in these two tables indicate a feeling for tones having simple vibration-ratios, such tones forming what may be termed the boundaries of the songs.

At this point it should be stated that the writer uses the term "scale" for convenience. It is applied only to the series of tones commonly known as the major and minor diatonic scales, appearing either in complete or incomplete form, and to the five five-toned scales which are designated by Helmholtz, appearing in complete form. The vibration ratios in the first-named are as follows:

Major diatonic scale
9/8, 10/9, 16/15, 9/8, 10/9, 9/8, 16/15,
Minor diatonic scale
9/8, 16/15, 9/8, 10/9, 16/15, 9/8, 10/9

The tone material of the songs is presented in Table 6 and, before considering the principal groups, mention should be made of a group of 71 songs (6 per cent) which contains a large variety of songs not otherwise classified. In this group are 42 songs which, in the first year of the writer's work, were transcribed in outline, no keynote being designated. There are 12 songs classified as irregular in tonality, and other series of tones appearing only twice in the 1073 songs. The largest subdivision of this group consists of 10 songs containing the first, second, fifth and sixth tones of the diatonic octave (vibration ratios 9/8, 4/3, 9/8, 6/5). This group may contain material of value but our present concern is with the larger groups.

The seven tones, or degrees, of the diatonic octave (major or minor) occur in 62 songs (5.3 per cent). Six tones occur in 204 songs (19 percent) and four tones in 319 songs (29 per cent). The number of tones preferred by the Indian is five, since 499 songs (46.4 percent) contain 5 tones or degrees of the diatonic octave.

Within the group of songs with five tones we find that 236 (47.1 percent) contain the series of tones designated by Helmholtz as the fourth five-toned scale and commonly known as the major pentatonic scale, having the following vibration-ratios:

9/8, 10/9, 6/5, 10/9, 6/5

Next in number are 106 songs (20 percent) which contain the series designated by Helmholtz as the second five-toned scale and commonly known as the minor pentatonic scale, having the following vibration-ratios:

6/5, 9/8, 10/9, 6/5, 10/9

A small group, 18 in number, contains the first five-toned scale according to Helmholtz which has the following vibration-ratios:

10/9, 6/5, 9/8, 10/9, 6/5

Only 2 songs are based on the fifth five-toned scale which has the following vibration-ratios:

6/5, 10/9, 6/5, 9/8, 10/9

The other songs containing 5 degrees of the diatonic scale are in many combinations of tones and are not regarded as on any scale. In 107 of these five-toned songs (not on the pentatonic scales designated by Helmholtz) the seventh and one other degree of the octave are absent. The total of 1073 songs does not show this group in detail but in a previous total of 820 songs we may examine the number of songs in which two degrees of the diatonic octave are absent. In this we find the largest group to be 29 songs which lack the seventh and sixth degrees, this series having the vibration-ratios 9/8, 10/9, 16/15, 9/8, 4/3. Next to the largest group comprises 26 songs which lack the seventh and second degrees, this series having the vibration-ratios 5/4, 16/15, 9/8, 10/9, 6/5. The general proportions would be the same if this detailed observation were extended to the analysis of 1073 songs. In the five-toned songs we find that 19 omit the sixth and one other tone, while in 10 songs the fourth and one other tone do not occur. It is, therefore, apparent that the seventh degree of the octave is omitted in a larger number of these Indian songs than any other degree of the octave.

Table 7 is devoted to a consideration of accidentals, or tones chromatically altered. In 923 songs (86 per cent) there are no accidentals. In 25 songs (minor in tonality) the seventh is raised a semitone, and in 22 songs the fourth is similarly raised. These are the largest groups containing only one accidental. Songs containing two accidentals number 89 and are of so many sorts that a detailed consideration of the group is not practical at this time.

From the foregoing it appears that tones with simple vibration-ratios are preferred by the Indians under observation as the boundary and the tone material of their songs, also that the seventh is the scale-degree most frequently omitted, and the seventh and fourth are the scale-degrees most often altered chromatically in the songs.

It is not enough for our purpose, however, to consider the tones used by the Indians in their songs. Equally important is the sequence in which these tones are used. For example, Indian songs containing the tones of the "major pentatonic scale" (fourth five-toned scale) do not resemble the Gaelic songs based on that scale, and the tone material frequently is not discerned until the song is analysed. The sequence of tones is shown in Tables 11 and 12 in which the number and sort of intervals are considered. These tables show that the interval occurring most frequently is the whole tone, or major second (9/8). The entire number of intervals in the 1073 songs under analysis is 28,956, and the whole tone progressions comprise 11,741 (40 percent) of that number. Next in frequency is the minor third (6/5) which comprises 8,029 (29 percent). The interval of a fourth (4/3) constitutes 3,717 (13 percent), and the semitone, or minor second (16/15), constitutes 1,117 (4 per cent). Attention is directed to the relatively small number of semitone progressions, which does not encourage the hypothesis that the Indian possesses a musical system consisting of small intervals or gradations of pitch. The intonation on the semitone is more variable than on any other interval. The tone transcribed as a minor third is more frequently a non-major third than a correct minor third. It is interesting to note that the major third comprises only 2,932 (10 per cent) of the total number, as that interval is part of the harmonic series already shown to be prominent in the framework of the melodies.

The interval of a fourth has been found to occur most frequently in songs concerning birds, animals and motion. Indeed, it may be said to characterise such songs. For example, it is a prominent interval in songs with the following titles which are derived from the words of the songs: "The ravens are singing," "The big bear, to his lodge I often go," "I am raising my pipe," and "A bubbling spring comes from the hard ground." The fourth may be called a progressive interval, implying action that is to be completed.

The foregoing general observation on a large number of intervals is, in the writer's opinion, more important than an intensive study of a limited number of intervals. Indian music is mental in its origin and the Indian evidently "thinks" most clearly the intervals which have simple vibration-ratios. His deviations involve a personal element. To follow such deviations is apart from our present purpose.

We will now proceed to a peculiarity of Indian songs which can hardly be tabulated but which is observed when the songs are studied. This may be termed an "interval formation" and has no counterpart in the music of civilization. It occurs most frequently in songs that lack a keynote and are classified as irregular in tonality. Perhaps, at some future time, the basis of classification may be changed and the songs divided into those which have a keynote and those which are formed by successive intervals. In many of the latter songs a few measures are within a small compass, the next few measures are within a different compass, and so on to the end of the song with no binding intervals that would unite these small groups in relation to a common keynote. For example, a song for the treatment of the sick, recorded by Pigeon-hawk, begins with a few measures on the descending fourth A to E, these are followed by a few measures on the descending fourth G to D, and the song closes with measures on the tones D to A. Each phrase is complete in itself, like a separate melody. In the songs of the Northwest Coast, not included in the present collective analysis, this peculiarity appears as a whole-tone formation, many songs having a compass of three or four tones with phrases based on whole tones, repeated within that compass. In such songs the feeling for a keynote is less prominent than the stepping from one tone to another which is adjacent or desirable for some other reason. This indicates the complexity of Indian music and the danger which lies in the making of generalizations.

It is difficult to trace the history of an Indian song more than 150 years and, with the utmost care in selection, we cannot be certain that every recorded melody is of purely Indian derivation. The Indians are imitative and when visiting other localities they are particularly eager to hear and learn new songs. In this manner there may have been alien influences in their music which they do not recognise. The Yaqui Indians, living on the Mexican border, said they had two sorts of songs, one of which was their own and the other was "like Mexican music." Examples of both were recorded, the former being ceremonial songs and the latter being modern songs accompanied by the guitar. One song was recorded on Cape Flattery on the northwestern boundary of the United States, which closely resembles the Cocopa dancing songs recorded in southern Arizona by members of a tribe which lives partly in the United States and partly in Mexico. It is said that long ago the Spaniards visited Cape Flattery and this coincidence is interesting. Other songs recorded on Cape Flattery resemble chants, yet are not like the chanting in the Roman Catholic Church and we are reminded that the Russian Church is widely established in the far north. Possibly this may have influenced the Indians from Cape Flattery on some of their journeyings. Songs recorded by Indians living on the west coast of British Columbia are characterised by a fluency and easy tunefulness that bears no resemblance to typical Indian songs but is like the easy, pleasing melodies used in missions of the Roman Catholic Church. The writer was not surprised to learn that the Roman Church has missionaries in that region and that certain of the recorded songs were used in Christmas festivities. The presence of such songs demonstrates the necessity for collecting a large amount of material on which to base conclusions.

The most conservative songs of the Indians are those connected with old ceremonies, the songs hereditary in families, the songs received in fasting dreams, and the songs used in the treatment of the sick. A very large majority of the songs collected and analysed by the writer belong to these classes, but other songs are also collected in order to secure a complete representation of a region and to afford material for comparison. If modern songs should be found to predominate in a region the writer would go elsewhere to collect songs. The desirability of a field for research is estimated by the number of medicine men still living and by the extent to which the native religious customs are observed. Distance from towns is also a factor. For example, the village on Cape Flattery where work has been conducted for two seasons is reached only by water and there is only one steamer a week, carrying freight and a few passengers. In winter this boat is often unable to land because of the high waves. The isolation of this village adds value to its musical material. Other songs have been recorded in a mountain village about 130 miles from a railroad. The Indians came a considerable distance to this village in order that their songs might be recorded phonographically. On the southern desert the writer has travelled more than 80 miles from a town or a telephone to record songs from the Indians, once spending Christmas in such a locality and attending a remarkable dance that was held only on Christmas night. This dance was given on the desert sand and was a wonderful sight in the moonlight. Many similar incidents could be related but do not concern our present purpose.

Mention may here be made of the use of a rest in Indian songs. A pause for the taking of breath is noted only in records made by younger Indians. It occurs rarely and can be distinguished from a musical rest as it does not occur uniformly in all renditions of the song. A rest occurred in only 10 Chippewa songs (less than one-half of one per cent) but was found in 13 (more than 11 per cent) of the Ute songs, being given with care and distinctness. It is used to a much larger extent in the songs of southern Arizona and in those recorded on Cape Flattery. If we were to form our opinion of Indian songs according to those of the Chippewa we might imagine a resemblance to the songs of the Hindu concerning which it is said that "Rests are seldom written (except in order to break up the meter intentionally in a dramatic way) in any of their songs. . . . . They appear to take breath when they want to take it, not at the end of words."[2] Further experience shows that such a conclusion would be erroneous, as rests are effectively used in the songs of many Indian tribes.

The suggestion that Indian melodies are based on the tones produced by an instrument is untenable, as the only instruments used by the Indians that produce tones of different pitch are the flute and whistle. The first was formerly made according to the physical measurements of the man who was to play it, and the second produces two tones by a peculiar manner of blowing it. Neither instrument produces tones of sufficient accuracy to form the basis for songs.

The rhythm of Indian songs is characterised by accents unevenly spaced, transcribed as measures of different lengths. The tempo of the voice and the accompanying drum or rattle are frequently different, yet each is steadily maintained. When the tempo is the same, they frequently do not synchronize, as proven by the test conducted by Dr. Dayton C. Miller and described in this paper.

SUMMARY: The music of the American Indians is formed and preserved mentally, not visually. The collective analysis of 1073 songs shows a perception of tones with simple ratios of vibration. These tones, however, are frequently used in what may be termed an "interval-formation" of melody which does not suggest a keynote and has no counterpart in our musical usage. The analysed songs of the North American Indians do not suggest a resemblance to the songs of Asiatic or European countries. Interesting resemblances to less distant music are occasionally noted but are considered less important than the larger data obtained through collective analysis. A group of songs now designated as irregular in tonality is reserved for further study.

The rhythm of Indian songs shows more striking peculiarities than the melodic progressions. In this connection we repeat the statement that Indian music was originally associated with the working of magic and the treatment of the sick and that its use in the old manner persists, in many localities, until the present day.

The music of the American Indian is not an art, in our use of the term, but is primarily a means by which the Indian believes that he

[2] FOX STRANGWAYS, *Music of Hindustan*, pp. 192–193.

puts himself in communication with the mysterious forces of the earth, sea, and air. These are beneficent forces, though he regards them with awe and reverence, and he looks to their aid for safety in his daily life and for success in his undertakings. The study of Indian music cannot be separated from a study of the Indian himself, his traditions and his highest beliefs.

ZOOLOGY.—*A new francolin from Abyssinia.*[1] HERBERT FRIEDMANN, Amherst College. (Communicated by A. WETMORE.)

Among the birds collected by the late Dr. Edgar A. Mearns while on the Childs Frick Expedition to Abyssinia and East Africa, 1911–12, are two examples of a francolin unlike any known form. They are nearest to *Francolinus africanus psilolaemus*, but are much darker and more abundantly and heavily marked with both rufous brown and with black on the breast, abdomen, and flanks. This new form I propose to name in honor of the leader of the expedition

Francolinus africanus fricki subsp. nov.

Type: U. S. N. M. no. 243201, adult ♂, collected in the Arussi Plateau (altitude 10,500 ft.), Abyssinia, 18 February 1912, by Edgar A. Mearns.

Subsp. Characters: Similar to *psilolaemus* G. R. Gray, but much darker above, the feathers largely blackish, the underparts as in *psilolaemus* but the breast, abdomen, and flanks heavily marked with arrow-shaped black, subterminal marks as well as with broad spots of deep rufous brown, while in *psilolaemus* the black marks are very few and narrow, only the rufous brown ones being abundant; also the size is larger (wing ♂ and ♀ 174 mm. as against 164–167 mm. in *psilolaemus*).

Measurements of type: wing 174 mm.; tail 81 mm.; culmen from base 27 mm.

Measurements of ♀ (*topotype*)*:* wing 174 mm.; tail 83 mm.; culmen from base 26.5 mm.

Range: known only from the type and topotype, both of which come from the heath zone at 10,500 feet, Arussi Plateau, Abyssinia. According to Dr. Mearns' field notes, it is abundant up to 11,000 feet.

Remarks: I have been able to compare these two birds with but a single example of *psilolaemus*, an adult female from Antoto, Abyssinia, and with the colored plate in the Catalogue of Birds in the British Museum,[2] with which the Antoto specimen agrees very closely.

The female of *fricki* is similar to the male but is very slightly darker above, has more of the black markings and less of the reddish brown ones below.

It seems that *fricki* is the representative of *psilolaemus* in the very high districts of the Arussi country.

[1] Received July 9, 1928.

[2] Vol. 22, *pl. 3*. 1893.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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PHYSICAL CHEMISTRY.—*Petroleum and the filtering earths.*[1]

P. G. Nutting, U. S. Geological Survey.

It has been well known to chemists for many years that many clays, soils, etc., are attacked by certain salt solutions, giving off some things and taking up others.[2] In 1907, E. C. Sullivan of the U. S. Geological Survey published a comprehensive review of the subject including his own investigations (*Bull.* 312). Sullivan powdered his mineral, covered it with twice its weight of known salt solution and after several days standing with repeated shakings, analyzed the solution for changes. What happened was simply a base exchange according to the mass law. Copper sulphate solution in contact with kaolin, for example, gives up copper to the kaolin and takes up calcium in its stead. The solution of mineral by the solvent (water) and the adsorption of basic ions from solution by the solid were both found to be relatively small but either may have played an important intermediate rôle in the base exchange.

In the case of earths used in filtering oils, the liquid contains many organic radicals varying widely in basicity. The filtering earths are silicates which are combinations of bases with the weak silicic and aluminosilicic acids. There can be little base exchange proper between the oils and the untreated filtering earths, however, for the exchangeable organic radicals are too weak. Furthermore, in such filtering action as may occur, the reaction products (silico hydrocarbons) are not generally soluble in oil. To get good filtering action the filter

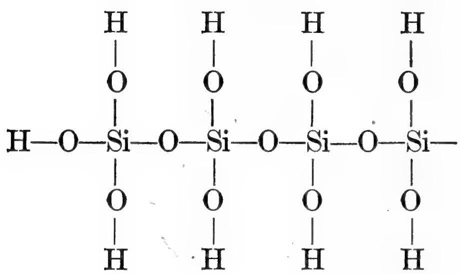
[1] Published by permission of the Director of the U. S. Geological Survey. Received June 20, 1928; revised July 23, 1928.

[2] H. S. Thompson. Journ. Roy. Agric. Soc. **11**: 68–74. 1850; J. Thomas Way. ibid. **11**: 313–379. 1850; **13**: 123–143. 1852; **15**: 491. 1854.

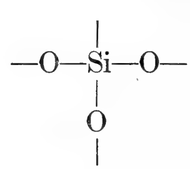
must have its basic radicals removed, leaving open bonds ready to attach to the radicals of the oil to be filtered. In other words the filter is chosen or prepared so as to have terminal hydroxyl (−OH) radicals. Heating drives off water from these, leaving the open bonds essential for filtering. The filtering action is a removal of the less firmly bound alkyl radicals of certain hydrocarbons.

A theory of oil adsorption and filtration essentially as given above was advanced by the writer in 1926 on the basis of known data and some preliminary investigations.[3] Supplementary work since that time has confirmed this theory and supplied many interesting details.

The ideal filter of this class is of course silica gel. In this case a hydrosilicon chain



$(n+1)H_2O \cdot nSiO_2$ or $Si_n(OH)_{2n+2}O_{n-1}$, containing about 23 per cent water is heated nearly to red heat until the water is reduced to about 3 per cent and used before more water can be taken on from the air. The stripped chain will have somewhat the form



the free bonds extending out partly from Si and partly from O atoms. The last of the water is driven off only by heating to very high temperatures (800–1000°C.) for some time. Such treatment destroys filtering power and the power of taking up water, perhaps because the free bonds unite with each other, reducing the silica gel to inactive quartz O=Si=O having but slight affinity for water or for acid or basic radicals.

[3] *Geochemical relations between petroleum, silica and water.* Econ. Geol. May 1926.

Alumina and ferric oxide make almost as good filters as silica if prepared by drying the hydroxide gel. Their action appears to be the same as that of silica gel toward hydrocarbons. Colloidal silicates of the metals (Cu, Zn, Ni, Pb, Mn, etc.) precipitated from salt solutions by sodium silicate, washed and dried, were also found to be good filters. A slight trace of acid remaining on a filter does not affect its action; a trace of alkali destroys it. A large surface area, and free percolation of oil are essential.[4]

This theory of the filtering action of silicates on oils assumes an affinity or surface reaction between the silicates and certain hydrocarbons resulting in a film of organic silicate (or silico hydrocarbon) over the surface. Many hundreds of such compounds are known. Much of the earlier work on them was done by Friedel, Crafts and Ladenburg and a number of them are listed in Beilstein. Much recent work on the structure of the more complex compounds has been done by F. S. Kipping[5] and by Schlenk. A common characteristic of their structure is of interest here.

In a hydrosilicon molecule, Si atoms are usually not directly attached to each other, an oxygen atom intervening. In the hydrocarbons, carbon is bonded directly with carbon without intervening oxygen. In the structure of the organic silicates a mixture of the two habits prevails. Triethylsilicol is considered $(C_2H_5)_3SiOH$; the hydrogen is bonded through O, the ethyl radicals are not. In $C_2H_5Si(OC_2H_5)_3$, three of the ethyls are bonded through O while one is not. A partly stripped (of H_2O) hydrous silicate, as indicated above, has open bonds partly from Si and partly from O atoms, hence might well be selective toward alkyl radicals of various kinds.

This selective action may account for the varied action of different filters toward oils. Many filter to water white, some filter to an amber color, some (slightly alkaline or moist) filter to a canary yellow. Some natural earths are best on mineral oils, others on vegetable oils. Some will even render fish oils tasteless and odorless. Fats and vegetable oils containing oxygen would be expected to require a different filter from petroleum containing little or none. Using very dilute solutions, the writer has prepared silica gels (also those of alumina and

[4] The adsorption of piperidine, nicotine and sixteen other organic compounds from water solution by silica, alumina and ferric oxide has recently been studied by GRETTIE and WILLIAMS. Journ. Am. Chem. Soc. March 1928. They found adsorption by silica gel to be roughly proportional to the basicity of the adsorbed compound. The adsorption of ferric oxide varies widely with mode of preparation.

[5] *Cf. Organic derivatives of silicon* XXXII. Journ. Chem. Soc. **1927**: 104.

ferric oxide) so powerful as to break up paraffin hydrocarbons, even paraffin itself and very stable oils of the nujol type.

A spent fullers earth cannot be washed clean by even the most powerful solvents (such as tetrachlorethane) or detergents. Even a boiling sodium carbonate solution fails to lift the film coating the grains. Burning to 800°C. in air simply carbonizes it though some earths may be used four or five times by burning off. Burning in pure oxygen removes most of it. This behavior indicates the formation of some compounds much more stable than any simple hydrocarbon.

A good filter may be flushed with even a heavy clear oil and this afterward driven out by a black crude. The filtering action is not impaired. A filter with all its $-OH$ radicals in place (i.e. with no open bonds) would be expected to filter out only basic radicals stronger than OH. This appears to be substantiated by experiment. An undesiccated filter takes out the black and dark brown near-carbons from petroleum but passes the lighter yellow and orange colored oils.

The matter of color in oils, fats and waxes is a vast subject in itself. Considering briefly only the petroleum hydrocarbons, if we plot as ordinates the series C_nH_{2n-2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4}, etc., and as abscissae the number of carbon atoms, the region of colored hydrocarbons lies to the left of the diagonal C_nH_n (acetylene, benzene, retene, etc.) where the hydrogen atoms are fewer than the carbon atoms in the molecule. The higher the carbon ratio, the higher the color. It is the near carbons that are filtered out (retained by the filter) while the colorless hydrocarbons, having more hydrogen than carbon atoms per molecule, are passed by the filter or are very loosely held.

Many of the best filtering earths must be acid treated and washed before being dried for use as filters. These have terminal $-OK$, $-ONa$ or $-O_2Mg$ radicals. Acid treatment converts these to $-OH$ and salts. Washing out the salts and drying produces the open bonds necessary to filtration. Greensand and serpentine make excellent filters after acid treatment. Even natural weathering and leaching is sufficient for some serpentines. Tests with natural clays high and low in alkalies and alkaline earths (selected by C. S. Ross) amply verified the theory just stated.

Still a third method of preparing filters is of scientific interest. A nondescript mixture of clays, such as Texas gumbo, in itself almost without filtering power, may be converted into good filters by dissolving in fused sodium or potassium carbonate. Dissolving the fusion in hot water gives (1) an alkaline solution which is rejected, (2) a floc, chiefly colloidal alumina which is a good filter after washing and drying,

(3) a solid residue, the acid extract of which yields a good filter after precipitation by an alkali, washing and drying and (4) a final residue not soluble in acid, which is a fairly good filter after grinding, washing and drying. It is theoretically possible to split up complex silicates by fused alkalies and to convert the components into filters by acid treatment.

In an oil sand, that oil is considered adsorbed on or combined with silica which will not yield to washing with gasoline. The thickness of the fixed layer is readily determined, for it may be completely removed from a non porous sand with chromic acid. Using a very pure and uniform silica sand (Tensleep, Oregon Basin, Wyoming, 3850 feet) a thickness of 0.75μ was found, which is 15 to 20 times the thickness of the water film adsorbed by the same silica at ordinary room humidities. The clean sand, soaked in an asphalt base oil over night, acquired a new film of very nearly the same thickness. This method may be of assistance in the analysis of heavy oils and asphalts as silica is a definite weak acid.

Some geological and practical applications of the principles just advanced are of interest. The question is often raised, how could petroleum have replaced water solutions in oil sands when tests show that water drives out oil and oil can not be made (by pressure) to drive out water except from the larger pores. The answer is simple. If the petroleum contains heavy unsaturated hydrocarbons, the whole or some part of which is stronger than OH, these first coat the sand grains which then in effect become tar grains and absorb oil in preference to water.

In the soda process for petroleum recovery, developed by the writer in the laboratory and now being used in the field, a soda solution was found to be very effective in freeing the sand from petroleum. With tar coated sand grains the action of the soda is much slower as the diffusion of the soda through the adsorbed film is necessarily very slow. Nevertheless in the end very clean removals are obtained. Much effort has been spent on the measurement of the retention of oil by sand ignoring the enormous effect of but a few parts per million of tarry constituents in the oil.

Trinidad asphalt contains uniformly 35.5 per cent of silicate matter in the form of clay and fine earth and 10 per cent water of hydration. If this mineral matter is partly a filtering earth as defined above, then it is not difficult to account for the formation by the upward percolation of an asphalt base petroleum. With the clay wet, only the heavier tars would be strongly adsorbed, carrying the clay with it in a definite proportion.

In summary then we may say that filters filter because of open O and Si bonds. These are produced by removal of H_2O from terminal OH radicals. They act by attacking certain alkyl or weakly basic radicals of the hydrocarbons. The result may be mere adhesion but is in many cases a surface reaction in which a film of organic silicate is formed over the surface of the filter grains. Many of the organic silicates thus formed are insoluble in any single known solvent.

Clays of the kaolin type (kaolinite, halloysite, anauxite, $H_4Al_2Si_2O_9$) do not filter because they contain no hydroxyl water that can be driven off leaving open bonds.

Clays of the bentonite type make only poor filters even after acid treatment because they contain only a little alkali replaceable by hydroxyl.

Good filters, either artificial or natural, are of two types; (1) those well supplied with hydroxyl water removable by moderate heating and (2) those having originally had terminal alkali radicals subsequently converted to hydroxyl by acid treatment.

The selective action of filters is readily accounted for by the varying activity of open bonds toward organic radicals retained by bonds of varying strength.

The penetration of petroleum into water-soaked sand and the possible formation of Trinidad asphalt are discussed.

GEOLOGY.—*The stratigraphy and age of the Pleistocene deposits in Florida from which human bones have been reported.*[1] C. WYTHE COOKE, U. S. Geological Survey.

Human remains in close association with extinct vertebrates of Pleistocene aspect have been found at three places along a hundred-mile stretch of the east coast of Florida. In 1916 E. H. Sellards announced the first discovery at Vero, a town 65 or 70 miles north of West Palm Beach. In 1924 F. B. Loomis found artifacts mingled with a similar extinct fauna at Melbourne, 30 miles north of Vero, and later Gidley and Loomis found human bones there apparently in the same bed with the extinct fossils. Early in 1928 Gidley made additional finds at Melbourne and discovered another locality at New Smyrna, a town 15 miles south of Daytona and 100 miles north of Vero. In

[1] Read before the Geological Society of Washington, May 9, 1928. Published by permission of the Director of the U. S. Geological Survey. Received May 18, 1928.

a paper recently presented before the National Academy of Sciences, Gidley reaffirmed his previous conclusions that man and extinct animals were contemporaneous. In view of these repeated discoveries of fossil man in Florida, it seems desirable to summarize again the stratigraphy of the region and to attempt to determine the age of the deposits in which the human bones are reported to have been found. I shall assume throughout this paper that the human remains really occurred in and formed part of the bed to which they have been attributed by their discoverers, although it should be distinctly understood that the burden of proof of this very important fact lies directly upon those who have found the bones. It is to be hoped that Doctor Gidley will soon publish an account of his latest observations and discoveries. References to the literature are listed in the footnote.[2]

The stratigraphic succession at Vero, Melbourne, and New Smyrna is essentially the same. The bed rock at all three localities is a marl composed of sea shells and sand and known as the Anastasia formation. Most previous writers have referred to it as the Number 1 bed. This formation underlies the East Coast from St. Augustine to Palm Beach County. It is obviously a littoral marine formation. The shells in it are nearly all of living species and give no clue as to what part of the Pleistocene it belongs.

The Number 1 bed is overlain unconformably by the Number 2 bed, or, as I prefer to call it, the bone bed. The bone bed consists chiefly of fine sand. At Melbourne the sand varies from white to light brown and contains a few local irregular lenses of marine shells that appear

[2] E. H. SELLARDS. *Literature relating to human remains and artifacts at Vero, Fla.* Am. Journ. Sci. (**4**) **47**: 358–360. 1919; Florida Geol. Surv. 12th Ann. Rept., pp. 1–4. 1919 (cites 24 titles). H. F. WICKHAM. *Fossil beetles from Vero, Florida.* Am. Journ. Sci. (**4**) **47**: 355–357. 1919; Florida Geol. Surv. 12th Ann. Rept., pp. 5–7. 1919. T. C. CHAMBERLIN. *Investigation versus propagandism.* Journ. Geol. **27**: 305–338. 1919. F. B. LOOMIS. *Artifacts associated with the remains of a Columbian elephant at Melbourne, Florida.* Am. Journ. Sci., (**5**) **8**: 503–508. 1924. W. H. HOLMES. *The antiquity phantom in American archeology.* Science, (N.S.) **62**: 256–258. 1925. F. B. LOOMIS. *Early man in Florida.* Nat. Hist. **26**: 260–262. 1926. J. W. GIDLEY. *Investigations of evidences of early man at Melbourne and Vero, Florida.* Smiths. Misc. Coll. **78**: 23–26. 1926. O. P. HAY. *On the geological age of Pleistocene vertebrates found at Vero and Melbourne, Florida.* This JOURNAL **16**: 387–392. 1926. J. W. GIDLEY and F. B. LOOMIS. *Fossil man in Florida.* Am. Journ. Sci. (**5**) **12**: 254–264. 1926. J. W. GIDLEY. *Fossil man in Florida* (Abstract): Bull. Geol. Soc. Am. **37**: 239–240. 1926. C. WYTHE COOKE. *Fossil man and Pleistocene vertebrates in Florida.* Am. Journ. Sci. (**5**) **12**: 441–452. 1926. O. P. HAY. *A review of recent reports on investigations made in Florida on Pleistocene geology and paleontology.* This JOURNAL **17**: 277–283. 1927. O. P. HAY. *Again on Pleistocene man at Vero, Florida.* This JOURNAL **18**: 233–241. 1928.

to have been washed or blown in from the sea at a time when the shore stood close by. Where shell lenses are absent the bone bed appears massive or is streaked horizontally by dark carbonaceous sand. The bone bed ranges in thickness from a thin film up to perhaps 10 feet. No muck, peat, or leaves have been found in it at Melbourne, although the bed that has been correlated with it at Vero contains local accumulations of vegetable matter in old drainage channels.

It is possible that the bed at Vero called "Number 2" by Sellards is younger than the Number 2 bed at Melbourne, for "within the stratum, filling holes or channels in the underlying deposit, are found local accumulations of muck, including often wood, sticks, acorns, snail shells, and vertebrate fossils. As a rule the sand near the base of this stratum is light-colored and distinctly cross-bedded."[3] This description fits the stream deposits much better than it fits the bone bed which I saw in a freshly-dug trench at Vero in 1926. Sellards' original excavations are filled or overgrown.

I have called the Number 2 bed the bone bed because it contains great numbers of bones. Many of the bones represent species that are now extinct. Among them are camels, horses, mastodons, elephants, tigers, and armadillos. Man lived among them, for Doctor Gidley has found a skull, crushed as if trampled by an angry elephant. These extinct animals, according to Dr. O. P. Hay, comprise a fauna of very early Pleistocene aspect that is usually referred to the Aftonian or first interglacial stage. The association of human remains with this fauna is of the utmost significance, for it proves either that man has been in America since the early Pleistocene or that the so-called Aftonian fauna did not perish at the close of the first interglacial stage.

A few words as to the manner of accumulation of the bone bed are appropriate at this point. Sea level had been depressed and the newly-emerged shell-covered bottom stood a few feet above tide. Back of the sandy beach ridge lay poorly drained, grassy meadows, the pastures of countless herds, upon which wind-blown sand gradually accumulated and buried the skeletons of animals that died there. It is quite likely that the meadows were occasionally flooded by torrential rains, by back water from lagoons, or by salt water blown ashore by gales, just as the plains around Moorehaven were overwhelmed by Lake Okeechobee during the recent hurricane. The presence of a few lenses of marine shells in the bone bed, a continental deposit, may thus be accounted for. Some of the animals whose bones are found

[3] E. H. Sellards. Journ. Geol. **25**: 8. 1917.

in the Number 2 bed may have been drowned in floods; more, doubtless, died the natural deaths of the wilderness.

Sometime during this episode man appeared on the scene. Some of his bones and implements were buried by the drifting sand and became part of the bone bed. Others, remaining longer on the surface, were eventually covered by the stream and bog deposits that I shall now describe.

Lying upon the bone bed and effectually sealing it from the accidental intrusion of objects from above, are patches of fresh-water deposits that have been called the "Number 3 beds." At Vero and Melbourne the "Number 3 beds" are swamp and stream deposits that consist of muck and partly decomposed roots, bark, and leaves, interstratified with yellowish sand. Fresh-water mussel shells are abundant in the stream deposit at Melbourne. At New Smyrna, according to Doctor Gidley, there is no clearly-defined stream channel, but the bone bed, Number 2, is covered by a peaty bog. It is very unlikely that human bodies could have been buried in the bone bed by sorrowing relatives without leaving easily discoverable traces of the hole in the peat bed through which the remains of the late lamented were interred. Neither Doctor Sellards nor Doctor Gidley has detected any evidence of such intrusion. The human bones must have been there before the peat bed accumulated.

The Number 3 beds are obviously recent. The accumulation probably began immediately after a rise of sea level that drowned the valleys of Van Valkenburg Creek at Vero, Crane Creek at Melbourne, and St. Johns River at Jacksonville on the East Coast and produced Charlotte Harbor and Tampa Bay on the West Coast. The fresh-water deposits continued to accumulate until the process was interrupted by the cutting of drainage canals a few years ago. How many years elapsed during this interval I am not prepared to say. Estimates based upon the thickness of the Number 3 beds (about 5 feet at Melbourne) and the rate of accumulation of various kinds of fresh-water deposits might be attempted but there are so many variable factors that such estimates would not be very reliable.

The topography of the region throws some light on the probable ages of the beds. The fossil-bearing localities near Vero, Melbourne, and New Smyrna are all on a nearly level plain that extends inland a distance of 20 or 25 miles and stands chiefly between the altitudes of 20 and 30 feet above sea level. They lie back of a low sandy ridge whose crest is less than 40 feet above sea level in the vicinity of Melbourne but which is more conspicuous and perhaps somewhat higher near Vero. This ridge probably is a former beach ridge that marks a temporary position of the shore during emergence of the sea bottom.

The plain that I have just described is the lowest well-defined member of a series of terrace plains that front the Atlantic Ocean from Delaware Bay to the Straits of Florida. In Georgia it is called the Satilla terrace. It probably corresponds to the Chowan terrace of North Carolina and to the Talbot terrace of Maryland. It obviously is an emerged sea bottom, for it is floored with sea shells. Before its emergence the shore line stood at an altitude of approximately 60 feet above the present sea level. Farther north in Florida and in Georgia, still older shore lines can be traced on topographic maps at altitudes 100 and 160 feet above sea level and there are even higher terraces that also may be marine.[4]

These ancient shore lines and the flight of step-like terraces that lie between them are supposed to represent different stages of the Pleistocene epoch. The highest terrace, being presumably the first to emerge, is the oldest; and the lowest, being most recently under water, is the youngest.[5] The Satilla terrace with the 60-foot shore line does not correspond to the very latest stage of the Pleistocene, for, although the Satilla is the lowest *well-defined* terrace, there appears to be a still lower and younger terrace with a shore line 20 or 25 feet above sea level and bordered by the somewhat higher beach ridge mentioned above. Stephenson has recognized such a low terrace in North Carolina and named it the Pamlico. Wentworth has detected it also in Virginia.

Doctor Hay has recently published the statement that none of the terraces, not even the one on which the fossil bones are found, is marine because they do not contain any marine fossils.[6] This statement seems surprising in view of the fact, well known to Doctor Hay, that the Anastasia formation or Number 1 bed is composed chiefly of sea shells. He is evidently confusing the deposits on the terrace with the terrace

[4] For a description of the terraces in Georgia see C. Wythe Cooke. *Physical geography of Georgia.* Georgia Geol. Survey Bull. **42**: 21–35. 1925.

[5] Melting of the existing polar ice caps would raise the level of the sea to a height comparable to that of the highest shore line definitely recognized in Florida. If the land has remained stationary and the elevated shore lines correspond to inundations caused by melted ice, then deglaciation during the interglacial stages of the Pleistocene was more complete than now, and the height of each shore line is a measure of the extent of deglaciation during the corresponding period. If, as is commonly assumed, the highest terrace is the oldest and the lower terraces are progressively younger, the highest terrace should have been under water during the first interglacial stage or before the first glaciation and the lowest terrace during the last interglacial stage. During the intervening glacial stages sea level may have been depressed below its present position.

[6] O. P. Hay. This Journal **18**: 236. 1928.

itself—the table cover with the table. A marine terrace is an emerged sea bottom. The marine terrace at Vero and Melbourne, strictly speaking, is the surface of the Number 1 bed, which was the old sea floor. The Number 2 and Number 3 beds, which are nonmarine, are *on* the terrace. They correspond to the table cover.

It is true, as Doctor Hay contends, that no sea shells have been found on the higher terraces, but that fact does not outweigh other evidences of their marine origin. The marine deposits on the higher terraces consist only of a thin veneer of loose sand. What chance would sea shells embedded in porous sand have of resisting through many centuries the corrosive action of organic acids in the soil? Great caves have been dissolved in solid limestone by rain water in no longer time than the higher terraces have been above the sea.

What agency but the sea could distribute a cover of fine white sand over a plain several thousand square miles in extent on the divide between the Atlantic Ocean and the Gulf of Mexico? What agency but the sea could build on the outer edge of this plain a sand bar 130 miles long and 2 to 4 miles wide extending parallel to the present coast and 40 feet higher on the seaward side than on the landward side? I refer to the Okefenokee terrace and Trail Ridge.

Let us now trace the principal events in the history of Florida during the Pleistocene epoch. Early in Pleistocene time, possibly during the first interglacial stage, much of the peninsula of Florida was submerged beneath the sea and the shore line stood at the 160-foot level. A long sand bar, now Trail Ridge, was built northward into Georgia from an island and shut off a sound similar to the present Pamlico Sound of North Carolina. Later the sea withdrew to the 100-foot level, Trail Ridge became the sea shore, and the sound was converted into Okefenokee Swamp. Once more the sea lowered, and came to rest at an altitude of only 60 feet above its present level. The shore line then stood at most places west of the present course of St. Johns River. The sites of Vero, Melbourne, and New Smyrna were still under water.

As a result of the next oscillation the sea halted about 20 feet above its present level. Shell-covered barrier beaches separated from the mainland by lagoons appeared above the waves, were covered with vegetation, and became the home of a great variety of land animals and turtles. Sand blown from the beach gradually silted up the lagoons and accumulated in hollows in the lee of the beach ridge. Man at last appeared. This was the period during which the bone beds at Vero, Melbourne and New Smyrna accumulated.

The next event appears to have been a further emergence of perhaps 60 feet. The sea retreated to a position about 40 feet below its present level, the lagoons were emptied, and streams began vigorously to erode their channels.

Erosion had not progressed very far before it was checked by a submergence that drowned the lower courses of the streams and brought the sea to its present level. This event may logically be considered the beginning of the Recent epoch.

The more important facts of history and stratigraphy can be summarized as follows: Bones of prehistoric animals of early Pleistocene aspect and human bones were buried by sand blown from the neighboring seashore and deposited on the Satilla terrace, a newly-emerged sea bottom. Further emergence of 60 feet removed the shore to such a distance that deposition of sand ceased and streams began to trench the deposits already formed. Partial submergence then choked the lower courses of the streams and made them boggy.

Deposits of three ages have been distinguished: First, a Pleistocene marine shell marl, known as Number 1 bed. Second, a Pleistocene bone bed with human remains, called Number 2 bed. Third, Recent stream and bog deposits called Number 3 beds.

As to the age of the bone bed: In view of the long succession of Pleistocene events that preceded the emergence of the Satilla terrace on which it rests, it seems scarcely possible that the bone bed can be as ancient as the Aftonian or first interglacial. On the other hand, it can hardly be the very latest Pleistocene, for we have to allow time at the close of the Pleistocene for an uplift and a depression. If the emergence that followed the accumulation of the bone bed was contemporaneous with the Wisconsin glaciation, the bone bed might well have been formed during the Peorian or fourth interglacial stage.

The purpose of this paper has been simply to describe the stratigraphy of the region in which human remains have been found and to endeavor to ascertain the ages of the various beds. I have given no details regarding the manner of occurrence of the human bones and artifacts because I have not been so fortunate as to find any human remains myself nor to be present when they were discovered by others. I have assumed that the association of human remains with the Pleistocene fauna as reported by Dr. Gidley is so well authenticated that there seems little reason to doubt that man actually lived in Florida during the latter part of the Pleistocene.

Is it after all so surprising to find him there? Need we assume for man a more rapid evolution than that of other almost equally complex mammals? Nearly all of the existing species of mammals are survivals from the Pleistocene. The essential difference between the Pleistocene and the Recent faunas is one of quantity rather than kind. Many species became extinct during or at the close of the Pleistocene, but few new species or subspecies originated during that time. One would therefore expect to find that the Pleistocene progenitors of the modern man are indistinguishable from ourselves. Other contemporary races of primitive man that are now extinct represent collateral lines and are not our ancestors.

The presence of man in America, assuming that he originated in the old world, is no more difficult to explain than the presence here during by-gone ages of camels, horses, elephants, rhinoceroses, and other genera that are now restricted to Africa or Asia.

PALEONTOLOGY.—*Characteristic mammals of the Early Pleistocene.*[1]
OLIVER P. HAY, Washington, D. C.

For the writer the Pleistocene is the equivalent of the Ice Age. We may say that it began when the first ice sheet, the Nebraskan, had pushed southward to about the 55th degree of latitude. It had perhaps even then begun to disturb the ancient drainage systems. It ended when the Wisconsin glacier had retreated to the same latitude, opening up the main river systems of our times. Within that interval there had occurred momentous changes in the physiography of our continent, in its climates, and in its highest forms of animal life.

I wish to discuss especially the composition of the mammalian life of the Pleistocene and some of the changes which it underwent.

The kinds of mammals that existed on our continent during the late Pliocene are not sufficiently well known. We know, however, that there were present a few edentates, various carnivores of dog-like and cat-like forms, mastodons, tapirs, horses (possibly not yet *Equus*), peccaries, camels, and antelope-like hoofed animals. After the close of the Pliocene no doubt some of those mammals, somewhat modified, lived on into the Pleistocene. We are sure that a few of the edentates did so; also some of the tapirs, peccaries, camels, and some of the early horses.

About the beginning of the Pleistocene a passage was opened up

[1] Received July 20, 1928.

between Asia and North America. Over this many kinds of Old World mammals entered our continent. Elephants of perhaps several species, new mastodons, bisons, musk-oxen, deer, moose, wolves, tigers, possibly horses and camels, descendants of former migrants from this country into Asia, pressed in and spread over the land. About the same time, perhaps a little earlier, a highway was established between South America and North America and our land was invaded by the strange fauna of the southern continent. The most conspicuous of these animals belonged to the order of Edentates, and consisted of huge ground-sloths, armadillos, and glyptodons. More than a dozen genera of these edentates have been described; and they varied in size from that of the existing Texan armadillo to that of an elephant. Our early Pleistocene mammalian fauna was, therefore, a product of three continents and it was a fauna probably more abundant in numbers and more diverse in species than any other known.

About the genera and species of mammals which existed in our country during the first glacial stage we know little or nothing, I mean little that is derived from actually discovered remains. We can only judge as to their general nature from those which preceded them and those which followed them.

I shall now attempt to show that certain important elements of the mammals I have mentioned existed in our country in what is believed to be the first interglacial stage.

Along the Missouri River, from the northwestern corner of the State of Missouri to the mouth of Sioux River and along this to the northwestern corner of Iowa, at many localities, have been discovered deposits, gravels and sands, intercalated between the first (Nebraskan) and the second (Kansan) drifts. These gravels and sands are known as Aftonian deposits. In these have been discovered a considerable number of fossil mammals. In one gravel pit near the town of Missouri Valley, 18 species have been reported. Of these, 90 percent are extinct. They represent eight families and twelve genera. There are two species of ground-sloths (*Megalonyx* and *Mylodon*), three species of elephants, one or two of mastodons, four species of horses, at least one species of camel, a moose, a bison, a musk-ox, a goat, the existing bear, and a beaver.

In this one pit, therefore, have been found representatives of 8 families of mammals, *Megatheriidae* (ground-sloths), *Castoridae* (beavers), *Elephantidae* (elephants), *Equidae* (horses), *Camelidae* (camels), *Cervidae* (deer), *Bovidae* (oxen), and *Ursidae* (bears).

Near Akron, Plymouth County, were found two teeth of *Stegomastodon mirificus* in Aftonian deposits. In a deposit of the same stage, at Mapleton, Harrison County, was found a fine tooth of *Elephas imperator*. At Afton, Iowa, were collected foot bones and a tooth of *Hipparion*. At Rockport in northwestern Missouri, in the Aftonian sands and gravels, were found a foot-bone of a horse, a tooth of a camel, and a molar tooth of *Hipparion*.

Near the present post-town of Peters, Sheridan County, in northwestern Nebraska, near Niobrara River, in a deposit of sand lying between 50 and 100 feet above the little tributary of the river, were collected many years ago about 20 species of mammals. Of these at least 70 percent are extinct. The fossils represented 13 families and 16 genera. These include two genera of ground-sloths, two dogs, an extinct genus of bears (*Arctotherium*), a prairie dog and a musk-rat, a field mouse, two elephants, one of them *Elephas imperator*, an extinct genus of peccaries, three species of camels, two species of prong-horn antelopes, one possibly the existing species, the other the extinct *Capromeryx furcifer*. The bed of sand containing these fossils is about 12 feet thick and overlies late Tertiary deposits. Since the bed was laid down, Niobrara River has cut its valley nearly 100 feet deeper.

I ask you now to consider Pleistocene fossil mammals which have been found in the canyon of Tula Creek, Briscoe and Swisher Counties, Texas. During probably the early part of the Pleistocene, by a quickening of a stream, approximately 100 feet of deposits were removed from the Miocene. Then came a change either in a reduced slope of the country or in a smaller amount of water or both, and deposition recommenced. There was laid down first about 30 feet of coarse sand, over this 15 feet of bluish clay, then again course sand, and finally 25 feet of fine white sand. This variation in the materials implies changes in climate and of elevation, and consequently this deposition of 90 feet of sand and clay required a long time. Then occurred a more momentous change in affairs. The region must have been considerably elevated as also the country west of it, for extensive cutting began. This continued until a broad valley had been eroded through all of that 90 feet of Pleistocene materials, then through the Miocene and down into the Triassic clay below. That canyon so cut is, less than 10 miles farther down, 400 or 500 feet deep. We can not doubt that those deposits belong to an early stage of the Pleistocene.

Now in the first coarse sand laid down and in the last stratum of fine sand have been found numerous specimens of Pleistocene mammals.

About 20 species have been collected. These include a ground-sloth (*Mylodon*), a glyptodon, two elephants, one being *Elephas imperator*, from four to six species of horses, a peccary, four species of camels and two species of dogs. All of the species collected are now extinct.

I ask you now to consider a fourth important locality, one whose geology certifies to the age of the fossils discovered.

Frederick, Tillman County, is in southwestern Oklahoma, about 12 miles north of Red River. From the town there runs northward for about ten miles a prominent ridge, and this near the town stands about 100 feet above the adjacent country. In one side of this ridge a sand and gravel pit has been opened and is being extensively operated. The ridge is found to be a filled-up and abandoned river bed, probably that of the ancient North Fork of Red River. The filling consists of, first, a stratum a foot or two thick, of broken rocks and gravel cemented by carbonate of lime, forming a mass of considerable hardness. Above this is a rather hard sandstone of about the same thickness. This is overlain by some ten to fifteen feet of compact sand and gravel; while above all comes about three feet of a red clay. The whole rests on a red clay of Permian age. At present the North Fork runs about ten miles west of Frederick and at a level of 200 or more feet lower down.

Now principally in the lowest cemented layer, but to some extent in the compact sand, have been discovered numerous fossil bones of mammals. Since they were buried there the river valley was filled and choked up, the river diverted into other channels, and the immediate region has been eroded away more than 100 feet, while further west probably more than 200 feet. It will be understood at once that a very long time must have been required to accomplish that work. Inasmuch as the animals found there are in general the same as those found in the three other localities mentioned it is concluded that the time of their burial was during the first interglacial stage. The fossils collected consist of a megalonyx, a mylodon, a mastodon, a glyptodon, three or four horses, a large tapir, a large and a small camel, a peccary, an elephant more primitive than *E. imperator*, two other elephants, a mastodon which appears to belong to the long-jawed genus *Gomphotherium*. All of the species are extinct.

Collecting together then the animals found in the western Iowa localities (1), that on Niobrara River (2), that in Tula Canyon (3), Texas, and that at Frederick (4), Oklahoma, we have the following list:

Megalonyx jeffersonii 1, 2, 4	Symbos cavifrons 1
Mylodon harlani 1, 2, 3, 4	Aftonius calvini 1
Glyptodon petaliferus 3, 4	Bison sp. indet. 1
Equus complicatus 1, 3, 4	Elephas haroldcooki 4
E. niobrarensis 1, 2	E. imperator 1, 2, 3
E. laurentius 1	E. columbi 1, 2, 3, 4
E. scotti 3	E. boreus 1, 4
E. excelsus 1, 2, 3	E. primigenius ? 4
E. calobatus 3	Mammut americanum 1
E. tau ? 3	M. progenium 1
E. semiplicatus 3	Stegomastodon mirificus 1
Tapirus haysii 4	Gomphotherium sp. nov. 4
Platygonus compressus 3	Castor canadensis 1
P. sp. indet. 2, 4	Castoroides ohioensis ? 2
Camelops huerfanensis ? 3	Microtus sp. indet. 2
C. vitakerianus 2	Ondatra nebrascensis 2
C. macrocephalus 3	Thomomys sp. indet. 2
C. kansanus 2	Cynomys ludovicianus 2
C. hesternus 3	Lepus sp. 4
C. niobrarensis 4	Ursus americanus 1
Lama sp. nov. 4	Arctotherium sp. indet. 2
Camelus americanus 2	Ænocyon dirus 3
Eschatius conidens 3	Canis occidentalis ? 2
Alces shimeki 1	C. texanus 3
Capromeryx furcifer 2	C. latrans 2
Antilocapra americana ? 2	Smilodon nebrascensis 2

In this list there are included more than 50 species which appear to have lived during the first interglacial stage. I do not see how this conclusion can be escaped. Most of those of the list represent mammals which are to be found in deposits all over the Great Plains into Texas and Mexico and many of them are found in Florida and South Carolina. When white men discovered this continent the great majority (80 percent) of the animals here listed no longer existed.

Now the question arises: Did all of these animals that are now extinct, and many others not here mentioned, live on until near or into the Recent epoch and then suddenly disappear, or did the extinctions occur at various times during the first interglacial stage and since that time?

What can we learn about the longevity of mammalian genera and species on comparing them with genera and species of mollusks? Several genera of mollusks have persisted ever since the Jurassic; many more from the Cretaceous. The oldest living genus of mammals is, I think, *Didelphis*, the opossum, and this comes down to us from only the Eocene. Following Matthew's list[2] we find that of

[2] Bull. U. S. Geol. Surv. No. 361.

90 Miocene genera only 11 now exist (12 percent); of species none. With few exceptions the Miocene species do not continue from one formation to the next. In a geological sense, therefore, mammalian genera and species are short-lived. This being true I hold that it is improbable that all of the species of the list presented lived until the close of the Pleistocene. In that first interglacial stage there were thrown together three incongruous faunas, and it was inevitable that in the struggle for existence some would succumb. This would have happened even if the physical environment were favorable, but with the changes resulting from three or four glacial stages and two or three interglacial stages extinctions would be multiplied.

The fact that the collections from the older Pleistocene deposits show a much higher percentage of extinct forms than from known later ones is evidence that the extinctions occurred at all times. Had all the first interglacial species lived until the end of the Pleistocene, collections from all of the stages would show approximately the same percentage of extinct species.

The history of the Pleistocene animals of Europe shows that the older deposits contain a higher proportion of non-existing species, the majority or all of the earliest deposits being extinct.

Out of the list which has been presented I select the following species as being a part of those of which we find no traces after the close of the first interglacial stage, or at least, after the Kansan glacial stage.

Glyptodon petaliferus
Equus niobrarensis
E. laurentius
E. excelsus
E. semiplicatus
E. calobatus
Camelops huerfanensis
C. hesternus
C. niobrarensis
C. vitakerianus
C. macrocephalus
C. kansanus
Eschatius conidens
Camelus americanus
Elephas haroldcooki
E. imperator
Smilodon nebrascensis

To these I add the following because they have been found associated with those of the number just given and are evidently of the same geological age.

Smilodon floridanus
Neochœrus pinckneyi
Stegomastodon mirificus
Megatherium mirabile
Chlamytherium septentrionale

Here are listed 22 species of large and important animals of which the writer affirms that they have not been found at any locality the geology of which can be determined as being later than the first interglacial or the second glacial stages. In support of my position I present the following five sources of evidence.

1. Remains of none of these species have been found in deposits overlying either the Kansan, the Illinoian, or the Wisconsin drift sheets. Many other extinct species have been found in such deposits, ground-sloths, a horse or two, the giant beaver, various species of peccaries, elephants and mastodons. Species of the last list furnished may be found around the borders of these drift sheets; and it is for those who believe in their late existence to explain why these animals did not venture to cross the moraines. The mastodons and the elephants, *Elephas boreus* and *E. columbi*, which more than once were driven from the glaciated regions returned to their old pastures. The camels which inhabited western Iowa did not return.

2. In a fissure in northwestern Arkansas Barnum Brown collected about 50 species of mammals. These appear to have lived about the time of the Illinoian drift stage. Not one of the species of the last list presented was found there.

3. A considerable number of collections of fossil mammals have been made in the Appalachian Mountains from Lookout Mountain, in southern Tennessee, to Frankstown, Pennsylvania. At Lookout Mountain have been found a small horse, a ground-sloth and a tapir. From Winterburg, in northeastern Tennessee, there have been described 18 species of mammals, including 2 horses, a tapir, 3 deer, and *Elephas boreus*. In Wythe County, Virginia, Cope long ago collected 19 species of Pleistocene mammals, among them a megalonyx, a tapir, a horse, a peccary, a bison, and an extinct bear. From a cave in western Maryland the writer has recorded 24 species of mammals, including 2 horses, 6 peccaries, 2 deer, an elephant, probably *Elephas columbi*, and one species of saber-tooth tiger. From a fissure in limestone, near Corriganville, Maryland, Gidley collected 40 or more species of mammals, among them an extinct bear, a mastodon, a horse, a tapir, 5 species of peccaries and many small species of rodents.

Near Frankstown, Pennsylvania, 10 miles south of Altoona, in a limestone cave, were collected by the Carnegie Museum, Pittsburgh, a considerable number of fragmentary fossils, a megalonyx, a tapir, a peccary, a bison, a mastodon, 2 bears, the dog *Ænocyon dirus*, a musk-ox, and a horse.

Now all of these collections made in the Appalachian ranges appear to belong somewhere about the middle of the Pleistocene, in possibly the Yarmouth or the Sangamon interglacial stages. In none of them are there any of the forms which I regard as peculiar to the first interglacial. If these species were then living it is hardly comprehensible that they did not occupy that region. At Nashville a large camel, perhaps a species of *Camelops*, has been found, accompanied by 2 species of horses, a *Mylodon*, and a deer; but these fossils occurred in stratified deposits at a depth of 30 feet and on a level with low water in the river; so that there is no reason for believing that they are not old. The occurrence of these at that locality shows that these animals were once able to visit that region.

4. The Mississippi embayment extends from Cairo to the Gulf. On each side of the river is a deposit which has been called the Port Hudson. In this deposit at various localities have been found important fossils.

From a deposit of blue clay believed to belong to this Port Hudson, and overlain by some 50 or more feet of a later deposit, situated near Natchez, Mississippi, or possibly partly collected from the later deposit, have been described the following seventeen species of mammals:

Megalonyx jeffersonii
M. dissimilis
Mylodon harlani
Ereptodon priscus
Equus complicatus
E. leidyi
Tapirus haysii
T. terrestris
Odocoileus virginianus
Symbos cavifrons
Bison latifrons ?
Mammut americanum
Elephas columbi ?
Castoroides ohioensis
Ursus americanus
U. amplidens
Felis atrox

In Louisiana, in this Port Hudson, have been discovered at various localities mastodons, elephants, mylodons, megalonyx, horses, and tapirs. These genera and species are such as lived during the middle portion of the Pleistocene. We have, however, no account of there having been found, either in Louisiana, or any of the states bordering on the Mississippi as far north as Cairo, any camels or any of the other extinct animals the writer named as characterizing the first interglacial deposits. They abound, however, in Texas, and again in Florida. On account of the mild climate we might expect to find in this embayment *Megatherium, Glyptodon, Elephas imperator*, various camels, capabaras and saber-tooth tigers. If they ever left their bones and teeth in this Mississippi River region the remains appear to have been swept away by the floods of that great stream or to have been buried out of sight in its later deposits.

5. There is another important deposit in which we might expect

to find descendants of the early Pleistocene animals named, if there were any such descendants. This deposit, laid down during probably two distinct stages of the early middle and late middle Pleistocene, is known as the loess, a wind-laid element. It is found as a deep deposit along the Mississippi River from Natchez to northern Wisconsin and along the Missouri River to western Iowa and beyond. In places it abounds in land shells, but it has afforded here and there a few vertebrate fossils. In a deposit of loess at Alton, Illinois, the following list of 15 species of mammals were discovered many years ago.

Megalonyx jeffersonii	Bison sp. indet.
Equus sp. indet.	Mammut americanum
Platygonus cumberlandensis ?	Castor canadensis
Sangamona fugitiva	Marmota monax
Cervalces roosevelti	Castoroides ohioensis
Rangifer muscatinensis ?	Geomys bursarius
Taurotragus americanus	Ursus americanus
Symbos cavifrons	

It will be observed that at least two-thirds of these fossils are of extinct species. This suggests that their time of existence was well back in the Pleistocene. Dr. Leighton, who studied[3] the situation, was unable to determine with exactness the ages of the two beds of loess which overlay the bones. The lowest bed may be as old as the late Illinoian or early Sangamon stages. At any rate, none of the species regarded by the writer as belonging to the early Pleistocene are present in the collection.

The writer maintains therefore that he has demonstrated that the list of 50 species of mammals given on page 425 lived during an early stage of the Pleistocene, probably the first interglacial, or Aftonian, and that, further, he has shown that those species have not been found to have existed after that stage.

If we extend now our investigations into Florida we shall find some interesting facts.

At Arcadia many years ago about 25 species of vertebrate fossils were obtained. These consist of 15 mammals, an alligator, turtles, sea fishes, and sharks. The principal mammals are a megalonyx, *Chlamytherium septentrionale*, two species of *Glyptodon*, two horses, a tapir, a mastodon, and two elephants, one of which is *Elephas imperator*. Here we have many of the same genera and some of the same species as we have found in the four localities we have examined west of the

[3] Journ. Geol. **29**: 505–514.

Mississippi River. *Chlamytherium* we have not mentioned in any collection until now, but it is found in Texas associated with other early Pleistocene fossils.

A second locality furnishing similar fossils is near Vero, St. Lucie County. From a deposit about 2 feet thick have been described about 30 species of mammals besides birds and reptiles. Among the mammals are *Chlamytherium*, three species of horses, two tapirs, a camel, a bison, the mastodon, the giant capybara (*Neochœrus*), a large tiger, and the floridan saber-tooth, *Smilodon*. In a sandstone of quite certainly the same geological age the skull of *Elephas imperator* was collected.

At Melbourne, Brevard County, Dr. J. W. Gidley and Dr. F. B. Loomis collected many vertebrate remains, among them *Elephas imperator*, three species of horses, one or more camels, *Chlamytherium*, and *Glyptodon*. It is wholly improbable that if these species existed during the middle and late stages of the Pleistocene, they had become so degenerate that they could not occupy the regions that I have mentioned.

The writer believes, therefore, that he is justified in maintaining that the deposits and their fossils found in the localities named and in other places in Florida and in Texas belong in the first interglacial stage. If there are yet those who believe otherwise it seems to be incumbent on them to present their reasons therefor.

PALEONTOLOGY.—*A new species of bear from the Pleistocene of Florida.* JAMES W. GIDLEY,[1] U. S. National Museum.

Two excellent papers recently published, one by Merriam and Stock[2], the other by Kraglievich[3], have done much to lessen the confusion which for many years has existed regarding the proper classification and relationship of the Arctotheres of the Western Hemisphere. Merriam and Stock placed the group under a subfamily of the Ursidae, Tremarctinae, to include the living genus *Tremarctos*, *Arctotherium*, and, doubtfully, *Arctodus*. They recognized five described species from the Pleistocene of North America, and

[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 13, 1928.

[2] *Relationship and structure of the short-faced bear*, Arctotherium. Contr. Paleont., Carnegie Institution of Washington, **347**: 1–33, 10 plates, 1925.

[3] *Los Arctoterios Norteamericanos*. Ann. Museo Nac. Hist. Nat., **34**: 1–16, 1 plate, 1 text fig., 1926.

placed them, with the exception of *Arctodus pristinus*, in the genus *Arctotherium*, which is based on a South American Pleistocene species, *A. latidens*. These authors recognized the nearer approximation of *A. haplodon* Cope (Port Kennedy Cave) to the living *Tremarctos* as compared with the western species.

In his valuable work cited above, Lucas Kraglievich has pointed out the generic differences between *Arctotherium latidens* and other South American species and the North American species referred to that group, proposing a new genus, *Tremarctotherium*, to include the species *yukonense* Lambe, *simum* Cope, *californicum* Merriam, and doubtfully *haplodon* Cope. This arrangement, satisfactory in other respects, still leaves in doubt the status of *Arctodus* Leidy,[4] the first-named genus of this group. As is generally known, the genotype, *A. pristinus*, was based on a single lower second molar from Pleistocene deposits of the Ashley River at Ashley Ferry, South Carolina. The type has apparently been lost and by some this has seemed sufficient reason for discarding both the species and genus as indeterminate. Since, however, the excellent figures and description given by Leidy are sufficiently clear and the characters shown are such that its place in the Arctothere group can be established without much question, the name should be retained regardless of what disposition is made of *Tremarctos* and the other genera of the group.

Several specimens from the Pleistocene deposits at Melbourne, Florida, representing a new species here described, evidently belong to the *Arctodus* group and furnish additonal reasons for reestablishing the genus.

A critical comparison of Leidy's figures and description of the type specimen with the corresponding tooth in Cope's type of *Arctotherium* ("*Ursus*") *haplodon* seems to leave little doubt regarding the close relationship of these species. Their size and general proportions are identical, the only difference of importance being the slightly greater width of the talonid portion of the tooth in *A. haplodon*, a difference which seems not of more than specific significance and may come within the range of individual variation.

The new species from Florida is in many ways intermediate between *Arctodus* and the living *Tremarctos*, but certain features seem to exclude it as well as *A. haplodon*, and, by inference, also, *A. pristinus* from the South American genus. *Arctodus* then, as now recognized, comprises the following species: *pristinus* Leidy, *haplodon* Cope, and

[4] Proc. Acad. Nat. Sci. Phila., 7: 90, 1854; LEIDY in HOLMES, *Post-Pleistocene of South Carolina*, p. 115, *pl. 23, figs. 3, 4*, 1860.

floridanus Gidley. It may be distinguished from *Arctotherium* by the greater relative length of the molars; the relatively greater expansion of the heel, or posterior expansion of upper m^2; and the relatively broader, flatter, and finer tuberculated area in the upper molars included between the continuous protocone-hypocone ridge and the bases of the main two outer cusps forming the paracone-metacone ridge. *Arctodus* may be distinguished from *Tremarctos* by its distinctly longer relative space occupied by the premolars, indicating a longer muzzled species; the relatively deeper proportions of the jaw; and the distinctly higher position of the point on the anterior border of the coronoid process where it is met by the anterior end of the ridge which divides the masseteric fossa and the antemasseteric pit.[5]

There are doubtless other and perhaps better generic characters that may be observed when the species comprising the genus are better known.

In March, 1926,[6] Peterson described some fine material of a bear which he referred to "*Arctotherium haplodon* (Cope)," with which it agrees very closely in size. However, if the figures may be relied on for comparison, it seems to belong rather definitely to the western genus *Tremarctotherium* Kraglievich, as is decided by the very narrow talon of m^2 and the apparent absence of the finely tuberculated areas of the molar in general.

Arctodus floridanus, new species

Type: Parts of skull and jaws with dentition represented by upper I^3; all the canines; left lower pm_4; left lower $m_{1\,\&\,3}$, right lower m_2; upper $m^{1\,\&\,2}$ of both sides; and alveoli of the left upper incisors and left pms 2 & 3. (Catalogue number 11,833, U. S. National Museum.)

Paratypes: Teeth from the same locality and horizon as the type (Catalogue Nos. 11,473, 11,474, 11,475, U. S. National Museum) and an upper m^2 from Florida, exact locality not known (No. 11,476).

Type locality and horizon: Country Club golf course, 2 miles west of Melbourne, Florida. Lower stratum of "No. 2 bed" of Sellards; Pleistocene.

Diagnosis: Size intermediate between the large *Arctodus haplodon* Cope and the living South American bear *Tremarctos ornatus* Gervais. Molars relatively long as in *T. ornatus;* relatively long diastema between lower premolars 2 and 3 and a somewhat shorter one between p_3 and p_4. Lower jaw relatively deep, depth at m_1, including this tooth, as great as the combined length of the molar series; antemasseteric fossa relatively deeper and larger than in *T. ornatus.*

Arctodus floridanus is distinguished from *A. pristinus* and *A. haplodon* by

[5] This name is proposed to avoid the use of the customary misnomer, "double masseteric fossa."

[6] *The fossils of the Frankstown cave, Bliss County, Pennsylvania.* Ann. Carnegie Mus., **16**: (no. 2) 286–292, *pls. 24, 25.* 1926.

its smaller size and relatively narrower molars as well as by a tendency to greater numbers of the minute tubercles of the flat triturating surfaces of the molars.

COMPARATIVE MEASUREMENTS

	Arctodus floridanus Gidley Type	*Arctodus haplodon* Cope Cast of type	*Tremarctos ornatus* Gervais No. 210324 Dept. Biol. U.S.N.M.
	mm.	*mm.*	*mm.*
Upper dentition			
Length[7] of I^3 (base of crown)	10.3	.....	7.7
Width of I^3	9.3	.....	8.0
Length of canine (base of crown)	22.2	.....	18.3
Width of canine	14.6	.....	11.5
Length of m^1	19.7	.....	17.5
Greatest width of m^1 (posterior half)	15.7	.....	14.2
Length of m^2	31.0	.....	25.5
Greatest width of m^2 (anterior half)	16.6	.....	14.2
Lower dentition			
Length of canine (base of crown)	22.5	30.5	17.0
Width of canine	14.5	16.6	11.0
Length of p_4	9.0	11.0 (est.)	8.0
Width of p_4	5.6	.....	5.5
Length of m_1	22.3	28.0	20.0
Width of trigonid m_1	9.5	12.5	8.5
Width of talonid m_1	11.5	15.0	10.0
Length of m_2	22.0	25.6	20.0
Width of trigonid m_2	14.2	18.1	12.0
Width of talonid m_2	14.2	19.0	12.0
Length of m_3	18.2	21.2	14.5
Width of m_3	13.8	16.3	12.0
Length of dental series (canine to m_3)	133.7	164.0 (est.)	103.5
Depth of jaw at and including m_1	65.0	75.0	49.0
Diastema between p_2 and p_3	11.3	9.0	none
Diastema between p_3 and p_4	5.5	7.5	none

[7] Length = antero-posterior diameter. Width = transverse diameter.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

397TH MEETING

The 397th regular meeting was held December 1, 1927, in Room 43 of the National Museum. Vice-president J. E. Graf presided.

Program: Dr. S. B. FRACKER: *Control activities on the pink bollworm in the Southwest.* This subject is of interest from two standpoints: (1) The insect is attacking a crop of enormous value, a leading agricultural resource of this country; (2) the apparent total eradication of the pink bollworm where it became established in the main cotton belt of eastern Texas and Louisiana was a noteworthy achievement. The present distribution of the insect includes practically all the cotton-growing areas between the Pecos River in Texas and New Mexico on the east and Tucson, Arizona, on the west. Of these areas the Arizona and western New Mexico portions are now the subject of clean-up measures and attempted eradication. In the Rio Grande Valley, however, the United States is subject to continuous infestation from Mexico and the elimination of the pink bollworm from that section is not being attempted. Present operations include search for new infestations, sterilization of all cottonseed in the infested areas, compression and fumigation of all cotton lint produced before being moved to outside points, the maintenance of road stations to prevent tourists from transporting cotton bolls, and clean-up activities in the western part of the area to eradicate infestations if possible.

Discussed by MARLATT and HOWARD.

Dr. A. C. BAKER: *The campaign of eradication of the Mexican fruitworm* Anastrepha ludens. The speaker gave a brief summary of the origin of the work and its progress and growth to date, and indicated on a map the various areas of infestation and centers of control operations. Details illustrating the various ramifications of the work were brought out, especially the co-operation of citrus growers, Rotary clubs, Chambers of Commerce, press service, and prominent citizens in eradication campaigns. A résumé of inspection activities was also given.

Discussed by BISHOPP, CURRIE, MARLATT, and HOWARD.

President DAVID L. CRAWFORD of the University of Hawaii made a brief address, emphasizing his special interest in Dr. Baker's paper because of his own work several years ago on the same problem. He discussed some of his observations made in Hawaii on the pest and outlined the status of the parasite control work. He also gave a short account of the work and scope of the Entomological Society of Hawaii.

Dr. GEORGE SALT, of Bussey Institute, discussed recent observations on banana insects in the San Marcos region of Colombia, notably a bee, *Trigona amalthea* Oliv., and a beetle, *Colaspis hypochlore* Laf. He gave information regarding the life history, habits and control of *Colaspis hypochlore* Laf., which in recent years has been an important pest of bananas, especially in low and wet areas. Good results have been obtained by drainage when lack of rainfall permitted.

Mr. C. P. CLAUSEN referred briefly to some of his recent activities in India in connection with collection and study of parasites of the Japanese beetle *Popillia japonica* Newm. At Shillong, he was especially fortunate in having the best possible location in the entire country for handling the parasite work on a large scale.

Mr. S. S. CROSSMAN, of the Gypsy Moth Laboratory, Melrose Highlands, Massachusetts, gave an account of the conditions following the recent flood disaster in Vermont. He also gave a short résumé of the present status of the gypsy moth work in New England, including a review of the parasite situation since 1905. He emphasized the fact that the data thus far assembled in Europe, on parasites, especially the marked variations in species that predominate in certain sections, indicate that studies of this kind should be made over a considerable period of years in order to obtain best results.

The regular program was followed by the annual election of officers. Those elected for the year 1928 are as follows: *Honorary President,* E. A. SCHWARZ; *President,* S. A. ROHWER; *First Vice-president,* J. E. GRAF; *Second Vice-president,* A. C. BAKER; *Recording Secretary,* J. S. WADE; *Corresponding Secretary-Treasurer,* S. A. ROHWER; *Editor,* W. R. WALTON; *Executive Com-*

mittee, the officers and C. T. GREEN, A. N. CAUDELL, and T. E. SNYDER; Representing the Society as a Vice-president of the Washington Academy of Sciences, A. G. BÖVING.

398TH MEETING

The 398th regular meeting was held January 5, 1928, in Room 43 of the National Museum. President ROHWER presided. The annual reports of the Recording Secretary, the Editor, and the Corresponding Secretary-Treasurer were read and approved, and the latter referred to an auditing committee.

The President reported the recent death of a member of the society, Mr. Jacob Kotinsky. T. E. SNYDER and A. N. CAUDELL were appointed to draw up suitable resolutions for presentation at the next meeting, for the records of the society, and for the bereaved family.

Program: R. C. SHANNON: *Experiences in the Argentine.* The speaker gave a brief general survey of the Argentine, its location, physical contour, agriculture, imports, exports, character of inhabitants, social customs, etc. Then he outlined his itinerary and summarized his entomological observations, especially his work on various species of mosquitoes, notably *Anopheles pseudopunctipennis* Theobald and related species, concerning which much detail was given. Maps of the region were shown and locations of more important studies and observation points were indicated. Mr. Shannon hopes at some future date to give a paper covering trips to Patagonia, the Bolivian border, and the Cataracts of Iguazu. Mr. Shannon adds the following: "I would like to state that my references to the life zones of Argentina, about which there was some controversy, were very brief remarks abstracted and summed up from a paper which I presented at the Argentine Entomological Society and which has probably been printed by this time in the Anales de la Sociedad Entomologica Argentina. This paper is entitled 'Contribution to the Study of the Life Zones of Argentina.' The different regions which I indicated in my talk are primarily based upon the physiographic and climatic features, coupled with the presence or absence of forests. In most of these areas, I found species of insects which appear to be peculiar to them; no doubt many occur, and it is, in general, evident that they represent natural areas so far as fauna and flora are concerned. In view of the above, it would be better to call these regions 'physiographic zones.' I feel sure, however, that these different zones will be found to coincide closely with the life zones which would be proposed by the ecologist."

Discussed by HYSLOP, ALDRICH, SNYDER, BISHOPP, and ROHWER.

Dr. F. C. CRAIGHEAD: *Forest insects.* A brief summary of major investigations of several of the more destructive species of tree-killing bark beetles of the genus *Dendroctonus* was given. By means of maps, blackboard diagrams, lantern slides and specimen report forms, the various areas of greatest infestation were located, the character and extent and methods of estimating injury were described, and control operations were reviewed. Some noteworthy details were brought out, such as the recent use of airplanes in estimating losses by forest tree insects, and the relation of "blue stain" fungus to insect injury in various sections of the country.

Discussed by ALDRICH, HYSLOP, ST. GEORGE, WALTON, CURRIE, and McINDOO.

Dr. B. A. PORTER of Vincennes, Indiana, a non-resident member, made a few remarks. He stated that he especially enjoyed the meeting because there was no mention of codling moth or of poison residues.

399TH MEETING

The 399th regular meeting was held February 2, 1928, in Room 43 of the National Museum. President S. A. ROHWER presided.

Program: J. A. HYSLOP: *Our most important insects* (address of the retiring president). The speaker commented on the present tendency in economic entomology to follow the line of least resistance. From a vote cast by the working entomologists of the country as to the relative importance of the several insect pests throughout the United States, it would appear that the ten most important insects, in their order of importance, are: Codling moth, cutworm, San José scale, bollworm, grasshopper, plum curculio, boll weevil, Hessian fly, potato leafhopper, and white grub. The insects were then taken up in detail and a careful analysis made of the actual damage done by each, as near as can be ascertained. From this analysis the author concluded that the ten most important insects in the United States, in their order of importance, are: Mosquito, boll weevil, bollworm, spruce budworm, potato leafhopper, Hessian fly, grasshopper, cattle grub, cutworm, and chinch bug. The next ten insects in importance are: Potato beetle, cattle fly (other than grub), termite, corn root worm, alfalfa weevil, plum curculio, codling moth, apple aphid, army worm, and bark beetle. The granary pests would rank seventh in this list if taken as a group. (*Author's abstract.*)

Discussed by ROHWER, HOWARD, MORRISON, LARRIMER, GRAF, BISHOPP, SNYDER, MANN, SASSCER, and BURGESS.

CURTIS P. CLAUSEN: *Entomology in Japan.* An account of the development of entomological science in Japan from the time of its inception, approximately fifty years ago, to the present time was given, and the leading entomologists of the present day were mentioned. An account was given of the lines of investigation being conducted by the various laboratories under the Department of Agriculture and Commerce, the Imperial Universities, the Plant Quarantine Service, the provinces and the private institutions. The principal economic problems were discussed and compared with those of other oriental countries and of the United States. (*Author's abstract.*)

Discussed by BURGESS, HOWARD, and HYSLOP.

Dr. LOREN B. SMITH, of the Japanese Beetle Laboratory in New Jersey, spoke briefly about his work. He emphasized the extreme difficulty of making really satisfactory estimates of injury by Japanese beetle because of the many factors to be considered, especially the varying value of injured trees—some being worth only sale value of the wood therein, whereas others, located on fine estates, possess a high valuation for aesthetic reasons. He also reviewed briefly investigations during the past summer on the digestive system of the Japanese beetle in relation to the toxic effects of various chemicals, and effects on insects of what may possibly prove to be variations of radiant energy from various portions of the spectrum.

J. S. WADE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

WM. D. JOHNSTON, Jr., has been appointed assistant geologist and RALPH M. LEGGETTE junior geologist in the Water-Resources Branch of the U. S. Geological Survey.

FRANCIS G. WELLS has been appointed junior engineer in the same branch of the Survey.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, Oct. 2. The Botanical Society.
Wednesday, Oct. 3. The Medical Society.
The Engineering Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Journal of the Washington Academy of Sciences

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JOURNAL

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VOL. 18 OCTOBER 4, 1928 No. 16

MATHEMATICAL STATISTICS.—*On damping effects and approach to equilibrium in certain general phenomena.*[1] BIRGER MEIDELL, University of Oslo, Norway (Communicated by RAYMOND PEARL).

1. INTRODUCTION

In various branches of applied mathematics one is often confronted with problems which involve a certain function of the time, called the *resultant* $W(t)$ in what follows, that can be looked upon as built up through a cumulative process started and continually kept up by another function of time, the *originator* $n(t)$, the effect of which on $W(t)$ is brought about through the intervention of a certain function of *elapsed* time, the *distributor* $w(\xi)$.

The following are some instances drawn from the field of population statistics: The total existing population, or certain subgroups of the population, such as the number of men, or women, or men in certain age groups, at a certain moment of time, or the annual number of deaths or of marriages, are all resultants, i.e., functions of time which are originated through another function of time, namely the number of births in previous years; in these examples, the distributors are certain functions derived from the age distributions at death, at marriage, etc. Again, the total reserve at a given moment for a particular kind of insurance is a resultant which is originated through the "production," i.e., the new insurance written each year; here the distributor is the

[1] Received June 8, 1928. The present paper is a revised and somewhat generalized version of the author's article *Ueber periodische und angenäherte Beharrungszustände,* Skandinavisk Aktuarie Tidskrift. 1926.

function of elapsed time that represents the total reserve resulting from a unit of production of one year for the kind of insurance considered.[2]

In all the above cases the effect of the distributor is *limited* by the maximum length of human life. An analogous limitation is present in a great variety of cases occurring in other fields.

The most important case is perhaps that in which the cumulative process is such that the originator-element $n(\tau)d\tau$ for the moment of time $t = \tau$ is the cause of a contribution of amount $w(\xi)n(\tau)d\tau$ to the resultant at the subsequent moment of time $t = \tau + \xi$. We then have, since $w(\xi) = w(t - \tau)$,

$$W(t) = \int_{-\infty}^{t} w(t - \tau)\, n(\tau)\, d\tau \ldots\ldots\ldots\ldots\ldots (1.1)$$

As, however, the originating process will in general start at some definite time which we may select for $t = 0$, we may assume $n(\tau) = 0$ for $\tau < 0$; thus we obtain

$$W(t) = \int_{0}^{t} w(t - \tau)\, n(\tau)\, d\tau \ldots\ldots\ldots\ldots\ldots (1.2)$$

If the originator $n(t)$ is a constant n, we have

$$W(t) = n \int_{0}^{t} w(t - \tau)\, d\tau \ldots\ldots\ldots\ldots\ldots (1.3)$$

which, upon substituting $t - \tau = \xi$, $d\tau = -d\xi$ (since t is a definite fixed time), may also be written

$$W(t) = n \int_{0}^{t} w(\xi)\, d\xi \ldots\ldots\ldots\ldots\ldots (1.4)$$

If the effect of the distributor is limited, i.e., $w(\xi) = 0$ for $\xi \geq T$, where T is some positive constant, we get for values of $t \geq T$

$$W(t) = n \int_{0}^{T} w(\xi)\, d\xi = const. \ldots\ldots\ldots\ldots (1.5)$$

This last equation expresses a well known equilibrium theorem.

[2] The advantages of considering actuarial reserves from this point of view has been pointed out by the writer in an article in Skandinavisk Aktuarie Tidskrift, 1921, p. 210. See also the work of Norwegian actuaries in Nyt beregningsgrundlag for livsforsikring, Oslo, 1922, p. 27, and Fr. Lange-Nielsen, *A proposal for a new basis . . . .* , Skand. Akt. T., 1922, p. 235.

In practical cases where the originator and the distributor are known with sufficient accuracy, these equations give a means of forecasting the magnitude of the resultant. In particular, if $n = const.$, and the distributor is limited, equation (1.5) gives a means of predicting the time from which there will be equilibrium in the sense of $W = const.$ It is obvious that it would be of great practical importance to obtain criteria for cases in which equilibrium will be approximately reached when the originator $n(t)$ is not constant; the attempt to do this is the chief aim of the present paper.

2. The Originator and the Distributor as Solutions of Integral Equations

In the following we shall write equation (1.2) in the form

$$W(t) = \int_0^t w(\xi)\, n(t-\xi)\, d\xi = \int_0^t w(t-\tau)\, n(\tau)\, d\tau \ldots (2.1)$$

A generalization of this equation would be

$$W(t) = \int_0^t \sum_i w_i(\xi)\, n_i(t-\xi)\, d\xi \ldots\ldots\ldots\ldots (2.2)$$

where w_i and n_i are two series of distributors and originators; if either the w_i or the n_i are identically proportional, this case reduces to (2.1). In the present paper, attention will be confined to the case (2.1).

Equations (2.1) are *integral* equations, in $w(\xi)$ and in $n(\tau)$ respectively, of the so-called generalized Abel type; to obtain practical solutions of them, it is desirable (when the nucleus remains finite) to transform them by differentiation with respect to t, whence we obtain[3]

$$\frac{W'(t)}{n(0)} = w(t) + \frac{\int_0^t w(\xi)\, n'(t-\xi)\, d\xi}{n(0)} \ldots\ldots\ldots (2.3)$$

$$\frac{W'(t)}{w(0)} = n(t) + \frac{\int_0^t n(\tau)\, w'(t-\tau)\, d\tau}{w(0)} \ldots\ldots\ldots (2.4)$$

If in (2.3) the quantity $n(0)$ vanishes, the differentiation must be repeated until $n^{\nu}(0) \neq 0$; and similarly if $w(0)$ vanishes in (2.4). Equations (2.3) and (2.4) are integral equations, in w and n, respec-

[3] E. B. Wilson, *Advanced Calculus*, p. 283.

tively, of the so-called Poisson type; the existence theorems established by Volterra[4] give a solution of the form

$$w(t) = \frac{W'(t)}{n(0)} - \frac{\int_0^t \Gamma(t-\xi)\, W'(\xi)\, d\xi}{n(0)} \quad \text{.........(2.5)}$$

or, transforming the variable of integration from ξ to $\tau = t - \xi$, $d\tau = -d\xi$,

$$w(t) = \frac{W'(t)}{n(0)} - \frac{\int_0^t \Gamma(\xi)\, W'(t-\xi)\, d\xi}{n(0)} \quad \text{.........(2.6)}$$

in which $\Gamma(t - \xi)$ is called the resolvent kernel or solving function; numerical methods for determining Γ have been given by Whittaker,[5] Kameda,[6] and others. If the kernel $n'(t - \xi)/n(0) \equiv K(t - \xi)$ in (2.3) is of the form $K(x) = \Sigma_i\, a_i \exp(c_i x)$, where the a_i and c_i are constants, Γ will be of the same form $\Gamma(x) = \Sigma_i\, \alpha_i \exp(\gamma_i x)$, where the α_i and γ_i are simple functions of the a_i and c_i. In particular, if $n(t) = \alpha + \beta \sin \lambda t$, $K(t - \xi) = 2b \cos \lambda (t - \xi)$, where α, β, λ, b, are constants, we have

$$\left.\begin{aligned} \Gamma(t) &= 2\, b e^{-bt} (\cos \mu t - \nu \sin \mu t),\ \lambda^2 > b^2 \\ \Gamma(t) &= b e^{-bt} [(1 - \nu)\, e^{\mu t} + (1 + \nu)\, e^{-\mu t}],\ \lambda^2 < b^2 \\ \mu &= b/\nu = +\sqrt{|\lambda^2 - b^2|} \end{aligned}\right\} \quad \text{.....(2.7)}$$

3. Some General Relations between the Fluctuations of the Originator and the Value of the Resultant at a given Instant

Let $W_0(t)$ be the function which expresses what the resultant would have been at time t (with the given form of w) if the originator had been equal to a constant n_0; and let us find an expression for the *deviation* $U(t) = W(t) - W_0(t)$.

If $n_0 = n(0)$, we have from (1.4) and (2.6), remembering that $W(0) = 0$ and that the value of a definite integral is independent of the particular variable in terms of which the integrand is expressed,

[4] Goursat, *Cours d'Analyse*, 3 ed., T. III, chap. xxx.

[5] Whittaker. Proc. Roy. Soc. Lond. **94**: 367. 1918. Whittaker and Robinson, *The Calculus of Observations*, p. 376.

[6] Kameda, Tôhoku Math. Journ. August, 1924.

$$U(t) = W(t) - \int_0^t n(0)\, w(t)\, dt$$

$$= \int_0^t d\tau \int_0^\tau \Gamma(\xi)\, W'(\tau - \xi)\, d\xi$$

or, interchanging the order of the integrations by Dirichlet's Formula,[7]

$$U(t) = \int_0^t d\xi \int_\xi^t \Gamma(\xi)\, W'(\tau - \xi)\, d\tau$$

Hence, evaluating the second integral (in which W' is now the derivative with respect to τ), we have

$$U(t) = \int_0^t \Gamma(\xi)\, W(t - \xi)\, d\xi = \int_0^t \Gamma(t - \xi)\, W(\xi)\, d\xi$$

Again, from (2.1) we get directly

$$U(t) = \int_0^t w(\xi)\, n(t - \xi)\, d\xi - n_0 \int_0^t w(\xi)\, d\xi$$

The deviation $U(t)$ may be computed from either of these equations for any value of t. The last equation is also valid if n is an arbitrary constant.

Generally, let $W(t)$ and $H(t)$ be two resultants, generated by the originators $n(t)$ and $h(t)$ respectively, and with the same distributor $w(\xi)$. The function $h(t)$ will be called the trend function. The difference $u(t) = n(t) - h(t)$ will represent the deviations or fluctuations of the originator $n(t)$ measured from the trend function, and $U(t) = W(t) - H(t)$ will represent the corresponding deviations of the resultant.

We shall first suppose $h(t)$ to be an arbitrary function without any connection with $n(t)$. By (2.1)

$$\frac{U(t)}{H(t)} = \frac{\int_0^t u(t - \xi)\, w(\xi)\, d\xi}{\int_0^t h(t - \xi)\, w(\xi)\, d\xi}$$

$$= \frac{\int_0^t \frac{u(t - \xi)}{h(t - \xi)} \cdot h(t - \xi)\, w(\xi)\, d\xi}{\int_0^t h(t - \xi)\, w(\xi)\, d\xi}$$

[7] GOURSAT, *Cours d'Analyse*, 4 ed., T. I., p. 299.

Thus, by a well known property of definite integrals,

$$\left|\frac{U(t)}{H(t)}\right| \leq \frac{\int_0^t \left|\frac{u(t-\xi)}{h(t-\xi)}\right| \left|h(t-\xi)\, w(\xi)\right| d\xi}{\left|\int_0^t h(t-\xi)\, w(\xi)\, d\xi\right|}$$

Hence

$$\left|\frac{U(t)}{H(t)}\right| \leq M \frac{\int_0^t \left|h(t-\xi)\, w(\xi)\right| d\xi}{\left|\int_0^t h(t-\xi)\, w(\xi)\, d\xi\right|}$$

where M is the maximum of $|u(\tau)/h(\tau)|$ in the interval $0 \leq \tau \leq t$. If $h(t-\xi)\, w(\xi)$ has the same sign throughout the interval $0 \leq \xi \leq t$. which in practice it usually will have,[8] we have simply

$$\left|\frac{U(t)}{H(t)}\right| \leq M$$

Therefore we have

THEOREM I. Whatever the trend function $h(\tau)$, if the product $h(\tau)\, w(t-\tau)$ does not change sign in the interval $0 \leq \tau \leq t$, the relative deviation of the resultant $W(t)$ from the value which this function would have assumed if the originator had been the trend function $h(\tau)$ has at any given point t an absolute value not greater than the maximum absolute value of the relative deviation of the originator from the trend function in the interval $0 \leq \tau \leq t$.

In other words, since this theorem holds for any t, a damping of the relative fluctuations of $W(t)$ as compared with the relative fluctuations of $n(t)$ must in all such cases take place. Upon the intensity of this damping will depend the possibility in practice of computing $W(t)$ *as if* $n(t)$ were a suitable trend function $h(t)$ of a less complicated form than $n(t)$ but still representing the main features of $n(t)$—e.g., as if $n(t)$ were a constant in cases where the underlying trend of $n(t)$ is recognized to have the form of a horizontal line.

The damping effect will be more fully examined below, through the introduction of the standard deviation as a measure of the fluctuations of $W(t)$.

[8] In most cases, both $h(t)$ and $u(t)$ will be positive.

If the originator $n(t)$ has a marked variation confined to a short interval in the neighborhood of time t, and if the distributor $w(x)$ is positive and has a pronounced maximum at $x = a$, then there will obviously be a more or less pronounced fluctuation in the resultant in the neighborhood of time $t + a$. We may obtain some information about this effect by considering the originator to be increased over a small finite interval of length $p = 2q$, say: Let $n_1(x)$ be a function which is positive in the interval $0 \leq x \leq p$, and equal to zero outside this interval; $n_1(x)$ might be called the "extra originator." We wish to know the effect on the resultant W when, starting from any time t, the extra originator is added to or subtracted from n.

The resultant which would be produced at any instant of time $t + y \geq t + p$ by n_1 alone, viz.,

$$W_1(y) = \int_0^p w(y - \xi)\, n_1(\xi)\, d\xi \qquad (3.1)$$

might be called the "extra resultant." The problem is to determine the maximum of this function. If there is a maximum at $y = \eta + q$, η must satisfy

$$\int_{-q}^{+q} w'(\eta - \xi)\, n_1(q + \xi)\, d\xi = 0$$

if $w(x)$ is symmetric about its maximum $x = a$, and $n_1(x)$ symmetric about the midpoint $x = q$, this equation will be satisfied for $\eta = a$. Hence, the maximum effect on W of a temporary, symmetric fluctuation in the originator n is produced after a lapse of time which, counted from the midpoint of the fluctuation in n, is equal to a, where a is the argument for which the symmetric distributor $w(x)$ has its maximum.

The conditions under which this solution holds are often realized in practise, because several distributors encountered in statistical and actuarial work, e.g., are approximately of the symmetric type. A striking instance is the reserve

$$w_t = c\left(1 - \frac{\bar{a}_{x+t}}{\bar{a}_x}\right)\frac{l_{x+t}}{l_x}$$

of a sufficiently great number of whole life insurances entered at age x.

4. The Damping Coefficient

A formula will now be established that expresses the way in which the general character of the fluctuations of $W(t)$ in $z - q \leq t \leq z + q$

depends on the fluctuations of $n(t)$ in the time previous to $z + q$. The distributor will be assumed limited in its effect, i.e., $w(x) = 0$ for $x \geq T$; hence for $t \geq T$

$$W(t) = \int_0^T w(\xi)\, n(t-\xi)\, d\xi = \int_0^T w(t-\xi)\, n(\xi)\, d\xi \quad (4.1)$$

Assume also that $z \geq T + q$; T is the instant of time at which equilibrium would have been reached, i.e., the time from which W would have been constant, if the originator n had been independent of time, and it will be called the *equilibrium point* regardless of whether or not equilibrium actually is reached there. The equilibrium point evidently is independent of the constant value assumed for n, and depends only on the distributor $w(x)$.

The function

$$\omega(x) = \frac{w(x)}{\int_0^T w(\xi)\, d\xi}$$

will be called the *normalized distributor,* or the *distribution function.* We further introduce the means

$$h(z) = \frac{1}{p}\int_{z-q}^{z+q} n(\tau)\, d\tau; \quad H(z) = \frac{1}{p}\int_{z-q}^{z+q} W(\tau)\, d\tau$$

in which $p = 2q$; if z is varying, h and H can be regarded as the moving averages of n and W.[9] The deviations of n and W from their means will be denoted by

$$u(t, z) = n(t) - h(z)$$

$$U(t, z) = W(t) - H(z)$$

It should be noted that the position of the interval which determines the means from which u and U are measured is fixed independently through z, and does not change with t.

[9] In my original analysis of the character of the oscillations of W (t) over a given interval, I considered only the case of a periodic originator, which evidently amounted to considering the trend function h to be a constant. The more general definition of h and H, above, as moving averages has been suggested to be by my friend and colleague Dr. Frisch.

We evidently have for any z

$$\int_{z-q}^{z+q} u(\tau, z)\, d\tau = \int_{z-q}^{z+q} U(\tau, z)\, d\tau = 0$$

The means and the deviations satisfy the same equations as do the functions themselves; in fact, we have by (4.1)

$$H(z) = \int_0^T w(\xi)\, h(z-\xi)\, d\xi \quad \ldots\ldots (4.2)$$

and

$$U(t, z) = \int_0^T w(\xi)\, u(t-\xi, z-\xi)\, d\xi \quad \ldots\ldots (4.3)$$

for $t \geq T$ and $z \geq T + q$.

The standard deviations $s(z)$ and $S(z)$ of $n(t)$ and $W(t)$ over the interval $z - q \leq t \leq z + q$ are defined by

$$s^2(z) = \frac{1}{p}\int_{z-q}^{z+q} u^2(\tau, z)\, d\tau$$

$$S^2(z) = \frac{1}{p}\int_{z-q}^{z+q} U^2(\tau, z)\, d\tau$$

Finally, we introduce the coefficient of correlation $C(2\delta, z)$ between the 2δ-spaced ordinates $n(t-\delta)$ and $n(t+\delta)$ of the originator, the correlation being taken over the interval $z - q \leq t \leq z + q$:

$$C(2\delta, z) = \frac{\frac{1}{p}\int_{z-q}^{z+q} u(\tau+\delta, z+\delta)\, u(\tau-\delta, z-\delta)\, d\tau}{s(z+\delta)\, s(z-\delta)} \quad \ldots (4.4)$$

Since C is a correlation coefficient, we always have $-1 \leq C \leq 1$. Further $C(0, z) = 1$ for any z, which simply means that the correlation is perfect between infinitesimally spaced ordinates. C is symmetric in δ.

The relative standard deviation $r(z) = s(z)/h(z)$ measures the closeness with which the originator $n(t)$ fluctuates about its mean in the interval $z \pm q$; and the ratio $R(z) = S(z) / H(z)$ has the same significance for the resultant $W(t)$. The ratio $R(z)$ may therefore be taken as a measure of the degree to which equilibrium is approximately realized over the interval $z \pm q$.

Making use of (4.3), we have for $R(z)$, after some reductions,[10] the expression

$$R^2(z) = \frac{G^2(z)}{k^2(z)} \int_0^T \int_0^T \omega(\xi)\omega(\eta) s(z-\xi) s(z-\eta) C\left(\xi - \eta, z - \frac{\xi+\eta}{2}\right) d\xi \, d\eta \ldots (4.5)$$

where

$$G(z) = \frac{\int_0^T w(\xi)\, d\xi \int_0^T h(z-\xi)\, d\xi}{T \int_0^T w(\xi)\, h(z-\xi)\, d\xi} \ldots\ldots\ldots\ldots (4.6)$$

$$k(z) = \frac{1}{T} \int_0^T h(z-\xi)\, d\xi$$

We can further reduce (4.5) by means of the following formula due to Frisch:[11] Let $f(x_1, \ldots, x_n)$ or, for brevity, f_x, be a function of the n variables $x_1, \ldots, x_n$, and let $\int_x$ denote $\int_a^b \ldots \int_a^b dx_1 \ldots dx_n$. Further let $m_f = \frac{1}{(b-a)^2} \int_x f_x$ be the mean of f, and let

[10] The reductions consist in writing

$$U^2(\tau, z) = \int_0^T d\xi \int_0^T d\eta \, w(\xi)\, w(\eta)\, u(\tau - \xi, z - \xi)\, u(\tau - \eta, z - \eta)$$

then transforming the resulting triple integral

$$\int_{z-q}^{z+q} d\tau \int_0^T d\xi \int_0^T d\eta \ldots\ldots\ldots\ldots$$

into

$$\int_0^T d\xi \int_0^T d\eta \int_{z-q}^{z+q} d\tau \ldots\ldots\ldots\ldots$$

and finally putting

$$\tau = \tau' + \frac{\xi + \eta}{2}$$

[11] RAGNAR FRISCH. *On approximation to a certain type of integrals.* Skandinavisk Aktuarie Tidskrift. 1928. The formula there given is a generalization of a formula which Frisch had previously given; for other generalizations of Frisch's formula see Steffensen. *On the sum or integral of the product of two functions.* ibid., p. 44. 1927.

$$\sigma_f = + \sqrt{\frac{1}{(b-a)^n} \int_x (f_x - m_f)},$$

$$\rho_f = \frac{\sigma_f}{m_f}$$

(m_f assumed $\neq 0$) be the standard deviation and the relative standard deviation, respectively, of f. Finally, let

$$r_{fg} = \frac{\int_x (f_x - m_f)(g_x - m_g)}{\sigma_f \sigma_g (b-a)^n}$$

be the coefficient of correlation between the two functions f_x and g_x. Then we have

$$(b-a)^n \int_x f_x g_x = \int_x f_x \cdot \int_x g_x (1 + \rho_f \rho_g r_{fg})$$

the means m_f and m_g being assumed $\neq 0$. Substituting for ρ_f, ρ_g and r_{fg}, we see that this is an identity.

Applying this to the two functions of two variables

$$f(\xi, \eta) = s(z-\xi)\, s(z-\eta)$$

$$g(\xi, \eta) = \omega(\xi)\, \omega(\eta)\, C\left(\xi - \eta, z - \frac{\xi+\eta}{2}\right)$$

in (4.5), and also to the two functions of one variable $w(\xi)$ and $h(z-\xi)$ in (4.6), we have

$$R(z) = D(z) \frac{\int_0^T s(z-\xi)\, d\xi}{\int_0^T h(z-\xi)\, d\xi} \quad \ldots\ldots\ldots\ldots (4.7)$$

where

$$D^2(z) = \frac{1 + \rho_f \rho_g r_{fg}}{(1 + \rho_w \rho_h r_{wh})^2} \int_0^T \int_0^T \omega(\xi)\, \omega(\eta)\, C\left(\xi - \eta, z - \frac{\xi+\eta}{2}\right) d\xi\, d\eta \ldots (4.8)$$

The ratio of the integrals in (4.7) may be regarded as an average relative standard deviation of the originator for the interval previous to $z + q$. We may therefore adopt the factor $D(z)$ in (4.7) and (4.8) as the *coefficient of damping,* which expresses the ratio between the relative standard deviation of the resultant over the interval $z \pm q$ and the average relative standard deviation of the originator over the interval previous to $z + q$; the magnitude of $D(z)$ measures the intensity of the damping. If $D(z)$ is a small fraction, a heavy damping has taken place. It is true that a small value of $D(z)$ does not exclude the possibility that there may have taken place, within the interval $z \pm q$, *isolated* deviations of W of comparatively great magnitude, but such fluctuations must necessarily have been confined to very short intervals of time; in practise, such extreme cases will be of little importance.

The expression (4.8) enables us to recognize certain cases in which $D(z)$ will be small; we shall consider, in particular, the case of a periodic originator.

5. The Case of a Periodic Originator

If the moving average h is constant, i.e., if the originator is periodic with period p, then h, s, H, and S (for $z \geq T + q$) will be constants, hence $\sigma_f = \sigma_h = 0$. Furthermore, $u(t, z)$ and therefore $C(\delta, z)$ will be independent of z. The ratios r and R, and hence also D, will be constants. We have merely $R = Dr = Ds/h$, and

$$D^2 = \int_0^T \int_0^T \omega(\xi)\, \omega(\eta)\, C(\xi - \eta)\, d\xi\, d\eta \qquad (5.1)$$

Since $w(x) = 0$ for $x \geq T$, we have further

$$W(t + p) - W(t) = \int_0^T w(\xi)\, [n(t + p - \xi) - n(t - \xi)]\, d\xi = 0$$

for $t \geq T$. Hence we have

Theorem II. If the originator is an arbitrary periodic function, the resultant will be periodic after equilibrium has been reached, and the length of its period will be equal to the length of the period of the originator.

This condition, realized from the point of time T on, might be termed periodic equilibrium. For the constants h and H we have

$$h = \frac{1}{p} \int_c^{c+p} n(\tau)\, d\tau, \quad H = \frac{1}{p} \int_c^{c+p} W(\tau)\, d\tau$$

where $c \geq T$ but otherwise arbitrary. Furthermore, from (4.2)

$$H = h \int_0^T w(\xi)\, d\xi$$

whence

THEOREM III. If the originator is periodic, the actual mean value of the resultant (after equilibrium) is equal to the constant value which the resultant would have had (after equilibrium) if the originator had been constant and equal to its actual mean value.

For the function $C(\delta) = C(\delta, z)$, now independent of z, we have

$$\alpha\, C(\delta) = \int_c^{c+p} u(\tau + \delta)\, u(\tau)\, d\tau \qquad \text{(5.2)}$$

where

$$\alpha = \int_c^{c+p} u^2(\tau)\, d\tau$$

Since $\alpha = 0$ is a trivial case, we may assume $\alpha > 0$; $C(\delta)$ is evidently independent of the constant c in (5.2), and by integrating (5.2) over δ we find

$$\int_c^{c+p} C(\delta)\, d\delta = 0$$

Furthermore, $C(\delta)$ is an even periodic function with period p: $C(\delta + p) = C(\delta)$, $C(\delta) = C(-\delta)$. Hence C is symmetric about $\delta = kp$, where k is an arbitrary positive or negative integer or zero; C is even symmetric about $\delta = kq$, where $p = 2q$, for $\alpha\, C(q + \delta) = \alpha\, C(-q - \delta)$ is equal to

$$\int_c^{c+p} u(\tau - q - \delta)\, u(\tau)\, d\tau = \int_c^{c+p} u(\tau + q - \delta)\, u(\tau)\, d\tau = \alpha\, C(q - \delta)$$

If u possesses derivatives of all orders, then (5.2) gives by ν repeated integrations by parts,

$$\alpha\, C^{(m)}(\delta) = (-1)^{\nu} \int_c^{c+p} u^{(m-\nu)}(\tau + \delta)\, u^{(\nu)}(\tau)\, d\tau \qquad \text{(5.3)}$$

From this, we have for $m = 2\rho + 1$, $\nu = \rho$ $(\rho = 0, 1, \ldots)$,

$$2\,\alpha\, C^{(2\rho+1)}(0) = (-1)^{\rho} \int_c^{c+p} d\,[u^{(\rho)}(\tau)]^2 = 0$$

because $[u^{(\rho)}(\tau)]^2$ is periodic with period p. Hence $C^{(2\rho+1)}(0) = 0$, since $\alpha > 0$. For $m = 2\rho$, $\nu = \rho$, we get $C^{(2\rho)}(0) = (-1)^\rho \alpha_2^\rho$, where

$$\alpha_{2\rho} = \frac{1}{\alpha}\int_c^{c+p} [u^{(\rho)}(\tau)]^2 \, d\tau$$

We thus obtain the Taylor series (assumed convergent)

$$C(\delta) = \sum_{\rho=0}^{\infty} (-1)^\rho \frac{\alpha_{2\rho}}{(2\rho)!} \delta^{2\rho} \ldots\ldots\ldots\ldots \quad (5.4)$$

Putting $m = 1$, $\nu = 0$, and $m = 1$, $\nu = 1$, in (5.3), and adding, we have

$$2\alpha C'(\delta) = \int_c^{c+p} [u'(\tau+\delta) - u'(\tau-\delta)]\, u(\tau)\, d\tau$$

Hence $C'(q) = 0$.

We shall next develop C in a Fourier series. Putting

$$\delta = \frac{px}{2\pi} \qquad C(\delta) = \dot{C}(x)$$

$$t = \frac{py}{2\pi} \qquad u(t) = \dot{u}(y)$$

we have

$$\dot{C}(x) = \dot{C}(-x), \int_c^{c+2\pi} \dot{C}(x)\, dx = 0, \int_c^{c+2\pi} \dot{u}(y)\, dy = 0$$

In the expansion

$$\dot{C}(x) = \sum_{m=1}^{\infty} a_m \cos mx$$

assumed convergent, the coefficients a_m are given by

$$\pi a_m = \int_c^{c+2\pi} \dot{C}(x) \cos mx \, dx$$

Introducing the expression for $\dot{C}$ in terms of $\dot{u}$, derived from (5.2), we get

$$\dot{\alpha}\pi a_m = \int_c^{c+2\pi}\int_c^{c+2\pi} \dot{u}(x+y)\, \dot{u}(y) \cos mx \, dx\, dy \ldots \quad (5.5)$$

where

$$\dot{\alpha} = \int_c^{c+2\pi} \dot{u}^2 (y)\, dy$$

Assuming that $\dot{u}(y)$ can be developed in a Fourier series, let β_μ and γ_μ be the coefficients of this development, so that

$$\dot{u}(y) = n\left(\frac{py}{2\pi}\right) - \frac{1}{p}\int_c^{c+p} n(\tau)\, d\tau$$

$$= \sum_{\mu=1}^{\infty} (\beta_\mu \cos \mu y + \gamma_\mu \sin \mu y, \ldots\ldots\ldots\ldots (5.6)$$

Now substitute for $\dot{u}(x + y)$ in (5.4), leaving $\dot{u}(y)$ as it stands; expanding the terms $\cos(\mu x + \mu y)$ and $\sin(\mu x + \mu y)$, we see that in the integration with respect to x all terms containing $\sin \mu x. \cos mx$, as well as all terms containing $\cos \mu x. \cos mx$, $m \neq \mu$, will vanish, while

$$\int_c^{c+2\pi} \cos^2 mx\, dx = \pi$$

Introducing, next, the Fourier development of $\dot{u}(y)$ and integrating with respect to y, we get

$$\dot{\alpha}\, a_m = \pi (\beta_m^2 + \gamma_m^2)$$

From Parseval's Theorem[12], we have

$$\dot{\alpha} = \int_c^{c+2\pi} \dot{u}^2 (y)\, dy = \pi \sum_{\mu=1}^{\infty} (\beta_\mu^2 + \gamma_\mu^2)$$

Hence, finally

$$C(\delta) = \sum_{m=1}^{\infty} a_m \cos\left(\frac{2\pi m \delta}{p}\right) \ldots\ldots\ldots\ldots (5.7)$$

where

$$a_m = \frac{\beta_m^2 + \gamma_m^2}{\sum_{\mu=1}^{\infty} (\beta_\mu^2 + \gamma_\mu^2)} \ldots\ldots\ldots\ldots (5.8)$$

β_μ and γ_μ being defined by (5.6). Since all the a_m are positive, it follows again that $a_1 + a_2 + \ldots = C(0) = 1$ is the greatest value

[12] WHITTAKER and WATSON. *Modern Analysis*, 4 ed., p. 182.

that $C(\delta)$ can assume. Summing up our results concerning $C(\delta)$, we have

THEOREM IV. Let $u(t)$ be an arbitrary periodic function with period $p = 2q$, and such that $\int_c^{c+p} u(\tau)\, d\tau = 0$. Then the function $C(\delta)$ defined by (5.1) is also periodic with period p, and $\int_c^{c+p} C(\delta)\, d\delta = 0$. If k is an arbitrary positive or negative integer, or zero, $C(\delta)$ is symmetric about all the points $\delta = kq$, and the first derivative $C'(\delta)$ vanishes at all these points; $C(\delta)$ attains at the points $\delta = kp$ its greatest value, viz., unity. The Taylor and the Fourier expansions of $C(\delta)$ are given by (5.4) and (5.7), provided these series are convergent.

This shows that even though the fluctuations of the periodic originator $n(t)$ be quite arbitrary, the function $C(\delta)$ which occurs in the damping coefficient is subject to conditions that put definite restrictions on the character of its variation.

It may be seen that $\cos 2\pi\, \delta/p$ is a function which satisfies the conditions to which $C(\delta)$ is subject.

6. THE DAMPING COEFFICIENT IN THE PERIODIC CASE

Substituting the Fourier expansion (5.7) in (4.8), we get

$$D^2 = \sum_{m=1}^{\infty} a_m \left\{ \left[\int_{-\infty}^{+\infty} \omega(\xi) \cos \lambda_m \xi\, d\xi \right]^2 + \left[\int_{-\infty}^{+\infty} \omega(\xi) \sin \lambda_m \xi\, d\xi \right]^2 \right\} \quad (6.1)$$

where $\lambda_m = 2\pi\, m/p$. For convenience, the integration has been extended over the interval $(-\infty, +\infty)$; this is allowable, since by definition $\omega(x) = 0$ for $x < 0$ and $x \geq T$.

We shall now introduce the expansion of $\omega(x)$ in a series of Hermite polynomials or parabolic-cylinder functions:[13] Let a and b be two arbitrary constants, and put $z = x - a$; then

$$\omega(x) = \omega(z + a) = f(z) = \sum_{\nu=0}^{\infty} \frac{k_\nu}{\nu!} \varphi_\nu(z) \quad (6.2)$$

[13] ARNE FISHER. *Mathematical Theory of Probabilities*, vol. I. The convergence of this series is discussed in a recent paper by CRAMÉR, *On some classes of series used in mathematical statistics.* Den Sjette Skandinaviske Matematikerkongres i Köbenhavn pp. 399–425. 1926. See also T. KAMEDA, *Theory of Generating Functions and its application to the theory of probability*, Journ. Faculty of Science Imp. Univ. Tokyo, Sec. 1, **1** (1): 1–62. 1925. *Proc. Tokyo Math.-Phys. Soc.*, (2) **8**: 262–295, 336–360. 1915. The H_ν are tabulated by Jörgensen, *Undersögelser over frequensflader og korrelation*, Köbenhavn. 1916. *Cf.* Whittaker and Watson, *Modern Analysis*, chap. xvi.

in which

$$\varphi_0(z) = \varphi(z) = \frac{1}{b\sqrt{2\pi}} \exp\left(-\frac{z^2}{2b^2}\right)$$

$$\varphi_\nu(z) = \frac{d^\nu}{dz^\nu}\varphi(z) = (-b)^{-\nu} H_\nu\left(\frac{z}{b}\right)\varphi(z)$$

$$H_\nu(z) = (-1)^\nu e^{z^2/2} \frac{d^\nu}{dz^\nu} e^{-z^2/2}$$

$$k_\nu = (-b)^\nu \int_{-\infty}^{+\infty} f(z)\, H_\nu\left(\frac{z}{b}\right) dz \qquad (6.3)$$

the H_ν being the Hermite polynomials. Substituting (6.2) in the general term of (6.1), and expanding $\cos\lambda(z+a)$ and $\sin\lambda(z+a)$, we see that it is necessary to compute the two integrals

$$\left.\begin{aligned} J_\nu &= \int_{-\infty}^{+\infty} \cos\lambda z \cdot \varphi_\nu(z)\, dz \\ K_\nu &= \int_{-\infty}^{+\infty} \sin\lambda z \cdot \varphi_\nu(z)\, dz \end{aligned}\right\} \qquad (6.4)$$

in which for brevity we have written $\lambda = \lambda_m$. Since $\varphi_\nu(z) = (-1)^\nu \varphi_\nu(-z)$, we have $J_{2\rho+1} = K_{2\rho} = 0$. Integrating by parts, we have from the second of (6.4), $K_{2\rho+1} = -\lambda J_{2\rho}$. To determine $J_{2\rho}$, 2ρ integrations by parts of the first of (6.4) give

$$J_{2\rho} = \frac{(-1)^\rho \lambda^{2\rho}}{b\sqrt{2\pi}} \int_{-\infty}^{+\infty} \cos\lambda z \cdot \exp\left(-\frac{z^2}{2b^2}\right) dz$$

$$= (-1)^\rho \lambda^{2\rho} \exp\left[-\frac{(\lambda b)^2}{2}\right]$$

hence

$$K_{2\rho+1} = (-1)^{\rho+1} \lambda^{2\rho+1} \exp\left[-\frac{(\lambda b)^2}{2}\right]$$

Using this, we see that the general term of the sum (6.1) will be

$$\left[\sum_{\rho=0}^{\infty} \frac{k_{2\rho}}{(2\rho)!} J_{2\rho}\right]^2 + \left[\sum_{\rho=0}^{\infty} \frac{k_{2\rho+1}}{(2\rho+1)!} K_{2\rho+1}\right]^2 = \exp\left[-(\lambda_m b)^2\right]\left[B_m^2 + C_m^2\right]$$

where

$$\left.\begin{aligned} B_m &= \sum_{\rho=0}^{\infty} (-1)^{\rho} \frac{k_{2\rho}}{(2\rho)!}\left(\frac{2\pi m}{p}\right)^{2\rho} \\ C_m &= \sum_{\rho=0}^{\infty} (-1)^{\rho+1} \frac{k_{2\rho+1}}{(2\rho+1)!}\left(\frac{2\pi m}{p}\right)^{2\rho+1} \end{aligned}\right\} \ldots\ldots (6.5)$$

The k_ν have the values given by (6.3); if desired, the k_ν can also be expressed in terms of the semi-invariants or the moments of $\omega(z)$; the explicit expression for k_ν for any ν in terms of semi-invariants has been given by Frisch.[14]

The expression for D is finally

$$D^2 = \sum_{m=1}^{\infty} a_m \exp(-\kappa^2 m^2) \cdot (B_m^2 + C_m^2) \ldots\ldots\ldots (6.6)$$

where $\kappa = 2\pi\, b/p$, a_m being given by (5.8), and B_m and C_m by (6.5).

In numerical work, the arbitrary constants a and b would usually be disposed of by putting a equal to the mean $M = \int_{-\infty}^{+\infty} \xi\omega(\xi)d\xi$, and b equal to the standard deviation $\sigma^2 = \int_{-\infty}^{+\infty} (\xi - M)^2\, \omega(\xi)\, d\,\xi$. If this be done, k_1 and k_2 will vanish in (6.5).

Since all the a_m in (6.6) are positive, and $a_1 + a_2 + \ldots\ldots = 1$, we have

$$D^2 \leq Q \ldots\ldots\ldots\ldots\ldots\ldots (6.7)$$

where Q is the maximum of

$$Q_m = \exp(-\kappa^2 m^2) \cdot (B_m^2 + C_m^2)$$

for positive integral values of m. Hence we have the interesting

THEOREM V. The limit (6.7) for D^2 involves the period p, but otherwise is completely independent of the originator. In particular, the magnitude of the fluctuations of the originator does not influence the limit of the damping coefficient if the originator is periodic with period p.

If, for instance, the distribution function (i.e., the normalized distributor) is the normal, or Gaussian, error function, we have $B_m = 1$

[14] RAGNAR FRISCH. *Sur les semi-invariants et moments employés dans l'étude des distributions statistiques.* Skrifter utgitt av Det Norske Videnskaps Akademi, **1926**: 23. Oslo.

and $C_m = 0$; hence $Q = \exp[-4(\pi\sigma/p)^2]$, where σ is the standard deviation of the normal error function which represents the normalized distributor. Consequently

$$D \leq \exp\left[-2\left(\frac{\pi\sigma}{p}\right)^2\right] \qquad (6.8)$$

We therefore have

THEOREM VI. If the originator is periodic with period p, and the distributor is a normal error function with standard deviation σ, the damping coefficient is not greater than $\exp[-2(\pi\sigma/p)^2]$.

In other words, the ratio of σ and p has such a powerful influence on the magnitude of the fluctuations in the resultant that when the ratio σ/p becomes small a practically perfect equilibrium—in the sense of a small value for D—will be brought about, regardless of the magnitude of the fluctuations in the originator. The damping effect is such that, e.g., if $\sigma = p$, the value of D is less than 3.10^{-9}. In such cases, it will rarely ever be necessary for practical purposes to take into account the fluctuations of the originator—the resultant may, under such circumstances, be computed as if the originator were constant and equal to its actual mean value.

In view of Theorem V, the extremely low value of D found in the type of case just considered renders it reasonable to expect that a heavy damping will likewise take place when additional terms of the expansion (6.2) have to be taken into account. In each special case, the *exact* criteria have to be derived from (4.8) or (6.6) – (6.8); and the computed value of D has, of course, always to be viewed in relation to the nature of the particular problem under consideration.

It may be expected that a closer study of the more general cases, when the underlying trend is not constant, would reveal, in substance, the same characteristic features in the damping effect.

PALEOBOTANY—*A palm fruit from the Miocene of western Panama.*[1]

EDWARD W. BERRY, The Johns Hopkins University.

The Tertiary flora of Central America is very incompletely known so that considerable interest attaches to any additions that can be made to our knowledge of it. The palm fruit described below is such an addition. Unfortunately it has not been possible to assign this

[1] Received May 26, 1928.

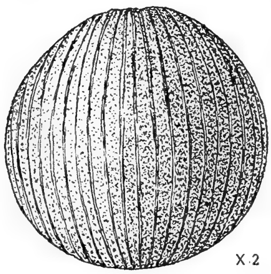
fruit to an existing genus, but in extenuation it may be mentioned that not only are the recent palms of that region very incompletely known, but the majority are not represented by fruits in existing collections.

Twenty-two genera of palms are enumerated in Standley's Flora of the Canal Zone,[2] but all of these except the genera *Acanthorhiza* and *Geonoma* are quite different from the fossil, and there must be many species and even genera in Central America as a whole which remain undiscovered.

The present fossil is referred to the form genus *Palmocarpon*, and may be described as follows:

Palmocarpon geonomoides Berry, n. sp. (see fig. 1)

Fruit small, symmetrical, nut-like, nearly spherical—being 18.5 millimeters long and 17 millimeters in diameter. Lacking a raphe or any trace of a tripartite division, or of the basal pores of the cocoid palms. Fibres simple and flat, parallel with one another to the extreme base, not over 1.25 millimeters in maximum width, continuous from the base to within a millimeter or two of the apex, where their acute points are slightly raised as if free tipped in life; united by their edges to form a pseudo-shell.



X 2

Fig. 1.—*Palmocarpon geonomoides* Berry, n.sp., Miocene of western Panama.

The single specimen is a sandstone cast with a very slight film of carbonaceous matter in places. The general form is simulated in existing species of *Oenocarpus*, *Geonoma*, *Acanthorhiza*, etc., and the fibres suggest comparisons with existing species of *Rhopalostylis* and the outer coat of *Astrocaryum*. The fibres are, however, more regular than in *Astrocaryum*, especially toward the base, pores are lacking, and there is no trace of an inner fibrous layer which could hardly have disappeared during fossilization. Nor does it seem possible that the surface in life could have had several layers of imbricated lanceolate flat fibres without some trace of them having remained on the fossil. The fact that the specimen is fully inflated and perfectly round in transverse profile shows that it did not grow in a crowded inflorescence.

Because of the uncertainties of a positive generic identification and the lack of adequate recent comparative material it is referred to the form genus *Palmocarpon* instituted by Lesquereux in 1878 for palm fruits of uncertain generic affinities, the specific name being indicative

[2] STANDLEY, P. C. Contr. U. S. Nat. Herb. **27**: 93–100. 1928.

of my opinion that it belongs to the tribe *Geonomeae*. The specimen comes from half a mile northwest of Zembrano, Province of Chiriqui, in western Panama, and was collected by James Terry Duce, and presented to the National Museum by T. D. A. Cockerell (U. S. N. M. no. 37193). It is labelled as having come from the Uscari formation, which on the Caribbean side of the Isthmus lies beneath the Gatun formation, but which has not been definitely recognized in Chiriqui Province. The age is undoubtedly Miocene.

Silicified palm wood was described by the writer[3] in 1918 from the Cucuracha formation (Oligocene) in the Gaillard Cut; and an Iriartea-like fruit was described[4] from the Gatun formation one and a half miles northeast of Gatun in 1921. These with the foregoing comprise all that is at present known of the Tertiary palms of Panama. No palms were represented in the small Tertiary florule described from Costa Rica in 1921,[5] but palm rays are not uncommon in collections from the Isthmus of Tehuantepec in southern Mexico.[6]

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

972D MEETING

The 972d meeting was held at the Cosmos Club March 17, 1928.

Program: F. L. MOHLER: *Recombination of atomic ions and electrons.* Spectra result from recombination of atomic ions and electrons. When a thermionic discharge tube designed to favor high concentration of ions was operated in caesium vapor with relatively high current and low voltage, continuous bands appeared at the limits of each series, in general agreement with theoretical predictions. Electrical measurements of discharge conditions have been made by the Langmuir probe wire method. The current voltage curves to the probes show that the electron velocities have a strictly random or temperature distribution with very low average speeds ranging between 0.2 and 0.3 volts. The ion concentration is of the order of 10^{13} per cc. On the basis of data on the intensity distribution beyond a limit and the electron velocity distribution one can compute the chance of recombination of an electron into the corresponding energy level as a function of the electron speed. This probability decreases very rapidly as the speed increases. From this can also be derived the probability of absorption of an atom in this state. The continuous emission bands beyond the 2P and 3D limits of caesium give similar absorption curves which drop rapidly from the limit to

[3] BERRY, EDWARD W. U. S. Nat. Mus. Bull. **103:** 24. 1918.

[4] BERRY, EDWARD W. Proc. U. S. Nat. Mus. **59:** 21–22. 1921.

[5] BERRY, EDWARD W. Idem. 169–185.

[6] BERRY, EDWARD W. Idem. **62** (Art. 19): *5, pl. 5, fig. 4.* 1923.

higher frequency. The form of curve is apparently quite different from the theoretical, which decreases approximately as the 4th power of the wave length. It resembles the curve for the 1S state derived by Foote and Mohler from photoionization measurements. (*Author's abstract.*)

R. M. Langer: *Dispersion and quantum theory.* The interaction between radiation and matter can be expressed in terms of a property of the atom, namely the electric moment. The expressions for the rate of emission and absorption of light were given and discussed. The connection with the duration of emission or life of an atom in the excited state was mentioned. The relation between electric moment and absorption coefficients as well as refractive index was pointed out. Slides were shown of experimental results which proved that the positions of anomalous dispersion, absorption and emission were identical. This fact was decidedly in disagreement with the picture of the atom developed by Bohr and the discrepancy was one of the chief sources of dissatisfaction with this older form of quantum theory. The new quantum mechanics gives rise to a picture of the atom in which there is a movement of charge which matches in frequency the light given out, or absorbed. The positions of anomalous dispersion are then those to be expected from general electromagnetic theory and coincide as found in experiment with the absorption lines. We can therefore have more faith in the new model of the atom given by Schrödinger and it becomes interesting to calculate some of its properties. The distribution of charge in normal hydrogen was computed and a section of it was portrayed as the concentration of white dots on a black background. The atom looked like a spherical globule of charge with density decreasing gradually from the center outwards. The sphere with radius equal to the radius of the atom on the Bohr picture contained only half the charge. The considerable concentration outside this radius gives the impression of stray fields and fits in with our notions of the chemical notions of hydrogen. The excited state of hydrogen 2S was shown on a similar slide. It is also spherically symmetrical but the charge is not so concentrated, and is distributed as a diffuse shell concentric with the inner globule. In general S states of quantum number n would have n shells. The lithium atom is similar to 2S hydrogen, the sodium atom to 3S hydrogen, and so on. Normal helium was also shown and contrasted with hydrogen. The density at the center is very much higher but diminishes much more rapidly with radius so that practically all of the double electronic charge is within 10^{-8} cm. of the nucleus. This means there is very little stray field as we should expect from the fact that helium is an inert gas. The helium structure is characteristic of the outer shell of the elements of the second column of the periodic table, e.g., Hg and Cd. Another property which can be calculated with the help of the quantum mechanics is the atomic absorption coefficient. The total absorption of many molecules will involve an integration and not a simple multiplication by the number of molecules.

The mean life can also be computed and for the atom in the second quantum state has a value of about 1.58×10^{-9} seconds. (*Author's abstract.*)

973d MEETING

The 973d meeting was held at the Cosmos Club March 31, 1928.

Program: C. J. Davisson: *Reflection and diffraction of electrons by a crystal of nickel.* It has been found in recent experiments by the writer and

Dr. L. H. Germer that a stream of electrons is regularly reflected from a face of a nickel crystal. This phenomenon could be understood if electrons were waves, but is incomprehensible in terms of atoms and electrons and their interactions as we have pictured them. Reflection is not observed from a polycrystalline target, which suggests that if electrons are waves, their wave-lengths, like those of x-rays, must be comparable with the distances between atoms in solids. The reflection from the crystal is selective in speed of bombardment; intensity maxima occur at nearly equal intervals in this variable. This would be comprehensible if electrons were waves of wave-length inversely proportional to their speed. These results suggest by analogy with x-ray phenomena, that electrons will be regularly reflected also from sets of atom planes which do not lie parallel to the surface of the crystal. Beams of electrons of this type are found issuing from the crystal at critical speeds of bombardment, but their directions are not those of regular reflection from the principal atom planes. The difference between x-ray and electron diffraction in this respect is due apparently to a difference in the refractivity of nickel for the two kinds of radiation. It is shown that if this is the case the wave-length of the diffraction beam will nevertheless satisfy the plane grating formula with respect to the atomic plane grating lying parallel to the crystal face—files of atoms serving as the lines of a grating. This formula which does not involve the refractive index of the crystal is used to calculate electron wave-lengths, and all values so found agree, within the limits of accuracy of the measurements, with the corresponding values of h/mv—Planck's constant of action divided by the momentum of the incident electron. They agree, that is, with the wave-length associated with a freely moving particle in the undulatory mechanics introduced by L. de Broglie. The regularly reflected beams cannot be used for calculating wave-lengths. The Bragg formula cannot be used because the refractive index of the crystal is not unity, and the plane grating formula cannot be used because the beams are of order zero. Assuming h/mv to be the wave-length of the incident beam the data of regular reflection may, however, be used to calculate indices of refraction. When this is done it is found that the index of refraction of nickel for electrons decreases from about 1.15 to 1.01 as the bombarding potential is increased from 60 to 600 volts. (*Author's abstract.*)

H. L. Curtis in an informal communication called attention to the close agreement between the recently measured velocity of light and value of the ohm, and the calculations of Rosa and Dorsey twenty-one years ago based upon their measurements of the ratio between the electromagnetic and electrostatic units of electricity.

974th meeting

The 974th meeting was held at the Cosmos Club April 14, 1928.

Program: L. W. Kephart: *Plant hunting through East Africa.*

H. E. Merwin, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

In connection with the Thirteenth Annual Meeting of the Optical Society of America an exhibition of optical instruments, apparatus and products will be held under the joint auspices of the Bureau of Standards and the Optical Society, from October 31 to November 3.

Dr. A. S. Hitchcock has returned from Newfoundland and Labrador, where he has been studying and collecting grasses. In Newfoundland he collected at Port-aux-Basques, St. Georges, Corner Brook, Little Harbor, Grand Falls, and St. Johns, and in Labrador at Battle Harbor and Cartwright.

Dr. C. G. Abbot, Secretary of the Smithsonian Institution, returned to Washington on September 23 after a successful expedition to Mount Wilson, California. Bolometric observations of the infra-red solar spectra and radiometric observations of the spectra of many stars formed his principal work. The results, which have not yet been fully worked up, appear to be very gratifying.

Mr. M. W. Stirling, Chief of the Bureau of American Ethnology, attended the meeting in New York City of the XXIII Session of the International Congress of Americanists, which convened on Monday, September 17. Mr. Stirling was appointed by the State Department to represent the United States Government at the Congress. He returned to Washington September 24.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, October 4.	The Entomological Society
Saturday, October 6.	The Biological Society
Tuesday, October 9.	The Electrical Engineering Society
Wednesday, October 10.	The Geological Society
	The Medical Society
Thursday, October 11.	The Chemical Society
Saturday, October 13.	The Philosophical Society
Tuesday, October 16.	The Anthropological Society
Wednesday, October 17.	The Engineering Society
	The Medical Society
Thursday, October 18.	THE ACADEMY

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Vol. 18 October 19, 1928 No. 17

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

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Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. 18 October 19, 1928 No. 17

GEOPHYSICS.—*Evaporation from large bodies of water and some figures for Chesapeake Bay.*[1] Roger C. Wells, U. S. Geological Survey.

The subject of evaporation may be considered on several different scales. For the earth as a whole it is obvious that the total evaporation must very nearly equal the total precipitation. Both processes take place to a much greater extent in warm than in cold regions, however. In comparing large land and water areas in the same latitude it appears that in the water areas evaporation must exceed precipitation slightly, the excess moisture passing in the atmosphere to the land, whereas in most land areas precipitation is in excess, in spite of the increased surface offered by foliage and vegetation, and the excess water precipitated returns through lakes and rivers to the ocean.

Data on rainfall are much more abundant than data on evaporation, yet in theory the two processes are complementary, and even practical considerations would seem to warrant further scrutiny of the phenomena of evaporation.

Numerous formulas have been proposed for computing evaporation from the humidity of the air,[2] but when any particular humidity has been specified that near the surface of the water has generally been used. Unfortunately these formulas are of little use for computing

[1] Published by permission of the Director of the United States Geological Survey. Received August 6, 1928.

[2] G. J. Livingston, Mon. Weath. Rev. 1908 and 1909. Humphreys, *Physics of the Air*, p. 249. Duryea and Haehl, Trans. Am. Soc. Civil Engr., **80**: 1829. 1916. Horton and Grunsky, *Hydrology of the Great Lakes.* Engineering Board of Review of the sanitary district of Chicago, Pt. III, Appendix II. 1927.

evaporation from most natural bodies of water, either because no weather station is located near by with available records, or, as may be the case, the humidity at the weather station is different from that at the lake or other body of water. The variation of humidity with altitude has been very little studied, so that extrapolation to distant points is rather uncertain.

Formulas of the kind referred to are nearly all modifications of the so-called Dalton equation, but it may be noted in passing that a different line of attack is offered by Cummings and Richardson[3] in an equation in which evaporation depends on the "heat budget" of a unit area of the water, but this method also must rely, apparently, on tests with pans and observations at the localities under study.

The relative humidity at the surface of a natural body of water must be very close to 100 per cent, and similarly the absolute humidity at high altitudes where the temperature falls below the freezing point must be very low. But what is the average distribution of moisture or vapor-pressure gradient between these two extremes?

The gradient is certainly not linear. It must resemble the concentration gradient of a dissolved salt in diffusion experiments. True diffusion of the water molecules through the air from the water surface will account for the rate of natural evaporation only when that may prove to be the slowest feature of the process.[4] Now moist air is lighter than dry air, so that convection currents are set up, and an entirely different rate of transfer is developed. Winds assist in causing some vertical transfer in a way that G. I. Taylor has attempted to cover by the concept of "eddy diffusion,"[5] in which the "diffusion constant" remains to be evaluated and may possibly be a function of the altitude or some other factors.

Some observations of the vapor-pressure gradient were made by Professor Bigelow at the Reno reservoir, Nevada, in 1907.[6] The data referring to tower No. 3, which was located near the middle of the reservoir, are of greatest interest. Each of his figures is an average of a week's daily observations of the partial vapor pressure of the moisture in the air, $p'(=e_d)$, at different hours of the day. In Table I are shown the averages of two weeks' observations. The figures for zero altitude show the vapor pressure of water at its temperature at

[3] Phys. Rev. **30**: 527. 1927.

[4] H. S. Taylor, *Physical Chemistry*, p. 933.

[5] Phil. Trans. **215**: 1. 1915.

[6] Mon. Weath. Rev. **36**: 28. 1908.

TABLE I.—VAPOR PRESSURE, p', ABOVE THE SURFACE OF RENO RESERVOIR, AUGUST 1–10, 12–17, 1907

Height	*p′ in mm. of mercury*							Mean
	1 a.m.	*5 a.m.*	*8 a.m.*	*11 a.m.*	*2 p.m.*	*5 p.m.*	*8 p.m.*	
45 feet	5.9	6.0	7.2	7.1	6.2	6.4	5.8	
35	5.9	6.0	7.4	7.2	6.4	6.1	5.6	
25	6.2	6.1	6.6	6.7	6.9	6.1	5.9	
15	7.1	6.3	7.6	7.0	7.1	6.7	6.3	
7	7.5	6.7	7.5	7.8	8.2	7.5	6.9	
2	7.8	6.8	7.7	8.1	8.1	7.9	6.9	
0.5 inch	11.0	9.1	10.0	11.8	14.4	12.6	9.7	
0	15.3	14.6	15.2	18.6	20.3	18.1	15.2	

Diminution of vapor pressure with the altitude expressed as percentage of the difference between the pressure at 0 and 45 feet altitude

45 feet	100	100	100	100	100	100	100	100
35	100	100	98	99	98	102	102	100
25	97	99	107	104	95	102	99	103
15	87	97	95	101	94	97	95	95
7	83	92	96	94	86	91	88	90
2	80	91	94	91	86	87	88	88
0.5 inch	46	64	65	59	42	47	59	55
0	0	0	0	0	0	0	0	0

the time of observation. As the air above the water was never saturated its temperature does not concern us here. The change of the diffusion constant with temperature is very small for water vapor.

Unfortunately figures for the wind velocities corresponding to the vapor pressures shown in Table I are not given in Bigelow's paper. He says, however, "In the forenoon it is calm until about 10 o'clock, when a breeze begins in the southeast, increasing in strength up to 30 or 40 kilometers per hour on many afternoons." The average velocity at the surface of the water for all winds ranging between 20 and 40 kilometers is given as 28 kilometers for the period 2 to 5 p.m. The actual velocity of the wind for any particular period is not stated.

The influence of the wind can perhaps be seen in the humidity. The highest absolute humidity at heights from 15 to 45 feet occurs at 8 a.m. In the afternoon, when the breeze has sprung up, the humidity at these heights is lower in spite of the fact that the humidity at the surface of the water is much higher.

As Table I and figure 1 show, the vertical vapor-pressure gradient is very steep indeed immediately above the surface of the water.

Over 50 per cent of the diminution observed at 45 feet is found in the first half inch above the water. At a height of 2 feet we have similarly 88 per cent as an average of the figures for the seven periods. The diminution at heights above 45 feet must go on slowly though doubtless with considerable irregularity. Further data obtained by Bigelow at the Salton Sea, California,[7] 7500 feet from the shore, show a vapor pressure gradient that is slightly steeper but otherwise similar to the one found at the Reno reservoir. The values plotted in figure 1 are the means of the percentages given in Table I.

For the purpose of developing a formula for evaporation in terms of the humidity of the air it would seem that the humidity at an altitude of at least 1 foot, or perhaps best that at 2 feet, should be used, on account of the more steady relation it holds both to the vapor pressure of the water and to the partial vapor pressure at higher altitudes.

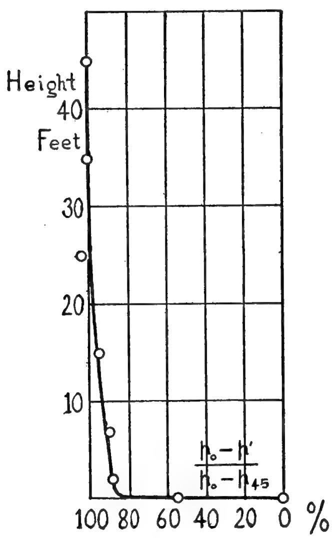

FIG. 1.—Vapor pressure-gradient, Tower No. 3, Reno Reservoir, Nevada, according to Bigelow's observations in 1907.

One form of the Dalton equation is

$$E = \frac{k}{B}(p - p')(1 + cw) \qquad (1)$$

in which E is the evaporation in centimeters per hour, B the barometer in millimeters of mercury, p the vapor pressure of the water evaporating and p' the partial pressure of moisture in the air, both in millimeters of mercury, w the velocity of the wind in kilometers per hour, and k and c constants.

The writer has derived values for k and c from some of Bigelow's data shown in Table II. Here p' is the vapor pressure of moisture in the air determined with a sling psychrometer 1 or 2 feet above the water surface. The figures are averages grouped according to different values of the velocity of the wind.

On plotting $\frac{E}{p - p'}$ against w it is seen that the values fall into three groups and are rather discordant. A graphic linear solution for

[7] Mon. Weath. Rev. **38**: 310. 1910.

TABLE II.—BIGELOW'S RESULTS ON EVAPORATION FROM A 6-FOOT TANK FLOATED IN THE MIDDLE OF THE RENO RESERVOIR (TOWER 3, PAN 1)

Wind	t *Temp. of water*	p *Vap. Pr. of water*	p' *Partial Pr. of moisture in air*	p-p'	E *Evaporation*
Km. per hr.	°*C.*				*Cm. per hr.*
1	15.3	13.0	6.7	6.3	0.033
2	16.1	13.7	6.6	7.1	.035
2	16.7	14.3	7.0	7.3	.032
2	17.2	14.7	7.0	7.7	.037
4	19.7	17.2	7.5	9.7	.040
4	18.3	15.8	7.0	8.8	.042
6	21.3	19.0	7.3	11.7	.047
6	20.0	17.5	7.0	10.5	.047
13	17.6	15.1	7.3	7.8	.043
13	17.8	15.3	8.8	6.5	.039
14	18.0	15.5	8.7	6.8	.039
14	17.5	15.0	6.5	8.5	.046
15	18.0	15.5	6.5	9.0	.055
16	19.2	16.7	6.7	10.0	.051
17	21.2	18.9	7.8	11.1	.061
17	20.2	17.8	7.3	10.5	.059
21	17.0	14.5	5.3	9.2	.044
22	16.9	14.4	5.4	9.0	.049
22	17.6	15.1	6.6	8.5	.044
24	16.7	14.3	5.7	8.6	.052
25	18.4	15.9	6.3	9.6	.059
26	17.0	14.5	6.3	8.2	.061
27	20.2	17.8	7.1	10.7	.069
28	19.3	16.8	7.6	9.2	.068

$\frac{E}{p - p'}$ when $w = 0$ gives $\frac{k}{B} = 0.0044$, whence, as $B = 658$ for Reno, $k = 2.90$ and $c = 0.018$, or $\frac{k}{B} = 0.0038$ for a barometer of 760 mm.

When equation (1) was applied with these constants to test some evaporation records for 6-foot pans sunk in the ground at several localities[8] the calculated results were generally too high for the higher temperatures and too low for the lower temperatures, with wide individual variations, ranging from 77 to 217 per cent of the observed evaporation. It is clear either that the Dalton equation is of little value or that some factors of these records with pans have not been correctly determined. On the assumption that the latter alternative may be the correct one an attempt has been made to apply the equation to

[8] HORTON, Mon. Weath. Rev. **49**: 553. 1921.

compute the annual evaporation from Chesapeake Bay from data available in the Weather Bureau records for Baltimore and Norfolk. Even if the result is only approximate, it may serve to induce further study of the problem, or calculations by others by other methods. The steps of procedure are as follows.

We have the mean monthly temperature and humidity for 37 years at Baltimore and Norfolk. These figures are first interpolated slightly in order to obtain figures corresponding to the upper half and the lower half of the bay, by adding 28 per cent of their difference to the Baltimore readings and subtracting 21 per cent of their difference from the Norfolk readings. The water and air temperatures were considered to be the same. The vapor pressure of water at each temperature is corrected very slightly, only 0.7 and 1.0 per cent for the upper half and lower half of the bay, respectively, for the salinity of the water, giving $p_{Cor.}$ The instruments at Baltimore and Norfolk are about 100 feet and 170 feet respectively above the level of the bay, so that the interpolated humidity of these heights, p_h, should be increased to correspond with an altitude of 1 or 2 feet above the water. It is difficult to decide just how great this increase should be. On the basis of the curve in figure 1, and allowing slightly for the greater altitude of the instruments a figure of 87 per cent of the difference $p_{Cor.} - p_h$ has been used to reduce the available data on humidity to an altitude of 2 feet above the water. This gives the figures in Table III.

TABLE III.—HUMIDITY

Month	*Observed*		*Computed for 2 feet above water*	
	Baltimore	*Norfolk*	*Upper half of bay*	*Lower half of bay*
January	71	75	75	77
February	68	75	74	77
March	67	74	72	77
April	62	72	70	74
May	65	74	72	75
June	68	77	75	79
July	69	79	76	80
August	72	80	77	81
September	73	80	78	81
October	71	78	76	80
November	69	74	74	76
December	70	75	74	76

TABLE IV.—EVAPORATION FROM CHESAPEAKE BAY

	Mean surface temperature	p (cor.)	p'	p-p'	w	E	E
Northern half							
	°C.	Mm.	Mm.	Mm.	Kilometers per hr.	Cm. per hr.	Cm. for month
January	2.1	5.3	4.0	1.3	8.1	0.0057	4.3
February	3.0	5.7	4.2	1.5	8.7	.0066	4.4
March	6.6	7.2	5.3	1.9	8.0	.0082	6.1
April	12.3	10.6	7.5	3.1	9.3	.0138	9.9
May	18.3	15.7	11.4	4.3	8.0	.0186	13.9
June	22.8	20.7	15.6	5.1	7.2	.0219	15.8
July	25.4	24.1	18.4	5.7	7.0	.0244	18.4
August	24.5	22.9	17.9	5.0	6.7	.0212	15.8
September	20.9	18.4	14.5	3.9	6.3	.0164	11.8
October	15.2	12.9	9.9	3.0	7.2	.0128	9.6
November	8.8	8.4	6.3	2.1	7.4	.0089	6.4
December	3.6	5.8	4.4	1.4	7.1	.0060	4.5
							120.9
Total annual evaporation = 48 inches							
Southern half							
January	4.0	6.0	4.7	1.3	10.6	0.0059	4.4
February	5.0	6.4	5.0	1.4	10.3	.0063	4.2
March	8.3	8.1	6.3	1.8	11.3	.0082	6.1
April	13.3	11.4	8.5	2.9	11.1	.0132	9.5
May	18.8	16.1	12.3	3.8	9.3	.0169	12.6
June	23.3	21.3	16.8	4.5	8.3	.0197	14.2
July	25.2	23.8	19.2	4.6	8.3	.0201	15.0
August	25.0	23.6	19.2	4.4	8.0	.0191	14.3
September	21.6	19.2	15.8	3.4	7.5	.0146	10.5
October	16.4	13.9	11.2	2.7	9.0	.0119	8.9
November	10.2	9.2	7.1	2.1	9.1	.0093	6.7
December	5.5	6.7	5.2	1.5	9.5	.0067	5.0
							111.4
Total annual evaporation = 44 inches							

The anemometers at Baltimore and Norfolk are respectively 113 feet and 205 feet above the ground. Bigelow found a uniform rise in wind velocity over the Reno reservoir of 0.66 per cent per foot of altitude. This rate was used up to 25 feet. Above 25 feet the variation was calculated by the Stevenson formula, quoted by Humphreys, so that, as a result, the Baltimore and Norfolk wind observations were reduced by 37 per cent and 49 per cent respectively, in order to represent wind velocities at the surface of the bay. The figures given in the tables were obtained by reduction from observations for 1907, 1908, 1920, and 1921. For the earlier years the anemometer altitudes were different.

Table IV is calculated by equation (1) for the special case in which p is the vapor pressure corrected for salinity and p' is the partial vapor pressure derived for the humidities of Table III corresponding to a height of about 2 feet above the surface of the water. It is easily seen that

$$p - p' = 0.87\ (p_{Cor.} - p_h)$$

The final result in Table IV is an annual evaporation of 46 inches (which happens to be almost exactly equal to the rainfall, 45 inches). The evaporation calculated by using the humidity observed at the Weather Bureau stations directly, without any correction for altitude, is 53 inches. This is probably too large. On the other hand, if the vapor-pressure gradient for the upper part of the curve is taken to be twice as steep as that used, an improbable assumption, the result is 38 inches. These results indicate for one thing the need of further study of the vapor-pressure gradient above natural bodies of water, although, as has been stated, there may still be fundamental errors in the Dalton equation, or even in the Reno data from which the constants were derived. However, the results are of the same order as some actual measurements of evaporation from large stretches of water near Arles, France, 15 miles from the shore of the Mediterranean, with about the same mean annual temperature.[9]

Summary

Some new constants have been derived for the Dalton equation for evaporation, to be used for large bodies of water when the humidity at a point 1 or 2 feet above the water, the temperature, and the velocity of the wind can be obtained or calculated from available data. Applied to Chesapeake Bay the formula gives an annual evaporation of 46 inches.

[9] Hegly, Ingénieur en Chef, Ponts et Chaussées, Chaumont (Haute-Marne), France. Trans. Amer. Soc. Civil Eng. **80**: 1994. 1916.

PHYSICS.—*Unit of thermal resistance: the "fourier."*[1] D. ROBERTS HARPER 3D, Union College, Schenectady, N. Y.

The proposal is advanced to assign to the practical metric unit of thermal resistance the name "fourier," in honor of the foremost contributor to the theory of thermal conduction. The absolute unit of energy, the erg, being too small for many purposes, the joule is regarded by the author as the practical metric unit of energy, and the watt for rate of energy transfer.

Accordingly the *fourier* is defined as that thermal resistance which will transfer heat energy at the rate of one joule per second (one watt) for each degree (Centigrade) temperature difference between its terminal surfaces.

The "laboratory fourier" may be visualized as a prism of silver or copper about 4 cm. long and 1 cm^2. cross section.

The paper outlines briefly the psychological reasons for naming some elementary units in each branch of physics, and discusses various possible choices of metric and English units for heat transfer problems.

Two tables are given; one, the author's estimate of the most suitable values to use for thermal resistivities of about 30 common materials; the other, a conversion table between 9 of the units of heat transfer per unit area, common in the literature of today.

The Ohm-Fourier law is, in its application to electrical quantities, familiar to every schoolboy who has taken a course in physics. In the application to thermal problems, it is not so generally recognized, and more or less haze surrounds the concepts involved in heat-conduction calculations. Would not the psychologist locate one of the reasons for this in a lack of definite names for the thermal units?

When a high school student first learns that "amperes are volts divided by ohms," he is generally learning words only, and has scant understanding of the fundamental concepts, but nevertheless he very soon acquires a sufficient grasp of elements to make correct calculations in a surprisingly large percentage of the problems which come to him. The familiarity gained with these three terms seems to lay a foundation that assists greatly in his more advanced studies, when developing the philosophy of electrical relations and determining the logical order in which units must be defined. Would the same result be secured if we had no term "volt," but only a phrase "work per unit quantity of electricity," or if instead of the single term "ampere" we had a dozen or so of expressions, each nameless, for rate of transfer of electric quantity? There is more to it than mere clumsiness of language. Not alone is one's vocabulary impoverished and the ease of expressing ideas hampered by lack of names; ideas themselves are by no means so clear when no name can be associated in the mental process. Every laboratory student in physics and engineering early gets a rather definite visualization of, let us say, 1000 ohms, a megohm,

[1] Received August 10, 1928.

a few microhms. Few amongst even mature workers have any such concrete mental picture of thermal resistance.

There will be a distinct advance in the understanding of the elements of problems in thermal conduction, if physicists and engineers can agree upon the use of a few primary units in which to express relations, and will give those units names. Sporadic attempts to do so have been noted in the literature. Dr. Hering's proposal for a temporary use of the term "thermal ohm" pending selection of a more permanent convention, is an example.

For the thermal "difference of potential" we have well recognized, universally adopted units, the degree Centigrade and degree Fahrenheit, and nothing further needs to be said regarding this quantity.

For the measure of rate of transfer of quantity of heat, corresponding to current in electrical parlance, the literature is not so well off. Instead of a single unit like the ampere, which everyone may be expected to use, we find many in fairly common use. It happens that, because of the extended areas through which heat transfer takes place in so many of the practical problems, it is much more usual to calculate in terms of heat flow per unit area than in terms of total heat flow. Interest centers, thus, on the analog of current density, amperes per unit area, rather than just amperes.

In Table I are collected nine of the units for current density of heat transfer which are in most common use. To assign names to all of these would confuse things far worse than they are at present. It would be absurd to burden a memory with the effort to recall which definition went with which name, and to recite its definition *every* time you use a name is cumbersome. To select some unit or units from the nine, for a christening, is a task which the author prefers to dodge. The advocates for each unit which is tabulated could marshal plausible reasons for not retiring it too far into the background, although probably not all of the combinations present equal claims to precedence as a primary unit. Any committee or individual who essays such selection will have no mean task.

In the metric units, the author inclines very strongly toward emphasis upon the watt as the unit for measuring rate of heat flow, in preference to calories per second or kilocalories per hour. Modern physics is inseparably associated with the concept of heat as identical with energy, and the erg is the natural unit for both if it is for the one. The multiplier, 10^7 (ergs to joules), is invariant, but the multiplier 4.18×10^7 (ergs to calories) rests upon experiment and has to be

TABLE 1.—CONVERSION FACTORS BETWEEN UNITS OF CURRENT DENSITY OF HEAT FLOW. QUANTITY OF HEAT ENERGY TRANSFERRED THROUGH UNIT AREA PER UNIT TIME

	$\frac{watts}{cm^2}$	$\frac{cal.}{sec. \times cm^2}$	$\frac{kilo\ cal.}{hr. \times m^2}$	$\frac{B.t.u.}{sec. \times ft^2}$	$\frac{B.t.u.}{sec. \times in^2}$	$\frac{B.t.u.}{hr. \times ft^2}$	$\frac{B.t.u.}{hr. \times in^2}$	$\frac{H.P}{ft^2}$	$\frac{watt}{in^2}$
$1\ \frac{watt}{cm^2} =$	1	0.2391	8606	0.8815	0.006123	3173	22.03	1.246	6.452
$1\ \frac{cal.}{sec. \times cm^2} =$	4.183	1	36000	3.687	0.02560	13270	92.17	5.211	26.99
$1\ \frac{kilo\ cal.}{hr. \times m^2} =$	$0.0^{3}1162$	$0.0^{3}0278$	1	$0.0^{3}1024$	$0.0^{6}7112$	0.3687	0.002560	$0.0^{3}1448$	$0.0^{3}7497$
$1\ \frac{B.t.u.}{sec. \times ft.^2} =$	1.134	0.2712	9765	1	0.00694	3600	25	1.414	7.320
$1\ \frac{B.t.u.}{sec. \times in.^2} =$	163.4	39.06	1,406,000	144	1	518,400	3,600	203.6	1,054.1
$1\ \frac{B.t.u.}{hr. \times ft.^2} =$	$0.0^{3}3152$	$0.0^{3}0754$	2.712	$0.0^{3}2778$	$0.0^{5}1929$	1	0.00694	$0.0^{3}3927$	0.002033
$1\ \frac{B.t.u.}{hr. \times in.^2} =$	0.04539	0.01085	390.6	0.04000	$0.0^{3}2778$	144	1	0.05654	0.2928
$1\ \frac{H.P.}{ft^2} =$	0.8027	0.1919	6908	0.7074	0.004913	2547	17.68	1	5.178
$1\ \frac{watt}{in^2} =$	0.1550	0.03705	1334	0.1366	$0.0^{3}9487$	491.8	3.415	0.1931	1

For the table above, the following conversion factors were used:

The calorie was defined to be 4.183 absolute joules. This makes it as closely the 20°C. calorie as present experimental work can tell. The B.t.u. is taken to be 252.00 calories, and is therefore not far from a 70°F. B.t.u. The degree Fahrenheit is 5/9 of a degree Centigrade. The inch is defined to be 1/39.37 of the international meter. Values for "g" and for the pound were used which lead to 1 H.P. = 745.69 watts (absolute). The international electric watt in use at this time (1928) differs from the absolute watt by very closely 1 part in 3000.

redefined every time a more accurate experiment on mechanical equivalent of heat is recognized.

There has always been a considerable confusion between the gram calorie and the kilogram calorie and, for exact work, between 20° calories, 15° calories, mean calories, etc. Although there are standardization movements on foot which are gradually lessening this confusion, the simplest way of reaching international agreement is the gradual discard of *all* calories in favor of the absolute joule, regarding which no differences of definition can arise. Most calorimeters are standardized today primarily by electric heating, so that their basis of reference is really the electric joule, and not the calorie at all.

For heat transfer work let us adopt, in the metric system, the watt per cm^2. as the primary unit for heat flow per unit area, in other words, the watt as the unit of rate of heat transfer, the "current." As this unit already has a name, no new proposal is involved in regard to naming it.

The unit of thermal resistance in the metric system will then be one degree Centigrade per watt, which needs a name. The physicist whose name is always associated with the subject of heat conduction is Fourier, and if his name is to be given to any unit it would seem most appropriate that this unit be one of those fundamentally involved in the transfer of heat by conduction. The logical one is the metric unit of thermal resistance.

The *fourier* will thus be visualized as that resistance between two isolated surfaces, one degree Centigrade different in temperature, which makes the rate of heat transfer one watt (10^7 ergs per second). It happens that the thermal properties of an average brass at room temperatures are such as to give us a concrete model in terms of a slab 1 cm. thick. Such a slab with a temperature difference of 1°C. between the faces has a heat flow of 1 watt per cm^2. of area, so that its resistance is 1 fourier for each cm^2. of cross section.

Silver and copper have approximately four times the thermal conductivity of brass, or one-fourth the resistivity, so that we picture the fourier in terms of these metals by noting that a slab of 1 cm. thickness has a resistance per cm^2. cross section of about 1/4 of a fourier, or a slab 4 cm. thick secures a resistance of 1 fourier per cm^2.

To make a laboratory fourier, we might cut a right prism of copper 1 cm^2. in cross section (the prism may be circular, square, or any other shape) and about 4 cm. long. The model is just as definite as is (approximately) 60 meters of copper wire 1 mm^2. in cross-section for an electrical ohm. The difference as regards laboratory use of the two pieces of apparatus is, of course, that the wire ohm requires few precautions to keep electric current from "leaking off the sides," while the metal fourier needs some auxiliaries to keep the heat flow axial.

Just as we might make our ohm (in wire of 1 square millimeter section) from either 60 meters of copper or about 1 meter of nichrome alloy so we may visualize our fourier in a variety of ways. In prisms of 1 square centimeter area, it is 4 cm. length of copper, or 1 cm. of brass, or about 0.1 mm. of glass, a few microns only of asbestos, or of cork or of air.

A few approximate values of thermal resistivities are collected in Table II to illustrate relative orders of magnitude:

It may be noted in passing that while resistivity of a material involves linear dimensions of a unit specimen thereof, resistance does not involve these (except insofar as a unit of distance is inherently a part of the definition of an erg). That is to say, a fourier is defined when the degree Centigrade and the watt have been specified, and the user of the unit may, if he likes, combine it with feet or inches instead of with centimeters, in any computation. The unit should therefore prove acceptable not only to physicists and chemists, but also to the large class of engineers, especially electrical engineers, who are accustomed to watts and degrees Centigrade. It will obviously not be acceptable to those engineers who prefer British thermal units to watts and Fahrenheit degrees to Centigrade. Instead of the fourier, the mechanical engineers engaged upon refrigeration problems, boiler insulation, etc., will want a unit of thermal resistance based on British measures. The difficulties which will be encountered in selecting one have been hinted above, in the section devoted to heat current-density.

Common practice among heat insulation engineers in America today is to base heat transfer computations on the use of a dimensional unit which is the board foot of the lumber industry. Dimensions in two coördinates are taken in feet, and the third coördinate in inches. This "commercial conductivity" as it has been named (B.t.u. per hr. per sq. ft. for rate of heat flow, and °F. per inch for temperature gradient), while very useful as a secondary unit for computation in many practical applications, is clearly unsuited to give a *primary* unit of resistivity. Any system which measures distances east and west in inches and those north and south in feet, is fraught with pitfalls. Imagine the mental gymnastics for a measurement northeast and southwest. In other words, the moment we attack problems where thermal resistivity is to be combined with viscosity or velocity or any other physical prop-

TABLE II.—THERMAL RESISTIVITIES AT 20°C. EXPRESSED IN FOURIERS FOR A CENTIMETER CUBE

Silver	0.239
Copper	0.258
Aluminum	0.49
Brass (30% Zn)	0.93
Iron	1.6
Nickel	1.7
Steel (1% C)	2.1
Constantan	4.4
Mercury	12.0
[Ice at 0°C.]	45
Glass*	133
Concrete*	140
Water	170
Mica* (⊥ laminations)	200
Firebrick*	200
[Firebrick 25°C. to 1000°C.]	90
Brick masonry*	250
Leather*	600
Hydrogen	600
Hard rubber	610
Helium	690
Rubber* (over 90%)	700
Wood (Virginia pine across grain)	710
Paper*	1000
Asbestos* (wool)	1100
Cork*	2000
Cotton batting (loose)	2500
Wool (loose)	2500
Air	4100
Carbon dioxide	6700

* Substances marked with the asterisk vary widely in thermal conductivity according to composition. For limits of such variation, consult International Critical Tables, Vol. II. The figure listed above for any such material represents the author's estimate of the "best guess" for use in those cases where the composition of the material is not specified.

In preparing this table, the author has consulted Vol. II, I. C. T. and has courteously been furnished advance values for some other materials by the editors of I. C. T. For still other materials, grateful acknowledgment is made to the staff of the U. S. Bureau of Standards, for advice in selecting most probable values in the light of present information.

erty, we are obliged to have a unit which is self-consistent, feet throughout or inches throughout, but not both at once. The board foot as a geometrical unit for resistivity can never be more than a secondary choice used for a particular class of problems.

Dropping the geometrical factor of resistivity and considering a unit for resistance, we note that commercial conductivity is expressed in B.t.u. per hour, while the second is the universally accepted unit of time. This means that although a resistance unit based on the hour would contain no inherent inconsistency, constant vigilance would have to be exercised with respect to using a conversion multiplier if it were brought into a formula with other physical quantities, for example "*g*," which would surely be in seconds, not hours.

The logical primary unit for thermal resistance in British measure is of course based on the British thermal unit, second, foot and Fahrenheit degree. The argument against dragging such a unit into the foreground, is the very cogent one that aside from a very few papers on theory of heat transfer, nobody would use it. The simple fact is that this combination has not found favor in calculations pertaining to engineering structures.

All in all, the author is inclined to beg the question of selecting and naming a unit of thermal resistance in British measure. The multiplicity of usage is too discouraging. In deference to this lack of standardization, would it not be quite as well to promote the universal tabulation of resistivities (and reciprocally, conductivities) in fouriers for the centimeter cube, and suggest to each engineer that he write in his handbook at the margin of the table, the multiplying factor which converts the tabulation in fouriers to that *particular combination* of British measure elements which his past experience has led him to prefer for his thermal conduction calculations.

The fourier is proposed as the name for a thermal resistance such that each °C. of temperature head applied at its terminal surfaces gives a heat flow of 1 watt (10^7 ergs per second).

APPENDIX

Factors by which to multiply a value of thermal resistivity, expressed in fouriers for a centimeter cube, to get values in other systems of units

Heat flow in	*Temperature Gradient*	*Multiplier*
Watts per cm².	°C. per cm.	1
$\frac{\text{Calories}}{\text{sec.}}$ per cm².	°C. per cm.	4.18
$\frac{\text{Kilocalories}}{\text{hr.}}$ per m².	°C. per m.	0.0116
$\frac{\text{B.t.u.}}{\text{hr.}}$ per ft².	°F. per ft.	.0172
	°F. per inch	.00143
	°C. per inch	.00080
$\frac{\text{B.t.u.}}{\text{hr.}}$ per in².	°F. per inch	.206
	°C. per inch	.115
$\frac{\text{B.t.u.}}{\text{sec.}}$ per in².	°F. per inch	745
	°C. per inch	414
H.P. per ft².	°F. per foot	44
	°F. per inch	3.67
Watts per in².	°C. per inch	0.394

PHYSICAL GEOGRAPHY.—*A preliminary note on blue-green algal marl in southern Florida in relation to the problem of coastal subsidence.*[1] ALFRED P. DACHNOWSKI-STOKES, U. S. Bureau of Chemistry and Soils, and R. V. ALLISON, Florida Agricultural Experiment Station.

In 1922 a paper was presented before the National Academy of Sciences in which the broad outlines of the stratigraphic successions between American and European peat deposits were pointed out, and a correlation was attempted of glacial, climatic and life stages since the last Ice-age.

In a later paper, dealing with the profiles of peatlands in New England, which appeared in 1926 in *Ecology*, evidence was set forth showing that the Atlantic Coast of North America had suffered a geologically recent subsidence or a rise of sea-level. The observations offered in the present paper are believed to demonstrate coastal stability during the last few thousand years.

Wide expanses of the bedrock floor of limestone in the southern part of the Florida Peninsula are covered by gray marl. The material varies in thickness from 1 to 2 feet and on it are found mangrove islands, saw-grass marshes, prairie vegetation north of Flamingo, and portions of the great cypress swamps to the west of the Everglades. In origin, appearance, and manner of deposition, this marl is unlike that representing chemical precipitation, the aggregation of shells, fragments of chara, or the calcareous ooze produced by bacterial action. In the present case blue-green algae constitute the bulk of the organisms which are building up and extending to a surprising degree the marly soil of the lower glades and of the shores along the southern mainland.

Notwithstanding their great economic interest to man as agents of decay, fermentation, and disease, the aggregate work accomplished by these organisms is far from being understood. Until recently bacteria and blue-green algae received little attention as agencies that encrust themselves with lime carbonate and thus stand out as builders of extensive areas of mineral soil. Today there is evidence to show that precipitation of calcium, silicon, iron, sulphur, and part of the colloidal organic material in soils is caused by algae and bacteria. From the geologist's standpoint Glock (4) and Diener (2) have reviewed the bibliography establishing these forms as reliable fossils of stratigraphic value and for the interpretation of past climatic changes;

[1] Received July 30, 1928.

Fig. 1.—Profile features of gray marl along the Ingraham Highway between 10 and 20 miles north of Flamingo, Florida. Photographed February 22, 1928, by R. V. Allison.

the organisms have been recorded since early geologic times, and are reported as existing in peat deposits. Botanists and ecologists, on the other hand, are beginning to direct attention to the lower order of plants as indicators, whose habitat includes extremes of temperature, geographic conditions, and aerial situations.

Investigations and views concerning the active organisms, the process, and the secondary changes accompanying precipitation of calcium carbonate have not, as yet, thrown much light on the formation of marl under natural field conditions. In regard to bacterial organisms Drew (3) and Vaughan (11) have discussed in considerable detail the accumulations of calcareous sediments and oolite made by the action of denitrifying bacteria in shallow water adjacent to the keys and living coral reefs of Florida. The specific identification of the living forms has been attended with difficulty, owing to the close connection between bacteria and blue-green algae. Further experimental evidence pointing to bacterial forms which precipitate calcium carbonate has been offered by Kellerman and Smith (7). The several researches in sedimentation reported more recently to the National Research Council (10) will also serve, it is hoped, to give in a short time an intimate knowledge of the number and character of the bacterial organisms as well as the nature and potency of their work in mild or subtropical regions like Florida.

Fig. 2.—Profile section in dense growth of *Distichlis spicata*, about 6 miles north of Flamingo, Florida, along southern extension of Dixie Highway. Photographed February 22, 1928, by R. V. Allison.

With reference to blue-green algae there is apparently a great lack of information regarding their number and geographical distribution in the southern part of the United States. Tilden (9) records the specific description of only 31 filamentous blue-green algae so far known to exist in Florida. They are grouped chiefly among 5 families and 19 genera.

Some of the material described below was collected in the Everglades in 1919 and kept dry for subsequent study. It was not until the winter of 1927 and 1928, during a reconnaissance trip made in coöperation with the Agricultural Experiment Station of Florida, that algal forms were found to contribute so materially to the deposition of calcareous matter at the surface of the soils.

The greater part of the blue-green algae has been identified by means of Tilden's volume on Myxophyceae (9), but they are classified here only on general resemblances of form.[2] The most abundant algae are the fresh-water plants belonging to the genera *Scytonema*, *Calothrix*, *Lyngbya*, and *Dichothrix*. The latter, together with others, occurs as a thin, soft, greenish-blue matted coating, closely attached to the friable, calcareous material about 1 or 2 inches below the surface. They form gray, laminated or flaky and nodular incrustations, which present a cavernous structure to a depth varying from 5 to 8 inches. Underneath is grayish-white, compacted, harder marl, more or less amorphous, plastic when wet, and frequently dark gray in color and mottled from rootlets to the contact line with the underlying bedrock limestone. Plate 1 shows a profile exposure at type localities along the Ingraham Highway between 10 and 20 miles north of Flamingo.

The vegetation of these places is similar in aspect to that of other parts of southern Florida, but it differs in composition. The trees and shrubs are woody evergreens. Among the herbaceous plants commonly observed on the "Ingraham marl" are sedges and grasses, (*Cladium mariscus*, *Eleocharis cellulosa*, *Rhynchospora tracyi*, *Dichromena colorata*, *Spartina bakeri*), reeds, and species of *Aletris*, *Crinum*, *Flaveria*, *Ludwigia*, and *Sisyrinchium*. The principal types of vegetation native to this region have been described from diverging viewpoints by Harshberger (6) and by Harper (5) whose paper contains many bibliographic references.

Very little use has been made thus far of any of this type of soil, but some of it has recently been cultivated for early tomatoes.

There are no detailed soil surveys for southern Florida, and hence the distribution and acreage of this material are practically unknown. The marls described by Matson and Sanford (8) in their paper on the geology and ground waters of Florida extend over hundreds of square miles, but too little is known to map them as a soil type. The northern boundary of the gray algal marls appears to coincide with a line near the Tamiami trail between Miami and Collier County. South of this line the marl was observed along the Ingraham Highway between

[2] A more detailed identification is being made in connection with precipitation studies to be published later.

Homestead and Flamingo, merging into the limy ooze of the islands along the shores of the southern mainland.

The average rapidity with which algal marl is now accumulating is not known, nor the rate of increase under favorable and unfavorable circumstances. The thickness is nowhere great and is only moderately irregular, in part due to the uneven surface upon which the marl was deposited at a particular place. From the profile features of the layer it may be inferred that throughout the time following the emergence of southern Florida from the sea, the conditions governing the deposition of the calcareous material were not marked by great disturbances. The emergence of the "lower Glades" and mainland with respect to sea level has been small and began probably only a few thousand (perhaps 3000 to 4000) years ago. In comparison with the series of profiles obtained in the "upper Glades" and on Torrey Island in Lake Okeechobee, already noted in another connection (1), the evidence discovered seems to prove essential coastal stability during the past few thousand years. The algal marl layer was formed during relatively recent or late Pleistocene times, and since then there has been no appreciable change in the relative positions of land and sea in southern Florida. A fuller treatment of this question is reserved for a later paper.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

218TH MEETING

The 218th meeting was a joint meeting with the Philosophical Society and was held in the Assembly Hall of the Cosmos Club on the evening of Thursday, January 19th. The general subject of discussion was methods of election, including the election of officers and governing bodies of Scientific Societies.

Program: L. B. TUCKERMAN of the Bureau of Standards: *Theoretical principles underlying balloting.* The complete expression of the will of an electorate on a plurality of candidates for the same office or plurality of similar offices would be contained in a single preferential vote if all questions of expediency could be eliminated from the vote. Certain mathematical conditions must be imposed on the count to ensure the complete elimination of expediency from the vote.

These conditions are not realized in any count so far devised, and may be impossible of realization. The mathematical problem, being a problem in combinatory analysis, is difficult. A number of able mathematicians have worked on the problem with the result that it is known that in certain broad classes of counts expediency can not be wholly eliminated from the vote. Further investigation is desirable.

Although expediency may never with certainty be eliminated from the vote, two different counts have been devised, meeting two distinct needs, in which expediency in voting has been so nearly eliminated as to be negligible from a practical standpoint. These are the Hare count for electing a representative body and the Condorcet count for filling a single office. These counts of a preferential ballot are far superior to any other known methods of election, and may be considered a practical solution of the problem of securing an effective expression of the will of an electorate. (*Author's abstract.*)

GEORGE H. HALLETT, Jr., Secretary of the Proportional Representation League: *An appraisal of election methods.* Dr. Tuckerman has suggested as a criterion for a perfect method of election the requirement that it shall always give most effect to a person's vote if he expresses on the ballot his real wishes. This seems a reasonable requirement, but unfortunately it conflicts with another which seems just as reasonable and perhaps even more important. It can be proved that a method of election under which it would never be profitable for the voter to falsify his real wishes would sometimes defeat a candidate for a single office who was preferred to all other candidates by an absolute majority of the voters.[1] Under such circumstances the unsolved question whether Dr. Tuckerman's test can be satisfied at all is one of considerable academic interest but probably not of great practical importance.

This does not mean that the test has no value. It can and should be satisfied for most practical purposes without sacrificing anything else of more importance.

The most workable system so far proposed seems to be the Hare system of proportional representation. This system is not mathematically perfect.

[1] The proof is given in footnote 14 on pages 396–397 of *Proportional Representation* by HOAG and HALLETT (Macmillan).

It defeats arbitrarily the candidate who stands lowest on the poll and occasionally such a candidate might be preferred to each other candidate considered singly by a majority of the voters. It is possible to overcome this defect also by introducing complications in the rules for counting,[2] but the Hare system in its usual simple form offers a small probability of error and its political as well as theoretical advantages over our ordinary methods are very great. It is in use for the election of important single officers in Australia and in the provinces of Manitoba and Alberta.

When a group of officers are being elected together to a legislative body, it is possible to do still better. For when a single place is to be filled it is only possible at the best to satisfy one point of view, but when a number of places for the same office are to be filled together it is possible to give just representation to all important points of view.

On this question of representation there is a great deal of confusion in the public mind. It is quite generally assumed that the principle of majority rule demands that each particular member be a majority choice. This is frequently qualified by a division of the whole territory to be represented into districts, in some of which a minority party may have a local majority and so get representation, but the idea of assuring representation to minorities whether they are a majority in any one neighborhood or not is thought to conflict with majority rule.

In fact, however, there can be no assured majority rule in a representative body without a representation of all elements in proportion to their voting strength.

The so-called majority methods of election very frequently defeat the majority will. In the last two Congressional elections in the State of New York the Republicans have polled a majority of the votes for Representatives and the Democrats have elected a majority of the members. This was because the Republican minorities in Democratic districts (like the Democratic minorities in Republican districts) were unrepresented. In 1888, when Harrison was elected President over Cleveland, Cleveland had 100,000 more popular votes. A similar miscarriage of justice happened on two other occasions. This was because the minorities in each state were unrepresented in the electoral college.

Though minority rule does not usually stand out so glaringly on the face of the election returns, it is in fact the rule rather than the exception. The remarkable phenomenon of machine rule the country over, with a majority of the people almost everywhere opposed to machine rule, is due simply to the fact that we do not provide a means of representation for the minorities into which the anti-machine majority is divided.

This situation can easily be remedied by a change in election methods to give representation to all elements in proportion to their voting strength. Three things are needed: first, districts large enough to elect several members each; second, a single vote for each voter instead of as many votes as there are members to be elected in the district, so that the largest group cannot elect its entire slate to the exclusion of others; and third, a vote that is transferable, so that, if the voter's first choice cannot be elected by it, it will not be wasted but be transferred to his second choice or third.

This combination of principles gives us the Hare system of proportional representation, otherwise known as the single transferable vote. In its usual forms it is not mathematically perfect and contains various minor

[2] Hoag and Hallett, *Proportional Representation*, pp. 494 ff.

defects which could be remedied by the introduction of considerable complications in the counting rules. Such complications, however, would have little effect on the results secured and without them the Hare system offers a practical remedy for most of our political ills which are not inherent in the people themselves. It is used for city elections in Cleveland, where it has secured the services of such able independent councilmen as Professor A. R. Hatton, charter consultant of the National Municipal League; in Cincinnati, where it immediately deposed one of the most thoroughly entrenched political machines in the country and changed the city from one of the worst-governed to one of the best-governed to be found anywhere; in Ashtabula and Hamilton, Ohio, and Boulder, Colorado, and in many cities abroad. In other countries it has been inaugurated for provincial elections, as in Manitoba, Alberta, and Tasmania; and even in national elections, as in the Irish Free State, and in Great Britain for a few university members of the House of Commons. It requires no primaries and in one election gives a free and practically complete expression of the real wishes of the voting public. (*Condensed from author's manuscript.*)

A demonstration election was then given with the audience as voters. The votes were counted by members of the audience under Mr. Hallett's direction and the results put on a blackboard and explained.

219TH MEETING

The 219th meeting was held in the Assembly Hall of the Cosmos Club on the evening of Thursday, February 16th, 1928.

Program: DAYTON C. MILLER, Professor of Physics in the Case School of Applied Science: *Photographing and analyzing sound waves.* The address was illustrated by latern slides and by experiments, including experiments with the "phonodeik," an apparatus devised by Dr. Miller for projecting "living" waves directly onto a screen.

220TH MEETING

The 220th meeting was held in the Auditorium of the National Museum on the evening of Thursday, March 15th, 1928.

Program: Showing of a moving picture film entitled *The Mechanics of the Brain,* prepared by Prof. IVAN P. PAVLOV, Director of the Physiological Laboratories in the Russian Academy of Sciences. The picture presented a series of experiments on children and animals chosen to illustrate the mechanism of the reactions to various external stimuli. Especial attention was given to the development of "conditioned reflexes," a subject that has been especially studied by Pavlov and his collaborators. The film was exhibited through the courtesy of the American Society of Cultural Relations with Russia.

221ST MEETING

The 221st meeting was held in the Auditorium of the National Museum on the evening of Wednesday, May 16th, 1928.

After calling the meeting to order the President of the Academy announced that a proposed revision of the By-Laws of the Academy, intended to clarify doubtful points and to meet changing conditions, had been duly proposed by three members of the Academy. Under the provisions for amending the By-Laws these proposals were automatically referred to the Board of Managers for further consideration and for submission to the Academy at a future meeting.[3]

Program: FRIDTJOF NANSEN, Arctic explorer, professor of Oceanography at the University of Oslo and President of the International Society for the Exploration of the Arctic by means of the Airship: *Problems of Arctic exploration.* The speaker emphasized the importance of polar exploration as against the popular view that polar expeditions are quests for adventure or bids for notoriety. He especially emphasized the importance of a knowledge of meteorological conditions in the polar regions and compared a study of meteorology with the polar regions omitted to a study of the steam engine with the condenser omitted. Many modern developments of meteorology are based on the "polar-front" theory.

The speaker then described the methods of polar exploration as they were in the nineties when he and his companions drifted across the polar sea in the *Fram* and told of some of the adventures encountered in that memorable expedition. He then described the advantages of exploration by airship and outlined the plans for a proposed expedition. At the conclusion of the address the audience gave the speaker a rising vote of thanks.

WALTER D. LAMBERT, *Recording Secretary.*

[3] The proposed changes are in fact the work of a special committee of the Board of Managers and have been considered by the Board itself at several meetings and approved in principle. Requests for further information regarding these changes may be addressed to the Corresponding Secretary, who is also Chairman of the special committee.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, October 20	The Biological Society
	The Helminthological Society
Wednesday, October 24	The Geological Society
	The Medical Society
Saturday, October 27	The Philosophical Society
Wednesday, October 31	The Medical Society
Thursday, November 1	The Entomological Society
Friday, November 2	The Geographic Society
Saturday, November 3	The Biological Society

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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Vol. 18 November 4, 1928 No. 18

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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JOURNAL
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BOTANY.—*New South American species of* Werneria.[1] S. F. Blake, Bureau of Plant Industry.

Werneria H. B. K. is a medium-sized genus of Asteraceae of the tribe Senecioneae, closely related to *Senecio* and distinguished from it by no definite character except the connation of its phyllaries to the middle or beyond. On the basis of this feature, *Werneria* is included by Bentham & Hooker and by O. Hoffmann in the subtribe Othonninae (Othonneae of Bentham & Hooker) along with several other genera which are restricted to southern Africa.

Werneria itself, with the inclusion of the 10 new species here described, is a genus of some 62 species, about 7 of which[2] (aside from the species described from the Old World) are of somewhat doubtful status. Fifty-eight species occur in the South American Andes from Venezuela (a single species) and Colombia to Chile and Argentina at high altitudes, usually 3000 to 5000 meters. The lowest altitude definitely recorded for any species is about 2750 meters, at which *W. nubigena* and *W. villosa* were collected in Peru by Macbride and Featherstone. The only species known outside this range in America is *W. nubigena* H. B. K., which occurs from Ecuador to Peru and Bolivia, and is found on the mountains of Guatemala at about 3355 to 3660 meters elevation in a form, described by DeCandolle as *W. mocinniana*, which I am unable to distinguish in any way from the typical South American one.

[1] Received August 11, 1928.

[2] *Werneria acerosifolia* Hieron., from description not clearly distinguishable from *W. villosa* A. Gray, but perhaps identical with *W. canaliculata* Sch. Bip.; *W. apiculata* and *W. brachypappa* Sch. Bip., perhaps not separable specifically from *W. pygmaea* Gill.; *W. calyculata* Turcz.; *W. disticha* H. B. K., very close to *W. nubigena* H. B. K.; *W. dombeyana* (Wedd.) Hieron., imperfectly described; *W. mandoniana* Wedd., very close to *W. orbignyana* Wedd., the latter known to me only from description.

Four species are accredited to the Old World, *Werneria africana* Oliver & Hiern and *W. antinorii* Avetta[3] from Abyssinia, *W. ellisii* Hook. f. and *W. nana* (Decaisne) Benth. from the western Himalaya of India and western Tibet, at high altitudes. The distribution of these four makes it extremely improbable that they are very closely related genetically to the typical South American species. I have seen no material of them and so cannot speak with assurance about their position, but the probability, almost the certainty, of their origin from *Senecio* independently of the South American species is in itself no obstacle, in my opinion, to their being placed unequivocally in *Werneria* if their characters agree with those of that genus. A tendency to connation of the phyllaries at base is widespread in the vast genus *Senecio*. The accentuation and fixation of this tendency in one or more *Senecio* prototypes is undoubtedly the source of the genus *Werneria* as represented in South America, where its considerable variation in habit makes it probable that it arose from *Senecio* at several different foci. The appearance of this same widespread tendency to a gamophyllous involucre in two regions of the Old World is in no way remarkable. It is indeed surprising that it has not happened more frequently, particularly in the high altitudes with which it appears to be in some way correlated.

As originally described by Humboldt, Bonpland, and Kunth the genus *Werneria* included six species. Six were added by Schultz Bipontinus in 1856 from Lechler's Peruvian collections; eight by Weddell in 1856, and two more in 1894, the latter manuscript names published with descriptions by Klatt; four by Asa Gray in 1861, from the Peruvian collections of the Wilkes Expedition; six by Hieronymus in 1895, and two more in 1901. One was described from Chile by Philippi in 1873, and four more in 1891. The other accessions to the genus have been mainly single species described by various authors. Weddell's monographic treatment of 17 species in his "Chloris Andina" (1856) is the only available recension of the American species as a whole and is quite inadequate at present, including less than a third of the species now known. A working key prepared by the writer several years ago for the identification of the material of the genus accumulated at the United States National Herbarium from the South American collections of Dr. F. W. Pennell, E. P. Killip, and J. Francis Macbride has been entirely remade after the study of many more specimens, but is

[3] Ex O. Hoffm. in Engl. & Prantl, Nat. Pflanzenfam. 4^5: 301, 302. 1892, hyponym. Omitted from Index Kewensis. Said to be transitional to *Euryops*.

still not in state for publication owing to lack of material of several described species. A tentative grouping of the species, with partial keys, is here presented as an aid to future students of the genus. It is based on the material in the United States National Herbarium, the entire collection of the New York Botanical Garden and Columbia College (about 100 sheets), and a considerable amount of material borrowed from the Gray Herbarium and the Field Museum, as well as several photographs and fragments of authentic specimens obtained at Kew Herbarium in 1925 or (in the case of *W. rigida* Benth.) recently sent by Dr. A. W. Hill. I wish to express my thanks to the curators of the herbaria mentioned for the opportunity to examine the collections under their charge. In the following key the dagger indicates that no material has been examined by the writer; the placing of a name in parentheses, that the species is doubtfully a member of that group. In the first four groups the leaf blade is toothed or lobed; in the remaining three the blade is entire, although the margin is sometimes of different texture and pectinate-ciliate or finely glandular-denticulate.

One species of the genus, *Werneria poposa* Phil., of northern Chile and northwestern Argentina, is much valued in its native habitat as a remedy for intestinal colic, being used in the form of infusions and decoctions. It has been studied histologically and chemically by Dr. Fidel Zelada,[4] who extracted from it a glucoside which he calls "poposina" ("poposa" is the vernacular name of the plant).

I. Group of *W. pinnatifida.* Leaves pinnatisect.—A. Leaves strictly glabrous, their lobes 2–6 pairs, subequal, entire. *W. solivaefolia* Sch. Bip. AA. Leaves usually pilose along rachis above, their lobes 5–20 pairs, alternately unequal, often lobulate. B. Phyllaries 20–25; leaves about 9 cm. long. *W. pinnatifida* Remy. BB. Phyllaries 8–15; leaves mostly 6 cm. long or less. *W. heteroloba* Wedd., *W. obtusiloba* Blake, sp. nov.

II. Group of *W. dactylophylla.* Leaves bifid, trifid, or 3-lobed (the lobes sometimes again 3-lobed), small, 1 cm. long or less; plants leafy-stemmed, suffrutescent.—A. Leaves bifid. *W. rosenii* R. E. Fries. AA. Leaves trifid or 3-lobed. B. Stem and upper leaf surface densely pilose-lanate. *W. dactylophylla* Sch. Bip. BB. Stem and upper leaf surface glabrous, or apex of leaves loosely pilose (*W. amblydactyla*). C. Leaf segments linear, mostly 2–4 mm. long, acutely subulate-tipped. *W. digitata* Wedd. CC. Leaf segments not linear, 1.5 mm. long or less, obtuse. D. Leaves loosely pilose at apex when young, 1–1.5 mm. wide at apex, the linear petiole under 1 mm. wide and not glandular-denticulate. *W. amblydactyla* Blake, sp. nov. DD. Leaves not pilose. E. Leaves practically linear, cylindric-prismatic, 4–6 mm. long, barely 1.5 mm. wide above. *W. incisa* Phil. EE. Leaves linear-

[4] *Estudio botánico y químico de la* Werneria poposa *Philippi* (*n.v.* poposa). Univ. Nac. Tucumán, Mus. Hist. Nat. Bol. **10.** 17 pp., illust. 1927.

cuneate, 8–10 mm. long, 2–4 mm. wide above, densely pectinate-ciliolate with stiff acute non-glandular cilia. *W. decora* Blake, sp. nov.

III. Group of *W. pygmophylla.* Leaves crenately 3–9-lobed, 2 cm. long or less.—*W. pygmophylla* Blake, sp. nov.; († *W. melandra* Wedd.?).

IV. Group of *W. orbignyana.* Leaves (at least in part) 3–5-dentate or -denticulate at apex, spatulate to linear-cuneate or obovate, mostly 3–9 cm. long.—† *W. orbignyana* Wedd., *W. mandoniana* Wedd.

V. Group of *W. pectinata.* Leaves small, spatulate or linear-spatulate, rosulate at base of head and scattered on short horizontal rhizomes, with densely pectinate-ciliate margin (the cilia ca. 0.5 mm. long, stiff, acuminate, not glandular).—*W. pectinata* Lingelsh.,[5] † *W. knocheae* Perkins; († *W. denticulata* Blake?).

VI. Group of *W. lycopodioides.* Truly leafy-stemmed, suffrutescent, the stems densely covered with uniform small unlobed leaves 11 mm. long or less. (Through *W. marcida* and *W. sedoides,* this group nearly connects with the minor group in VIII centering about *W. humilis.* In all of the latter the leaf axils are woolly.)—A. Leaf axils woolly. † *W. poposa* Phil., *W. lorentziana* Hieron. AA. Leaf axils not woolly. *W. decumbens* Hieron., *W. marcida* Blake, sp. nov., *W. lycopodioides* Blake, sp. nov., *W. sedoides* Blake, sp. nov., *W. weddellii* Phil., † *W. juniperina* Hieron., († *W. denticulata* Blake?).

VII. Group of *W. caulescens.* Radical leaves tufted but scarcely rosulate, much larger than cauline, grass-like or plantain-like, or subacicular, erectish; stem evident, subscapose, 2–30 cm. high.—A. Larger leaves 1 cm. wide or more. *W. stuebelii* Hieron., *W. plantaginifolia* Wedd. AA. Larger leaves 6 mm. wide or less. B. Rays white. *W. staticaefolia* Sch. Bip., *W. caulescens* (Wedd.) Griseb., † *W. dombeyana* (Wedd.) Hieron.? BB. Rays yellow inside, red or purple outside. *W. villosa* A. Gray, († *W. acerosifolia* Hieron.?).

VIII. Remaining species. Leaves entire (or margin glandular-denticulate), rosulate or densely crowded on very short or sometimes elongate caudices, occasionally rather scattered on spreading rhizomes; heads usually sessile, sometimes short-peduncled. A varied group, capable of subdivision. —A. Leaf sheaths not ciliate and without axillary tufts of hairs. B. Heads discoid. C. Anthers black or violet. † *W. melanandra* Wedd. CC. Anthers yellow. *W. carnulosa* A. Gray.—BB. Heads radiate. C. Leaves 4–6 cm. long, linear or very narrowly linear-oblanceolate, the blade not distinguished from the petiole; involucre 13–17 mm. high. *W. glaberrima* Phil. CC. Leaves much shorter, or else spatulate and scattered on short rhizomes; involucre 7–12 mm. high. D. Leaves scattered on slender rhizomes, definitely spatulate, the blade 2–6 mm. wide. *W. spathulata* Wedd. DD. Leaves rosulate or densely clustered. E. Involucre 4–5 mm. high. *W. aretioides* Wedd. EE. Involucre 7–12 mm. high. *W. ciliolata* A. Gray, *W. cochlearis* Griseb., († *W. denticulata* Blake).

AA. Leaf sheaths long-ciliate or with axillary tufts. B. Leaves densely setose-strigose on surface. *W. strigosissima* A. Gray. BB. Leaves not setose-strigose. C. Leaf blades glandular above, pilose beneath, ovate to subspatulate, 6–10 mm. wide. *W. glandulosa* Wedd. CC. Leaf blades

[5] *W. ciliata* Wedd., never described, was published by Schultz Bipontinus as a synonym of *W. ciliolata* A. Gray. Examination of *Mandon* 99, chirotype collection, in the herbarium of the New York Botanical Garden, shows that the name is synonymous with *W. pectinata* Lingelsh., described in 1910.

glabrous on both surfaces. D. Leaf sheaths marcescent (whole leaf sometimes so), long-persistent, conspicuous, nearly or quite as long as the blades. E. Leaves bristle-tipped. *W. leucobryoides* Blake, sp. nov. EE. Leaves obtuse to acute, not bristle-tipped. F. Rays rosy. *W. rosea* Hieron. FF. Rays white. G. Involucre 12–18 mm. high; leaf blades 12–28 mm. long. *W. crassa* Blake, sp. nov. GG. Involucre 5–8 mm. high; leaf blades 6–9 mm. long. H. Leaves articulate at or just below junction of sheath and lamina, the latter normally deciduous in all but the younger leaves. *W. articulata* Blake. HH. Leaves not definitely articulate, the whole sheath and blade persistent, becoming corky. I. Lamina of leaves about 4–6 mm. long, 1–1.2 mm. wide; leaves mostly spreading. *W. humilis* H.B.K. II. Lamina of leaves 3–4 mm. long, 1 mm. wide or less; leaves mostly erect or appressed. *W. soratensis* Hieron.—DD. Leaf sheaths not marcescent or long-persistent or conspicuous, usually very much shorter than the blades. E. Rays yellow. F. Leaf blades 1.8 mm. wide or less, the costa prominent beneath. *W. canaliculata* Sch. Bip., *W. cornea* Blake, sp. nov. FF. Leaf blades mostly 2–3.5 mm. wide, the costa obsolete or impressed beneath. *W. pumila* H.B.K. (including *W. densa* Benth.!), *W. rigida* H.B.K.; († *W. calyculata* Turcz.?).—EE. Rays white. F. Leaf blades usually 3–12 mm. wide. G. Achenes and ovaries glabrous. *W. graminifolia* H.B.K. GG. Achenes and ovaries silky. *W. nubigena* H.B.K., † *W. disticha* H.B.K.—FF. Leaf blades mostly under 1.5 mm. wide. G. Leaves very densely rosulate, acicular, the blades 5–20 mm. long, 0.3–1 mm. wide, mucronate. *W. caespitosa* Wedd. GG. Leaves looser, less densely rosulate; plants when well developed with short spreading rhizomes bearing more or less scattered leaves (doubtfully so in *W. brachypappa*). H. Leaves acutely mucronate. *W. apiculata* Sch. Bip. HH. Leaves obtuse. *W. pygmaea* Gill., † *W. brachypappa* Sch. Bip.

Werneria obtusiloba Blake, sp. nov. Fig. A.

Acaulescent perennial; rhizome very short, erect; leaves rosulate, the broad scarious sheaths glabrous, 1.3–2 cm. long, the blades linear or lance-linear in outline, 1–2.5 cm. long, 4–7 cm. wide, pilose along costa above, pinnatisect into 5–11 pairs of very unequal obovate, ovate, or oval, obtuse, entire or 3-lobed segments, the larger about as long as the breadth of the rachis between them; heads discoid, short-peduncled; involucre 8–10 mm. high, 11–13-fid.

Rhizome thick, 1 cm. long or less, glabrous; leaves stellate-imbricate, 2.5–4.5 cm. long, the petiole ("sheath") amplexicaul, 3-nerved, 3–5 mm. wide at base, often purplish-margined, the blade fleshy, glabrous beneath, the lobes obtuse to broadly rounded, 1–4 mm. long, 0.6–2 mm. wide, the larger often with 1–2 supplementary lobules at base; peduncle essentially glabrous, clavate, 1 cm. long or less, sometimes with 1 or 2 linear entire bracts; involucre campanulate, glabrous, the teeth triangular or deltoid, 3–3.5 mm. long, 1.8–2.4 mm. wide at base, obtuse, ciliolate at apex, the subscarious margin often purplish; flowers numerous, their corollas white becoming purple-tipped, 6–6.5 mm. long, the tube 3.2–3.5 mm., the funnelform throat 2 mm., the ovate teeth 0.8–1 mm. long; ovaries glabrous; pappus white, in age purple, 6 mm. long; style tips truncate, minutely hispidulous around apex.

PERU: In sandy soil, with cushion and rosette plants, cordillera east of Carumas, Prov. Moquegua, alt. 4500–4600 m., 7–8 Mar. 1925, *A. Weberbauer* 7362 (type no. 552591, Field Mus.; dupl. no. 44298, U. S. Nat. Herb.).

Wet seepy soil along streamlet, Vincocaya, Dept. Arequipa, 4370–4380 m., 18 Apr. 1925, *F. W. Pennell* 13338 (Field Mus., Gray Herb.).

Closely allied to *Werneria heteroloba* Wedd., of which it may eventually prove to be a form. In that species, as described by Weddell and as represented by a considerable series of specimens before me, the principal leaf segments are linear or essentially so and acute or acuminate to the callous tip.

Werneria amblydactyla Blake, sp. nov. Fig. B, C.

Rhizomes short, branched, the branches or stems tufted, about 2.5 cm. high, densely leafy above, glabrous; leaves about 9 mm. long, loosely crisped-pilose toward apex when young, glabrate, the scarious-margined, barely amplexicaul sheath about 2 mm. long and 2 mm. wide, entire or slightly denticulate at base, the petiole 5 mm. long, 0.6–1 mm. wide, linear, thick, flat above, rounded beneath, entire, the blade 1.5 mm. wide or less, of 3 ovate-oblong, obtuse, erect, connivent, thick lobes 0.6–1 mm. long, subequal or the middle one usually slightly shorter than the lateral; heads subsessile, radiate; involucre 9–10 mm. high, 9–13–(-"20")-fid about to middle.

Rhizomes about 3 mm. thick, covered with the persistent bases of the sheaths, the erectish branches about 4–7; leaves densely imbricated; heads campanulate, solitary, terminal; lobes of involucre triangular, acuminate to an obtusish apex, sparsely pilose above along midline, scarious-margined, 4 mm. long, 1.5 mm. wide at base, 1-vittate; receptacle convex, alveolate, glabrous; disk 10–11 mm. high, 8–12 mm. thick; rays slightly exserted, glabrous, the slender tube 3 mm. long, the narrowly obovate lamina entire, 3-nerved, 7.5 mm. long, 1.8 mm. wide; disk corollas glabrous, 6 mm. long, the tube 1.6 mm., the funnel form throat 3.4 mm., the ovate teeth 1 mm. long; disk achenes (immature or infertile) glabrous, columnar, 2.5 mm. long, about 7-nerved; pappus brownish white, 6 mm. long, the bristles somewhat united in groups at extreme base; style tips hispidulous around the subtruncate apex, usually tipped with a setose tuft nearly 0.5 mm. long.

Peru: Alpamarca, in the Andes, *Wilkes Expedition* (type no. 44300, U. S. Nat. Herb.).

Related to *W. digitata* Wedd., as a form of which it was recorded and briefly described by Gray.[6] The examination of material clearly referable to that species (*F. L. Herrera* 1033, Hacienda Churu, Prov. Paucartambo, Peru, 3700 m., Jan. 1926, U. S. Nat. Herb.) makes it evident that the Wilkes specimens are to be separated specifically. In *W. digitata* the plants are much larger and coarser, the considerably broader leaves are without the loose hairs of *W. amblydactyla*, their lobes are longer (mostly 2–4 mm.) and acutely subulate-tipped, and the broader sheaths and petioles are definitely ciliolate or denticulate. As already noted by Dr. Gray in his examination of the same specimens, the conspicuous tuft of bristles terminating the subtruncate style tips is sometimes absent (at least in more mature flowers of the disk). I have not found any of the "truly opposite" leaves described by him, although some subopposite leaves, apparently due to the obsolescence of the internodes, can be seen.

[6] Proc. Amer. Acad. **5**: 140. 1861.

Werneria decora Blake, sp. nov. Fig. D, E.

Suffruticulose, about 1 dm. high; rhizome branched, the branches erectish, thick, densely leafy above, covered below with the imbricated bases of old sheaths; leaves 7–10 mm. long, conspicuously ciliolate throughout, linear-cuneate in outline, 3-vittate, the scarious sheath 2.5–3 mm. wide at base, amplexicaul, the flat petiole 1.8–2 mm. wide, the blade passing gradually into the petiole, 2.5–4 mm. wide, 3-lobed, the lobes rounded or subtruncate, thickish, the lateral about 1–1.3 mm. long and wide, the middle one usually about half as long and wide, sometimes obsolete; heads sessile, radiate, "the rays white, the disk yellow;" involucre 12–14 mm. long, about 13-fid to middle.

Rhizomes 4–7 mm. thick, much branched, densely covered with the imbricated bases of old sheaths, the green leafy tips 2–4.5 cm long; leaves somewhat yellowish green, fleshy, thickened above, their cilia stiffish, subulate, acuminate, eglandular, 0.1–0.3 mm. long; disk shorter than or equaling the involucre; involucre campanulate, the tube multivittate, the lobes oblong, very obtuse, 3–5-vittate, often somewhat erose on the narrow subscarious margin, minutely ciliolate-tufted at apex, 6–7 mm. long, 2–2.5 mm. wide; rays about 18 (more numerous than phyllaries), glabrous, the tube 3.5 mm. long, the lamina linear-spatulate, 10 mm. long, 1.5–2 mm. wide, 4–7-nerved, entire or obscurely emarginate; disk corollas glabrous, 7.5 mm. long, the tube 2.5 mm., the funnelform throat 4 mm., the teeth ovate, obtusish, 1 mm. long; achenes (immature) glabrous; pappus brownish white, about 7.5 mm. long; style tips of disk flowers truncate-rounded, hispidulous in a ring all around at apex, with terminal rounded naked umbo, of ray truncate-rounded, irregularly and unevenly hispidulous, sometimes with a short terminal tuft of hairs; anthers "reddish in age."

PERU: In loose soils of alpine basin slopes, Casapalca, Dept. Lima, alt. about 4725 m., 21 May 1922, *Macbride & Featherstone* 849 (type no. 517377, Field Mus.; dupl. no. 1,185,462, U. S. Nat. Herb.).

An attractive and very distinct species, at once distinguished from *W. rosenii* R. E. Fries by its conspicuously ciliolate leaves with much broader, very blunt lobes, normally 3 in number, and from *W. incisa* Phil. by its much larger and broader, ciliolate leaves, and much larger involucre.

Werneria pygmophylla Blake, sp. nov. Fig. F, G.

Tiny, caespitose, acaulescent, spreading-pilose throughout; leaves rosulate, without axillary tufts, the petiole linear, about 1 cm. long, the suborbicular blade 2–4 mm. long and wide, crenately 3–9-lobed, conduplicate; heads discoid, small; involucre 6–8 mm. high, about 18-fid, the blunt teeth ustulate-tipped; achenes densely papillate.

Plants in small tufts, altogether 1–1.8 cm. high; rhizomes branched, short, slender, leafy only at apex; leaves 8–15 mm. long; petioles subscarious toward base, 3-vittate, flat, ciliate, sparsely pilose on back above, 7–11 mm. long, 2 mm. wide or less at base, scarcely amplexicaul; blades abruptly distinguished from petioles, green, fleshy, strongly conduplicate, often slightly inequilateral, very obtuse and often slightly cucullate at apex, at base subcordate to rounded-cuneate, shallowly crenate-lobate with rounded lobes, pilose on both surfaces; peduncles 4 mm. long or less, bearing a few linear entire leaves; heads campanulate-hemispheric, about 8 mm. high, 9 mm. thick (as pressed), about 49–flowered; receptacle flattish, alveolate, glabrous; involucre loosely pilose especially on the lobes, these mostly oblong, obtuse, 2.5–2.8 mm. long, 1–1.5 mm. wide, sometimes irregularly united nearly to apex, narrowly scarious-margined, with blackish brown tips, minutely brown-ciliolate at apex; disk corollas "now greenish-, now bluish-white," glabrous, 4.2–4.5 mm. long, the tube much swollen at base, 2.2–2.4 mm., the cylindric-campanulate throat about 1.7 mm., the ovate teeth 0.5 mm. long; immature achenes oblong, 1.5 mm. long; pappus whitish, copious, easily deciduous, 4 mm. long; style tips truncate, minutely hispidulous at apex; "anthers and stigmas dark brown."

PERU: On sandy soil, growing with cushion and rosette plants, Cordillera east of Carumas, Prov. Moquegua, alt. 4500–4600 m., 7–8 Mar. 1925, *A. Weberbauer* 7358 (type no. 552587, Field Mus.; dupl. no. 1,233,480, U. S. Nat. Herb.).

A unique species, at once recognized by its rather dense pubescence, ustulate-tipped phyllaries, papillate achenes, and suborbicular shallowly crenate-lobed conduplicate leaf blades, resembling in their normal folded condition a fist, whence the name. The species is closely similar in many respects to a species of *Senecio* collected by Pennell in the Department of Arequipa (*Pennell* 13344), but in that the phyllaries are distinct essentially to base, while in *W. pygmophylla* they are truly connate to well above the middle.

Werneria marcida Blake, sp. nov. Fig. H, I, J.

Suffrutescent (?), caespitose, glabrous, the rhizomes branched, the branches apparently erect, densely leafy throughout, 2–4 cm. long, the green leafy growth of the year only about 1 cm. long or less; leaves at first erect, glaucescent green, in age marcescent, brownish, shrunken and spreading, lance-oblong or ovate-oblong, 8.5–10.5 mm. long, 2.5–4 mm. wide, acute and apiculate to obtusish, not at all dilated at base, 1-vittate, subglandular-denticulate especially above, flat, the petiolar portion 5–7 mm. long, narrowly scarious-margined, the lamina narrower, about 3.5 mm. long, triangular or triangular-oblong; heads sessile or subsessile, radiate, the rays "white," the disk "yellowish green;" involucre 9–10 mm. high, 13–16-fid.

Branches numerous, about 8–12 mm. thick including the leaves; leaves densely imbricate; heads 2.2–2.8 cm. wide; disk about 1 cm. high, 1.5 cm. thick; involucre campanulate-hemispheric, the tube multivittate, the teeth triangular to deltoid, obtuse or acutish, 3–4-vittate, ciliolate at apex, 5–6 mm. long, 2.5–4 mm. wide at base, the narrow subscarious margin sometimes denticulate; rays 19–22 (more numerous than phyllaries), glabrous, the tube 3.5–3.8 mm. long the elliptic lamina 10–11 mm. long, 3.5 mm. wide, 2-3-denticulate, about 5-nerved; disk corollas glabrous, 6.5 mm. long, the tube 1.8 mm., the cylindric-funnelform throat 3.7 mm., the ovate teeth 1 mm. long; disk achenes (immature) oblong, 2 mm. long, with about 7 thick ribs; pappus brownish, 4.5–5.2 mm. long, the bristles united at extreme base into a sort of collar; style tips truncate, minutely hispidulous at tip, in disk flowers rather conspicuously papillose on back.

PERU: In mounds by brook, Rio Blanco, Dept. Lima, alt. about 4575 m., 20–25 Mar. 1923, *J. Francis Macbride* 3032 (type no. 534102, Field Mus.; dupl. no. 1,191,416, U. S. Nat. Herb.).

Nearest *Werneria decumbrens* Hieron. (ex char.) from between Tomarape and Tacora, Peru, in which the leaves have a conspicuous amplexicaul ciliate sheath 3 mm. long and 5 mm. wide and a subacerose blade 8 mm. long and 1.25 mm. wide at base.

Werneria lycopodioides Blake, sp. nov. Fig. K, L, M.

Suffrutescent, glabrous, the rhizomes apparently decumbent, up to 25 cm. long, fastigiate-branched, densely leafy above, the leaves scattered below; leaves triangular, 3–5 mm. long, ciliolate-denticulate below apex, the short amplexicaul scarious sheath 2.5–3 mm. wide, the blade about 2 mm. wide above the sheath, fleshy, acute or obtuse, erect or in age spreading; heads sessile, radiate, yellow, the rays scarcely exceeding involucre (heads young); involucre about 6 mm. long, 8–9-fid for less than half its length, the lobes broad and blunt.

Rhizomes about 3 mm. thick below, glaucescent, the internodes on the lower parts (still bearing green leaves) up to 4 mm. long; densely leafy young growth 3–6 cm. long; blades flat above, convex beneath, usually acutely whitish-apiculate when young, becoming obtuse, slightly cucullate at apex, yellowish green; heads 8–9 mm. high, about 41-flowered; involucre campanulate, 5–7 mm. high, purple throughout, glabrous, the tube multivittate, the lobes deltoid or deltoid-ovate, 2–2.5 mm. long, 2–3 mm. wide at base, minutely ciliolate-tufted at apex, 3-vittate; receptacle convex, alveolate; rays (immature) 10, definitely yellow, linear-oblong, entire or emarginate, 2–3-nerved, 5 mm. long; disk flowers about 31, their corollas (submature) glabrous, 5.8 mm. long, the tube 1.3 mm. long, the cylindric-funnelform throat 3.5 mm. long, the ovate acutish teeth 1 mm. long; ovaries glabrous; pappus straw-color, about 6 mm. long; style branches truncate or rounded-truncate, hispidulous or papillose at apex.

CHILE: Cordillera Volcan Tacora, Co. Quiñuta, Prov. Tacna, Dept. Tacna, alt. ca. 5000 m., April 1926, *E. Werdermann* 1164 (type in Gray Herb.; photog. and fragm. no. 44297, U. S. Nat. Herb.).

An attractive plant, the deep purple involucres and yellow flowers contrasting with the yellowish green Lycopodium-like stems and leaves. *Werneria weddellii* Phil., which has similar leaves, is distinguished by its considerably narrower, fewer-flowered, green involucre, with longer and relatively much narrower lobes. The rays of that plant, moreover, are described by Philippi as whitish.

Werneria sedoides Blake, sp. nov. Fig. N, O, P.

Suffruticulose, caespitose, decumbent, forming dense mats up to 7 cm. wide, the very numerous branches mostly 2.5 cm. long or less, densely leafy, glabrous; leaves of the year erect, glaucous green, those of previous years persistent, blackening, spreading, broadly ovate, 4–4.5 mm. long, finely subglandular-denticulate throughout, 1-vittate, the sheath scarious, about 2 mm. long, 2.5–3.5 mm. wide, the lamina thickish, flattish with somewhat elevated margin above, about 2 mm. wide at apex of sheath, about 0.8 mm. wide near the usually minutely apiculate or sometimes obtusish apex; heads sessile, radiate, "white;" involucre about 10 mm. high, about 13-fid.

Leaves very densely imbricate; involucre broadly campanulate, 9–12 mm. high, 13–14-fid, the tube multivittate, the lobes triangular to oblong-ovate, acute to obtusish, 4.5–7 mm. long, 2.5–3.5 mm. wide at base, 3-vittate, minutely ciliolate-tufted at apex, green, very narrowly scarious-margined; rays about 18 (more numerous than phyllaries), exserted, glabrous, tube 3 mm. long, the lamina narrowly spatulate, 4–6-nerved, subentire, about 9 mm. long, 2.5 mm. wide; disk flowers numerous, their corollas glabrous, 6.3 mm. long, the tube 1.8 mm., the cylindric-funnelform throat 3.5 mm., the ovate teeth 1 mm. long; achenes (submature) oblong, glabrous, 3.5 mm. long, with about 8 thick ribs; pappus brown, 11 mm. long, the copious bristles deciduous irregularly in groups; style branches in both ray and disk truncate, hispidulous around the apex.

PERU: In tufts on wet rocky slopes, Punco, Dept. Huánuco, about 34 km. west of Huallanca, alt. about 4115 m., 1 Oct. 1922, *Macbride & Featherstone* 2475 (type no. 518901, Field Mus.; dupl. no. 1,186,098, U. S. Nat. Herb.).

Related to *W. marcida*, *W. lycopodioides*, *W. weddellii* Phil., and *W. juniperina* Hieron. In the two last the involucre is much narrower and fewer-flowered, shorter (7–8 mm. long), and only 8–10-fid; in *W. juniperina* the rays are described as only 2–6 with ligules 4.5 mm. long. In *W. marcida*, a much coarser and apparently laxer plant, the leaves are much larger and not at all dilated at base. *W. lycopodioides* is a much larger plant with less densely imbricated, yellowish green leaves, very much smaller yellow heads, and much smaller 8–9-fid involucre.

Werneria leucobryoides Blake, sp. nov. Fig. Q, R, S.

Densely caespitose; rhizomes branched, erectish, very densely covered with marcescent erect leaves, the green growth of the year only 2–3 mm. long; leaves linear-subulate, acuminate, tipped with a more or less deciduous bristle nearly 1 mm. long, flat, densely long-ciliate for about half their length but glabrous on the surfaces, not amplexicaul at base, not lanate at base within, 4–5 mm. long, 0.5–0.8 mm. wide near base; heads tiny, sessile, radiate; involucre 6 mm. high, 11-fid.

Rhizomes up to 6.5 cm. long, 1 mm. thick (when denuded); branches with their leaves 3–5 mm. thick; leaves densely imbricate, the older ones completely persistent except for the bristle, becoming whitish and corky, the younger erect, 1-vittate, the petiolar portion or "sheath" thickish, 2.5–3.2 mm. long, densely ciliate for about 2 mm. with hairs 1–1.5 mm. long, the thinner light-green lamina 0.5–1.5 mm. long, often lacerate-denticulate toward apex, passing into the lax bristle, this 0.5–1 mm. long, deciduous except for its base, leaving the old leaves acuminate; heads about 6 mm. wide; involucre campanulate, glabrous, the tube multivittate, the lobes triangular, acuminate, ciliolate on the narrow scarious margin, 1–3 vittate, 3 mm. long, 1 mm. wide at base; rays 12, evidently white, glabrous, the tube 1 mm. long, the lamina 3.5 mm. long, 0.9 mm. wide, minutely 2–3-denticulate, 2–4 nerved; disk flowers 11, their corollas evidently white, glabrous, 2.6 mm. long, the tube 0.5 mm., the funnelform throat 1.6 mm., the ovate teeth 0.5 mm. long; young disk achenes glabrous, about 0.6 mm. long; pappus brownish, 2.8 mm. long; style tips in rays obtuse, essentially glabrous, in disk flowers tipped with a short obtuse cone, finely hispidulous around its base.

ECUADOR: At level of perpetual snow, Mount Quilindaña, Dec. 1897, *A. Sodiro* (type in herb. N. Y. Bot. Gard.; photog. and fragm. no. 44299, U. S. Nat. Herb.).

A species of the *W. humilis* group, nearest *W. soratensis* Hieron., as which the type was distributed. In that species, according to Hieronymus's description, the leaves are about 8 mm. long, 1.25–1.5 mm. wide at base, and merely acute, the "sheath" is lanate within, and no reference is made to the characteristic bristles terminating the leaves.

Werneria crassa Blake, sp. nov. Fig. v.

Acaulescent herbaceous perennial; rhizome (apparently solitary) vertical, densely covered with matted sheaths and tomentum, the whole forming a cylindric or conical body 1.5–3 cm. thick and usually 5–15 cm. long; leaves rosulate, the petioles ("sheaths") linear, 1.3–2 cm. long, long-silky-lanate on margin and with long silky tufts within, the blade nearly linear, fleshy-coriaceous, entire, obtusely callous-tipped, 1.2–2.8 cm. long, 1.3–3 mm. wide; heads appearing sessile, large, radiate, white; involucre 1.2–1.8 cm. high, about 19-fid.

Leaves densely stellate-imbricate at base of head; petioles about 2 mm. wide at base, not amplexicaul, their cilia more or less deciduous; leaf blades deciduous after the year of flowering, slightly narrowed toward apex and base, erect or spreading, 1-nerved, the nerve usually slenderly impressed on both sides, the tuft of hair within the sheath about equaling the latter, arising from the rhizome at base of blade; heads about 2.5–3.3 cm. wide, borne on short thick peduncles concealed by the leaves; involucre campanulate, glabrous, its lobes linear or linear-triangular, obtusish, finely ciliolate above and at apex, obscurely lucid-papillate, narrowly subscarious-margined, 7–9 mm. long, 1–1.2 mm. wide at base; rays 19–20, white, glabrous, the tube about 4 mm. long, the lamina elliptic, 14 mm. long, 3 mm. wide, entire, 4-nerved; disk corollas numerous, white, glabrous, at maturity 8.5 mm. long, the tube 4 mm., the subcylindric throat 3.7 mm., the ovate teeth 0.8 mm. long; mature disk achenes prismatic-subcylindric, about 8-ribbed, glabrous, whitish, 3.5 mm. long, 1 mm. thick; pappus brownish white, 14 mm. long, the bristles irregularly deciduous in groups; style tips in ray flowers obtuse, minutely hispidulous, in disk flowers truncate, hispidulous.

COLOMBIA: Swale along stream, Paramo del Quindio, Dept. Caldas, Cordillera Central, alt. 3700–4200 m., 15–20 Aug. 1922, *F. W. Pennell & T. E. Hazen* 10031 (type no. 1,141,291, U. S. Nat. Herb.; dupl., N. Y. Bot. Gard.); same locality, 4100–4300 m., *Pennell & Hazen* 9878 (U. S., N. Y. Bot. Gard). Swale, Paramo de Ruiz, Dept. Tolima, 3500–3700 m., 16–17 Dec. 1917, *Pennell* 3062 (U. S., N. Y. Bot. Gard.); in bogs, same locality, 3000–3500 m., 1918, *M. T. Dawe* 778 (N. Y. Bot. Gard.). Paramo de Buena Vista, Huila group, Central Cordillera, State of Cauca, 3000–3600 m., Jan. 1906, *Pittier* 1205 in part (U. S.).

A species of the *W. humilis* group readily distinguished by its very large and thick rhizome, comparatively large leaves, and large heads and involucre. The rhizomes, as preserved, are almost always solitary, but no. 9878 is described as forming large tufts. In some numbers the flowers are said to be white; in no. 9878 the rays are described as white, the disk yellow. In dried specimens the disk flowers appear to have been white or whitish.

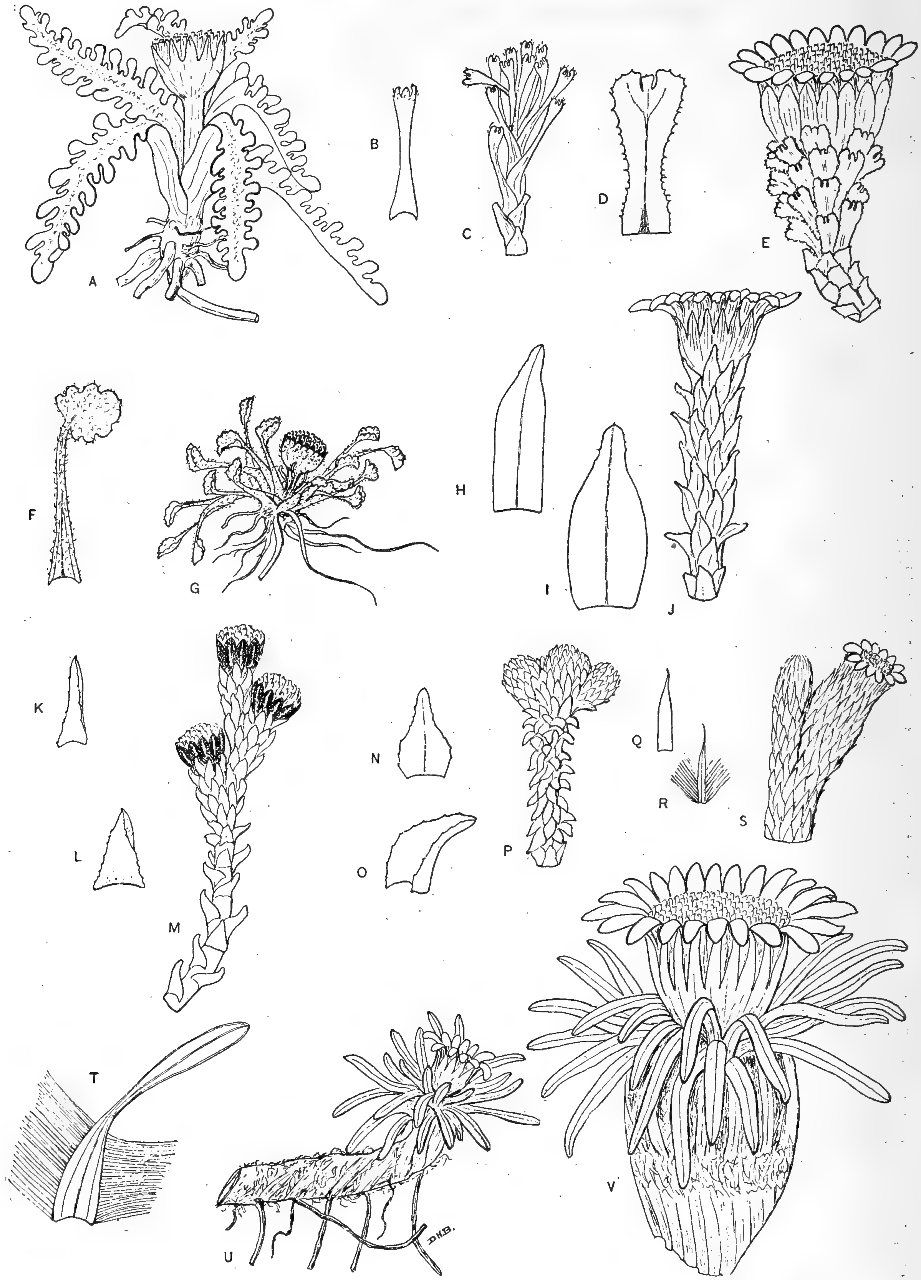

Fig. 1. New South American species of *Werneria*.—A, *W. obtusiloba;* B, C, *W. amblydactyla;* D, E, *W. decora;* F, G, *W. pygmophylla;* H, I, J, *W. marcida;* K, L, M, *W. lycopodioides;* N, O, P, *W. sedoides;* Q, R, S, *W. leucobryoides;* T, U, *W. cornea;* V, *W. crassa*. All drawn from specimens of the type collections. Habit figures all $\times$ 1, leaves $\times$ 2.

Werneria cornea Blake, sp. nov. Fig. T, U.

Rhizomes creeping, branched, densely clothed with persistent leaf sheaths and tufts of hair; living leaves rosulate, rather few, the sheath scarious, triangular, about 7 mm. long, 3 mm. wide at base, densely long-pilose-ciliate and with a fringe of still longer hairs within at base, the blade spreading, linear-spatulate or essentially linear, 7–10 mm. long, 1–1.5 mm. wide above, very obtuse, coriaceous, somewhat canaliculate below, flattish above, the margin and costa (this prominent beneath) corneous-thickened; heads subsessile, "yellow," radiate, small; involucre 9–10 mm. high, 9–13-fid.

Rhizomes up to 7 cm. long, 5–6 mm. thick (including the leaf bases); sheaths 3-nerved, somewhat amplexicaul, appressed, densely ciliate with whitish hairs 5–6 mm. long, and with a tuft of hairs about 8 mm. long at extreme base within (arising from the rhizome); blades inconspicuously lucid-papillate; peduncle short and thick, concealed by the leaves; heads 1–1.2 cm. wide; involucre glabrous, the tube multivittate, the teeth triangular, somewhat callous-thickened at the obtusish tip, with green yellowish-papillate center and usually deep purple, scarious, above ciliolate margin, 6.5 mm. long, 3 mm. wide at base, 3-vittate, ciliolate at tip; rays about 11, glabrous, in dried specimens deep violet above, the tube 1.5 mm. long, the lamina linear-spatulate, 7.5 mm. long, 1.3 mm. wide, 3-nerved; disk flowers about 23, their corollas glabrous, 5.7 mm. long, the tube 1.5 mm., much swollen at base, the funnel form throat 3 mm., the ovate teeth 1.2 mm. long; immature achenes glabrous, about 7-nerved; pappus whitish, 5.5 mm. long; style tips (ray and disk) with subtruncate hispidulous tips.

PERU: Dry gravelly slopes, Punco, Dept. Huánuco, about 34 km. west of Huallanca, altitude about 4115 m., 1 Oct. 1922, *Macbride & Featherstone* 2477 (type no. 518903, Field Mus.; dupl. no. 1,121,767, U. S. Nat. Herb.).

Closely allied only to *W. canaliculata* Sch. Bip. In that imperfectly known species, to which I refer *Mandon* 103 (Gray Herb., N. Y. Bot. Gard.), the leaf blades, although sometimes no longer (but at times reaching a length of 3.5 cm.), are proportionately much narrower (0.5–0.8 mm. wide) and decidedly acicular.

WERNERA (sic) BORAGINIFOLIA Kuntze, Rev. Gen. Pl. 3^2: 184. 1898.

Kuntze's type, collected by him at Paso Cuchichanchi, Bolivia, alt. 4000 m., is in the herbarium of the N. Y. Botanical Garden, and is identical with *W. strigosissima* A. Gray (1861). Of the other species listed by Kuntze, all of which are in the herbarium of the New York Botanical Garden, his "*W. glaberrima* Phil." is *W. pygmaea* Gill.; his "*W. graminifolia* HBK." is *W. apiculata* Sch. Bip; his "*W. humilis* HBK." is *W. dactylophylla* Sch. Bip.; his "*W. minima* Meyen & Walpers" is not at all that plant (which from description seems correctly referred by Weddell to a variety of *W. pygmaea*), but appears to be allied to *W. carnulosa* A. Gray. It may represent a new species, but the material is too scanty and poor for description. His "*Wernera wernerodes*" (*Senecio wernerioides* Wedd., *Werneria cortusifolia* Griseb.) is that plant, which is certainly a *Senecio* and to be known as *S. wernerioides* Wedd.

WERNERIA LEHMANNII Klatt, Ann. Naturh. Hofm. Wien **9**: 368. 1894.

Werneria glandulosa Klatt, Bot. Jahrb. Engler **8**: 50. 1886. Not *W. glandulosa* Wedd. 1856.

Klatt's *Werneria glandulosa*, renamed *W. lehmannii* because of the earlier *W. glandulosa* of Weddell, was based on *Lehmann* CXIV from Mount Chimborazo, Ecuador, and is represented in the United States National Herbarium by two good specimens of the type collection recently received in the herbarium of Capt. John Donnell Smith. They agree perfectly with Klatt's description, and are normal specimens of *Hypochaeris sessiliflora* H. B. K. Klatt's description referred to the 5-toothed ligules, but he failed to appreciate their significance, and he made no mention of the plumose pappus. His "*W. graminifolia* H. B. K." (*Lehmann* 425) is *W. pumila* H. B. K.; his "*W. humilis* H. B. K." (*Lehmann* 423a) is *W. articulata* Blake. Both the latter are also in the Donnell Smith herbarium, now a part of the United States National Herbarium.

BOTANY.—*Seven new species of* Valeriana *from Colombia and Peru.*[1]

ELLSWORTH P. KILLIP, U. S. National Museum.

Recent collecting in Peru by Dr. F. W. Pennell and in Colombia by Mr. Albert C. Smith and myself has resulted in the discovery of several new species of *Valeriana.* Descriptions of these follow.

Valeriana vetasana Killip, sp. nov.

Plant herbaceous, perennial, forming clumps; rootstock woody, thickened above to 2 cm. in diameter and densely fibrose with the remnants of dead leaves; stem up to 35 cm. high, slender, glabrous except at the nodes; basal leaves narrowly linear to linear-spatulate, 8 to 15 cm. long, 1.5 to 5 mm. wide, obtuse, entire, slightly revolute at margin, 1-nerved, glabrous, fleshy; cauline leaves 1 or 2 pairs, bract-like, linear, 6 to 10 mm. long, 1 to 1.5 mm. wide; bracts similar to cauline leaves, 1 to 0.5 mm. long; inflorescence trichotomous (ultimate branches dichotomous), forming a loose panicle; bractlets linear, 2 to 3 mm. long, 0.5 mm. wide, obtuse, at length divaricate, pink; corolla greenish white to pure white, the tube funnel-shaped, 1 mm. long, the limb 2 mm. wide, 5-lobed to middle; anthers slightly exserted; fruit oblong, about 2 mm. long, compressed, 3-nerved on one face, 1-nerved on other, glabrous, the pappus white, 10-rayed.

Type in the U. S. National Herbarium, no. 1,353,163, collected on the Páramo de Mogotocoro, near Vetas, Department of Santander, Colombia (Eastern Cordillera, 3,700 to 3,800 meters altitude), January 18, 1927, by E. P. Killip and Albert C. Smith (no. 17601).

Additional specimen examined:

COLOMBIA: Department Santander, Páramo de Las Vegas, 3700–3800 meters, *Killip & Smith* 15665.

This is a much more slender plant than its relatives, *V. longifolia, V. plantaginea,* and *V. tatamana,* with narrower leaves and a less compact inflorescence, and with more evident, spreading bractlets. The fruit is nearly twice as long as in *V. longifolia.*

The description was drawn from living material at the time of collection.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received September 6, 1928.

Valeriana smithii Killip, sp. nov.

Plant perennial, herbaceous, erect, 75 to 100 cm. high, the rootstock apparently woody, the stems stout, 5 to 7 mm. thick toward base, striate, glabrous except at nodes; lower leaves narrowly oblong-lanceolate, about 10 cm. long, 1.5 cm. wide, widest just above middle, acute, sessile at base, finely glandular-serrulate, thickish, minutely puberulous and dark green above, pilosulous on midnerve above, otherwise glabrous, paler beneath; cauline leaves varying from cordate-ovate to lanceolate, from 3.5 cm. long and 2 cm. wide to 6 cm. long and 1 cm. wide, (uppermost smaller), acute or acuminate, distinct to base, glandular-serrulate (serrulation more pronounced toward base); bracts linear-lanceolate, 1 cm. long, 0.5 cm. wide, acute; inflorescence paniculate, repeatedly trichotomous, the flowers in dense clusters at the ends of the branchlets; bractlets linear-oblong, 3 mm. long, 1 to 2 mm. wide, rounded at apex, purplish at center, light green at margin; corolla tube funnel-form, 2 mm. long, very slender in lower half, abruptly dilated at middle, the limb 5-cleft to throat, the segments about 1 mm. long, rounded at apex; anthers slightly exserted; fruit subcylindric, 2 mm. long, trigonous, glabrous, purplish, pappose, the pappus yellowish white.

Type in the U. S. National Herbarium, no. 1,353,481, collected on the Páramo Frailejonale, near Vetas, Department of Santander, Colombia (Eastern Cordillera, 3750 to 3850 meters altitude), January 21, 1927, by E. P. Killip and Albert C. Smith (no. 17984).

Valeriana smithii is allied to *V. longifolia*, but is differentiated by glandular-serrulate leaves, the cauline leaves being proportionately broader, and by the elongate, 3-angled, rather than short and much flattened fruit.

It is a pleasure to name this species for my companion on a four months' trip through the heart of the Eastern Cordillera of Colombia, from the Magdalena River to the Venezuelan border.

Valeriana pennellii Killip, sp. nov.

Perennial herb, 40 to 45 cm. high, glabrous throughout; rootstock thickened, woody; basal leaves lanceolate, 4 to 7 cm. long, 1.5 cm. wide, long-petiolate (petiole 8 to 12 cm. long), pinnately compound, the terminal leaflet ovate, 1.5 to 2 cm. long, 0.7 to 1 cm. wide, obtuse, subentire, the lateral leaflets 4 to 6 pairs, ovate or ovate-lanceolate, 0.5 to 0.8 mm. long, 0.3 to 0.5 mm. wide, obtuse or acutish, sessile, subentire; cauline leaves 1 pair, subsessile, similar to the basal but the leaflets slightly longer and more acute; bracts linear-spatulate, 1 cm. long, 0.25 cm. wide, obtuse; flowers densely congested in globose, sessile (or the lower short-peduncled) heads up to 1 cm. in diameter, borne on the main stem or on axillary branches; bractlets linear-spatulate, about 3 mm. long, 1.5 mm. wide, rounded or truncate at apex, light brown, purplish toward apex; fruit oblong, 1.5 mm. long, obscurely nerved, densely purple-dotted, pappose, the pappus 6-rayed, white.

Type in the herbarium of the Field Museum of Natural History, no. 557,927, collected on rock ledge, in cascade, La Raya, Department of Cusco. Peru, altitude 4,400 to 4,500 meters, April 22, 1925, by F. W. Pennell (no. 13510). Duplicate in U. S. National Herbarium.

This species is nearest *V. cephalantha*, from which it is distinguished by fewer and larger leaflets, the terminal one being much larger than the lateral, more obtuse bracts, and proportionately narrower fruit.

Valeriana parvula Killip, sp. nov.

Low, perennial herb, glabrous except at base of bracts; rootstock thickened; leaves all basal, petiolate (petioles up to 10 mm. long, dilated), orbicular or ovate-orbicular, 7 to 10 mm. long, 7 to 8 mm. wide, rounded, at apex, abruptly narrowed at base, entire or obsoletely lobulate, fleshy; stems several, erect or decumbent, 2 to 4 cm. long; bracts linear-oblong, about 3 mm. long, 0.8 mm. wide, obtuse; flowers in small cymes up to 5 mm. wide, the lowest pair of cymes often distant and peduncled; bractlets oblong, 2 to 3 mm. long, obtuse, hyaline, the midnerve dark; corolla white; fruit broadly lance-ovate, 2 mm. long, 1.5 mm. wide at base, acute, glabrous, compressed, 1-nerved on one face, obscurely 3-nerved on other, apparently epappose.

Type in the herbarium of the Academy of Natural Sciences, Philadelphia, no. 635,824, collected on open grassy puña, Cerro de Colquipata, Department of Cusco, Peru, altitude 4,000 to 4,200 meters, by F. W. Pennell (no. 13756).

Valeriana oblongifolia Ruiz & Pav., to which the proposed species is obviously allied, is a much larger plant, pilose throughout, and has deeply dentate cauline leaves. In general appearance *V. parvula* more nearly resembles *V. globiflora*, but in that species the basal leaves are deeply pinnatifid.

Valeriana linearifolia Killip, sp. nov.

Plant suffrutescent, erect, about 75 cm. high; stem terete, striate, minutely pilosulous, woody below, herbaceous above, few-branched; leaves linear, 2 to 4 cm. long, 0.2 to 0.4 cm. wide, obtuse at apex, slightly narrowed below, dilated at base, sessile, entire and subrevolute at margin, minutely pilosulous, the upper internodes becoming elongate and the leaves decreasing toward infloresence; inflorescence cymose-paniculate, the branches dichotomous, ascending; bractlets linear-lanceolate, 3 to 5 mm. long, about 1 mm. wide, acuminate, green below, deep purple toward apex; corolla white, the tube funnel-form, 0.5 mm. long, the lobes 5, orbicular; style exserted, purplish; fruit lance-ovate, 2 mm. long, 1 mm. wide at base, compressed, 3-nerved on one face, 1-nerved on other, pappose, the pappus white, 12-rayed.

Type in the U. S. National Herbarium, no. 1,340,661, collected on rocky paramo banks, Paso de Tres Crucis, Cerro de Cusilluyoc, Department of Cusco, Peru, altitude 3,800 to 3,900 meters, May 3, 1925, by F. W. Pennell (no. 13856). Duplicate in herbarium of the Field Museum of Natural History.

The position which this species occupies within the genus is problematical. The suffrutescent habit and general aspect suggest *V. hirtella* and *V. alophis*, of Graebner's section *Galioides.* In the branching of the inflorescence and the shape and size of the bractlets and fruit the species resembles *V. pinnatifida* and *V. pedicularioides. Valeriana ledoides,* the only Peruvian species of *Galioides,* is described as having densely brown-tomentose stems and much smaller oblong or linear-oblong, petiolate leaves.

Valeriana stenophylla Killip, sp. nov.

Cespitose perennial herb, forming clumps; rhizome repent (?), thickened above to 2 cm. in diameter, branched at summit; leaves all basal, erect or spreading, narrowly linear-spatulate, 2 to 2.5 cm. long, 0.1 to 0.2 cm. wide, obtuse or acutish at apex, dilated at base, conspicuously 1-nerved, entire, subrevolute, fleshy, retrorse-hirtellous with white hairs or glabrous; scapes about as long as the leaves, erect; bracts ovate-lanceolate, about 5 mm. long, connate, fleshy; flowers white, in clusters of 3 or 4; corolla funnel-shaped; the tube 2 to 3 mm. long, 1.5 mm. wide at throat, the lobes 5, oblong, about 1 mm. long, obtuse; stamens slightly exserted, the anthers orbicular.

Type in the U. S. National Herbarium, no. 1,351,519, collected on the Páramo de las Vegas, east of Bucaramanga, Department of Santander, Colombia (Eastern Cordillera, 3,700 to 3,800 meters altitude), December 20, 21, 1926, by E. P. Killip and Albert C. Smith (no. 15673).

Additional specimens examined:

COLOMBIA: Department Cundinamarca, Páramo de Choachi, near Bogotá, *Pennell* 2260 (U. S. N. H., N. Y. B. G., Field Museum), *Killip & Ariste Joseph* 11953 (U. S. N. H.)

This has the general appearance of two species occurring farther south in the Andes, *Valeriana crassipes* (Wedd.) Höck, and *V. niphobia* Briq. (*V. hispida* (Wedd.) Höck). Both of these plants, however, have 3-lobed corollas, on the basis of which they were originally placed in the genus *Phyllactis* by Weddell. *Valeriana stenophylla* is doubtless more nearly related to *V. bracteata*—from which it differs in having much shorter and narrower leaves, 1-nerved instead of several-nerved. The type specimens are more hairy than the other collections cited here, but it is doubtful if more than a single species is represented by the material.

Valeriana imbricata Killip, sp. nov.

Low, matted shrub, freely branching at base, the branches 4 to 6 cm. high; leaves closely imbricate, 4-ranked, linear-spatulate or linear-oblong, 3 to 5 mm. long, 1 to 1.2 mm. wide, obtuse or acutish, 1-nerved, sessile, entire, (opposite leaves connate at base), revolute at margin and ciliate with stiff, spreading hairs, fleshy, ascending, at length recurved; flowers in a single sessile cluster at the tip of the stem, nearly hidden by the uppermost leaves (bracts); bractlets linear, 1.5 mm. long, acute, hyaline at margin; corolla narrowly funnel-shaped, 5 mm. long, 1 mm. wide at throat, 3-lobed, the lobes triangular-ovate, about 1.3 mm. long, acutish; anthers long-exserted.

Type in the Field Museum of Natural History, no. 548,677, collected above Huancabamba, Province of Huancabamba, Department of Piura, Peru, altitude 3,200 meters, April, 1912, by A. Weberbauer (no. 6088).

This apparently has a relationship to the species grouped by Graebner in the segregated genus *Aretiastrum*, namely *A. aretioides*, from Ecuador, *A. sedifolium*, from the Falkland Islands, and *A. aschersoniana*, from Peru. All of those plants, however, have 4 or 5-lobed corollas, and each differs from *V. imbricata* in various details. This group of species may well constitute a genus distinct from *Valeriana*, but in view of our present imperfect knowledge of the lines of demarkation between the genera of Valerianaceae, the proposed species is tentatively referred to *Valeriana*.

BOTANY.—*A new representative of the grass genus* Timouria *from Mongolia.*[1] Dr. R. ROSHEVITZ, Principal Botanic Garden, Leningrad, Russia. (Communicated by A. S. HITCHCOCK.[2])

Recently[3] Dr. A. S. Hitchcock, the well known American agrostologist, published a note entitled "Two new grasses, *Psammochloa mongolica* from Mongolia and *Ortachne breviseta* from Chile," in which he described a new genus and new species of grass collected by R. W. Chaney (nos. 502 and 443) on the Third Asiatic Expedition of the American Museum of Natural History. The drawing accompanying the description, illustrating the analysis of the spikelet of the new grass, at once recalled to me my new genus *Timouria.*[4] A detailed comparison of the characters of the two genera confirmed my impression that they were the same. The species described by Dr. Hitchcock (*Psammochloa mongolica*) is, however, evidently different from the original species of *Timouria, T. Saposhnikowi.* The latter species is found in the upland steppes of the main ridge of Tian-Shan, while the former inhabits the dunes of Mongolia at an altitude of about 1000 meters.

It is therefore necessary to reduce *Psammochloa* Hitchc. to a synonym of *Timouria* Roshev. The species described by Dr. Hitchcock being transferred to *Timouria* becomes: **Timouria mongolica** (Hitchc.) Roshev. (*Psammochloa mongolica* Hitchc.).

In conclusion it may be mentioned that the finding of a second species of the genus *Timouria* is of great botanical interest as proving that this genus which includes several characters of the genera *Stipa* (Section *Lasiagrostis*) and *Oryzopsis*, is apparently a very ancient group. The fact of having been found in such distant localities as the mountain chain of Tian-Shan and the dunes of Mongolia, is proof that the genus was spread over vast areas in early times and seems to indicate that the two species here considered are survivals that have maintained themselves in only a few places in the immense Asiatic continent.

[1] Received April 15, 1928.

[2] Soon after the publication of *Psammochloa* I found the genus *Timouria* described in the Flora of Asiatic Russia, a work which had not been earlier accessible because of the world war. I at once recognized that *Psammochloa* was the same as *Timouria* but that the Mongolian species was distinct. I had planned to make the correction, transferring that species to the earlier genus *Timouria.* Happily Dr. Roshevitz, a recognized authority on the flora of central Asia, has come to the same conclusion, which he has presented in the short paper here published. A. S. H.

[3] This JOURNAL **17**: 140. 1927.

[4] *Timouria* Roshev. in Fedtsch. Fl. Ross. Asiat. 1^{12}: 173. *pl. 12.* 1916.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

975TH MEETING

The 975th meeting was held at the Cosmos Club, May 12, 1928.

Program: Colloquium on units and standards. L. V. JUDSON: *Length.* The accuracy at present obtainable in length measurements at the Bureau of Standards, when two line standards of length having the same nominal length are compared, was shown by a chart on a lantern slide. The percentage accuracy was given as a function of the magnitude in question and the distinguishing features of the graph were a maximum for one meter comparisons, a dip for 5 meters, and a slight rise for 50 meters. It is possible that the falling off for magnitudes greater than 1 meter may be to a considerable degree due to the fact that there have not been urgent reasons for developing methods to increase the accuracy above that rather easily obtainable. The recent work of the Japanese in measuring a five-meter bar directly in terms of cadmium wave-length was given as an illustration of the possibility of increasing the accuracy should there be a real demand. The present uncertainties of the true corrections to apply to the platinum iridium standards were referred to and the opinion expressed that these would be remedied at an early date. (*Author's abstract.*)

A. T. PIENKOWSKY: *Mass.* Recomparisons of about 30 of the National Prototype Kilograms just like the International Kilogram have indicated that they, and presumably the international standard itself, are remaining constant within 0.02 mg. or less, except where there were known causes for change, and except one or two that gained about 0.02 mg.

Limiting the discussion to magnitudes measured in the laboratory, and for which real standards are maintained, and omitting exceptional degrees of precision and the measurement of small differences where the total mass is not known, the curve of per cent precision versus total mass has a sharp maximum at one kilogram.

At 10^{-6} kg. (1 mg.) the precision of measurement is about one in 10^4; at 1 kg. it is one in 10^8; and at 10^3 kg. it is about one in 10^6.

With one type of microbalance, quantities from 10^{-4} kg. to 10^{-6} kg. (100 mg. to 1 mg.) have been measured with a precision from one in 10^8 to 10^6.

The most conspicuous factor limiting the precision is the density of the air, which varies slightly even under standard conditions and in the same locality, while weighing in a vacuum involves unknown effects on the gases and vapors adsorbed on the surfaces. The most important subjects needing investigation for increasing the precision of measurement are: adsorbed surface films, air density, and methods of determining and controlling the buoyant effect of the air. (*Author's abstract.*)

PAUL SOLLENBERGER: *Time.* In the measurement of time we have to deal with two different sorts of problems, depending on whether the interval is of comparatively long or short duration. In the former case the interval may be measured in terms of the Earth's rotation whereas in the latter case it must be measured by the use of some auxiliary timekeeping device, which must in turn be rated by comparison with the Earth's period of rotation. In order to observe the rotation, telescopes are employed. There has not recently been any decided improvement in dealing with this part of the problem; the best instruments in actual use for this purpose are probably the small reversible transit telescopes with self-recording micrometers.

Probably the best known work in the field of timepieces which has been recently performed has been the development of the Shortt clock; it is claimed that its long period running is much better than that of clocks heretofore in use.

In the matter of time distribution the steady improvement in radio transmission and of apparatus for the accurate reception of time signals has made possible increased accuracy and usefulness.

The measurements of short periods of time, as a few seconds, must obviously depend on the accuracy of artificial timekeeping devices, and upon the accuracy with which they can give signals. The rates of the very best clocks may perhaps be determined to within one part in ten million. The accuracy with which a single second can be measured is not anything nearly so good. The best mechanical break circuit devices may give signals having errors less than a thousandth of a second, and by special electrical means this error may possibly be decreased by another decimal place. If the interval to be measured is only a fraction of a second we can not use the precision pendulum, but must bring in some other device, as a tuning fork, to be calibrated at the time of use by the more accurate pendulum.

The measurement of long time periods, as a number of days, give the greatest possible relative accuracy. In fact the only limit in the increase of accuracy as the period lengthens is the variation in the Earth's rate of rotation. Concerning the exact amount of this variation we, of course, still remain in doubt. (*Author's abstract.*)

H. L. CURTIS: *Electrical units. Resistance.* Resistances of the value of one ohm can be intercompared with an accuracy of one or two parts in 10,000,000. The accuracy of intercomparison decreases with both higher and lower values of resistance. With a value of a millimicrohm the accuracy is not more than 10 per cent while the same accuracy can be obtained with a megamegohm.

Electromotive force. Two cells having a value of about one volt can be intercompared with an accuracy of about one part in 10,000,000. A microvolt can be measured with an accuracy of about 1 per cent whereas a megavolt can be measured with an accuracy of about 10 per cent.

Current. Currents of one ampere can be intercompared with an accuracy of about one part in 1,000,000. However, a micromicroampere can be measured with an accuracy of only 10 per cent whereas a kiloampere can be determined with an accuracy of one part in 10,000.

Inductance. Inductances of a value of millihenry can be intercompared with an accuracy of about one part in 100,000. A millimicrohenry, however, can be determined with an accuracy of only about 10 per cent while a kilohenry can be determined with an accuracy of 1 per cent.

Capacitance. Two microfarads can be intercompared with an accuracy of one part in 100,000. A micromicrofarad can be determined with an accuracy of about 1 per cent. Also a millifarad can be determined with the same accuracy. (*Author's abstract.*)

E. F. MUELLER: *Temperature.*

C. V. HODGSON: *Angle.*

976TH MEETING

The 976th meeting was held in the Cosmos Club, May 26, 1928.

Program: R. W. BOYLE: *Ultrasonics.*

H. E. MERWIN, *Recording Secretary.*

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, November 6	The Botanical Society
Wednesday, November 7	The Engineering Society
	The Medical Society
Thursday, November 8	The Chemical Society
Friday, November 9	The Geographic Society
Saturday, November 10	The Philosophical Society
Tuesday, November 13	The Electrical Engineering Society
Wednesday, November 14	The Geological Society
	The Medical Society
Thursday, November 15	THE ACADEMY
Friday, November 16	The Geographic Society
Saturday, November 17	The Biological Society
	The Helminthological Society
Tuesday, November 20	The Anthropological Society
	The Historical Society

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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JOURNAL

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PHYSICS.—*A new equation for the determination of surface tension from the form of a sessile drop or bubble.*[1] N. Ernest Dorsey, National Research Council.

Although the value of the surface tension can not be deduced from measurements of the dimensions of a sessile drop or bubble with as high an accuracy as it can be obtained by other methods, yet the method of sessile drops and bubbles, especially with the aid of photography, is particularly well adapted to the investigation of any secular change that may occur in the surface, such as the progressive decrease in the effective tension when the liquid contains certain colloidal substances.

The measurements can be made upon a suitable photograph of the profile of the surface. Photographs can be taken at such intervals as may be desired, and the time at which each is taken can be accurately determined. While doing this, the surface under study is not disturbed in any way. By none of the methods commonly used can such a series of measurements upon an undisturbed surface be obtained. Furthermore, the measurements of the photographs can be made at one's leisure, and can be repeated as often as may be desired.

Heretofore, the only means available for computing the surface tension from the dimensions of a sessile drop or bubble have been formulae (1), (2), (3), and (4) and a table prepared by Heydweiller[2] from Siedentopf's graphical computations and the formulae (2), (3), and (4):

[1] Received October 6, 1928.

[2] A. Heydweiller. Wied. Ann. **65**: 311–319. 1898.

$$A^2 = \frac{K_\theta^2}{4\cos^2\frac{\theta}{2}}\left[1 - \frac{8A^3\left(1-\sin^3\frac{\theta}{2}\right)}{3rK_\theta^2} + \frac{4A^2}{RK_\theta} - \cdots\right] \quad (1)^3$$

$$\left(\frac{r}{A}\right)^8 + 328\left(\frac{r}{R}\right)^2\left(\frac{r}{A}\right)^6 + \left[720 + 2520\left(\frac{r}{R}\right)^4\right]\left(\frac{r}{A}\right)^4$$
$$+ \left[17280 + 2880\left\{\left(\frac{r}{R}\right)^2 + \left(\frac{r}{R}\right)^6\right\}\right]\left(\frac{r}{A}\right)^2 = 138240\left(\frac{R-r}{r}\right) \quad (2)^4$$

$$\sqrt{\frac{1+\frac{3A^2}{RK_{90}}}{2+\frac{K_{90}}{r}}} > \frac{A}{K_{90}} > \frac{1+\frac{2A^2}{RK_{90}}}{\sqrt{2+\frac{2K_{90}}{r}+\frac{8A^2}{rR}-\frac{4A^2}{r^2}}} \quad (3)^5$$

$$\frac{A}{R} = \frac{2\sqrt{2}\,\pi}{1+\sqrt{2}}\left(\sqrt{\frac{r}{A}+2} - \sqrt{2}\right) e^{\left(\sqrt{2}-2-\frac{r}{A}\right)} \quad (4)^6$$

In these formulae, $A^2 = T/g(d - d')$, T being the surface tension, g the acceleration of gravity, and $(d - d')$ the positive difference in the densities of the fluids separated by the surface; r is the radius of the maximum horizontal section of the drop or bubble, R is the radius of curvature of the vertex (B, Fig. 1) of the surface, and the quantities represented by the other symbols are as indicated in Fig. 1.

Heydweiller's table is based on the quantities r and K_{90}, covers the entire range of sizes, and is estimated to be of such accuracy as to give T with an error not exceeding 1 per cent in excess of that introduced by errors in the measurements. He seems to have prepared and checked the table with care, but it appears to have remained unused by others.

[3] W. F. Magie. Phil. Mag. (5)**26**: 162–183. 1888; Wied. Ann. **25**: 421–437. 1885; A. Ferguson. Phil. Mag. (6)**25**: 507–520. 1913; J. E. Verschaffelt. Proc. K. Akad. Amsterdam **21**: 836–849. 1919; Leiden Communications, Suppl. 42e. 1918; S. D. Poisson. *Nouvelle théorie de l'action capillaire.* 1831.

[4] Th. Lohnstein. Wied. Ann. **54**: 713–723. 1895.

[5] Th. Lohnstein. Wied. Ann. **53**: 1062–1073. 1894.

[6] S. D. Poisson. *Nouvelle théorie de l'action capillaire* (See Heydweiller, *l. c.*).

All the formulae involve the quantity R, and, excepting (2) and (4), the quantity K. Under suitable conditions, the value of R can be determined with fair accuracy from observations made upon the surface itself, but it can not be satisfactorily determined from photographs of the profile. The determination of K_{90} involves an exact determination of the position of the plane of maximum horizontal section; this can not be done satisfactorily. Equation (1) might be used with any value of θ, but in each case the difficulty of determining the position of the plane at which the surface has that inclination arises, except when θ corresponds to the line of contact of the surface with the solid against which the drop or bubble rests. In that case,

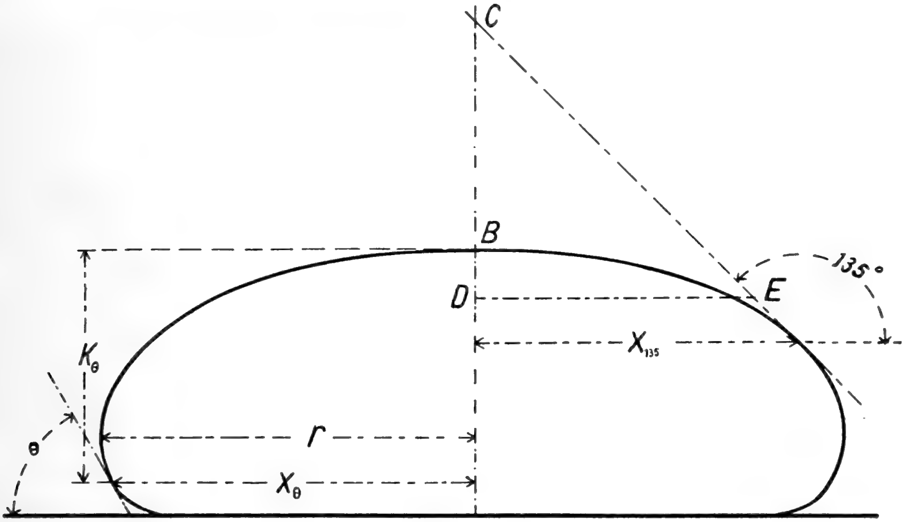

Figure 1

θ must be determined experimentally, and such a determination is beset with difficulties.

The table and all the formulae involve quantities that can not be determined satisfactorily from measurements of the profile of the surface. Furthermore, the formulae are awkward to use, and the order of approximation of the one (1) that is simplest and most frequently used is quite unsatisfactory except for large drops or bubbles. For example, if $r^2 = 10A^2$, which corresponds to a water drop about 1.7 cm. in diameter, the values of A^2 as computed from equation (1) with $\theta =$ 0°, 90°, and 135° will be too great by 3.7 per cent, 6.6 per cent, and 16.5 per cent, respectively.

Hence, in view of the special adaptation of this method to the study of secular changes in the surface, it seemed desirable to attempt to obtain from the tables of Bashforth and Adams[7] an empirical equation that contains only such linear quantities as can be readily determined from a photograph of the profile of the surface, and as require no exact knowledge of the position of the horizontal plane at which the surface has a specified inclination. This equation should have an accuracy well in excess of that set by the inherent errors in the measurement of the photograph.

Equation (5), in which $f = \frac{x_{135} - K_{135}}{r} - 0.41421$, fulfills thes

$$A^2 = r^2 \left[\frac{0.05200}{f} - 0.12268 + 0.0481f \right] \qquad (5)$$

conditions. The value of $(x_{135} - K_{135})$ is equal to the distance CB (Fig. 1), which is equal to $(DE - DB)$ where E is *any* point upon the 135° tangent. Consequently, it is not necessary to know either the exact point of tangency or the exact position of the horizontal plane at which the inclination of the surface is 135°. If the surface were a true sphere of radius r, CB would be equal to $(\sqrt{2} - 1)\, r = 0.41421r$. Hence f may be regarded as a measure of the flattening of the drop or bubble. Both the radius r and the difference $(x_{135} - K_{135})$ can be determined directly from a photograph of the profile of the surface. An error of 0.001 in f will produce an error of 0.8 per cent in A^2, and this is probably as high an accuracy as should be expected. The computed percentile correction that must be added to the right member of equation (5) in order to make it equal to the true value of A^2 does not exceed ± 0.06 per cent if r lies between $1.5A$ and $3.2A$ (Table 1), and actually differs little from the errors of computation. Hence, equation (5) itself is of ample accuracy, and the computed data in Table 1, covering the entire range of the Bashforth and Adams' tables, indicate that this equation will be quite satisfactory for still larger drops. For such drops, the accuracy of the values derived by equation (5) can be checked, within the limit of accuracy with which K_{90} can be determined, by means of Heydweiller's table.

[7] BASHFORTH and ADAMS. *An attempt to test the theory of capillary action.* Cambridge Univ. Press, 1888.

TABLE 1.—Constants for Sessile Drops and Bubbles

$$A^2 = r^2 \left[\frac{0.05200}{f} - 0.12268 + 0.0481f\right] (1 + \delta); \frac{dA^2}{A^2} = -\omega\frac{df}{f}$$

r_w = value of r if A^2 = 0.075 cm.,[2] approximately the value for water.

$\left(\frac{R}{A}\right)^2$	$\frac{r}{A}$	r_w	δ	f	ω	$\frac{\omega}{f}$
0.125	0.3466	0.095 cm.	+1.34%	0.00624	1.015	163.
1.0	0.8853	0.242	+0.48	0.03739	1.094	29.2
3.0	1.3350	0.366	+0.10	0.07652	1.206	15.76
6.0	1.6645	0.456	0.00	0.10872	1.311	12.07
12.5	2.0388	0.558	−0.02	0.14595	1.453	9.96
25.	2.4074	0.660	−0.02	0.18147	1.598	8.81
50.	2.7841	0.763	−0.04	0.21543	1.789	8.30
100.	3.1646	0.868	+0.01	0.24685	1.991	8.07

VOLCANOLOGY.—*Scientific papers at the 1928 meeting of the Section of Volcanology, American Geophysical Union.*[1]

These papers were communicated at the Eighth Annual Meeting of the Section of Volcanology of the American Geophysical Union, held in the Board Room of the National Academy of Sciences on April 27, 1928. The manuscript was prepared by Robert B. Sosman, Secretary of the Section, and approved by the speakers.

Present volcanic activity over the earth. H. S. Washington, Geophysical Laboratory, Carnegie Institution of Washington.

The period covered by these brief remarks includes the years 1926, 1927, and the first few months of 1928. This period was one of moderate activity, with few major eruptions, the main one being that of Mauna Loa, in Hawaii, in April 1926, which, however, lasted only about three weeks. Since then it has been quiet. Subsequent to the very violent explosive eruption of Halemaumau in Kilauea (May, 1924) the crater of Halemaumau has been nearly quiescent, the lava having sunk out of sight some years ago. Lava appeared for two weeks in July, 1927, but there are no very striking signs of renewed activity. The 40 odd volcanoes of the Aleutian Islands would seem to have had a season of unusual activity during 1927, according to Dr. Jaggar, who visited them that year. Mageik, near the volcano of Katmai (Valley of Ten Thousand Smokes) was in eruption in October, 1927, when a large area was covered with ash. Throughout the Pacific the volcanoes generally have been quiet, except for an eruption

[1] Received September 28, 1928.

at the Tonga Islands (1927) and a new volcano at the Galapagos (1926). Lassen Peak was quiet during most of this period, but there was an unverified report of an eruption in May, 1927. An observatory was established at this volcano in 1926 to study the vocanic phenomena and earthquakes. In Japan there were two volcanoes in eruption on the island of Hokkaido during 1926 which did considerable damage. Izalco, in San Salvador, almost continuously active, had a specially violent eruption in November, 1926, when 56 people were killed by a flood of lava. Colima, in Mexico, was reported active in January, 1926, after 12 years of repose.

Vesuvius was in its usual state of minor activity, but had eruptions in the summer of 1926, when lava is said to have poured down the outer slope. This was much exaggerated in the newspapers. The reported activity of the Solfatara is somewhat doubtful (1926). The eruption of the Fouqué Volcano at Santorini, Greece, which began in August, 1925, came to an end in 1926, but it is reported to have resumed activity in May, 1927. The volcanoes of the Dutch East Indies appear to have been in their normal condition of activity, except that an apparently somewhat violent submarine eruption at Krakatoa took place in January, 1928. It is not known whether this is continuing or not. This is the volcano that had a first-magnitude explosive eruption in 1883.

There were no reports of eruptions in South America or in Iceland. (*Abstract.*)

The year's volcanological publications. ARTHUR L. DAY, Geophysical Laboratory, Carnegie Institution of Washington.

The volcano reports of the leading periodical of volcanology, the *Zeitschrift für Vulkanologie*, are of two kinds: (1), student's studies of individual volcanoes; (2), reports from field observers. The latter were relatively few in 1927. A descent of Etna was described, but the conditions as regards gases and smoke must have been very different from those met with by the speaker in 1924.

The most conspicuous publication of the year was Karl Sapper's *Vulkankunde.* This is particularly strong on the historical side. It is the result of about ten years of work. Less attention is paid in the book to the psysico-chemical side than the speaker would have liked. Historically, the account is very complete from the Tertiary down. There is full discussion of the kind of phenomena seen at volcanoes: gases, lavas, and sequences of products. Silicate relations are hardly considered. In all, it is the best available book on volcanism.

Another conspicuous event is the establishment of regular reports from the Dutch East Indies in languages other than Dutch, in pursuance of a proposal made at the Japanese Pan-Pacific Congress.

The amount of information on hot earth zones in the United States is increasing. Since the publication of Allen and Day's monograph on the steam wells in California, additional borings have been made, and there have also been added one boring in the Imperial Valley of California and three in the Dutch East Indies.

(*Secretary's abstract.*)

The classification of the hot areas in the Yellowstone Park and the causes of their development. E. T. Allen, Geophysical Laboratory, Carnegie Institution of Washington.

The numerous hot areas in the Yellowstone Park, though quite varied in external characteristics, may all be referred to a few distinct types. These are distinguished from one another by the nature of the deposits, the composition of the waters, the abundance of the water-supply, the thermal intensity, etc. The key to the differences in the waters and the deposits is found in the ratio of the sulphur and the water-supplies to one another. The two principal types show a rather striking segregation into distinct areas. This segregation, as well as the wide variations in thermal activity, in the depth of springs, and, in some measure also, in the size of the areas and the abundance of the water supplies, is tentatively attributed to differences in the character of the faulting in different parts of the Park.

(*Abstract.*)

The acid gases contributed to the sea during volcanic activity. E. G. Zies, Geophysical Laboratory, Carnegie Institution of Washington.

A study of the emanations given off in the fumarolic area of the Valley of Ten Thousand Smokes brought out the fact that even though the percentage concentration of hydrochloric and hydrofluoric acids in the steam may have been small, yet the aggregate amount emitted per year was very great.

In this paper attention is directed to the importance of considering both the intensity and capacity factor involved in gaseous emanations. These factors govern the kind of work done by the gases. Thus the amount of halides of the various bases that can be transported from a deep-seated igneous body to the surface at some given temperature will depend on the partial pressure or percentage composition of the acid gas. This is the intensity factor in the steam. On the other hand, for a given temperature, it is the total quantity of these acid gases in the steam that is effective in the alteration of the rocks over which they may be passing. This is the capacity factor.

A specific case of the effect of the capacity factor is discussed, namely: The amounts of hydrochloric and hydrofluoric acids that were contributed per year to the sea. The quantitative basis for these calculations is presented and the theory put forward by Suess and Becker that part of the chlorine of the sea is derived from the hydrochloric acid given off during volcanic activity is discussed.

It is also shown that the amount of hydrofluoric acid emitted by the fumaroles in the Valley of Ten Thousand Smokes is less than the amount of hydrochloric acid but that it is of a similar order of magnitude. The amount of the former acid that was contributed to the sea was so large that some mechanism must be invoked by which fluorine is continuously removed from the sea either through biological or chemical processes or both.

The various methods by which fluorides can be coprecipitated with other substances even when only very small concentrations of fluorine are present in solution are discussed. The great sedimentary phosphate beds of the world are cited as an example of the concentration of relatively large amounts of fluorine through biological and chemical processes. The fluorine content of these beds is discussed both as to percentage concentration and total amount present.

Finally, attention is directed to the desirability first of finding a direct method for the quantitative estimation of small amounts of fluorine; secondly, of making a careful determination of the average and regional fluorine concentration in the sea; and thirdly, of making systematic determinations of the chlorine, fluorine, and boron content of sedimentary and of altered rocks.

(*Abstract.*)

Volcano research of the United States Geological Survey. T. A. JAGGAR, U. S. Geological Survey.

In Hawaii, the tilt, tremor and sulphur accumulation about Halemaumau during 1926 indicated upward magmatic pressure. On July 7, 1927, lava burst through the talus of the bottom of the pit. It followed a line parallel to the Kau Desert cracks. The frothy black basalt spouted at three vents for two weeks, made a new floor about fifty feet thick, threw up small cones all within the pit, and ejected flames and incandescent streams, basaltic pumice and Pele's hair.

There was no unusual earthquake frequency such as accompanies subsidences at Halemaumau. There was no reaction of subsidence nor any inward tilt following the cessation of visible flowing. On January 11, 1928, there was avalanching from Halemaumau walls. One large slide so overweighted the floor of the previous July that pasty incandescent lava flowed up cracks. There was no gas-activity and no eruption followed. The flowing endured only a few hours.

The section of Volcanology of the U. S. Geological Survey is now operating seismographs at Lassen Volcano, Kodiak, Kilauea, Kealakekua and Hilo. Two stations on opposite sides of Kilauea crater, northeast and west, are now registering earthquakes. The new west station is the Uwekahuna observatory on the highest Kilauea summit. The seismograph is a three-component Imamur instrument built by Akashi of Tokyo, with modifications suggested by Jaggar. All three components write on one drum, the damping is magnetic, the suspensions are of wire, and timing devices are being developed by R. M. Wilson whereby the clock-contacts at intervals register the clock-error by wireless on an amplifier-controlled chronograph at the main station. The time at the main observatory is similarly controlled by wireless reception from Pearl Harbor, Mare Island and Arlington.

A new seismograph has been designed and constructed in the shop of the Hawaiian Volcano Research Association by the officers of the Observatory. Three two-component machines are finished and placed for testing, one at Kodiak, Alaska, one in a new specially constructed cellar at Hilo, Hawaii, and one at Cheltenham, Maryland, destined for Sitka, Alaska. These machines hang directly from iron plates in cellar walls, on cardan hinges, with adjustments for period and centering, with hollow heavy masses to be filled with sand at the installation locality, oil damping, jewelled pens, magnification 130 and mass about 80 lbs. The chronograph registers both components on one sheet of smoked paper, and the time-marks are gaps in the record made by a Howard clock through lift of the pen-tips electro-magnetically. Time is received by wireless and the correction impressed on the seismogram once a day through a telegraph key.

During the past year, geodetic coöperation by the Coast Survey has created a new line of precise levelling to the top of Mauna Loa, a new tide-gauge station at Hilo and gravity measurements at Hilo, Kilauea and Mauna Loa. The levelling will be repeated from time to time to check changes of elevation. The tide-station will be continued, and the mareograms are recorded by Mr. Wilson with a view to discovering tidal waves and interpreting changes of elevation of the Hilo bench-mark datum. The gravity measurements indicated anomalies in the direction of excess of mass, Kilauea greater than Hilo, and Mauna Loa greater than Kilauea.

The Uwekahuna observatory at Kilauea is also a museum and lecture hall, and this has been transferred to the National Park Service for motion-picture lectures to tourists and explanations of the geology of the crater by ranger-naturalists. Retriangulation of the Kilauea net and adjustment of the observations by Mr. Wilson has disclosed constriction of the crater, to match the vertical collapse that accompanied the explosive engulfment of 1924.

The Lassen volcano observatory has now been in service for a year and a half under R. H. Finch. No eruptions of Lassen Volcano have occurred. Occasional local seismic spells are indicated by the seismograph at Mineral. Hot-spring temperatures have been measured here and in the steam region of Sonoma and Napa Counties.

Dr. Jaggar established a seismograph in the basement of the residence building of the Agricultural Experiment Station at Kodiak, Alaska, in August 1927. At the end of August there was an explosive eruption of Mageik volcano in the Katmai group in the Alaskan peninsula. This caused falls of pumice and ash in the western bays of Kodiak Island for several days. In the first week of July he visited Gareloi and Bogoslof volcanoes in the Aleutian Islands. Gareloi was sending up dense yellow fumes from its summit crater-cup. Bogoslof was in full lava eruption after the fashion of 1907. A pile of steaming andesite had risen between Castle Rock and Grewingk, surrounded by a warm salt-water lagoon at 74°F. The outer sea water was at 50°. The lagoon was nearly circular, and surrounded by a gravel ridge, without any channel connecting lagoon and ocean. On the gravel were impact craters and clinkery black bombs and pumice boulders. There were hundreds of sea lions, and thousands of murres and gulls. The new activity of Bogoslof had started in mid-July, 1926, as reported by mariners, and prior to that there had been open sea water between Grewingk and Castle Rock. There were explosions every few months in 1926 and 1927. Akutan volcano was wholly quiet in the summer of 1927, Shishaldin and Mount Martin were steaming.

The 1927 reconnaissance of the Aleutian belt had in view the establishment of a seismograph station at Dutch Harbor as well as at Kodiak, and as both of these places are Naval radio stations, good time service is assured. The Dutch Harbor instrument will be installed in 1928. The reconnaissance included a journey to Bristol Bay, another to Attu and exploration in a motor-boat of Pavlof Bay, Volcano Bay, Belkoski and Morzhovoi Bays, and examination of the Izembek shore of Bering sea. These explorations revealed an unnamed volcano approximately 5000 feet high southwest of Pavlof Peak, to which the name Dutton Peak was tentatively given. It was also determined that the Aghileen Pinnacles are very remarkable minaret peaks apparently encircling a basin. The exploration of the whole group will be continued, a topographic map will be made, and photographs, both cinematographic and still, will be taken in the summer of 1928, by an expedition of the National Geographic Society, directed by Mr. Jaggar.

Active exploration of the Aleutian belt for natural history purposes depends on maps. The making of hydrographic charts and topographic maps may be done most expeditiously by joint service of the Coast Survey and the Geological Survey from Dutch Harbor. The buildings there are available as a base. There is needed a sea-worthy Diesel yacht of the halibut-boat class for this purpose; the boat should be of shallow draft and from 60 to 100 feet long. Both government services are ready to begin work in 1929. If appropriations for such a vessel can be obtained, with a small increase of funds, the Volcano Section of the Geological Survey will place an associate volcanologist in Alaska permanently.

ENTOMOLOGY.—*A new* Reticulitermes *from Baltic Sea amber* (*Insecta—Isoptera*).[1]

THOMAS E. SNYDER, Senior Entomologist, Bureau of Entomology, U. S. Department of Agriculture.

Among a collection of fossil termites, which I purchased several years ago, is a very small new species of *Reticulitermes,* Family Rhinotermitidae. The other fossil termites in this collection are representatives of the Families Kalotermitidae and Rhinotermitidae; no species in the highest family, Termitidae, have been found in Baltic amber.

This new *Reticulitermes* shows that several distinct species in this genus existed in the warmer Baltic region of the Lower Oligocene period, several millions of years ago, and that the very destructive species now living in the Palaearctic and Nearctic regions of the world are remnants of an ancient genus, once more widely distributed, including in prehistoric times diverse forms not greatly different from living species.

[1] Received September 27, 1928.

Reticulitermes minimus Snyder, n. sp. (Figure 1)

Winged adult.—Head dark castaneous brown, longer than broad, with scattered long hairs; ocelli separated from compound eyes by a distance slightly less than the long diameter of an ocellus. Postclypeus lighter colored than head, dark yellow-brown, bilobed.

Antennae dark yellow-brown, with 14 segments; with long hairs on segments.

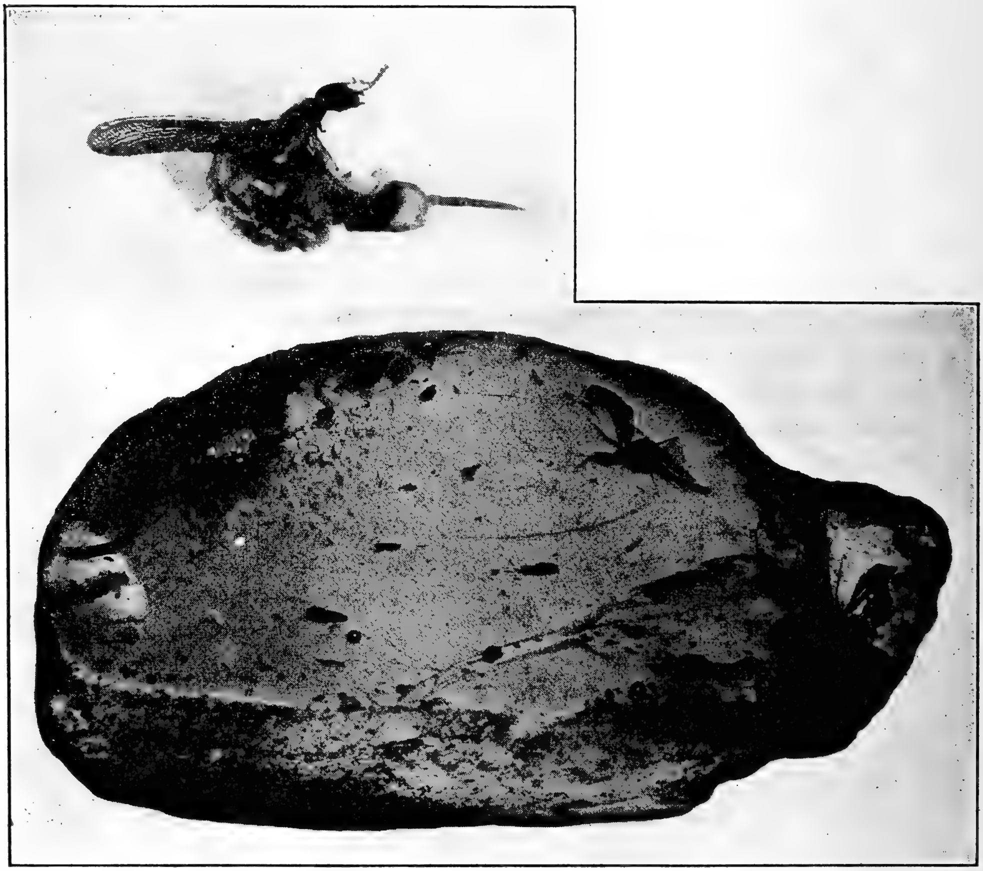

Figure 1a (below).—The winged adult of *Reticulitermes minimus* in Baltic Sea amber. Dorsal view, × 2½.

Figure 1b (above).—View showing details of wing venation, × 6.

Pronotum slightly lighter in color and not as broad as the head, roundedly and shallowly emarginate posteriorly; long hairs on margins.

Wings of a smoky color, costal area darker, membrane markedly reticulate, but no hairs on margins of wings, except at base, on wing scale or stub.

Legs with tibiae not darkened.

Measurements:—

Length of entire winged adult: 6.15 mm.

Length of head: 0.90 mm.
Length of pronotum: 0.35 mm.
Length of fore wing (to wing scale or base): 4.40 mm.
Length of fore wing scale: 0.50 mm.
Long diameter of eye: 0.22 mm.
Width of head (at the eyes): 0.60 mm.
Width of pronotum: 0.50 mm.
Width of fore wing: 1.20 mm.
Holotype, winged adult, number 41546, U. S. National Museum.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

714TH MEETING

The 714th meeting was held at the Cosmos Club, January 14, 1928, with President GOLDMAN in the chair and 205 persons present. New member elected: ROBERT SHOSTECK.

E. A. GOLDMAN was nominated as Vice-president of the WASHINGTON ACADEMY OF SCIENCES to represent the Biological Society.

R. M. LIBBEY mentioned the observation of a saw-whet owl in Arlington Cemetery on a recent walk of the Audubon Society.

A. N. PACK, American Nature Association: *In Glacier Park with the white goats, big horns, beavers, and other wild life* (illustrated).—The speaker showed several reels of moving pictures taken on a recent trip to Glacier Park by himself, W. L. FINLEY, and others, and gave an account of the trip. The pictures of mountain goats were especially noteworthy.

VERNON BAILEY: *A real live beaver from Michigan.*—The speaker exhibited a beaver about nine months old and weighing about twenty pounds belonging to VICTOR J. EVANS. For about twenty minutes the animal sat quietly on a small table in front of the audience and munched a large sweet potato and a few crusty rolls. The beaver is kept in a special house and presents an unusual opportunity for studying its food preferences and general habits. Captured beavers very quickly become tame and are extremely gentle and intelligent pets. A large old beaver weighing 50 pounds is just as quiet and gentle when first taken from the live trap as was this young one. Further studies are being carried on, and later it is hoped that something can be learned of their breeding habits and other habits which are important in the management of the many beaver farms being started in the north country.

S. F. BLAKE, *Recording Secretary.*

715TH MEETING

The 715th meeting was held at the Cosmos Club, January 28, 1928, with President GOLDMAN in the chair and 58 persons present. New member elected: Mrs. MARGARET M. NICE.

E. P. WALKER presented notes regarding the weight of elk.

THOMAS K. CHAMBERLAIN, U. S. Bureau of Fisheries: *Life history and conservation of fresh water mussels of the Mississippi River* (illustrated).—The speaker outlined research work in progress and the importance of mussels commercially in button manufacture and pearl production, 40,000 to 50,000 tons of shells being used annually in button manufacture, having an aggregate value of from $7,000,000 to $8,000,000. The life history of mussels, including development of the eggs in the *marsupium* of the mussel gill chamber, the manner of attachment of the *glochidia* to fish, their growth, development, and distribution were discussed. Recent experiments employing a culture medium designed to eliminate the heavy losses of mussel glochidia under natural means of development and distribution were described and the importance of making the production of mussels a farming proposition through planting of suitable mussel-producing areas was stressed.

LEWIS RADCLIFFE: *The International Halibut Commission.*—The history and work of the Commission, the importance of the halibut fisheries, and the life history and habits of these fish. The system of tagging fish as a means of studying their migration on the various important banks and the significance of the percentage recaptured as a means of determining the percentage of all fish taken in the commercial fisheries was discussed. He also called attention to the strenuous and often dangerous character of the work of the crews and scientific staff engaged in the work.

W. H. RICH discussed the two preceding papers briefly and called attention to the importance of research work now being conducted upon the salmon of the Pacific Coast which he stated would be discussed in greater detail by Commissioner O'MALLEY. Brief comments were also made by President GOLDMAN on observations made in connection with the menhadden fisheries.

W. B. BELL, *Recording Secretary pro tem.*

716TH MEETING

The 716th meeting was held at the Cosmos Club, February 11, 1928, with President GOLDMAN in the chair and 135 persons present. New member elected: BOWEN S. CRANDALL.

A resolution regarding the recent death of BRADSHAW H. SWALES was presented.

F. L. THONE announced that the translation of WILLSTAETTER's great work on chlorophyll by Dr. F. M. SCHERTZ has just been published.

C. W. STILES reported the receipt from the central West of an interesting specimen, consisting of the cyst of the larval stage of an armed tapeworm. Twelve such cysts were found in the brain of a foreigner, who was taken with Jacksonian epilepsy and died in a few hours. It was probably a case of reversed parasitization. The disease is very rare in the United States.

EDGAR BROWN reported that for the last three winters a female cardinal had been in the habit of flying repeatedly against a window in his house. The window has been covered with a screen to prevent injury to the bird, but it still flies against it. Dr. WETMORE stated that this habit is well known, and that it is generally believed that it is an attempt on the part of the bird to fight its own reflection.

HENRY O'MALLEY: *Life and habits of the fur seal and the salmon of the Pacific coast* (illustrated).—The speaker showed several reels of moving pictures from the Alaskan coast and islands, in part taken by the Finley-Church Expedition, showing nesting murres, sea lions, blue foxes, fur seals, and the pursuit, capture, and subsequent disposal of a whale. The different methods of capturing salmon were also fully illustrated. In conclusion, a film was shown, taken at the Fish Commission Building, showing the way in which the male large-mouth black bass guards its young from other predaceous fish. Discussed by LEWIS RADCLIFFE, who mentioned that 75 per cent of the world-take of sealskins comes from the Pribilof Islands and 60 per cent of the world-pack of canned salmon from Alaska.

717TH MEETING

The 717th meeting was held at the Cosmos Club, February 25, 1928, with President GOLDMAN in the chair and 110 persons present.

L. O. HOWARD gave an account of the last meeting of the New Jersey Mosquito Extermination Association. Discussed by C. H. MERRIAM.

A. A. DOOLITTLE, referring to the cardinal reported at a previous meeting as persistently flying against a window to fight its reflection, suggested that it would be interesting to hang a white curtain behind the window to cut off the reflection.

C. D. MARSH reported the fatal poisoning of a ranger in Yellowstone Park last year from eating the roots of a species of *Cicuta*, mistaken for edible camas.

W. B. MILLER: *Alaska reindeer and forage problems* (illustrated).—The speaker showed numerous slides of Alaskan scenery and animals and discussed the reindeer situation in Alaska, referring particularly to numbers of animals, range problems, and the results of cross-breeding experiments with reindeer and caribou.

C. W. STILES: *Zoology and religion.*—The speaker presented by request a paper already given before the Mt. Pleasant Congregational Church, an abstract of which has appeared in Science **47** (no. 1729): Suppl. p. xiv. Discussed by C. H. MERRIAM, who defined religion as the relation of man to the supernatural, and illustrated by reference to the religions of the California Indians.

718TH MEETING

The 718th meeting was held at the Cosmos Club, March 10, 1928, with President GOLDMAN in the chair and 95 persons present. New member elected: L. T. GAGER.

TITUS ULKE exhibited a specimen of pelicanflower, *Aristolochia grandiflora sturtevantii*, and discussed its fertilization.

A. S. HITCHCOCK stated that funds are now being raised to finance the work of the Interim Committee on Botanical Nomenclature appointed at the International Botanical Congress at Ithaca in 1926. Discussed by C. W. STILES, who felt that the work of such a committee should be supported by one of the big scientific foundations. Nomenclature is not a mere academic matter, and a great amount of time and money is lost through changes in names which bring no corresponding return to science.

STANLEY P. YOUNG: *Predatory animals and methods for their control* (illustrated).—The speaker described the four main predatory animals in the far West, the wolf, mountain lion, coyote, and bobcat, as well as the stock-killing bear. The early history of organized procedure against predatory animals as practiced by the Biological Survey was briefly discussed. This brought in brief mention of the rabies epidemic among coyotes occurring on the far western ranges, particularly in the States of Nevada, Utah, Idaho, and Oregon, at the same time stressing the fact that the coyote is a harborer of rabies. The history of the coöperative development of predatory animal control work was also discussed as this coöperation pertains to the various range States, counties, and local stock and game associations. The various methods used by the Biological Survey in controlling predatory animals were described, three main methods of control in particular, trapping, poisoning, and den hunting, being graphically illustrated by lantern slides. Depredations occasioned by predatory animals to stock and wild game were also stressed and examples of such depredations shown on the screen. In describing the wolf infestations which occurred in Colorado in 1921, a brief account was given pertaining to each individual wolf pack known to exist in that State, which totalled 8 individual packs, the largest of which contained 33 wolves. In the 8 packs were 9 distinct outlaw wolves which taxed the ingenuity of the Government hunters to the utmost before they were captured. (*Author's abstract.*)

Ernest P. Walker: *Alaska bird colonies* (illustrated).—Bird colonies are ordinarily supposed to be few and far between, and in most regions they are, but again Alaska proves the exception. In addition to the notable colonies of sea birds on Forrester, Hazy, St. Lazaria, Tuxedni, Bogoslof, St. Matthew, Chamisso, and the Aleutian Chain, administered by the Biological Survey, and the Pribilof Islands, administered by the Bureau of Fisheries, there are numerous less well-known islands and portions of the mainland coast where large numbers of sea birds nest. The ledges and cliffs of both islands and mainland coast supply nesting sites for more than twenty-five species of birds. The swampy delta regions and tundra country, so extensive in some sections, afford choice homes for myriads of ducks, geese, brant, swans, and shorebirds of a number of species. The sand and gravel bars and glacial moraines as well as the swampy sections afford nesting sites for the Aleutian and arctic terns, gulls, and shorebirds. (*Author's abstract.*)

719th meeting

The 719th meeting was held at the Cosmos Club, March 24, 1928, with President Goldman in the chair and 135 persons present.

C. W. Stiles exhibited a bottle containing 365 specimens of *Ascaris lumbricoides*, all taken from a child about three years old, and commented on the symptoms shown by such a serious infestation. Cases sometimes terminate fatally although this one did not.

F. G. Ashbrook: *Muskrat farming* (illustrated).—The muskrat is now the most important fur animal, commercially, in the United States, the average annual production of skins being about 13 million. Its ability to maintain itself in the face of constantly changing conditions makes it of great economic importance, and a large amount of acreage is now devoted to the raising of muskrats, particularly marsh areas bordering the Great Lakes and tidewater marshes of New Jersey, Delaware, Maryland, and Louisiana. The first essential is good marshland, with luxuriant food and sufficient water so that it will not freeze solid during the winter. The entire area should be inclosed in a fence to retain the muskrats and keep out enemies. Marsh areas on the eastern shore of Maryland have yielded as high as 4205 pelts in a season from 800 acres, while in Louisiana 163,000 acres of marshland produced 350,000 muskrats. Muskrat raising is particularly profitable because the carcasses as well as the pelts are salable. In 1904 muskrat pelts were selling at about 25 cents each and the carcasses at about \$1 a dozen. In 1925 the pelts were \$1.50 each and the carcasses \$3 a dozen. The carcasses are packed in ordinary barrels and sold on the markets of Baltimore, Washington, Wilmington, and Philadelphia under the name of "marsh rabbit," but in using this name no attempt is made to conceal the fact that the offering is muskrat meat. The flesh, a light mahogany color just after the pelt is removed, becomes darker when exposed to the air. It is almost black after it is fried and therefore not very appetizing, but is greatly appreciated by some people. The breeding season starts late in February or early in March in the northern part of North America, and earlier in the South. The average litter produced by a young female is about four, but animals two years old average eight to ten young to the litter. Young born in the first litter in the spring will produce young in the fall. Pen-raised muskrats produce three litters a year; but four and sometimes five litters have been born when autumn weather was mild. The young muskrats are blind and naked when born, but develop rapidly. Muskrat farmers have shown that the muskrat is polygamous.

N. B. McClintock: *The ways of beaver* (illustrated).—The speaker, a member of the faculty of the University of Pittsburgh who devotes his time to making moving pictures of wild life to be used for educational purposes, exhibited excellent moving pictures of beaver taken in Pennsylvania and Michigan. The animals are monogamous and mate for life. The houses are of two types, bank houses and island houses. The houses are usually about six feet in diameter inside and may be twelve feet across outside, and usually have two or more entrance holes. The floor is lifted only four to six inches above the level of the water, in order that the weight of the stick the beaver is eating may be supported principally by the water. The animals do not hibernate, but feed every day during the winter on the supply of branches gathered during the fall. They swim by alternate strokes of the hind feet at a rate of about five miles an hour when not frightened. The speaker found that the beaver could remain under water for at least nine and a half minutes. They have from three to six young, born in April. The pictures exhibited showed a mother beaver with six young beavers, beavers repairing a broken dam, and other aspects of their life. Discussed by C. W. Stiles and P. B. Johnson, with especial reference to possible correlation between their ability to remain so long under water and the size of the liver and suprarenal glands.

S. F. Blake, *Recording Secretary.*

THE GEOLOGICAL SOCIETY

441st meeting

The 441st meeting was held at the Cosmos Club, April 25, 1928, President Hewett presiding.

Informal communications: W. C. Mansfield called attention to an exposure in a stone quarry about 8 miles south of Emporia, Va., where three formations and two unconformities are exposed. The lower 50 feet of the outcrop consists of the basement rocks. Fossiliferous strata 7 or 8 feet thick occupy a depression in these basement rocks. The fossils indicate that the formation is marine Yorktown (Miocene), here much farther inland than previously reported. The Yorktown formation is in turn overlain by unfossiliferous terrace deposits. Discussed by R. S. Bassler.

Waldemar Lindgren reported the discovery of the bismuth mineral, wittichenite ($3Cu_2S \cdot Bi_2S_3$), in a mine 6 miles from Cerro de Pasco, Peru. This is the first known occurrence of this mineral in North or South America.

Program: Prof. W. H. Bucher, University of Cincinnati: *Cryptovolcanic regions.* The term "crypto-volcanic" was coined by Branca and Fraas[1] for the structure of the Steinheim Basin in Southern Germany. The basin forms.

[1] W. Branca and E. Fraas. *Das kryptovulkanische Becken von Steinheim.* Abh. Kön. Preuss. Akad. Wiss. **1905**.

a ring-shaped depression of $1\frac{1}{2}$ miles diameter in the limestone plateau of the Schwaebische Alp. Its center is occupied by a hill crowned with deposits of calcareous sinter. Natural exposures and tunnels dug for the purpose of geological investigation have proved this central hill to consist of older rocks carried above their normal level in intensely disturbed position. The basin surrounding it is the result of a depression below the normal level. Originally, in Miocene time, the basin was occupied by a freshwater lake in which deposits were laid down that have become famous for their mammal and fish remains.

The essentially circular outline, an outer ring-shaped depression and a central uplift, unaccompanied by true volcanic activity, are the characteristics of the American crypto-volcanic structures as well. Two such structures have been mapped by the writer since 1920: The "Serpent Mount Structure," on the boundary line of Adams and Highland Counties in Ohio,[2] and the "Jeptha Knob Structure," centering in the isolated Jeptha Knob of Shelby County, Kentucky.[3] A third structure of apparently similar nature, Wells Creek Basin, of Stewart County, Tennessee,[4] will be mapped by the writer this summer for the Tennessee Geological Survey.

Two major objections have been raised against the interpretation of these structures as of volcanic origin:

1.—The interior of the United States has since Cambrian time been notoriously free from all volcanic activity. It seems unjustified in such a region to turn to vulcanism for the explanation of structures not associated with lavas or tuffs, or at least with some evidence of contact metamorphic alterations.

2.—Even if a volcanic origin were conceded, no known volcanic process seems adequate to account for the peculiar character of the disturbance. The structures are decidedly not of laccolithic character. Up to the very edge of the structures the surrounding stata lie undisturbed. The magmatic body whose activity is reflected at the surface must therefore have had the shape of a plug. But no process is known that would allow us to picture the rise of a volcanic plug, $1\frac{1}{2}$ to 4 miles in diameter near the surface, without making room for the ascending lava column by volcanic explosion.

As to the first objection, it can be shown that while true vulcanism is absent in the interior of the United States, the number of places is growing constantly in this region where igneous rock is found to have risen to the now exposed level of the stratosphere. In all such cases the amount of contact metamorphism is negligible. A few especially significant cases referred to in the address follow. In the case of the peridotite dike of Fayette County, Pennsylvania, the contact effects are nil in limestone and extend but a few inches in the shales. This dike is especially instructive in the fact that it does not reach the surface and yet, according to L. B. Smith,[5] at one place it has lifted a zone 12 feet wide in the Waynesburg sandstone, four feet.

In Hardin County, Illinois, the association of the intricate block faulting, and especially the nearly circular, abrupt Hicks dome, with lamprophyre and

[2] W. H. Bucher. *Crypto-volcanic structure in Ohio of the type of the Steinheim Basin (Abstract).* Bull. Geol. Soc. Am. **32: 74**. 1921. Complete report in preparation for Ohio Geol. Surv.

[3] W. H. Bucher. *Geology of Jeptha Knob.* Ky. Geol. Surv. (6) **21**: 193–237. 1925.

[4] See *Geologic map of Tennessee.* Tenn. Geol. Surv. 1919; also *Erin Quadrangle* topographic sheet, Tenn.

[5] L. B. Smith. *Biennial Rept.* 1910–12. Pa. Top. Geol. Surv. **1912**: 150–156.

peridotite dikes and with tuff-like materials as in the Sparks Hill plug, is significant.[6] In Missouri, on the Camden-Laclede County line, in the midst of an area of abnormal and rapidly changing dips, a pegmatite dike outcrops, covering but a few square yards. "The rocks for many acres around, representing the lower formations, either stand on edge or are greatly tilted."[7] Metamorphic effects are limited to the immediate contact. On the Rose Dome, in Woodson County, Kansas, intrusive granite outcrops over something like 100 acres. Metamorphism is limited to a distance of 15 inches from the outcrop.[8]

In Riley County, Kansas, a porphyritic peridotite forms an outcrop of about one acre. This small size makes it improbable that this, like the other igneous bodies quoted above, ever reached the surface. In this case the abundance of shale inclusions is significant. They amount to $\frac{1}{3}$ to $\frac{1}{4}$ of the volume of rock.

These, together with the scattered discoveries of less significant volcanic dikes, show that volcanic materials actually traveled upward into the stratosphere in the interior of the United States, and that it is characteristic of them not to have reached the original surface.

The second objection is removed by observations of Du Toit in South Africa. He has described volcanic plugs that never reached the surface. He called them "bell-jar shaped intrusions." The observations were made in much dissected country of up to 1500 feet relief, with many excellent natural sections where the details were quite clear, justifying this description:

"The magma welled up along a fracture that was oval in plan and thus came to isolate a vertical and presumably cylindrical mass of sediments from the surrounding horizontal strata. It then spread out at the top, thus severing the enclosed column from the formation above; the nature of the base is purely conjectural. Deprived of support on all sides, the contents of the 'bell-jar' collapsed, the strata within became extensively injected with the magma, suffered tilting—sometimes to a high angle—and as a whole experienced considerable subsidence as well."[9] It is characteristic that almost up to the edge of the structure, the surrounding rocks lie undisturbed. Here, then, we have definite evidence that circular plugs of volcanic material have risen into the stratified rocks nearer the surface without breaking through.

It is interesting to note that the diameters of these South African bell-jar intrusions compare well with those of the known crypto-volcanic structures. The smallest has the same diameter as the Steinheim Basin, $1\frac{1}{2}$ miles. The two larger ones, $3\frac{1}{2} \times 6$ miles and 4×7 miles, compare favorably with the largest American example, the Serpent Mound Structure with a diameter of about 4 miles.

The conclusion seems justified, therefore, that crypto-volcanic structures represent surficial disturbances produced by circular or elliptical plugs that rise as "bell-jar injections" and fail to reach the surface. As such they are to be expected in regions which are free from volcanic activity and show

[6] L. W. CURRIER in STUART WELLER. *The geology of Hardin County.* Ill. Geol. Surv. **41**: 237–244. 1920.

[7] E. M. SHEPARD, letter quoted in C. N. GOULD. *Crystalline rocks of the Plains.* Bull. Geol. Soc. Am. **32**: 548. 1923; ARTHUR WINSLOW. *Lead and zinc deposits. Pt. 2.* Mo. Geol. Surv. **7**: 432–433. 1894.

[8] W. H. TWENHOFEL. Bull. Geol. Soc. Am. **37**: 403–412. 1926.

[9] A. L. DU TOIT. *The Karoo dolerites of South Africa; a study in hypabyssal injection.* Trans. Geol. Soc. South Africa **23**: 10–11. 1920 (1921).

igneous rocks only in the form of scattered dikes and finger-like plugs that at the time of intrusion failed to reach the surface, and have been made visible only by regional denudation.

Discussed by Messrs. KEITH, GILLULY, HEWETT, STOSE, BAKER, BASSLER, and SEARS.

ARTHUR KEITH: *Structure composite of North America.* (See Bull. Geol. Soc. Am. **39**: 321–385. 1928.)

Discussed by Messrs. G. R. MANSFIELD, BUCHER, REESIDE, and SCHUCHERT.

442D MEETING

The 442d meeting was held at the Cosmos Club, May 9, 1928, President HEWETT presiding.

Informal communication: W. C. ALDEN showed several photographs of the Sperry Glacier, Glacier National Park, Mont., taken in August, 1913, and 14 years later, in August, 1927. This small glacier, in the west side of the Continental Divide near Lake MacDonald, lies in a north-facing cirque above the great cliff at the head of Avalanche Basin. The foot of the glacier is 7,000–7,400 above sea level.

In 1913 the front of the glacier rested on top of the innermost ridge of the latest terminal moraine. This rock moraine is very fresh, with no soil nor vegetation upon it. By 1927 the front of the glacier had receded about 100 yards from the 1913 moraine, leaving exposed a bare rock surface with scattered pebbles and boulders upon it. A short distance outside the 1913 moraine is an older moraine somewhat smoothed down by erosion and with scrubby trees growing upon it. These relations are in accord with the opinion among geologists that the fronts of glaciers in the United States are, in general, receding.

Program: C. W. COOKE: *The stratigraphy and age of the Pleistocene deposits in Florida from which human bones have been reported.* (This JOURNAL **18**: 414–421. 1928.)

J. W. GIDLEY: *The contemporaneity of man and extinct animals in Florida.*

O. P. HAY: *Age of the "No. 2" bed at Vero and Melbourne.*

Joint discussion of the three papers by Messrs. W. C. ALDEN, PAUL BARTSCH, A. V. KIDDER, J. B. REESIDE, JR., H. G. FERGUSON, and W. T. SWINGLE.

W. W. RUBEY, A. A. BAKER, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

N. ERNEST DORSEY, Associate Editor of the International Critical Tables of Numerical Data, has been appointed Principal Consulting Scientist (Physics) in the Bureau of Standards.

EDGAR W. WOOLARD, assistant meteorologist, U. S. Weather Bureau, has resigned to accept an appointment as instructor in the Department of Mathematics at George Washington University for the academic year 1928–29.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, November 20.	The Anthropological Society.
	The Historical Society.
Wednesday, November 21.	The Medical Society.
	The Society of Engineers.
Saturday, November 24.	The Philosophical Society.
Wednesday, November 28.	The Medical Society.
	The Geological Society.
Saturday, December 1.	The Biological Society.
Tuesday, December 4.	The Botanical Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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METEOROLOGY and OCEANOGRAPHY.—*Scientific papers presented at the joint meeting of the sections of Meteorology and Oceanography, American Geophysical Union.*

The joint meeting of the sections of Meteorology and Oceanography during the ninth annual assembly of the American Geophysical Union was held in the building of the National Academy of Sciences on April 26, 1928. The joint meeting was devoted to a symposium and discussion on interrelations between the sea and the atmosphere, and the effect of these relations on weather and climate. The communications presented were on problems related to (*a*) solar radiation, (*b*) surface-water temperatures, and (*c*) atmospheric circulation. Reference to the papers under (*a*) will be found in Bulletin 68 of the National Research Council, and also to one by Sir Frederic Stupart, J. Patterson, and H. Grayson Smith under (*b*); the other three papers under (*b*) and those under (*c*) are printed below.

Problems Related to Surface-Water Temperature

Reliability of different methods of taking sea-surface temperatures. Charles F. Brooks, Clark University, Worcester, Mass.

This discussion is based chiefly on observations by the writer during 46 days at sea in middle and low latitudes of both Atlantic and Pacific, and on studies of the deck and engine-room logs of eight steamships. Altogether the conditions investigated cover practically the whole gamut of marine conditions from iceberg waters to calm tropical seas and from heavy storm to quiet weather.

Sea-surface temperatures, from a meteorological standpoint, involve more than the temperatures of the surface film. While it is the surface film alone that is in contact with the atmosphere, warming or cooling, humidifying or drying the air, the continuation of the influence of this sea surface at approximately the same level of temperature depends in considerable measure on the temperatures of the general surface layer of the sea, the layer that is commonly stirred by the wind to depths of 5 to 20 or more meters. Therefore, in this discussion of the reliability of different methods of taking sea surface temperatures, I shall include observations both at or near the actual surface and at a depth of 5 to 10 meters.

Two years ago an article of mine on "Observing water-surface temperatures at sea" appeared with a summary of the discussion that followed its presentation before the American Meteorological Society in Washington three years ago.[1] There was appended also a comment by Mr. F. G. Tingley, Chief of the Marine Division, U. S. Weather Bureau. Even in the low latitudes of the Caribbean Sea, I showed in this paper that in March, 1924, the sea was so well stirred by the wind that its temperature was within 0.1 degree the same at the surface near the bow, at the stern on the side or in the propeller wash and at intake depths, 6 or 7 meters. I indicated also that the usual canvas-bucket method was beset with numerous sources of error and that when air temperatures were appreciably lower than the sea temperature, errors of several degrees commonly arise, owing mainly to evaporational cooling of the bucket; and I found that the errors of condenser intake temperature records were appreciable, but less than those of the bucket. I concluded that the condenser intake temperature records were preferable to the canvas-bucket ones as indications of the surface temperatures under most conditions. I was convinced, however, that reliance would be placed better on a thermograph record than on those of uninterested observers. Mr. Tingley's studies of the canvas-bucket records made at Greenwich Mean Noon specially for the Weather Bureau indicated that they were sufficiently reliable, when used in fairly large numbers, for showing the changes in temperature occurring along the routes covered. But for well-founded marine meteorological studies we need to know the actual temperatures as well as the changes. With care, the errors of the canvas-bucket and condenser intake records can be reduced to insignificant proportions, but, unfortunately, that care cannot usually be commanded.

In the discussion of the paper there was no dissent from the general

[1] Monthly Weather Rev. **54**: 241–254. June, 1926.

conclusion that seawater thermographs should come into widespread use. The experience of several present pointed to the bulb-capillary-and-Bourdon-tube type of thermograph as most rugged and generally satisfactory, and a condenser-intake pipe installation as best. Some question was raised, however, as to how far sea temperatures at 5 to 7 or 8 meters depth could be used as representing the surface temperature in calm weather, especially in summer or in the tropics. A study of this question, submitted a year later showed that even in summer an accurate record of temperature at intake depth would, with few exceptions, represent more closely the slightly higher surface temperature than the usual evaporationally cooled canvas-bucket observation of the actual surface temperature.

Since 1925 six seawater thermographs have been placed on American and three on Canadian ships—two others are about to be installed. These eleven installations, nine of which are in the Atlantic, at least in part, are under the auspices of the U. S. Weather Bureau,[2] Clark University, The Scripps Institution of Oceanography, The International Ice Patrol (2), The Carnegie Institution of Washington, the American Meteorological Society, the Furness-Bermuda Line, and the Canadian Meteorological Office (3). The Canadian Meteorological Office still operates its group of three seawater thermographs on the Canadian Pacific steamers crossing the Pacific. Thanks to a grant from Clark University, it was possible to purchase a Tycos seawater thermograph and to travel with it on the FINLAND, on which the Weather Bureau had installed it, from San Francisco to New York last May. On this voyage I had an excellent opportunity to check the conclusions, just summarized, reached after a cruise in the West Indies on the EMPRESS OF BRITAIN in February and March, 1924, and to make observations in calm weather under a vertical sun.

The new set of observations made by me on the FINLAND were all by the same thermometer, calibrated by Mr. S. Chambers at the Scripps Institution of Oceanography. The necessary thermometric corrections, 0 to 0°.1C were applied throughout. For obtaining samples of sea water a rubber-covered tin bucket of broad cylindrical shape and having a capacity of 1.7 litres was dropped from the lowest open deck about 9 meters to the water. Experiments with the bucket before sailing showed that a full bucket cooled 0°.1C the first minute after leaving the water when it was exposed to a wet bulb temperature

[2] The Weather Bureau owns 1, operates another and will soon be caring for 2 more.

6°C below the water and to a wind of 9 m/s.[3] The bucket observations I made on the ship usually took 30 to 40 seconds from the time the sample left the sea till the temperature was obtained. Every set of observations included the wet bulb temperature and the wind velocity. Under the most extreme conditions it is probable that the bucket cooled 0°.2 in a one minute observation, but the average conditions were only one-quarter as severe. The average negative error for all the tin bucket observations is estimated at 0°.03C. Therefore it has appeared reasonable to accept the tin bucket temperatures as correct without making any allowance for the insignificant cooling.

The standard observations for checking intake temperature records by the engineers and the Tycos seawater thermograph were obtained with the same calibrated thermometer and insulated pail as were used for the surface data. A large drain faucet was installed for the purpose at the base of the intake pump by Mr. Schiffmann, refrigerator engineer, and from this faucet the temperature of a rapidly filled second bucket was obtained. Experiments were made to discover whether the heat of the room affected the temperature of this bucket of water to an observable degree in the 10 seconds required for an observation. No effect was detected.

In windy weather, when the surface layer of the sea is well mixed, table 1 shows that on the FINLAND as well as on the EMPRESS OF BRITAIN the difference fore and aft did not exceed 0°.1C more than once in 23 comparisons, and averaged 0°.05C. In quiet weather, however, under a nearly vertical sun the contrast between the warmer surface water sampled near the bow and the deeply stirred water in the propeller wash becomes appreciable. The following notes made May 10, 1927 at latitude 15°N. in the Pacific, about 40 miles from the coast of Oaxaca, Mexico, may be of interest in showing how large the differences may become on quiet days and how readily they are erased by light winds.

Today was a bright sunny day, with mostly light airs, and no land in sight. The sea temperature was from 84 to 88°F, and I found conditions unequalled for certain comparisons of surface and intake depth conditions. I had noticed that yesterday afternoon there was no opportunity of obtaining a constant temperature by any number of full dips, and suspected then that the farther from the ship the bucketful was obtained the higher would be the temperature. This afternoon at 2, after much bright sunshine and only a few ripples to disturb the surface, I found temperatures of 87.2–87.8 when my

[3] Details are presented in the 1928 report of the Committee on Submarine Configuration and Oceanic Circulation of the National Research Council.

buckets dipped more than 2 feet from the ship, and 85.3 to 85.5 when actually or practically in contact with the side when the sample was obtained. At the same time (just after) the propeller upwell (caught square in the middle) was 84.0. At 4, after about an hour of wind of B.1 the warm surface layer had become mixed so that both near and far the temperatures were 87.0 to 87.2. The propeller upwell was 85.6. More wind B.1 to 2 for 2 hours put the ship-side temperature constant at 86.6–7, while the propeller upwell was 85.9. After two hours more perhaps deeper water was involved in the mixing, for the temperature fell to 85.8. A water sampling from the stateroom port-hole at 9 showed 85.7 three-quarter hour after the last 85.8 sample on the stern, suggesting that the mixing of the top 15 or 20 feet had been fully accomplished by 9 p.m., with a wind of 1–2 Beaufort.

TABLE 1.—CONTRASTS IN SEA TEMPERATURE ABOUT A LARGE SHIP IN MOTION

Ship	Wind velocities (Beaufort)	Time	No. of comparisons	No. of diff. days	Tot. no. of bucket obs.	Shipside near bow vs. prop. wash temps.					
						°C difference					Bow side the warmer. Mean °C
						0	0.05	0.1	0.15	Av.	
EMPRESS OF BRITAIN	2–5	Any	10	8	42	3	5	2	0	0.04	−0.02
FINLAND	2–5	Any	13	9	78	5	3	4	1	0.06	−0.05
FINLAND	0–2[a]	Daytime exc. 12–4:30 p.	8	5	40						0.13
FINLAND	0–1[b]		5	3	43	Bow dips close in to ship's side.					0.9
			(3)			Bow dips away from ship's side					1.5

[a] When wind was B.2 the case was included here if the force 2 had been immediately preceded by light winds.

[b] Light winds since morning.

On the afternoons of three days which were quiet and fairly sunny, the forward hauls ranged from 0°.6 to 1°.4 and averaged 0°.9C warmer than those from the propeller wash, while dips made by flinging the bucket some distance out from the ship (1 to 3 meters) from the lowest open deck forward were 0°.6, 1°.9 and 2°.1, or a mean of 1°.5C the warmer. In quiet weather other than between noon and 4:30 p.m. the range of differences was from 0°.1C warmer forward than aft, and the mean of 8 cases 0°.13C warmer forward. Unfortunately, since no lights are permitted on the forward deck, it was impracticable to make more than a few comparisons (none of these in calm weather) between the ship-side forward and the propeller wash at night. So far as all these comparisons may indicate the extreme range of conditions, from sunny tropical calm to cold stormy weather, it appears that the temperatures of samples from the upwell from the propellers may be used interchangeably with those from ship-side hauls forward except between about 11 a.m. and 5 p.m. in calm sunny weather. Another limitation should also be noted. It is sometimes difficult to get clean up-well, and there is always a chance of getting a haul containing some of the hot out-take. In a series of hauls from the propeller wash I once obtained a temperature 0°.4C higher than the general run, and have at times hauled up an oily film. On the side of the stern I found the hauls 0°.2 to 0°.4C warmer than forward. Also, one fairly quiet sunny day, a range of 0°.5C was noted in a series of true propeller-wash hauls, owing apparently to the varying depth from which the water was pushed to the surface.

Table 2 shows that by eye observations the intake drain averages 0°.05C warmer than temperatures obtained by bucket at the surface in stirred water, but that there is no such close correspondence in quiet weather, the intake for the mean of three instances being 0°.3 colder than the surface at the side of the bow.

TABLE 2.—SEA TEMPERATURES AT SURFACE VS. INTAKE DEPTH, BY EYE OBSERVATIONS

Ship	Wind velocity (Beaufort)	No. of comparisons	No. of diff. days	Sea temps. °C	Shipside near bow or prop. wash. temps. vs. refrigerator intake pump drain faucet									
					Intake the warmer °C				0	Intake the colder °C		Mean diff.	Intake the	
					0.3	0.2	0.1	0.05		0.1	0.8		Warmer °C	Colder °C
EMPRESS OF BRITAIN	2–8	11	8	3–26	0	0	4	2	0	1		0.07	0.06	
FINLAND	1[a]–4	16	12	10–30	1	0	3	1	7	1		0.09	0.04	
FINLAND	0–1	3	3		1	0	0	0	0	1	1[b]	0.4[b]		0.3

[a] When light winds, propellor wash temperature taken instead of bow side temperature.

[b] Cf. the larger differences, found earlier in the afternoon, between shipside and propellor-wash temperatures, discussed above.

Table 3 gives *in extenso* the same facts as the first part of Table 2, the intake thermograph data being used for comparison with propeller-wash temperatures. Here the intake is a mean of 0°.03C, a negligible amount, warmer than the surface data.

TABLE 3.—SEA TEMPERATURES AT SURFACE VS. INTAKE DEPTH, BY EYE OBSERVATIONS AT SURFACE (IN PROPELLOR WASH) AND CORRECTED[a] THERMOGRAPH INDICATIONS ("TRUE INTAKE") BELOW. S. S. FINLAND.

Hour	°C	8 a.m.	10	12	2 p.m.	4	6	8	10	Total
				Number of cases						
True intake the colder by..	1.1	0	0	0	0	0	0	0	1	1
	0.6	2	5	6	2	2	2	1	1	21
No difference..................	0	7	0	7	8	6	3	6	4	41
True intake the warmer by . .	0.6	4	3	3	2	3	3	3	1	22
	1.1	1	0	0	0	0	0	1	1	3
Total cases....................		14	8	16	12	11	8	11	8	88
Mean diffs.°C................		0.2	−0.2	−0.2	0	0.1	0.1	0.4	0	0.03

[a] Corrected to pump drain faucet temperatures daily.

Combining the observations made by myself on the EMPRESS OF BRITAIN and on the FINLAND with those by Lieut. Commander Edward H. Smith on the MODOC and TAMPA[4] we find that except in calm or nearly calm weather the temperatures at 5 to 7 meters depth were the same, within 0°.2C, as those at the surface 49 times out of 50. Since quiet weather is uncommonly met at sea, this fact makes observations at either surface or 5–8 meters depth generally sufficient for both. In quiet weather, however, surface temperatures may be much higher than at 5 meters, the differences exceeding 1°.5C at times.[5] Near shore these surface excesses of temperature may be greater than any met with in the open sea. Observations by the Scripps Institution of Oceanography at 5 and 10 miles west of the Institution's pier at La Jolla, Calif., show such surface warming to be the normal condition in the warmer months there. According to a summary kindly furnished by Dr. G. F. McEwen[6] the mean surface temperature during 35 fortnights was 0°.66C ± 0.1 warmer than the water at a depth of 5

[4] Monthly Weather Rev. **54**: 252–253. June, 1926.

[5] Ibid. p. 252–253; also by surmise from the difference between ship-side and propeller-wash temperatures, of which I observed an extreme of 2.7°C.

[6] Details in the 1928 report of the Committee on Submarine Configuration and Oceanic Circulation of the National Research Council.

meters at the station 10 miles out, and for 29 fortnights was 1°.34C ± 0.11 warmer than at 5 meters at the station 5 miles from shore. The largest fortnightly mean difference was 2°.31C at the 10-mile station and 3°.96C at the 5-mile one. Half the fortnights averaged more than 0°.6 the warmer at the surface at the 10-mile station and more than 1°.1 the warmer at the surface at the 5-mile station. The data are for the months March, May, June, July, August, September and October during the period 1921–1926. June had the largest average difference, 0.92, at the station 10-miles out, while August had the largest, 1.95, at the 5-mile station. Owing to the upwelling of cold water and the relative lack of storminess here coupled with brilliant sunshine, the differences between surface and subsurface temperatures should approach the maxima to be found anywhere at sea.

We may conclude that in calm tropical regions and in periods of calm in summer elsewhere actual surface observations are indispensable.

Though many methods of taking sea surface temperatures have been tried, only two are in widespread use: (1) the reading of the fixed mercurial thermometer projecting into the condenser intake of a steamship, and (2) putting a mercurial thermometer into a sample of water obtained with a bucket heaved over the side of the ship. Electrical resistance thermometers (a) in condenser intake, (b) touching the inside of the shell of the ship, and (c) trailing behind, have been used but found impracticable except when closely supervised.[7] Outside exposures of thermograph bulbs (bulb and capillary type) have been tried on the sides of some battleships, I believe, and there is a new keel exposure of this type on the CARNEGIE. The bucket method has numerous variations, some involving lowering the thermometer in the bucket.

Condenser intake temperatures are observed once or twice each watch by an officer in the engine room. Table 4A provides various checks against these temperatures as recorded by the engineer. The difference between the two sets on the FINLAND, and especially the poor showing of the main engine-room observations need further details. (Table 4B).

One of the engineers told me that temperatures read within 5° would be close enough. His watch probably centered on 10 o'clock, the errors for which are about twice those for the other watches. However, he came well within a five-degree error. The location or errors of the

[7] Discussion by Dr. H. C. DICKINSON. Mo. Weather Rev. **54**: 251. June, 1926.

TABLE 4.—CONDENSER INTAKE TEMPERATURES AS RECORDED BY ENGINEER OBSERVERS

A. Comparison with quick surface observations in stirred water by C. F. B.

Intake minus tin bucket °C	−3	−1.0	−0.5	0	0.5	1.0	1.5	2	3	Total	Mean °C
				Number of cases							
EMPRESS OF BRITAIN (once each watch).....	1	1	5	20	21	6	1	0	1	56	0.3
FINLAND (Main eng.) (once each watch)....	0	2	3	7	8	6	3	5	1	35	0.8
FINLAND (Refrig.) (twice each watch).......	0	1	10	39	34	6	1	0	0	91	0.2

B. Main engine-room intake minus probable true intake (corrected thermograph)

Error °C	−3	−2	−1.5	−1	−0.5	0	0.5	1	1.5	2	3	5	Totals	Mean °C	Mean error °C
						Number of cases									
2 a. or 2 p..........	(1)[a]	0	0	2	6	2	11	6	1	2	0	0	30+(1)	0.4	±0.8
6 a. or 6 p...........	0	1	0	0	4	5	10	5	2	0	1	(1)	28+(1)	0.4	0.8
10 a. or 10 p...........	0	0	1	1	1	2	9	6	6	0	4	1	31	1.1	1.3
Totals................	(1)	1	1	3	11	9	30	17	9	2	5	1(1)	89+(2)	0.7	1.0

C. Refrigerator intake minus probable true intake temperature

°C	Hours—a.m. and p.m. together									Totals
	12	12 & 2	2	4	4 & 6	6	8	8 & 10	10	
−0.6	3		1	4		2	4		2	16
0	9		21	18		14	13		7	82
0.6	18		12	11		14	14		20	89
1.1	3		0	1		3	2		5	14
Totals....................	33		34	34		33	33		34	201
Means°C..................	0.3		0.2	0.2		0.3	0.2		0.4	0.3
		0.3			0.2			0.3		
Mean diff. °C.............	0.4		0.2	0.3		0.4	0.4		0.5	0.4
		±0.3			0.3			0.4		

D. Corrected fixed refrigerator intake temperature minus pump drain temperature

°C	−0.1	−0.05	0	0.05	0.1	0.2	0.3	Total	Mean °C
No. of cases..............	1	4	8	4	4	1	1	23	0.03

[a] Figures in () were for observations during periods of rapid changes in sea temperature. They are not included in the means.

main intake thermometer are unknown to me. Two of the officers told me that for the log the refrigerator room intake was read instead of the main engine-room intake. This may have been true much of the time, but the fact that the departure of the mean for the two best watches was twice as large as for the regular refrigerator intake record suggests that the engine-room intake thermometer was read somewhat higher than the refrigerator-room thermometer, owing probably to a combination of (a) greater heating of the water in the much hotter room, (b) larger thermometric error, and (c) greater parallax. (Table 4C.)

Subtracting from the means the thermometric error of 0°.3C, the mean indication of the refrigerator intake is 0 to 0.1°C below the pump drain temperature. (Table 4D.) A warming averaging 0°.03C seems to occur while the water passes from the pump to the intake thermometer. In connection with the foregoing, this means that the observers' parallax in reading is of the order of 0°.1C. This surprisingly small parallax for a thermometer graduated by 2°F is due to the very favorable location of the thermometer, about 1 meter above the floor in an accessible and well lighted position. The top of the scale is up. These observations, consistently good by all the observers, were made for checking the thermograph.

The usual condenser intake record is subject to (a) thermometric error, (b) error of parallax in reading, (c) time error (any time within a stretch of four hours), (d) personal errors of uninterested observers. (a) and (b) are readily determinable, (c) is unimportant except where the sea temperatures are changing rapidly, (d) is serious only infrequently. Observations on the EMPRESS OF BRITAIN and FINLAND (except for 10 o'clock watch) show 70 to 80 per cent of the intake records to be no more than 0°.6C off from the probable true intake temperature at the mid-watch hours, 2, 6 and 10.

The refrigerator intake record is likely to be better than the main engine condenser intake, for the refrigerator engineer in charge has to keep a closer watch of the temperature. The bihourly record kept on the FINLAND was 93 per cent within 0°.6C of the probable true intake.

The intake thermograph has the great advantages (1) of showing when important changes occur, (2) giving a continuous record from which any number of observations can be taken, and (3) in being free from erratic indications. But it has the disadvantages of being expensive and requiring careful attention and needing temperature and time checks. Experience on the FINLAND has shown, however, that engineers are capable and very willing to operate a thermograph and to make accurate observations for checking it.

It is evident from the foregoing discussion of intake observations by the engineers that any seawater thermograph that is to obtain reliable data must itself be of such quality that it may be considered a standard instrument. The thermograph should have a permanent adjustment and it should have pen arm attached directly to the coil and hinged so that the pressure of the pen on the paper will not be heavy. Joints to transmit the movement of the coil to the pen arm are very undesirable, for it is difficult to keep these free from corrosion and consequent "freezing."

The point of installation should be the intake pipe between the intake value and the pump. If there is a choice the hole should be drilled in the side or bottom of the intake pipe so that heated water cannot collect about the upper part of the bulb. The capillary should run directly from the bulb to the recorder, and any extra length should be coiled near the recorder, where it will have approximately the same temperature as the recorder.[8] Unusually hot locations for the recorder are to be avoided. According to the experience of the Canadian Meteorological Office, the recorder is best placed by bolting it to a shelf by the shell of the ship. Here it is relatively cool and free from excessive vibration. In any other location a spring suspension and guying has been found necessary to dampen the vibrations.

No matter how accurate the instrument itself may be it should be carefully checked at least once each month or two against a thermometer of known accuracy. Furthermore, since the recorder paper may not always be placed tight against the basal flange, and since this paper suffers some change in size with changing humidities, accuracy demands concurrent observations by engineers once daily or more often. From what has been said above, however, it is evident that the engineers' thermometer must be calibrated and the engineers must be trained and induced to make careful observations with it. The reliability of the bihourly checking observations on the FINLAND has already been mentioned. On the CALAWAII[9] the engineer in charge makes a particularly careful observation to the minute and fraction of a degree once a day and taps the recorder at this time to make a vertical mark on the trace. Without such a time mark it is difficult

[8] Detailed comment on the performance of the Tycos thermograph is presented in the 1928 report of the Committee on Submarine Configuration and Oceanic Circulation, National Research Council.

[9] Los Angeles to Honolulu. Instrument owned and operated by the Scripps Institution of Oceanography.

to take due account of the combined effect of clock error and change of time with change of longitude.

Tabulating the thermograph traces is complicated by four variables: (1) local time, (2) clock error, (3) departure of check observations from the stated hour, and, (4) for the Tycos thermograph at least, varying temperature-error rising vs. falling and at different temperatures. For the May voyage of the FINLAND I checked the thermograph against pump drain faucet temperatures and against time once or twice daily—always about 4:30 p.m., sometimes at 7:30 a.m. in addition. Usually every twelve hours, at a recorded time and temperature, the engineer in charge, Mr. Schiffmann, tapped the recorder, thus providing a ready check against all variables. The thermograph traces were tabulated in black by hours and directly above each bihourly reading was placed in red the refrigerator intake observation. Finally, the more exact corrections that I obtained personally once or twice daily were entered in their appropriate places. The hours at which the exact correction from one day would give way to those for the next were determined by sudden changes of temperature, if any, about 6 hours before or after the check point, otherwise by the refrigerator intake value, or simply exactly halfway to the next correction. Without the pump drain-cock checks it is necessary to average the bihourly intake observations approximately by 12-hour periods or by intervals having even temperatures on the thermogram, apply the calibration correction and heating correction, if any (on FINLAND refrigerator intake this was only 0°.03C. See Table 4D), compare this corrected temperature with the indicated one for the central hour, and apply the difference throughout the period.

The corrections for the U. S. Weather Bureau's thermograph on the COAMO (New York to Porto Rico) are obtained by comparison with eye-observations of condenser intake temperatures on that portion of the voyage where the sea temperatures are uniform. These corrections are then applied throughout the smooth and rough parts of the thermograms.

The common bucket used on commercial ships is a heavy canvas one of approximately 2 to 4 litres capacity. The base is heavy wood, to make it sink, and the top rim is stiff, to favor a good catch. Full catches are not the rule, and the evaporational cooling of the sample during the haul and while the thermometer is becoming adjusted may be considerable. The evaporational cooling and other errors are aggravated at night when the observer must carry the thermometer to a light. Other materials are sometimes used, e.g. leather and lead.

The bucket on the FINLAND was particularly good, as buckets go, having a double wall of canvas and a good diameter. It was 26 centimeters high by 15 centimeters in diameter. Of its height, 2.5 centimeters was the block of wood forming the bottom. Its capacity was 4 litres.

Table 5A shows that the mean error of all the canvas bucket observations on the FINLAND was less than that on the EMPRESS OF BRITAIN, probably because chiefly the FINLAND did not encounter so many days with air temperature considerably under the sea temperature. The FINLAND error exceeds that of the EMPRESS OF BRITAIN south of latitude 35. The low deck haul of the FINLAND vs. the high bridge of the EMPRESS OF BRITAIN and the double walls of the FINLAND's bucket should have put its observations to some advantage over those of the EMPRESS OF BRITAIN, but the lesser carefulness of the FINLAND's observers, coupled with some guess-work, seems to have offset these advantages. Tables 5B and 5C give further details on evaporational cooling and the personal element.

It is striking that for like conditions, the error of the canvas bucket observations on the EMPRESS OF BRITAIN (58 cases) and on the FINLAND (69 cases) should be identical. Note, for both ships, the increasing evaporational cooling at lower temperatures of the wet bulb relative to the sea. The greater cooling effects of stronger winds are of secondary importance.

Nighttime observations are nearly twice as much cooled as the daytime ones. The errors of the noontime "observation" (often not made, but guessed) are with one exception the greatest of the daytime errors. Significant of the admitted and observed guesswork of the quartermasters on duty at 10 and 12 is the fact that the mean departure for the daytime pairs is for this watch the greatest of all.

There is no reason for believing that these observations on the FINLAND are not a fair sample of those bucket series made more or less listlessly, without the urge of official scrutiny or iceberg menace. The crew of the EMPRESS OF BRITAIN, normally crossing the iceberg region, did better, considering the poorer bucket and higher haul. On both ships the mean error by day was a cooling of about 0°.5C, on the FINLAND the mean error by night was a cooling of about 1°C, with no seawater thermograph on the EMPRESS OF BRITAIN, no numerous comparisons at night were practicable on that ship. 70 per cent of the canvas bucket observations on the EMPRESS OF BRITAIN were within 0°.6C of the probable true surface temperature. After correc-

TABLE 5

A. Depression of canvas bucket below quickly-hauled tin-bucket temperatures

°C	−1.1	−0.6	0	0.6	1.1	1.7	2.7	2.8	3.3	3.9	Total cases	Mean °C
EMPRESS OF BRITAIN (all)	2	8	23	24	10	5	4	1	1	1	79	0.6
(South of lat. 35° only)	2	8	22	23	9	0	1	0	0	0	65	0.3
FINLAND	2	7	15	31	11	5	0	0	0	0	81	0.4

B. Cooling "error" of canvas bucket at different depressions of wet bulb temperature below sea temperature and at different wind velocities

Depression of sling wet bulb below tin bucket temperature °C		0–2		2.5–5		5.5–8		8.5		0–8.5+	
		Mean °C	No. of cases	Mean °C	No. of cases	Mean °C	No. of cases	Mean °C	No. of cases	Mean °C	No. of cases
Wind velocity (Beaufort) relative to ship	7–9 E[a]	−0.3	6	—	0	1.0	10	1.8	5	1.0	21
	F[a]	—	0	—	0	—	0	—	0	—	0
	4–6 E	−0.2	10	0.4	17	0.7	9	0.8	2	0.4	38
	F	+0.3	6	0.6	12	0.6	6	—	0	0.5	24
	0–3 E	0.0	4	0.1	5	1.0	9	1.7	2	0.7	20
	F	0.0	14	0.4	26	0.7	5	—	0	0.3	45
Means (0–6 E)		−0.2		0.3		0.8		1.2		0.4	
Cases			14		22		18		4		58
Means (0–6 F)		−0.2		0.5		0.7		—		0.4	
Cases			20		38		11		0		69

[a] E — EMPRESS OF BRITAIN; F — FINLAND.

C. Canvas-bucket "errors" through the 24 hours. Probable true intake (night and occasional daytime hours—and tin bucket—daytime and a few 8 and 10 p.m. observations) minus canvas bucket

	Night		Daytime							Night			Night	Day	All
	2A	4	6	8	10	12	2P	4	6	8	10	12			
Mean "error" corrected (0°.8F) for thermometer error.......°C	−1.3	−1.0	−0.7	−0.3	−0.3	−0.6	−0.4	−0.1	−0.3	−0.7	−0.9	−1.3	−1.1	−0.4	−0.7
Mean departure ±. Corrected to nearest whole degree F (1) for thermometer error...........°C	1.5	1.1	0.8	0.6	0.8	1.0	0.6	0.8	0.7	0.9	1.1	1.3	1.2	0.7	0.9
No. of cases......................	16	15	14	14	14	13	14	14	14	14	16	15	97	76	173

tion for thermometer error, 65 per cent of the FINLAND canvas-bucket observations were equally close.

The bucket method provides the only generally practicable means for obtaining the temperature of the actual surface of the sea, but under present usage it has unsatisfactory inaccuracies. Therefore, how to improve method and practice require consideration. In my previous paper[10] I listed 9 sources of error in the bucket method. I shall now add the tenth: guesswork. A brief review of these, with means for improvement in each case, may serve as a satisfactory concluding section of this paper.

(1) The bucket is not likely to have the same initial temperature as the sea surface. This would be of no consequence if the thermal capacity of the bucket were low. This suggests (a) hanging the bucket bottom-side up after every observation; or (b) at least making a pointed base so the bucket will have to empty; and, (c) where practicable, the use of water-shedding fiber, metal, rubber, or paraffined canvas, instead of water-holding canvas for buckets. Double dips, the first to warm the bucket closer to sea temperature, were found to raise the temperature by a mean of less than 0°.1C.[11]

(2) The water sample being hauled up is usually cooled by evaporation and conduction. This cooling takes place at the free water surface in the bucket and by conduction through the walls of the bucket. The problem, then, is to reduce the cooling at both places. Experiments with a bare and rubber-covered wide tin bucket indicated that for a bucket openly exposing a large free surface the cooling directly from the surface accounted for one-third the total cooling. This probably represents the maximum proportionate cooling from the water surface that is likely to be found, for the buckets used on ships are deeper relative to diameter. Furthermore, they rarely come up full. A cover or smaller top than body is the logical solution for the cooling of the surface. The rate of cooling through the walls of the bucket may be reduced by having the outside of the bucket paraffined to shed water, or insulated from the inside. A paraffined exterior, providing a dry surface, cannot be so helpful as might at first appear, for at sea the wet bulb temperatures rarely get many degrees below the dry. For insulation, a rubber covering 2–4 mm. thick on a tin bucket was found to hold up the cooling wave for $1\frac{1}{2}$ minutes, or enough time for observation. An outer cone of sheet

[10] Ibid., p. 245

[11] Ibid., p. 246.

iron insulated by air from the inner water-holding cone, both cones being covered, was found by Mr. Benjamin Parry to be twice as efficiently insulated as was the coverless, rubber-jacketed tin bucket just mentioned. Under a 9°C depression of wet-bulb temperature below the water temperature, a condition was rarely experienced at sea, Parry's first bucket cooled but 0°.6C in 4 minutes in a brisk wind.[12] A full canvas bucket, exposed to a 12°C depression of wet bulb temperature cooled 0°.6C in 3 minutes in a moderate wind. For an ordinary partial haul at such temperatures this amount of cooling is found after only one minute. At sea this bucket gave temperatures ½°C higher than the canvas bucket on 12 out of 15 simultaneous hauls. The other three hauls with the iron bucket gave ¼° (2) and ¾° warmer. Parry's improved bucket, put into experimental use after the first was lost at sea, has an inner water vessel with a rubber ball stopper. Its readings were ½°C higher than the canvas bucket's for 8 of 19 observations made, ¼° higher once, ¼° lower once, and the same 9 times, suggesting that it too was well insulated, and that its rate of cooling may be only half that for a full canvas bucket. The average of the 34 comparisons from January to mid-April, under diverse wind and sea conditions and in both middle and low latitudes, comes out insulated bucket 0°.4C the warmer—the same as the average error of the canvas bucket on the FINLAND. If the typical leisurely bucket haul could be speeded from two minutes down to one, and an insulated covered bucket used, the evaporational cooling could be reduced to but a quarter its present average, or to about 0°.1C.

Dr. G. F. McEwen's new metal water bucket, with valves top and bottom and lined with hard rubber, cooled but 0°.2C in 12 minutes in the shade, with wet bulb depression (below water temperature) of 6°.4C and a wind of 6 m/s. There was no cooling observed in the first four minutes.[13] In four other tests, made by Dr. McEwen, there was no cooling in the first four minutes in two and but 0°.04 and 0°.01C in the other two.

(3) The thermometer inserted is seldom at the same temperature as the water in the bucket. The typical thermometer used is a rather large mercurial one in a heavy metal case, the lower part of which is closed into a cistern. After an observation, this cistern may not be wholly dumped and the water may not evaporate before the next

[12] Further details are presented in the 1923 report of the Comm. on Submar. Config., etc., loc. cit.

[13] Personal communication.

observation. Since the bulb is in the cistern, the original temperature of the cistern and its water may have an appreciable effect on the indicated temperature. The essential part of a cure is to remove the cistern.

(4) While the thermometer is resting in the bucket further cooling, or perhaps heating, of the water sample may take place. For insulated and covered and, to a less extent, for buckets with water-shedding exteriors, this further cooling is reduced, but speeding up the process of determining the temperature of the sample is the easiest cure for this difficulty. The thermometer should have the quicker responding cylindrical instead of the usual spherical bulb. The observer should have the thermometer ready to immerse in the bucket at once. He should hold the bulb near the middle of the bucket and near the top and refrain from stirring the water, thereby mixing the usually cooler bottom and side water through the mass, and he should read it within a few seconds of the time of immersion. On the FINLAND readings were usually made in 45–60 seconds. It is possible to obtain the temperature only 20 seconds after the sample leaves the water. At night the *entire bucket* should be carried at once to the nearest light and the thermometer read there while its bulb is still in the water.

(5) When the thermometer is read it may not have reached the temperature of the water in which it is immersed. This is unlikely, but can be obviated by a quickly responding thermometer.

(6) If the thermometer is withdrawn, to be read more easily, the temperature of the very small sample in the reservoir may change before it is observed. Omitting reservoirs from sea-water deck thermometers should help, for only the least thoughtful observer would carry a bare thermometer from bucket to light, and expect it to show the water temperature. Anyway, a 3°[14] error is better than a 1°[15] one, for it is more easily spotted and discarded. On the FINLAND I saw an observer shake the water from the reservoir before reading.

(7) After the markings and numbers have become indistinct, errors of reading may creep in, and it is easy to see the same temperature as at the last reading. A bottle of thermometer-marking ink should be part of the ship's equipment.

(8) The thermometer should be calibrated, and its errors noted in each log. A spare thermometer with known errors should be carried.

[14] Case reported for P. E. James, in loc. cit., p. 247.

[15] See Table 4C above.

On the FINLAND the thermometer in use during the first few days was 0°.9F too high at the temperatures than prevailing. Before comparisons were made at higher temperatures this thermometer first suffered a 4°F separation of the mercury column—much to the elevation of a few observations, and then was broken when an observer tried to cure the trouble by heating. A galley thermometer brought into use for the remainder of the voyage was $\frac{3}{4}$°F too high in the eighties and $\frac{1}{2}$°F too low in the fifties, with intermediate errors between.

(9) There is a slight chance that the quartermaster may forget what the reading was by the time he gets to the log-book, and simply repeat the preceding figure. A hand pad for the observations would fix this.

(10) Observers may prefer guessing to observing. On the FINLAND two quarter-masters openly admitted guessing the sea temperature, usually 1°F above or below the air temperature. They had the 8 to 12 watch (see Table 5C). In justification they said such observations were of no consequence in waters not infested with icebergs and that towards noon, especially, they had too much to do to bother with the unimportant bucket observation. I was told by others, that some ship captains wouldn't have bucket observations—they were so far off in cold weather, and that some deck logs were filled in for bucket temperatures from the condenser intake temperatures of the engine-room log. Other quartermasters are faithful to the last degree. If the officers and observers could all be shown the value of the observations to investigators when accurately made, and how they were worse than worthless when guessed, this difficulty would be reduced.

The canvas bucket now in common use could be measurably improved by simply soaking it in melted paraffine and adding a cone of lead to its base. The paraffine would keep its heat capacity low, provide a water-shedding exterior, and increase the stiffness. The lead would make it sink better on striking the water and would prevent leaving the bucket in a standing position with residual water after an observation.

The bucket observation can be made reasonably accurate chiefly (1) by getting the observers more interested; (2) by having dry or insulated, non-collapsing buckets; and (3) by doubling the speed of the observation, both by quicker handwork and by using quicker thermometers.

Sea-surface temperatures both at the actual surface and at a depth of say, 5 to 8 meters (15 to 25 feet) are needed by the meteorologist who wishes to know the immediate temperature and vapor effects of the sea surface on the air and the general storage of readily available heat in the stirred surface layer. Observations on four ships showed that except in calm or nearly calm weather the temperatures at 5 to 7 meters depth were the same, within 0°.2C, as those at the surface 49 times out of 50. Since quiet weather is uncommonly met at sea, this fact makes observations at either surface or 5 to 8 meters depth generally sufficient for both. In quiet weather, however, surface temperatures are much higher than those at 5 meters, the differences amounting to as much as 1°.5C at times. Therefore, in calm tropical regions and in periods of calm in summer elsewhere actual surface observations are indispensable.

The methods most commonly employed for obtaining these sea temperatures are the bucket and the condenser-intake. A thermometer fixed in the condenser-intake pipe is read by an engineer at any time once during each watch. These readings are commonly subject to a mean error of 0°.2 to 0°.5C or more due to parallax and other coarseness in reading by an observer interested only in the general temperature of the water that is chilling the exhaust steam. Since the actual hour of his observation is not recorded, the best that can be done is to assign the record for each watch to the middle of it. The temperatures so assigned come within 0°.6C of the actual in about $\frac{2}{3}$ of the cases. Refrigerator intake observers on the FINLAND under favorable conditions averaged 93 per cent within 0°.6C of the actual temperature, during a 17-day voyage. A thermograph attached to the intake provides the most satisfactory service for continuity and accuracy, though not without due care and checking.

Bucket observations are usually made with a cylindrical canvas bucket of about 4 litres (1 gal.) capacity. The bucket is dropped from an open deck forward, hauled up and a thermometer used to obtain the temperature of the water. Cooling of the sample in the air is the chief source of error. The average error by day is about 0°.3C (too low) in weather when the wet bulb temperature is not much below the sea temperature (the average of observations equatorward of latitude 35), and up to several times this in severe weather. The average error at night on the FINLAND was 1°.1C (too cool) (vs. 0°.4C day) for a voyage from San Francisco to New York in May. The larger cooling at night is owing chiefly to the observer withdrawing the thermometer from the bucket to take the instrument to a light where he could read it. Some observers when pressed record a fictitious temperature instead of using the bucket. Like the engineers' observations, about $\frac{2}{3}$ of the daytime bucket observations were found correct within 0°.6C. The bucket observation can be improved chiefly by more interest, an insulated bucket, and more speed.

Accurate observations of surface temperatures and of those at 5 to 8 meters depth are both needed wherever and whenever the weather is calm and sunny. Bucket observations show surface temperatures to within 0°.5 and intake observations show the deeper temperatures with the same accuracy about two-thirds to three-fourths of the time and can be made to do better. General reliance on intake thermographs for sea "surface" temperatures is indicated by this study, provided that in quiet weather, carefully made bucket or other actual surface observations be used to supplement.

Significance of water-temperature measurements not made exactly at the surface. G. F. McEwen, Scripps Institution of Oceanography, La Jolla, California.

The difference between the surface temperature and that at a depth of five meters is least in mid-winter and greatest in mid-summer. In general it decreases with an increase of latitude and is negligible when the wind velocity exceeds about fifteen miles per hour. In the Pacific at distances ten to twenty miles off the Southern California Coast the temperature at five meters averages 0°.3 or 0°.4C less than that at the surface. During summer the difference is about twice this value, and during a calm clear day it may be as much as 1°.5C but this is very rare. The prevailing ocean winds are stronger farther from shore, and their maximum velocity occurs in summer, thus tending to reduce the temperature difference between the surface and five meter level below that found near shore.

Owing to the seasonal and regional change in this temperature difference, and its relation to meteorological conditions an extensive tabulation of data on surface temperatures and corresponding temperatures at depths of a few meters (those from condenser intakes, for example) should provide a means of estimating surface temperatures from subsurface temperatures.

An estimate of the accuracy with which the average surface temperature of a quadrangle thirty minutes on a side could be determined was based upon hourly observations made by the U. S. Destroyer Fleet of about thirty ships during a ten day period of maneuvers south west of San Diego, California. These temperatures were read from condenser intake thermometers and were divided into two equal groups, in one of which the thermometers were calibrated and the readings corrected. It did not prove practicable to calibrate those of the other group. Average temperatures of each of 141 quadrangles were computed from each group. The difference averaged about 0°.1C.

There were on the average 17 observations per quadrangle, from each group. The average difference in temperature of a quadrangle found from calibrated thermometers minus that found from uncalibrated thermometers was 0°.1C. The probable error of a single observation regarded as an estimate of the temperature of one quadrangle was 0°.8C. This estimate of error based upon about 5000 observations includes errors of reading, differences of position in the quadrangle and differences of time. The range of a group of readings corresponding to a single quadrangle was from 4 to 10°F. No appreciable difference was noted between means and medians. In order to obtain an estimate of the temperature of a single quadrangle with a probable error of 0°.2 about sixteen observations are required.

The time required for temperature-departures to cross from the western to the eastern side of the Pacific, and changes in departures during the crossing. G. F. McEwen.

Surface temperatures observed from Japanese ships and averaged by months and five-degree quadrangles have been published by the Imperial Marine Observatory at Kobe, Japan. Preliminary computations of surface drift have been made at the Scripps Institution from these data for the period 1916 to 1920.

One method was to plot as ordinates the departures from this five-year mean for each month using the distance along the direction of flow from a selected point, off Japan for example. Find by trial that horizontal displacement of one such curve with reference to that corresponding to the curve for one, two, or three months earlier which results in the best agreement of peaks and depressions. Thus the distance through which the water flows along this stream line in the corresponding time interval may be estimated. Sufficiently accurate data treated in this way should serve to determine seasonal and regional variations of velocity. The departures actually found rarely exceeded 3°.0C, and were usually less than 2°.0, while not infrequently greater differences were found between adjacent quadrangles. Temperature variations with respect to distance were especially marked near the boundaries of the Japan stream. Accordingly data from a large number of quadrangles could not be used in computations of currents.

The most satisfactory pair of curves tested in this way was for October and November, 1920, in latitude $32\frac{1}{2}°$ beginning near Japan. Comparing peaks and depressions, assuming no lag, there were 7 agreements and 11 disagreements. Assuming one month to be required for a flow equal to the breadth of one quadrangle, or displacing the curve corresponding to November one unit to the left, there were 15 agreements and 4 disagreements. The length of one unit at this latitude is 250 miles, therefore the estimated velocity is about 8 miles per day. Other pairs of curves gave approximately the same velocity, but the uncertainty did not seem to justify attempting to distinguish accurately between different regions or seasons.

Another method is to select a month and quadrangle in which the departure from the five-year mean is reasonably large. Find by trial that quadrangle in the general direction of drift having a somewhat smaller departure. Then find another farther along the stream-line having a still smaller departure, and so on. Make readjustments, if necessary to obtain a series of consistently decreasing departures as far along the stream-line as possible. Then assume the difference in distance between these successive quadrangles was traversed in the corresponding difference in time, and estimate the velocity in each interval. Actually it was found that the reduction of variability obtained by using a three month interval (January, February, March for the winter season, etc.) resulted in much more consistent results. For example in the quadrangle 27°.5 N and 142°.5 E the departure was + 1°.4 in the summer of 1916. In the fall it was 0°.8 C at a distance of 540 miles. Nine hundred miles from here it was 0°.6 C in the winter of 1917, and could not be detected by spring at an additional distance of 900 miles. The estimated velocities are respectively, 6, 10, and 10 miles per day, which agree with velocities estimated by the first method. The "Kobe" data when treated in this way frequently failed to give sufficiently consistent departures to warrant computing the velocities.

Using the stream lines assumed in either of the above methods, independent computations of velocity can be made from the difference between observed and "normal" surface temperatures, by the method explained on pages 230 to 235 of the publication of the Section of Oceanography, American Geophysical Union, April, 1927. These velocities were consistent with those estimated by the above methods.

These preliminary results indicate that oceanic circulation can be computed from temperatures by either of the above three methods.

However, care must be used in selecting appropriate intervals of time and space in order to reduce the effect of accidental variation. Also, the magnitude of the accidental variation in the "Kobe" data is rather large in comparison to the departures dealt with and thus tends to complicate the problem. Such data should be carefully examined in order to decide whether they are of sufficient accuracy to justify the particular use it is intended to make of them.

Problems Related to Atmospheric Circulation

The effect of surface-winds upon ocean-drift. G. W. Littlehales, Hydrographic Office.

The theatre of pure wind-driven currents is in the open ocean where the water is deep as compared with the depth to which the effect of the wind penetrates and where land masses are remote. When wind blows over a tract of the ocean, all the air does not pass over the water. The lowest parts of the air in the boundary between the atmosphere and the ocean remain in fixed contact with the water, giving rise to shearing stresses in overlying parts and generating eddies and turbulence whose effect is to produce a tangential pressure upon the surface of the sea in the direction of the force of the wind. This effect is augmented by the direct pressure of the wind upon the waves of the sea. The rate of drift thus communicated to the surface-waters varies directly with the velocity of the wind, relative to the sea and inversely as the square root of the sine of the latitude of the place, being approximately two percent of the velocity of the wind in high latitudes and four percent in low latitudes.

The deflective force arising from the rotation of the globe, which was passive before the motion of the water began, now comes into play, so that the direction of the drift does not follow the direction toward which the wind blows; but deviates 45° to the right-hand in the northern hemisphere and 45° to the left-hand in the southern hemisphere. And this deviation increases proportionately with the depth.

Descending from the surface into the depths, the vectors representing the velocity and direction of the movement are related to one another like the edges of the successive treads of a helical staircase whose steps decrease in radial extent in geometrical progression toward the bottom, in such a manner that the horizontal projection of the outer contour of the stair assumes the form of the logarithmic or equiangular spiral. That is to say, when the velocity of the current at any depth is denoted by V, and the angle between the direction of the current at the same depth and the direction of the surface current by a, there exists the relation $V = Ce^{-a}$, in which C is a constant and e is the base of the Naperian system of logarithms. When the tangential pressure exercised by the wind upon the surface of the sea decreases or increases in a certain proportion, the velocity of the current in the depths as well as on the surface will decrease or increase in the same proportion, while the direction of the motion relative to the direction of the wind will remain unchanged.

At a depth where the current has turned 180°, the velocity has decreased in the proportion $e^{-\pi} = 0.043$, or to about one twenty-third of the surface-velocity.

As one twenty-third of the surface-velocity may generally be disregarded on account of its smallness, it is usual to call the depth, D, at which the direction of the current has completed its first half revolution, the *drift-current depth.* In order to compute the drift-current depth, it is formulated that the resultant of the frictional forces acting upon the upper and lower surfaces of a layer must balance the deflecting force acting upon the same layer. The deflecting force acting upon the layer is for square centimeter $2\,\Delta \cdot d \cdot V\omega \cdot \sin\varphi$, where Δ is the thickness of the layer, d the density of the water, V the velocity, ω the angular velocity of the earth, and φ the latitude.

Likewise, the tangential force acting upon the surface of the water, due to the wind, is $u \cdot V \cdot 2\pi^2\Delta/D^2$ in which u is the virtual coefficient of friction.

Whence

$$D = \pi\,(u/d \cdot \omega \cdot \sin\varphi)^{1/2}$$

The drift-current depth thus depends not only upon the coefficient of friction but also upon the latitude of the place. If D is 100 meters at the Pole, assuming equal coefficients of friction it would be 108 meters in 60° of latitude, 141 meters in 30°, and 240 meters in 10°.

It appears from the above equation that D and u are mutually dependent, and, therefore, as Eckman has pointed out, that D may be used in place of u as a measure of the internal friction. This has the advantage of simplification, since it has been found, that for practical purposes, the drift-current depth may be expressed in feet by the equation

$$D = 4.5\,W/(\sin\varphi)^{1/2}$$

in which W represents the velocity of the wind in knots, and φ the latitude.

At a depth of one-fifth of D below the surface, the direction of the current will be deviated one-fifth of π or 36 degrees to the right of the direction of the surface current in the northern hemisphere, and to the left in the southern; and its velocity will be one-half of the velocity of the surface current. Therefore, since the velocity of the surface-current is from two per cent to four per cent of the velocity of the wind, according to the latitude, and since the direction of the surface-current is deviated 45° to the right of the direction toward which the wind is observed to blow in the northern hemisphere, and 45° to the left in the southern hemisphere, the direction and velocity of the current at the depth D (or any other selected depth) are readily deduced.

Of vital importance is the question, how long a time is required after the beginning of a new wind for the corresponding drift-current to set in. The initial influence will set in at the surface in a few minutes, and, by the time the waves show the effect of being wind-driven by the wind that is then blowing, the drift-current will have penetrated to a depth greater than the maximum draft of ships.

Seeing that the effective movement of the water within the range of the drift-current depth is at right-angles to the direction of the wind, how comes the concordance between the circulation of the surface-winds and the circulation of the surface-currents which is observed when comparison is made between wind-charts and current-charts? Operating around regions of barometric maxima in the eastern part of the temperate zone, both north and south of the equator, in all the oceans, where action-centers exist through the accumulation of more than the average amount of the atmosphere, the winds induce surface-currents in the ocean that move in a clockwise circuit in the northern hemisphere and in an anti-clockwise circuit in the southern hemisphere. In the northern hemisphere, these anti-cyclonic winds will all be driving the water to the right-hand and in the southern hemisphere to the left-hand, that is, toward the center of the system in each case. Under opposing pressures at the opposite ends of the diameters of the closed circuit, an elevation is raised. Down the slopes of the elevation the water will run under the influence of gravity; but the rotation of the globe will cause its course to be deviated to the right-hand in the northern hemisphere and to the left-hand in the southern hemisphere, and when a steady state is reached it will be flowing around the central elevation in a clockwise direction in the northern hemisphere and in an anti-clockwise direction in the southern hemisphere.

A critical review of the work of the Indian Meteorological Service in monsoon-predictions. R. HANSON WEIGHTMAN, Weather Bureau.

From time to time, due to the failure of the southwest monsoon and its attendant rains, terrible famines have visited India. With some fore-knowledge of such conditions, precautionary steps can be taken to provide food, at least, for an otherwise destitute population of many millions. It was the urgent needs for such fore-knowledge that inspired careful studies by the meteorologists of that country which culminated in the issuance by Blanford in 1884 of the first official prediction for a season in advance.

Over India there are two phases of the general wind-circulation known as the northeast and the southwest monsoon. The former, during which the winds are prevailingly from the northeast, is well established during December and January. The southwest monsoon consists of two branches, namely, the Arabian Sea current which prevails from June to September and the Bay of Bengal current which begins in April and ends in September. Between the northeast and the southwest monsoons there are transition periods: February to March, and October to November. These wind-systems are in harmony with the general barometric pressure-distribution; for during the northeast monsoon there is abnormally high pressure over Siberia and moderately high pressure over northern India, while during the southwest monsoon very low pressure prevails over and to the northwest of India. The southwest monsoon being warm and very moist after its long journey over the water, produces copious rains over India as the air mounts upslope. The Arabian Sea current brings rainfall to Bombay, Gujarat, Rajputana, and even into Punjab, and on the windward slopes of the Western Ghats the falls are heavy. The Bay of Bengal current passes along the Madras coast, producing showers but bearing more generous rains to Orissa, Chota Nagpur, the greater part of the Central Provinces, and Central India, and excessive rains to Bengal and Assam. At Cherrapunjii in Assam the rainfall averages more than 500 inches a year. Over northwest India the amounts diminish greatly, a large part of the precipitation being produced by cyclonic disturbances.

Blanford based his monsoon-predictions on the winter snowfall in the nearby Himalayas as an excess of snow had been noted to precede seasons of drought in India. His successor, Elliott, recognized that Himalaya snowfall exercised only a partial control and attempted to increase the reliability of the forecasts by considering pressure in the Indian Ocean, on the assumption that high pressure at Mauritius would lead to stronger northward-moving moist winds over India and consequently to a more abundant monsoon rainfall. Unfortunately, this idea was not in accordance with the facts and was later abandoned. For a while, in fact, publication of the forecasts ceased entirely, but predictions continued to be made, although treated as confidential documents.

It has been known for some years that the larger variations of seasonal weather, whether reflected in rainfall, atmospheric pressure, or temperature are in general not isolated phenomena, but are linked up with variations in other parts of the world, sometimes quite remote. This idea has had quite an application in connection with the development of the mathematical formulae of later years for predicting the monsoon-rainfall.

Up to about 1904 graphical or extremely simple mathematical methods were employed but in that year it was realized that the problem was too difficult for solution by *a priori* methods and recourse was had to examination by statistical methods. It was necessary to find empirically what reliable relationships there were between weather conditions in various parts of the world before attempting a general theoretical discussion. Pursuant to this plan the well-known statistical method of correlation was developed in addition to the graphs.

By means of correlation-coefficients, numerical relationships were found between meteorological conditions at many different points throughout both the northern and southern hemispheres, and also between these points and the monsoon-rainfall (June to September). Among the most important of the latter are the following: (1) April and May pressure in South America (mean of Santiago, Buenos Aires, and Cordoba), + 0.42; (2) accumulated snow at end of May to the north and northwest of India, − 0.36; (3) May pressure at Mauritius, − 0.36; (4) April and May rainfall at Zanzibar, − 0.31; (5) May rainfall at Seychelles, − 0.20.

The next step was to devise a method whereby some of these more important relationships could be brought to bear simultaneously in estimating the monsoon-rainfall. This was accomplished by Walker in India by means of the multiple correlation-coefficient. It is interesting to note that the same result was achieved by Carl Pearson in England at about the same time. The two men working entirely independently and employing different methods obtained exactly the same resulting formula.

The formulæ for multiple correlation-coefficients and regression equations are given in Yule[1] and other standard text-books on statistics.

In 1908 a preliminary formula was worked out for India as a whole with regression-equation as follows:[2]

Monsoon-rainfall = − 0.20, snowfall accumulation − 0.29, Mauritius (May) pressure + 0.28, South American (May) pressure − 0.12, Zanzibar (April and May) rainfall, which gives a multiple correlation-coefficient of 0.58.

Even as high a coefficient as 0.58 does not justify a forecast unless the abnormalities are fairly well marked,[3] but during the period of 16 years (1909–1924) this condition was satisfied in 9 years out of 16, and in 8 years out of the 9 the rains were in excess or defect when this was given by the formula.

Later in 1914 the rainfall of each of the 33 rainfall subdivisions employed in the monthly summaries for India was correlated with (1) May pressure in India as a whole, (2) May pressure at Mauritius, (3) April and May pressure in South America, (4) accumulation of snowfall at end of May to the north and northwest of India, (5) May rainfall at Zanzibar and Seychelles, (6) May rainfall in South Ceylon, and (7) the rainfall of Java during the preceding cold season (October to February), which latter was suggested by the work of Hildebrandsson.

A study of the results showed that the coefficients for the Bay Islands, Lower Burma, and Assam were insignificant, while Upper Burma depends mainly on South America and Seychelles. For the remainder of northeastern India, in which may be included Bengal, Orissa, Chota Nagpur, and Bihar, it is characteristic that Seychelles is unfavorable but in other respects there is lack of uniformity. If we divide the remainder of India roughly into Northwest India and the Peninsula, it is fairly conspicuous that, while South America and Zanzibar affect them both materially, snowfall and Ceylon rain have more influence over Northwest India than over the Peninsula, while Java has more influence over the Peninsula than over Northwest India. If we select the subdivisions most characteristic in these respects, we may consider that Northwest India comprises the United Provinces West, Punjab East and North, Kashmir, the Northwest Frontier Provinces and Rajputana. Similarly for the Peninsula we may take Gujarat, Central Provinces, Konkan, Bombay Deccan, Hyderabad,

[1] G. UNDY YULE. *An Introduction to the Theory of Statistics,* 8th ed., London, 1927.

[2] Mem. Indian Meteor. Dept. **21**(2): 31.

[3] GILBERT T. WALKER, Discovery (London) **6**: 100. March 1925.

and Madras coast north. The subdivisions Mysore, Malabar, Madras southeast, and Madras Deccan have been omitted as not sufficiently uniform with the rest.

It was evident, therefore, that by considering the Peninsula and Northwest India separately better forecasts could be made than for India as a whole, the added reason being that the different independent variables showed different relations with these two regions, as indicated by the following table.[4]

After a number of trials, the regression-equations set out below were found to give the most satisfactory results.

For the Peninsula a multiple correlation-coefficient of 0.73[5] was obtained, based on the regression-equation: Peninsula rain = + 0.44, South American pressure − 0.29, Zanzibar rain − 0.41, Java rain (Oct.–Feb.), while for Northwest India a coefficient of 0.57 was

TABLE 1.—Correlation-Coefficients

Region	Indian May Pressure	South American May Pressure	Snowfall Accumulation	Zanzibar Rainfall May	Ceylon Rain May	Java Rain Oct.–Feb.	Mauritius Pres. May
NW. India	+.22	+.50	−.38	−.24	−.29	−.20	(a)
Peninsula	(a)	+.47	−.16	−.48	−.22	−.45	−.21

(a) Too small to be considered important.

obtained based on the regression-equation: NW. India rain = + 0.35, South American pressure − 0.21, snowfall accumulation − 0.14, Zanzibar rain −0.13, Ceylon rain.

Even with these improvements, the predictions are subject to considerable weakness at times as shown by the tabulation which follows, giving results[6] for the period 1891 to 1921 for the Peninsula, which has the stronger correlation-coefficient.

When predicted values fall between the limiting values at the head of the columns, the actual departures that occurred are listed in that column, being separated however into two groups, one in which the predicted and actual departures have the same sign and the other in which they have opposite signs. The first part of the table is devoted to cases where the predicted departures were positive and the second part to cases where the predicted departures were negative. At the bottom the percentage of cases in which the correct sign was pre-

[4] Mem. Indian Meteor. Dept. **23(2)**: 25.
[5] Mem. Indian Meteor. Dept. **23(2)**: 26–27.
[6] Mem. Indian Meteor. Dept. **23(2)**: 36–37.

dicted is given for groups of cases in which the predicted departures exceeded certain amounts without regard to sign, for example, when the indicated departure was 3.0 inches or more, the sign of the actual departure was the same in 86 per cent of the cases.

TABLE. 2—PERFORMANCE, INDIAN MONSOON FORECASTS (PENINSULA), 1891–1921

Prediction limits	0″.0 to +0″.9		+1″.0 to +1″.9		+2″.0 to +2″.9		+3″.0 to +3″.9		+4″.0 and over	
	Same	Opposite	Same	Opposite	Same	Opposite	Same	Opposite	Same	Opposite
Actual departures and signs........	+0.8 +4.2* +6.7*	−1.7	+2.6	−0.5	+5.7 +1.0 +2.0	−0.6	+2.0 +8.6*		+9.9 +3.2	−0.9*
No. of cases.........	3	1	1	1	3	1	2	0	2	1
Prediction limits	0″.0 to −0″.9		−1″.0 to −1″.9		−2″.0 to −2″.9		−3″.0 to −3″.9		−4″.0 and over	
Actual departures and signs........		+4.0* +4.6* +1.5	−10.5*	+1.0 +4.3*	−3.9		−1.3 −2.4	+1.9*	−16.6 −4.2 −8.4 −6.2 −7.2 −11.1	
No. of cases........	0	3	1	2	1	0	2	1	6	0
For predicted departure[a] more than..............	0″.0		1″.0		2″.0		3″.0		4″.0	
Correct signs........	68%		75%		84%		86%		89%	
No. of cases........	31		24		19		14		9	

[a] Whether plus or minus.

* Predicted departures differ from actual by 3.0 inches or more.

In studying the table, it will be noted that one-third of the cases are starred indicating that the predicted departures differ from the actual by 3.0 inches or more. This may give us pause for a moment. However, considering that the main object of the forecast is to indicate the abnormally dry years, it will be noted that when the forecasts indicated 4.0 or more below normal, they were successful in every case, not only with regard to sign of departure, but substantially as to amount. Perhaps the most outstanding failure was in 1920 when a deficit of

10.5 occurred following a prediction of −0.18. Other failures that deserve mention were in 1909 when +4.3 was predicted and the actual was −0.9; in 1895 when the predicted was +2.1 and the actual −0.6; in 1906 when the predicted was −3.6 and the actual was +1.9, and in 1908 when the predicted was −1.5 and the actual was +4.3.

Attention may properly be invited also to the fact that out of the seven cases in which predictions were made for departures between +0.9 and −0.9, four had actual departures of 4.0 inches or more above normal.

It seems appropriate to call attention to the statement by Walker[7] in which he indicated that even if the relationship indicated by the correlation-coefficient be fairly high, it will not justify a forecast for public consumption and that, unless the chances of success are at least four out of five, i.e., with a correlation-coefficient of 0.80, a forecast should not be made.

The results obtained in India justify the issue of the monsoon forecasts for that country, which has conditions regarding its rainy season without parallel in other parts of the world.

Similar methods have been tried in other parts of the world and there is every reason to believe that they have their application in the United States.

In conclusion may I urge that Walker's criterion be followed and that caution be exercised in attempting forecasts until we have prospects of four successes out of five cases.

The effect of ocean-currents on the climate of continents. ALFRED J. HENRY, Weather Bureau.

As every one knows the specific heat of water is much greater than that of land, equal volumes being considered. This is equivalent to saying that when equal quantities of heat are received upon equal areas of land and of water the resulting increase of temperature is almost twice as great on land as on water, even when in the case of water the heat expended in the process of evaporation is neglected. When, therefore, a parallel of latitude runs partly over land and partly over water, differences in climate are brought about which would not exist if the parallel passed exclusively over a land or a water surface. This fundamental fact is the basis of classifying climates into two great groups: continental and marine. Briefly the part played by the ocean and ocean-currents in climatic changes is that of a great regulator and this function is exercised regardless of the speed of

[7] Quart. Journ. Roy. Meteor. Soc. **52**: 73–80. 1926.

movement of the oceanic waters. The greatest effect is produced, of course, when the ocean-current flows from low to high latitudes and vice versa, hence the effect is a graded one ranging from a modest influence in the case of no current to a very considerable one in the case of currents or drifts from low to high latitudes and vice versa. The effects naturally diminish with increase of distance from the ocean but there is no arbitrary limit at which the effect ceases.

Ocean-currents that originate in low latitudes and flow poleward, as for example, the Gulf Stream in the North Atlantic and the Japan Current in the Pacific, are in a class by themselves, since they transport large quantities of heat from equatorial regions poleward and in the case of the Gulf Stream drift, even to the Arctic Circle and beyond. This drift gives us a very striking example of the warming of a continent in winter as the direct result of heat borne by an ocean-current. Consider, for example, the region along the fifty-second parallel of north latitude from the Irish coast at Valentia to Barnaul, Siberia. The annual mean temperature in this distance of nearly four thousand miles diminishes 8°.4 C (15°.1 F) and the January mean is 23°.7 C (42°.7 F) lower in Siberia than at Valentia. This is, of course an extreme case.

Consider next, an oceanic current that flows in the reverse direction, the Humboldt or Peruvian current which flows northward along the west coast of South America. The effect of this current is twofold, first, a lowering of the temperature along the neighboring coast and, second, a great diminution in the rainfall as explained in the following: Warm currents flowing from low to high latitudes increase the precipitation on neighboring coasts and highlands because the air over the water is saturated with water-vapor at a higher temperature than that which belongs to the latitude in which it finds itself. Naturally its temperature departs but little from that of the dew-point of air in the higher latitudes, thus favoring precipitation with a small reduction in temperature.

Conversely currents flowing from higher to lower latitudes diminish the precipitation because as they gain distance toward the equator, the moist air over them has a temperature which is below the normal for the latitude. As this air becomes warmed, particularly over the neighboring land areas its temperature departs more and more from that of the dew-point at which condensation occurs and precipitation becomes more and more difficult. The west coast of South America, say between the equator and 30° south latitude, has a very small rainfall and is practically rainless in northern Chile and southern

Peru. The fogs that are a menace to navigation on the west coast of North America are a direct result of oceanic temperatures along the coast.

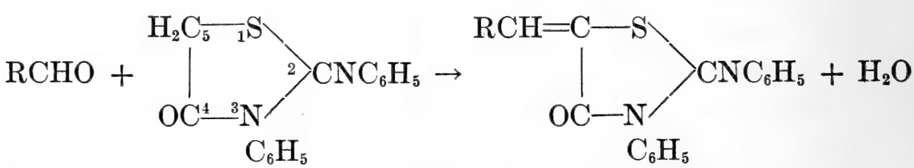
Many other cases might be cited and described but it seems needless to do so.

Just what part the warm ocean-water that is transported to high latitude plays in the origin and maintenance of the barometric formations that occupy the northeastern parts of both the Atlantic and the Pacific has never been evaluated, but it is conceivable that a much weakened cyclonic circulation would result if the relatively warm water were absent. The climate of high latitudes in both North America and in Europe-Asia would then be much different from what it is at present.

CHEMISTRY.—*Further aldehyde condensations with diphenylisothiohydantoin.*[1] STUART S. KINGSBURY and KLARE S. MARKLEY, George Washington and Johns Hopkins Universities. (Communicated by NATHAN R. SMITH.)

INTRODUCTION

It has been shown by Hann and Markley[2] that condensation takes place between aromatic aldehydes and diphenylisothiohydantoin when heated together in glacial acetic acid solution in the presence of anhydrous sodium acetate. The condensation takes place through the elimination of two atoms of hydrogen from the methylene group in the substituted pseudo-hydantoin and the oxygen of the aldehyde. The typical reaction is shown by the following equation.[3]



They succeeded in preparing the 5-(aldo)-2-phenylimino-4-thiazolidones of benzaldehyde, o-nitrobenzaldehyde, furfural, vanillin, chlorovanillin, nitrovanillin, bromovanillin, cinnamic, salicylic, 3,5-dichlorosalicylic and protocatechuic aldehydes. The present paper is a continuation of that study.

[1] Received October 19, 1928.

[2] HANN and MARKLEY. This JOURNAL **16**: 169. 1926.

[3] Numbering is according to the recommendation of BOGERT and ABRAHAMSON, Journ. Amer. Chem. Soc. **44**: 826. 1922.

EXPERIMENTAL

The diphenylthiourea and all the aldehydes, with the exception of citral, used in these preparations were obtained from Eastman Kodak Company and were used without further purification. Boric acid absorption[4] and direct titration of the ammonia with N/14.01 sulfuric acid was used in the Kjeldahl nitrogen determination. Electric melting point apparatus and Wheeler total immersed thermometers, standardized by the Bureau of Standards, were used in determining the melting points of the compounds.

Diphenylisothiohydantoin.—The parent substance was prepared by refluxing, for three hours, an alcoholic solution of diphenylthiourea and monochloracetic acid as directed by Lange.[5] After two recrystallizations from 95 per cent alcohol analysis gave 10.49 per cent nitrogen. Theory for diphenylisothiohydantoin is 10.45 per cent.

AROMATIC ALDEHYDE CONDENSATION PRODUCTS

5-o-Methoxybenzal-2,3-Diphenylisothiohydantoin.—Two and a half grams of diphenylisothiohydantoin and 1.6 grams of o-methoxybenzaldehyde were refluxed for 1.75 hours with 25 cubic centimeters glacial acetic acid containing 5 grams of fused sodium acetate. After 45 minutes refluxing crystals of the condensation product began separating from the reaction mixture. After the reaction was completed additional acetic acid was added to completely dissolve the reaction product and the hot solution filtered with suction. On cooling, the 5-o-methoxybenzaldehyde condensation product separated as a greenish-yellow, microcrystalline meal. The compound was filtered, washed with small portions of cold glacial acetic acid, alcohol and ether, and dried at 110° for 24 hours. Yield: 3.4 grams; m.p. 296–7°.

Anal. Subs., 0.2296: cc. of acid, 16.56. Calcd. for $C_{23}H_{18}O_2N_2S$: N, 7.25. Found: 7.21.

5-Anisal-2,3-diphenylisothiohydantoin.—Two grams of the substituted thiazolidone and 1.15 grams of p-methoxybenzaldehyde were refluxed in glacial acetic acid for 2.25 hours and the reaction product separated as described above. After recrystallization from glacial acetic acid and drying at 110° for 48 hours, 1.46 grams of 5-anisal-2,3-diphenylisothiohydantoin were obtained in the form of long, thin, bright-yellow needles. Heated in a capillary tube the compound melted at 199° (97° below the corresponding ortho compound) to a brownish yellow liquid.

Anal. Subs., 0.2203: cc. of acid, 15.28. Calcd. for $C_{23}H_{18}O_2N_2S$: N, 7.25. Found: 6.94.

5-Veratral-2,3-diphenylisothiohydantoin.—Two grams of the parent substance and 1.35 grams of 3,4-dimethoxybenzaldehyde were refluxed for 1.75 hours as described above. The reaction mixture was slowly poured into 500 cubic centimeters of cold water. The precipitate thus formed was collected on a Büchner funnel and washed with water. When recrystallized from

[4] MARKLEY and HANN. Journ. Assoc. Off. Agric. Chem. **8**: 455. 1925.

[5] LANGE. Ber. deutsch. chem. Ges. **12**: 595. 1879.

glacial acetic acid 2.34 grams of the veratraldehyde condensation product was obtained in the form of very fine, bright-yellow needles, melting at 177–8°.

Anal. Subs., 0.1646: cc. of acid, 11.07. Calcd. for $C_{24}H_{20}O_3N_2S$: N, 6.73. Found: 6.73.

5-Piperonal-2,3-diphenylisothiohydantoin.—Two grams of diphenylisothiohydantoin were refluxed 3.25 hours with 1.2 grams of piperonal in glacial acetic acid solution and the reaction mixture filtered with the aid of a heated Büchner funnel. On cooling beautiful dark-yellow needles separated from the reaction mixture which were filtered off, washed with water, and recrystallized from glacial acetic acid and subsequently from 95 per cent alcohol. From the latter solvent it was obtained in the form of bushy rosettes of bright-yellow, acicular needles, approximately 1 cm. long. Yield: 2.3 grams; m.p. 232°.

Anal. Subs., 0.2131: cc. of acid, 15.28. Calcd. for $C_{23}H_{16}O_3N_2S$: N, 7.00. Found: 7.17.

5-p-Tolual-2,3-diphenylisothiohydantoin.—Two grams of the cyclic ketone and 1.0 gram of p-tolualdehyde were condensed after 2 hours refluxing in the usual manner. The product separating upon cooling was recrystallized from glacial acetic acid and subsequently from 95 per cent alcohol. From both acetic acid and alcohol 5-p-tolual-2,3-diphenylisothiohydantoin crystallized in dark-yellow, rather thick, rods, melting at 197–8°.

Anal. Subs., 0.1549: cc. of acid, 11.68. Calcd. for $C_{23}H_{18}ON_2S$: N, 7.57. Found: 7.54.

5-p-Hydroxybenzal-2,3-diphenylisothiohydantoin.—One gram of p-hydroxybenzaldehyde after 3 hours refluxing condensed normally and separated from the reaction mixture on cooling. The product was filtered with suction, washed with a large volume of water followed by cold absolute alcohol and ether. Upon recrystallization from glacial acetic acid the compound was obtained in the form of greenish-yellow, microcrystalline, rhomboidal plates which did not melt below 300°. The corresponding ortho compound melted at 249–50°.[6]

Anal. Subs., 0.1809: cc. of acid, 13.73. Calcd. for $C_{22}H_{16}O_2N_2S$: N, 7.53. Found: 7.59.

5-o-Chlorobenzal-2,3-diphenylisothiohydantoin.—The corresponding aldehyde was condensed as usual after 2.75 hours refluxing and after cooling to allow the reaction product to completely separate, it was filtered, washed with water, alcohol and ether. After recrystallization from glacial acetic acid in which the product was only slightly soluble it was obtained as greenish-yellow, columnar crystals; m.p. 234–5°.

Anal. Subs., 0.2253: cc. of acid, 16.38. Calcd. for $C_{22}H_{15}ON_2SCl$: N, 7.17. Found: 7.27.

5-m-Nitrobenzal-2,3-diphenylisothiohydantoin.—Two grams of parent substance condensed with 1.2 grams of the m-nitrobenzaldehyde after 2.5 hours refluxing. The separated condensate was filtered, washed with water, followed by a few cubic centimeters of absolute alcohol and ether. The yield was 1.79 grams of deep orange, short, thin, microscopic needles; m.p. 219–20°. The corresponding ortho compound melted at 196–7°.[7]

Anal. Subs., 0.1716. Salicyl-sulfuric acid method. cc. of acid, 18.01. Calcd. for $C_{22}H_{15}O_3N_3S$: N, 10.47. Found: 10.50.

[6] HANN and MARKLEY. This JOURNAL **16**: 172. 1926.

[7] HANN and MARKLEY. *Op. cit.*, p. 173.

Symmetrical trinitrobenzaldehyde and hydrocinnamaldehyde failed to undergo this condensation. In the case of trinotrobenzaldehyde a brown, tarry mass was obtained in the course of a half hour. Hydrocinnamaldehyde gave a crystalline reaction product which contained no nitrogen but which was not further investigated.

Aliphatic Aldehyde Condensation

Previous to this work, one of us attempted to extend the above reaction to the aliphatic series of aldehydes but without success. Isobutyl aldehyde and citronellal were used but the only product isolated was unchanged diphenylisothiohydantoin. In the present study the reaction was attempted again, using citral, and it was found to undergo condensation with diphenylisothiohydantoin with ease and to give the expected product. Whether the failure with the first two aldehydes was due to the fact that they had become polymerized upon standing prior to their use or under the influence of the reactants is not known.

5-Citral-3,4-Diphenylisothiohydantoin.—Three grams of citral and 5.3 grams of diphenylisothiohydantoin were added to 25 cubic centimeters of glacial acetic acid containing 5 grams of sodium acetate and refluxed for 4.75 hours. On cooling the whole reaction-mixture soldified. The cake was broken up after a second addition of 25 cubic centimeters of glacial acetic acid. The fine meal thus obtained was filtered and thoroughly washed with water. Final recrystallization from glacial acetic acid gave 2.0 grams of the reaction-product in the form of long, thin, greenish-yellow needles; m.p. 230°.

Anal. Subs., 0.1132: cc. of acid, 7.82. Calcd. for $C_{25}H_{26}ON_2S$: N, 6.96. Found: 6.91.

Summary

Diphenylisothiohydantoin has been condensed with o-methoxybenzaldehyde, p-methoxybenzaldehyde, 3,4-dimethoxybenzaldehyde, piperonal, p-totualdehyde, p-hydroxybenzaldehyde, o-chlorobenzaldehyde, m-nitrobenzaldehyde and the aliphatic aldehyde, citral. The condensation products have been analyzed and described. Symmetrical trinitrobenzaldehyde and hydrocinnamaldehyde did not undergo the reaction, neither did the aliphatic aldehydes, citronellal and isobutyl aldehyde.

PALEONTOLOGY.—*A new gastropod from the Miocene of Virginia.*[1]

Julia Gardner, U. S. Geological Survey.

Turritella pilsbryi Gardner, new species

Shell very large and heavy, acutely conical in outline; spire elevated; whorls probably about twenty-five in number, laterally compressed, the lower whorls slightly overhanging at the anterior suture. Protoconch not strongly differentiated from the conch; first half turn placed almost at right angles to

[1] Received November 1, 1928.

the normal plane of coiling; incipient medial carina initiated on the second whorl, becoming sharper and more elevated anteriorly and migrating from the median horizontal toward the anterior suture; two equal and equi-spaced spiral lirations initiated rather abruptly on the fourth whorl between the keel and the posterior suture; spirals overridden by microscopically fine incremental striae, retractive on the posterior portion of the whorl, protractive on the anterior portion. Usual sculpture in adolescent stages of three narrow, obtuse, but prominently elevated lirae, equisized and symmetrically spaced with respect to the sutures; tendency toward an anterior migration of the prominent spiral sculpture fulfilled on the adult whorls. Characteristic adult sculpture of two to four primary spirals, the anterior directly behind the suture line, and often (as in the type) much lower and less sharply defined than the one or two in front of it, the posterior a little behind the median horizontal and often ill-defined or evanescent in maturity, the two intermediate spirals vigorous, rounded, strongly elevated cords,—the continuations of the medial and posterior spirals of the earlier whorls; secondary striations frequently developed particularly on the anterior portion of the whorl; base of body whorl sculptured with crowded, linear lirae. Sutures impressed on the earlier whorls, slightly undercut on the later. Aperture holostomous, transversely ovate; outer lip simple, obtusely angulated at the base; the inner strongly arcuate. Parietal wall glazed. Umbilicus imperforate.

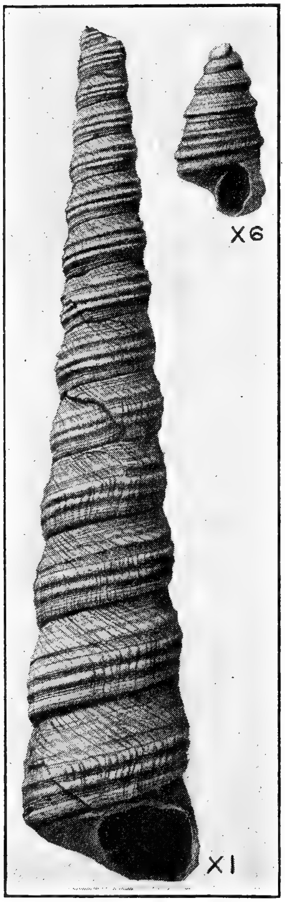


Figure 1.—*Turritella pilsbryi* Gardner, Yorktown formation. Adult shell ×1, young stage ×6.

Dimensions: Altitude, 110.5 mm.; latitude 22.9 mm.

Type: U. S. Nat. Mus. No. 325457.

Type locality: Schmidts Bluff, 4½ miles in an air line below Claremont Wharf, James River, Surry County, Virginia. Zone I of Yorktown formation, 26 to 34 feet above the base of the bluff.

Turritella pilsbryi is remarkable for its large and heavy shell, ornamented with coarse spiral lirae, of which two are characteristically more prominent than the rest, the posterior of the pair located near the median horizontal, the anterior, approximately midway between the median horizontal and the anterior suture. The only form with which *T. pilsbryi* is readily confusable is the *Turritella terebriformis* of Dall; in the latter, however, the medial portion of the whorl is demarcated by a concave area; in the former, as a rule, by the posterior of the two most prominent spirals.

An interesting evidence of the viviparous nature of the genus is offered in the material upon which this type is based: In cleaning one of the larger individuals, a sandy core was shaken out in which forty-seven embryos were embedded. As they are obviously the larvae of the same species, and as no other shells were present in the core, there seems to be no reasonable doubt that they are the young of the individual which contained them.

I have the pleasure of naming this fine species in honor of Dr. Henry A. Pilsbry, for many years the curator of the Mollusca in the Academy of Natural Sciences, Philadelphia.

SCIENTIFIC NOTES AND NEWS

At the recent meeting of the American Ornithologists Union in Charleston, S. C., Alexander Wetmore, Assistant Secretary of the Smithsonian Institution, was reelected President; T. S. Palmer, Biological Survey, Secretary; and W. L. McAtee, Biological Survey, Treasurer.

David White and M. R. Campbell, of the U. S. Geological Survey took part in the meeting of the National Academy at Schenectady and the Second International Conference on Bituminous Coal at Pittsburgh.

Professor Riuji Endo, of the Manchurian Teachers College, Mukden, China, will arrive in Washington in January. He plans to spend several years in the study of his collections from the Lower Paleozoic of Manchuria, obtained during field work under the auspices of the South Manchurian Railway, which maintains the college. Professor Endo's collections represent a region from which little had been previously obtained and are expected to contribute much to the understanding of the relations between Asia and North America in early Paleozoic time.

Obituary

JOSEPH SILAS DILLER, a member of the ACADEMY, well known for his studies of the geology of the Pacific Coast, died in Washington, November 13, 1928. He was born at Plainfield, Pa., August 27, 1850, graduated from Harvard University in 1879 and studied at Heidelberg University from 1880 to 1883. He joined the U. S. Geological Survey in 1883, serving with that organization 41 years, until his retirement from active duty in 1924. His interest centered in economic geology and petrography.

THOMAS CHROWDER CHAMBERLIN, Emeritus Professor of Geology in the University of Chicago and a member of the ACADEMY, died in Chicago, November 15, 1928. He was born at Mattoon, Illinois, September 25, 1843, studied at Beloit College and University of Michigan, and held numerous positions of trust during his long life. He left the presidency of the University of Wisconsin to become head of the Department of Geology at Chicago in 1892, retiring from active charge in 1919. Professor Chamberlin was well known for his studies of glacial geology in his earlier professional life and later for his philosophic discussions of the origin of the earth, in which he proposed the planetesimal hypothesis to replace the nebular hypothesis of Laplace. His work brought him many academic and scientific honors both in this country and in Europe.

Dr. EUGEN AMANDUS SCHWARTZ, the well known entomologist, died in Washington, October 15. He was born at Liegnitz, Silesia, April 21, 1844, studied at the Universities of Breslau and Leipzig, and came to America in 1873. In 1877 he entered the government service as entomologist and remained under the federal government until his death. Dr. Schwartz was one of the founders of the Entomological Society, to which he recently presented his library, and of the Biological Society of Washington.

ANNOUNCEMENTS OF THE MEETINGS OF THE ACADEMY AND AFFILIATED SOCETIES

Tuesday, December 4.	The Botanical Society.
Wednesday, December 5.	The Society of Engineers.
	The Medical Society.
Thursday, December 6.	The Entomological Society.
Saturday, December 8.	The Philosophical Society.
Tuesday, December 11.	The Institute of Electrical Engineers.
Wednesday, December 12.	The Medical Society.
	The Geological Society.
Thursday, December 13.	The Chemical Society. Program:

P. H. Groggins.—The Friedel-Craft Synthesis in the production of vat dye intermediates.

Max Phillips.—The chemistry of lignin.

Orville E. May.—The production of organic acids by mold fermentation.

Saturday, December 15.	The Biological Society.
	The Helminthological Society.
Tuesday, December 18.	The Anthropological Society.
	The Historical Society.
Wednesday, December 19.	The Society of Engineers.
	The Medical Society.

The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) short notes of current scientific literature published in or emanating from Washington; (3) proceedings and programs of meetings of the Academy and affiliated societies; (4) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the fifth or the twentieth of the month will ordinarily appear, on request from the author, in the issue of the JOURNAL for the following fourth or nineteenth, respectively.

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ASTRONOMY.—*Exact time in astronomy.*[1] JEAN BOCCARDI, Varazze, Liguria, Italy.

I

For about a century, as a result of the establishment of the principles and rules of the theory of errors, it has been the custom in sciences of observation and measurement to give, along with the numerical values obtained, the probable error, or the mean square error, which this theory enables us to assign. Experience has shown that the more closely the conditions of observation approximate to the theoretical conditions for the application of the rules of the calculus of probabilities, the more closely does the assumed error approximate to the actual error.

In any case, the probable or mean error gives a fairly good idea of the degree of accuracy attained. In the ordinary routine of daily observations, however, one is not usually concerned with the accuracy of the observations—this is a matter for consideration in the determination of geographic coordinates, parallaxes, masses of heavenly bodies, etc. Nevertheless, now that the radio-telegraph permits the transmission and reception of the exact time and consequently the systematic determination of differences of longitude, it is well to know the degree of accuracy of the time received and of the time determined on the spot.

On this subject I think there is some need for correcting the ideas held relative to the accuracy of the determination of local time. In 70 years much progress has been made in this direction, both in determining the time and in keeping it. It has been said that the accuracy attained in the transmission and reception of time by radio is

[1] Received November 5, 1928.

notably superior to the accuracy of the determination of the time itself. Now, if that holds good at some places, it is not true for all observatories, especially for those which have good instruments, well installed, under a clear sky, and in charge of observers skilled in the manipulation of the so-called *impersonal micrometer*.

I have cited elsewhere[2] numerous examples of time determinations, made chiefly in connection with differences of longitude between various places. From these it is seen that since 1909 an accuracy of 0.01 seconds has been attained; at least the mean square error is of this order of magnitude and is often less.

The purpose of this article is to indicate the conditions favorable to the attainment of so high a degree of accuracy in time determinations and also in predicting the corrections to be applied to the readings of a good clock.

II

To determine time accurately by the transit of stars across the meridian, it is first of all necessary to lay aside large instruments (meridian circles or simple transit instruments). With such instruments it is almost impossible to reduce the azimuth constant to a very small value and especially to keep it so. The collimation cannot be eliminated by the reversal of the telescope, an operation which demands a certain amount of time and which can be applied only to circumpolar stars. Besides, when the telescope is reversed the azimuth changes. The level correction is not well determined, either by means of large levels or by the mercury bath.

It is necessary, therefore, to employ instruments with broken telescopes, which are not heavy and may be reversed in a few seconds. The diameter of the objective should be between 70 and 100 millimeters. A telescope of 95 millimeters aperture permits the observation with an illuminated field of stars of the 7th magnitude, and even of magnitude 7.5, during twilight.

It has been proposed recently to use straight telescopes with zenithal eye-piece; but, for one thing, this eye-piece has its inconveniences; for another, the straight telescopes are heavier and the diameter of the objective must therefore be reduced to 70 millimeters, or to 75 millimeters at most. Now, to have the determinations of the time close together, one must profit by all the periods of clear sky, observing sometimes during twilight. With telescopes of 70 millimeters aper-

[2] Journ. Observateurs, 1928; Mem. Accad. Pontif. Sci., 1928.

ture small stars may be observed with an illuminated field during the night only.

Some one may say that the catalogue of fundamental stars does not give the places of the stars down to the 7th magnitude; but I have already proposed elsewhere[3] that in order to confine the observations to stars rather close to the zenith, each observatory should make for itself a list of its own stars and carefully determine their right ascensions, referring them to the same system.

If the instrument chosen possesses good levels, enabling the air bubble to be adjusted to a nearly constant length, then by reading them with all the recommended precautions one may rely upon the value of the inclination. The level will be read for each star, and, of course, the observer will try to reduce the azimuth and the inclination to a minimum. The effect of the azimuth is almost null on the stars culminating within a few degrees of the zenith, not more than 25°. As to the impersonal micrometer, the observer must learn to use it perfectly, otherwise, as experience has shown, the personal equation is not eliminated. Moreover, beyond a declination of 60° the impersonal micrometer adds nothing to the accuracy obtainable by the ordinary micrometer.

Let us examine now the degree of accuracy that may be attained. In the clock correction determined by *one* star there remains:

(1) The residual error of the apparent right ascension. It may be considered to amount at the most to $\pm 0.^s02$, if the observer employs the star places of the Auwers' *New Fundamental Catalogue* corrected by A. Kopff, Director of the Rechen-Institut of Berlin.

(2) The azimuth error, which for the zenithal stars amounts at the most to $\pm 0.^s006$.

(3) The error of the inclination, which is of the order of $\pm 0.^s01$.

(4) Finally, the error of the observation itself, which is a minimum, since with the impersonal micrometer the observations of different astronomers agree well. Let us assume $\pm 0.^s004$ for this error.

The total error will be

$$\sqrt{\overline{0.02}^2 + \overline{0.006}^2 + \overline{0.010}^2 + \overline{0.004}^2} = \pm 0.^s0235$$

But assume even $\pm 0.^s03$. It follows that in observing 9 stars the error to be feared in the clock correction is only $\pm 0.^s01$. Even if the observer did not have special skill, even if the atmospheric conditions were not completely favorable, etc., it will always be granted

[3] Mem. Accad. Pontif. Sci., 1928.

that except in unusual cases, with 15 or 16 stars an observer of moderate skill will determine the correction Cp or Δt for the clock with an error of $\pm 0.^s 01$.

Seventy years ago observations were made to the nearest second!

III

But astronomers are not satisfied with determining the exact time for a given instant. They must be able to give it at any instant. They must have a time-keeper. Today good Riefler clocks, kept at constant pressure and temperature, for several days following a direct determination give the time with an uncertainty of $0.^s 02$ or $0.^s 03$. But, as with the broken telescopes of the Bamberg type, one must know how to use these clocks and how to get from them all that is possible in the way of accuracy. It is known that by means of a pump one may change the air pressure in the metal case in which the pendulum swings.

To be able to interpolate and extrapolate the exact time when several determinations of the time are available, it is necessary to determine the clock-rate and to use first and second differences.

Abrupt variations, "jumps," in the rate of a good Riefler clock are improbable. In any case, it is sufficient to have another control clock beside the master clock, which enables abrupt variations in the rate of the latter to be detected. The next direct determination of the time will permit the elimination of any uncertainty.

IV

I submit here an example furnished by Riefler clock no. 60, the corrections for which have been furnished me by the Superintendent of the Naval Observatory at Washington. I here thank him for them.

These corrections come from the time determinations made with the small, straight, Prin telescope whenever the condition of the sky permitted. I believe that by using a Bamberg model broken telescope and the Kopff right ascensions, a greater accuracy would have been attained. The mean error would be only $\pm 0.^s 01$. Furthermore, clock no. 60 is not of the most recent model.

Let us consider first one point. It is said that by determining the clock rate by two successive determinations of the time spaced 7 or 8 days apart, the residual errors of these determinations are reduced as if by dividing them by 7 or 8. For example, if the mean error of one determination of the time is $\pm 0.^s 01$, the error of the rate during 10 days is only

$$\frac{0.^s 01 \sqrt{2}}{10} = 0.^s 00141 \ldots.$$

But this supposes that the clock rate has been constant during 10 days, which is not the case. The value obtained for the rate, supposing it to have a linear variation, applies exactly only at the epoch midway between the two dates corresponding to the two determinations of the time. It is the mean rate that is found; and when the question arises of giving the correction for the clock for an intermediate date—for example, 5 days after the first date—this correction, calculated from the mean rate, contains:

(1) The error of the first determination of the time.

(2) The difference between the *actual* rate during the 5 days following and the *mean* rate multiplied by 5.

In the same way, in predicting the correction for the clock for a later date, the mean rate during 10 days is not as exact as that which one would obtain with two determinations of the time spaced 3 or 4 days apart. The conclusion is that it is necessary to observe as often as possible and to determine the rate by means of first and second differences.

As to abrupt variations, they are more probable in an interval of 10 days than in one of 3 days.

The table which follows contains for a complete administrative year —July, 1926, to June, 1927—the daily rate of Riefler clock no. 60 of the Naval Observatory and the epochs to which they correspond. To construct this table from the series of clock-corrections that were so kindly supplied to me, I have grouped two by two all the sucessive corrections by taking the mean. I have likewise taken the means of the dates to which these values of *Cp* correspond. Then I have taken the first differences between these means of the *Cp* and I have done the same for the dates. Finally I have divided respectively the first, which are the variations of the *Cp*, by the second, which are the corresponding intervals of time. Since small intervals were concerned, I was entitled to assume that the values of *Cp* varied linearly. The rates given in the table thus apply to epochs midway between the two means of the dates that correspond to them.

An inspection of this table is very instructive. It shows that the rate of the clock varies very slowly and that the difference between two successive rates is, on the average, $\pm 0.^s 005$ or $\pm 0.^s 006$. These differences are due to the residual imperfections of the values of *Cp*

TABLE 1.—Daily Rates of Riefler Clock No. 60, at the Naval Observatory in Washington, in 1926–1927

1926				1927			
Date	Rate	Date	Rate	Date	Rate	Date	Rate
July 6, 579	$-0.^{s}037$	Oct. 14, 819	$-0.^{s}059$	Jan. 3, 825	$-0.^{s}078$	Mar. 31, 354	$-0.^{s}039$
10, 156	42	17, 767	51	6, 616	88	Apr. 5, 732	42
13, 316	40	20, 259	46	8, 636	68	10, 848	37
17, 053	30	23, 001	50	10, 898	59	13, 901	45
21, 300	34	26, 002	48	13, 671	62	16, 417	49
25, 370	48	29, 054	48	17, 908	70	19, 352	38
28, 934	34	31, 856	56	22, 909	65	22, 512	33
Aug. 1, 409	28	Nov. 4, 060	55	26, 164	67	25, 340	36
4, 392	43	6, 020	43	28, 640	64	28, 111	24
6, 609	39	8, 333	44	31, 871	66	May 1, 940	14
8, 066	26	11, 377	47	Feb. 4, 341	73	3, 625	33
9, 599	33	14, 810	45	7, 581	58	5, 099	25
17, 098	34	17, 765	38	10, 088	57	8, 046	33
24, 559	40	20, 281	40	16, 586	54	12, 856	17
27, 052	36	22, 775	46	21, 406	46	18, 435	18
31, 538	38	25, 262	34	24, 913	56	24, 212	18
Sept. 6, 569	41	27, 513	25	27, 126	79	27, 399	24
11, 356	35	29, 283	40	Mar. 1, 128	59	June 1, 365	30
14, 568	38	Dec. 1, 056	49	3, 640	45	2, 356	28
17, 305	39	3, 557	64	6, 650	41	7, 153	09
20, 071	39	7, 039	78	9, 171	29	8, 374	28
23, 304	42	11, 011	73	10, 902	52	12, 648	08
27, 794	38	16, 021	80	12, 862	52	13, 696	−0. 006
Oct. 2, 542	45	22, 064	86	15, 743	46	15, 743	+0. 001
6, 027	32	27, 076	89	19, 125	34	19, 989	−0. 015
8, 819	45	29, 072	78	22, 742	35	23, 917	−0. 023
11, 620	−0. 060	31, 068	−0. 070	25, 767	−0. 045	26, 380	−0. 032
						29, 165	−0. 024

and also to the small variations in the clock rate. Rarely does this difference reach $0.^s015$. Only during the spring are there greater variations, which are doubtless due to the variability of weather conditions. Perhaps the temperature has not been kept absolutely constant, or the pressure has not been adjusted every time that the *Cp* showed the necessity for it. We may conclude that today, with two good instruments available, in charge of skillful astronomers, and well-installed, under a sky which permits the determination of the time, on the average, every 2 or 3 days, the value of *Cp* may be found with a mean error of

$$\frac{\pm 0.^s01}{\sqrt{2}} = 0.^s0071$$

With one good clock checked against another we can forecast *Cp* for 3 or 4 successive days with an uncertainty amounting hardly to $\pm 0.^s02$.

It is a splendid triumph for astronomy!

GEOPHYSICS—*Geodetic constants.*[1] WALTER D. LAMBERT, U. S. Coast and Geodetic Survey.

The Newtonian constant of gravitation[2] and the mean density of the earth are so closely related that if one is known the other may be at once derived. The Newtonian constant is the quantity actually determined in the laboratory. The product of the two quantities is known within about one part in one hundred thousand, although neither quantity by itself is known within one part in ten thousand. The formula for the product may be written:

$$k\rho = \frac{3}{4\pi a}\left(g_\epsilon + \frac{3}{2}\,\omega^2\,a + \frac{3}{7}\omega^2\,a\,f\right)$$

Here k = Newtonian gravitation constant.

ρ = mean density of the earth.

a = equatorial radius of the earth considered as an ellipsoid of revolution.

g_ϵ = equatorial surface gravity.

ω = angular velocity of the earth's rotation, so that $\omega^2 a$ represents the centrifugal force of rotation at the Equator.

f = flattening (ellipticity) of the earth.

[1] Presented at the 977th Meeting of the Philosophical Society of Washington, October 13, 1928. The general subject of the papers given at the meeting was *Constants of Nature*. Received November 15, 1928.

[2] This paper followed one by Paul R. Heyl, in which the Newtonian constant of gravitation was discussed.

If we assume for the value of k that given by the preceding speaker, namely 6.664×10^{-8} c.g.s. units, and for the values of a and g_e those soon to be stated, the value of the mean density comes out as **5.522.** This mean density may be considered as one of the geodetic constants to be discussed in this paper.

The dimensions of the earth and the coefficients in the formula for gravity at its surface are the principal remaining geodetic constants that we are to discuss. Let us consider the former first. Theoretically at least, it is not essential to have astronomical observations in order to determine the size and shape of the earth's physical surface, or any portion of it. The work could be done even though the heavens were perpetually covered with impenetrable clouds. Consider any portion of the earth's surface with a number of points on it, each point visible to its nearer neighbors. These points could be considered as the vertices of an irregular polyhedron. The distance between two vertices could be measured directly and would serve as a base line for what might be termed three-dimensional triangulation. The face angles of each polyhedral angle could then be measured, the plane of the divided circle used being made coincident with the plane of the face angle. From these data the size and shape of the polyhedron could be deduced. All this work would be quite independent of considerations of potential or of level surfaces or of latitude and longitude.

Practically, however, the accuracy of the results would be vitiated by atmospheric refraction, especially refraction in a vertical plane for objects near the horizon. This refraction, as every geodetic observer knows, is exceedingly irregular and tricky. The method just outlined has therefore only a theoretical interest. Actual determinations of the figure of the earth depend on astronomical observations, that is, determinations of latitude, longitude and azimuth over a given region, combined with large-scale surveying operations over the same region. The ancient Greeks must have done something of the sort, though their astronomical observations were of the roughest and their determinations of distance probably mere estimates based on travelers' accounts. Even so, however, the Greeks of the time of Aristotle[3]

[3] "Moreover those mathematicians who try to compute the circumference of the earth say that it is 400,000 stadia, which indicates not only that the earth's mass is spherical in shape but also that it is of no great size as compared with the heavenly bodies." Aristotle, *De Caelo*, Book II, Chap. 14. This passage follows a long argument in favor of the sphericity of the earth. Some of the arguments sound modern enough, others seem strange to our present ways of thinking. This seems to represent the first scientific attempt or attempts now on record to determine the size of the earth. No further details are given. The entire treatise has been translated by J. L. Stocks and published by the Clarendon Press, Oxford, in 1922.

had an approximate knowledge of the size of the earth considered as a sphere. About a century later Eratosthenes[4] obtained an even better approximation by a process identical in principle with that used by every geodesist down to the time when the electric telegraph became available for determining longitudes. Just how approximate these early determinations were we can not say because of the uncertainty regarding the exact modern equivalents of the linear units used.

Let us skip over some two thousand years and consider now the most modern determinations of the dimensions of the earth. As the most acceptable figures let us take those adopted in 1924 by the Section of Geodesy of the International Geodetic and Geophysical Union and defined by the parameters of the International Ellipsoid of Reference. These figures are based on Hayford's[5] discussion of geodetic operations in the United States only, but have been substantially confirmed by Heiskanen's[6] discussion of European triangulation and by other geodetic and astronomical evidence.[7]

The fundamental parameters are:

a (semi-major axis) = 6,378,388 meters

f (flattening or ellipticity) = 1/297.0

From these there result:

b (semi-minor axis) = 6,356,912 meters

Q (quadrant of a meridian) = 10,002,288 meters

It is seen that the meridian quadrant is over 2 kilometers longer than

[4] Eratosthenes, librarian at Alexandria, died about 195 B. C. We owe our knowledge of his geodetic work to a book by Cleomedes, a Greek writer who is supposed to have lived about 100 A. D. The account of Eratosthenes' work is in Chap. 10 of his book, the Latin title of which is *De Motu Circulari Corporum Celestium.* Eratosthenes' result is a circumference of 250,000 stadia. There is no certainty that the stadium of Aristotle and that of Eratosthenes represented the same length. If we use 185 meters, which is usually given as the length of the Attic stadium, we get for the circumference according to Eratosthenes some 46,000 kilometers, instead of the actual 40,000.

I am indebted to Mr. Otis Hill of the Coast and Geodetic Survey for invaluable help in connection with these and other references to classical literature.

[5] J. F. HAYFORD. *Supplementary investigation in 1909 of the figure of the earth and isostasy.* Published by the U. S. Coast and Geodetic Survey, 1910.

[6] W. HEISKANEN. *Die Erddimensionen nach den europäischen Gradmessungen.* Veröff. Finn. Geod. Inst. 6. 1926. A slight revision of the conclusions from the same data is given by Heiskanen in the *Vierteljahrsschr. Astron. Ges.* **61** (Jahrgang 1926): 215.

[7] For references, see W. D. LAMBERT. *The figure of the earth and the new international ellipsoid of reference.* Science **63**: 242. 1926. A version revised by the author and translated into French by Col. Perrier appeared in the Bull. Géod. **10**: 81. 1926.

an even ten thousand kilometers, which was the figure aimed at when the metric system was devised.

What may be the probable limits of error of these figures (not the "probable errors" in the technical sense), it is rather difficult to say. Perhaps fifty meters in the semi-axes and a few tenths of a unit in the reciprocal of the flattening.

Let us make our formula for gravity at the surface of the earth consistent with the International Ellipsoid of Reference. We must then write as the value of gravity in cm/sec²:

$$g = \underset{\pm 8}{978.052} \, [1 + \underset{\pm 5}{0.005288} \sin^2 \phi - 0.000006 \sin^2 2\phi]$$

where ϕ = geographic latitude. Only the coefficients within the square brackets depend on the ellipticity. The coefficient outside, 978.052 cm/sec², is essentially independent of the dimensions of the earth and must be determined by observation. The value written down is the largest of all the more recent determinations[8] and this for two reasons: (1) There is reason to believe, as Bowie[9] has pointed out, that a more accurate reduction for the elevation of the station would slightly increase the values of gravity on land, and it is on these land values that our gravity formulas have hitherto been based; (2) The formula is meant to represent average conditions over the earth's entire surface, nearly three-fourths of which is ocean, and it appears from determinations of gravity at sea, which we are just beginning to obtain, that gravity at sea tends to be in excess of gravity on land even after the latter has been reduced for elevation. Bowie's suggested improvement in the method of reduction applies to sea stations also and should tend to harmonize the results for gravity stations on sea and on land.

I have written beneath the coefficients, estimates of their probable limits of error. They are largely matters of opinion, for a real basis of evaluation is lacking. The ±8 attached to the 978.052 is intended to include the error in the absolute determination of gravity, an exceedingly delicate and difficult operation when an accuracy of a few

[8] F. R. HELMERT. *Neue Formeln für den Verlauf der Schwerkraft im Meeresniveau beim Festlande.* Sitzungsber. K. Preuss. Akad. Wiss. **1915**: 676.

W. HEISKANEN. *Untersuchungen über Schwerkraft und Isostasie.* Veröff. Finn. Geod. Inst. 4.

[9] W. BOWIE. *The effect of the shape of the geoid on values of gravity at sea.* Am. Journ. Sci. **14**: 222. 1927.

Rapport de la Sous-Commission spécialement chargée de déterminer les réductions à faire subir aux intensités observées en mer. Bull. Géod. **17**: 29. 1928.

parts in a million is sought. The authors of the most recent absolute determination, Kühnen and Furtwängler,[10] estimate the mean error of their result as ± 0.003 cm/sec^2.

To return to the apparent systematic difference between gravity on land and gravity at sea, this may be represented very roughly indeed by putting within the square brackets a longitude term such as:

$$\pm 0.000023 \cos^2 \phi \cos 2 (\lambda + 5°), \text{ where } \lambda = \text{east longitude,}$$

so that our formula becomes:[11]

$$g = 978.052 [1 + 0.005288 \sin^2 \phi - 0.000006 \sin^2 2 \phi + 0.000023 \cos^2 \phi \cos 2 (\lambda + 5°)]$$

The form of the added term is that of a surface spherical harmonic of the second degree and is conceivably the first of a long series of spherical harmonic terms related perhaps to the configuration of the lithosphere.[12] Parenthetically it should be said that other harmonic terms of the second degree and terms of lower degree are either already implicitly contained in the gravity formula or are omitted from it for sound theoretical reasons.

The presence of such a term is rather puzzling, for it implies an ability of the earth's crust to sustain the stresses due to a wide-spread and rather large excess or deficiency of matter, an ability not in accord with much other evidence. Yet, unless we are the victims of an uncommonly perverse combination of accidental errors, we can hardly escape attributing some reality to this longitude term. It does not rest solely on the recently discovered systematic difference between gravity on land and gravity at sea, some of which difference can be explained by Bowie's suggested improvement in methods of reducing for elevation. It appeared thirteen years ago in Helmert's[13] discussion of gravity observations all made on land. The longitude term in the gravity formula implies a corresponding term in the figure of the earth, making the geoid an ellipsoid of three unequal axes instead of an ellip-

[10] FR. KÜHNEN and PH. FURTWÄNGLER. *Bestimmung der absoluten Grösse der Schwerkraft zu Potsdam mit Reversionspendeln.* Veröff. K. Preuss. Geod. Inst. **27**. 1906.

[11] W. HEISKANEN. *Ist die Erde ein dreiachsiges Ellipsoid?* Gerlands Beitr. Geophysik **19**: 356. 1928. Or in condensed form in the Astron. Nachr. **232** (5562): 305. 1928. The difference of one unit in the sixth decimal in the coefficients of $\sin^2\phi$ and $\sin^2 2\phi$ between the formulas of Heiskanen and of this article for the same flattening, 1/297, is due to the fact that Heiskanen's spheroid is not an exact ellipsoid.

[12] A. PREY. *Darstellung der Höhen- und Tiefenverhältnisse der Erde durch eine Entwickelung nach Kugelfunktionen bis zur 16. Ordnung.* Abh. K. Ges. Wiss. Göttingen. Math.-phys. Kl. **11**: 1. 1922.

[13] See note 8.

soid of rotation. Fifty years ago Clarke[14] deduced from triangulation and from astronomic determinations a figure of the earth that strongly suggests recent determinations of the longitude term in the gravity formula; furthermore, Heiskanen's recent discussion of European triangulation, in which discussion he allowed for the effects of topography and isostatic compensation, likewise tends to the same conclusion. So do results from discussions of the variation of latitude[15] and of the lunar parallax,[16] though these latter give at present only rough qualitative indications. All these results point to a difference between the maximum and minimum equatorial semi-axes of the order of two or three hundred meters, with the longer axis approximately in the plane of the meridian of Greenwich.

We should like to get a better hold on the real size of the longitude term and likewise to know whether it stands in the main by itself or whether it is only one of many spherical harmonic terms of about the same order of magnitude. If the latter, we should expect these terms to be related to the configuration of the continents and oceans. But if not, if this one longitude term stands practically alone, then perhaps we may see in it a vestige of some state of the earth as it was in the remote past when for some reason the earth was nearly a triaxial ellipsoid with one axis of the equator decidedly longer than the other. Perhaps we may imagine that this happened when the moon parted company with the earth, as in Darwin's theory, being expelled by the resonance effect of the solar tides at a time when the earth rotated much more rapidly than now. But this is frankly wild speculation and perhaps it will be well to close before we get too far away from observed facts. At any rate the longitude term, its reality, its size if real, and its geophysical significance, present one of the most interesting problems in present-day geodesy.

[14] A. R. Clarke. *On the figure of the earth.* Lond. Edinb. Dubl. Philos. Mag. Journ. Sci. **6**: 81. 1878.

[15] W. D. Lambert. *An investigation of the latitude of Ukiah, Calif., and of the motion of the pole.* Coast & Geod. Surv. Spec. Pub. **80**: 59. 1922.

[16] W. D. Lambert. *The figure of the earth and the parallax of the moon.* Astron. Journ. **38** (908): 181. 1928.

BOTANY.—*Mosses of western Mexico collected by Mrs. Ynes Mexía.*[1]

EDWIN B. BARTRAM, Bushkill, Pennsylvania. (Communicated by WILLIAM R. MAXON).

The small but interesting collection of mosses reported on herewith was made by Mrs. Ynes Mexía in the States of Jalisco and Nayarit in the winter of 1926–27, and has been intrusted to the writer for determination by Dr. William R. Maxon of the United States National Museum. If it is typical of the moss flora of the Sierra Madre Occidental we may well assume that western Mexico still holds a reserve of bryological knowledge that will amply reward further exploration.

Specimens representing the species listed below, together with the types of the new species described, are in the United States National Herbarium.

CAMPYLOPUS TALLULENSIS Sull. & Lesq.

On rocky precipitous slope, Real Alto, La Bufa, Jalisco, 2,500 meters, Jan. 30, 1927, no. 1595b.

This species has not been reported from Mexico before and the determination has not been made without some reservation. The costa is practically smooth on the back and the leaves are wider in the basal portion, with a relatively broader costa, than in typical plants from the southern United States; but in other respects the agreement seems to be complete. The broader costa, up to 0.06 mm. wide, is more suggestive of *C. Roellii* or *C. Hellerianus*, but these species are described as having a narrow blade, up to 80μ wide, just above the alar cells, while the leaves of this collection show the blade at least three times this width. This trio is known only in sterile condition. When the fruiting characters are available it would not be surprising to find them automatically reduced to forms of one rather variable specific type.

CAMPYLOPUS INTROFLEXUS (Hedw.) Brid.

Bare gullied hillside, red clay near stream, San Sebastian, Hacienda del Cura, Jalisco, 1,425 meters, Jan. 2, 1927, no. 1344.

METZLERELLA COSTARICENSIS (C. M.) Broth.

Around earth and roots of oak tree, Hacienda del Ototal, East of San Sebastian, Arroyo de los Hornos, Jalisco, 1500 meters, March 6, 1927, no. 1822a.

OCTOBLEPHARUM ALBIDUM (L.) Hedw.

On trunk of palm tree in dense nut palm woods, Túxpan, Jalisco, 20 meters, Nov. 3, 1926, no. 1028.

Merceyopsis mexicana Bartr., sp. nov. (FIG. 1, A–H)

Dioicous? Antheridial flowers not found. Plants in dense cushions, yellowish green at the tips, paler below, matted together with reddish radi-

[1] Received October 29, 1928.

cles. Stems up to 2 cm. high, erect or decumbent, irregularly branched by innovations, abundantly radiculose throughout, without central strand. Lower leaves not crowded, 2.5 to 3 mm. long, the upper longer, in comal tufts, up to 3.5 mm. long, carinate, undulate on the edges and strongly crisped when dry, erect-spreading when moist, lanceolate-spatulate, abruptly acute, carinate in the lower half, margin narrowly reflexed on one or both sides from just above the insertion about one-quarter of the way up, flat and lightly undulate above; costa 65μ to 70μ wide just above the base, tapering upward and ending slightly below the apex, reddish at the base, lutescent above, strongly convex on the dorsal side, smooth, in cross-section showing two or three guide cells with several smaller cells on the ventral side and a thick dorsal band of stereid cells with the outer row differentiated; leaf cells smooth, the upper rounded or transversely oval, about 7μ to 10μ in diameter, with incrassate, pellucid walls, the lower cells larger, seriate, several rows toward the costa rectangular with rounded corners, up to 38μ long by 12μ wide, at the extreme base short-rectangular, not or hardly incrassate, occasionally hyaline; seta terminal, erect, filiform, pale yellow, 2 to 3 mm. high; capsule ovoid-cylindric, pale yellow and lightly striate when empty, about 1.1 mm. long; exothecal cells large, thin-walled, broadly hexagonal, 4 or 5 rows around the mouth smaller and reddish; peristome none; lid and calyptra unknown; spores light brown, slightly rough, 10μ in diameter.

Type: On steep rock, San Sebastian, East of Segundo Arroyo, Jalisco, Mexico, 1,500 meters, January 25, 1927, Mrs. Ynes Mexía, no. 1568*a*.

These plants are so nearly identical with *Merceyopsis gedeana* (Lac.) Fleisch., of Java, that it has been difficult to find any really satisfactory diagnostic characters. The leaves of *M. mexicana* are relatively longer, with more strongly reflexed basal margins and less incrassate basal areolation; the setae are consistently shorter, more slender and paler; the capsules paler in color and striate when empty; but these differences are of degree only, and not entirely conclusive. The collection is of unusual interest, however, as it represents the first record for the genus on this continent, all the previously known species being confined to India, Java, and Luzon.

ANOECTANGIUM EUCHLORON (Schwaegr.) Mitt.

On north side of old rock wall, San Sebastian, north-east of Hacienda del Cura, Jalisco, 1,425 meters, Jan. 3, 1927, no. 1364.

ANOECTANGIUM CONDENSATUM Schimp.

On rock near stream, San Sebastian, Canyon El Ranchito, Jalisco, 1,500 meters, Jan. 12, 1927, no. 1470.

LEPTODONTIUM EXASPERATUM Card.

Rocky precipitous slope, Real Alto, La Bufa, Jalisco, 2,500 meters, Jan. 30, 1927, no. 1595a.

LEPTODONTIUM SULPHUREUM (C. M.) Mitt.

Growing on small trees near stream, San Sebastian, east of Arroyo del Cura, Jalisco, 1,425 meters, Jan. 5, 1927, no. 1389.

WEBERA SPECTABILIS (C. M.) Jaeg.

Jalisco, 1927, no. 1704.

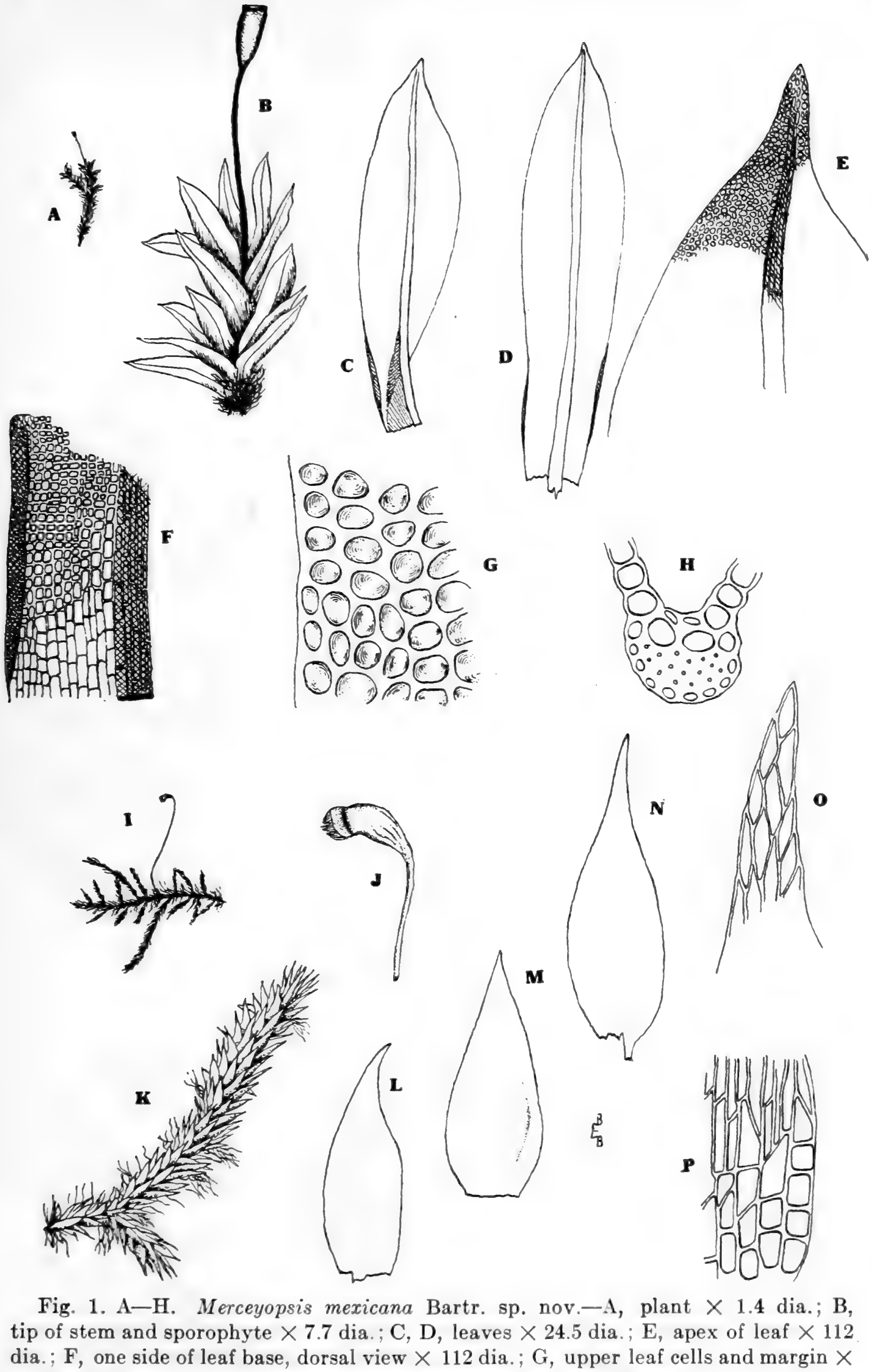

Fig. 1. A—H. *Merceyopsis mexicana* Bartr. sp. nov.—A, plant × 1.4 dia.; B, tip of stem and sporophyte × 7.7 dia.; C, D, leaves × 24.5 dia.; E, apex of leaf × 112 dia.; F, one side of leaf base, dorsal view × 112 dia.; G, upper leaf cells and margin × 560 dia.; H, cross-section of costa from upper part of leaf × 280 dia.

I—P. *Isopterygium dimunitivum* Bartr. sp. nov.—I, plant × 2.1 dia.; J, dry capsule × 11.2 dia.; K, end of stem × 7.7 dia.; L, M, N, leaves × 56 dia.; O, apex of leaf × 2.80 dia.; P, basal angle of leaf × 280 dia.

Bryum insolitum Card.

On top of old rock wall, San Sebastian, north-east of Hacienda del Cura, Jalisco, 1,425 meters, Jan. 3, 1927, no. 1365.

Bryum rosulatum C. M.

Rocky precipitous slope, on rock, Real Alto, La Bufa, Jalisco, 2,500 meters, Jan. 30, 1927, no. 1595b.

Philonotis tenella (C. M.) Besch.

On rock in stream bed, Santa Cruz de Vallarta, Jalisco, 700 meters, Dec. 10, 1926, no. 1278.

Breutelia tomentosa (Sw.) Schimp.

Steep damp stream bank, San Sebastian, east of Arroyo Santa Gertrudis, Jalisco, 1,500 meters, Jan. 18, 1927, nos. 1509 and 1510.

Funaria calvescens Schwaegr.

On dry clay bank near stream at canyon bottom, trail from San Sebastian to Arroyo Seco, Jalisco, 1,500 meters, Jan. 8, 1927; no. 1437. Near stream in gully, in dense shade, San Sebastian, trail to El Ranchito, Jalisco, 1,500 meters, Jan. 11, 1927, no. 1458. Densely wooded, damp north slope, growing on old tree roots and in earth, Real Alto, trail to El Tajo de Santiago, Jalisco, 2,500 meters, Feb. 23, 1927, no. 1746a. Santa Cruz de Vallarta, Jalisco, 700 meters, Dec. 1, 1926, no. 1304.

Macromitrium tortuosum Schimp.

Steep shaded ravine near stream, on rock, Cerro de San Juan, west of Tepic, Nayarit, 1000 meters, Sept. 19, 1926, no. 696. Steep, damp stream bank, on tree trunk, San Sebastian, east of Arroyo Santa Gertrudis, Jalisco, 1,500 meters, Jan. 18, 1927, no. 1519.

Pilotrichella pulchella Schimp.

Bare gullied hillside, red clay, by stream, San Sebastian, Hacienda del Cura, Jalisco, 1,425 meters, Jan. 2, 1927, no. 1343.

Thuidium involvens (Hedw.) Mitt.

On rocks in stream bed, Santa Cruz de Vallarta, Jalisco, 700 meters, Dec. 10, 1926, no. 1277.

Erythrodontium pringlei Card.

Rocky precipitous slope, on rock, Real Alto, La Bufa, Jalisco, 2,500 meters, Jan. 30, 1927, no. 1595.

Erythrodontium teres (C. M.) Par.

On tree trunk, trail from Tepic to Los Aquacates, near Arroyo Seco, Nayarit, 1,000 meters, Sept. 11, 1926, no. 551. Steep shaded ravine near stream, growing on rock, Cerro de San Juan, west of Tepic, Nayarit, 1,000 meters, Sept. 19, 1926, no. 695b.

The reddish setae and striated peristome teeth are characters that are shared in common by both *E. teres* and *E. densum.* I have been unable to find any antheridial flowers on either of these collections, but the relatively numerous sporophytes suggest that the inflorescence is probably autoicous. The broadly ovate, abruptly acuminate leaves are more suggestive of *E. teres* than of the other species.

Entodon erythropus Mitt. var. mexicanus Card.

On rocks near canyon bottom, trail from San Sebastian to Arroyo Seco, Jalisco, 1,500 meters, Jan. 8, 1927, no. 1427. Dense woods, on stream banks at canyon bottom, San Sebastian, east of Arroyo del Cura, Jalisco, 1,425 meters, Jan. 5, 1927, no. 1386. Bottom of steep ravine, along stream, Quimixto, trail to San Pedro del Tuito, Jalisco, 60 meters, Dec. 2, 1926, no. 1230.

TAXIPHYLLUM PLANISSIMUM (Mitt.) Broth.

Woods on mountain side, growing on rock, Santa Cruz de Vallarta, Jalisco, 300 meters, Dec. 8, 1926, no. 1258.

SEMATOPHYLLUM HAMPEI Besch.

Around earth and bark of oak, west of San Sebastian, Hacienda del Ototal, Arroyo de los Hornos, Jalisco, 1,500 meters, March 6, 1927 no. 1823c.

Isopterygium dimunitivum Bartr., sp. nov. (Fig. 1, I–P)

Autoicous; male buds minute, about 0.3 mm. long; antheridia 1 to 3, inclosed by 5 or 6 concave, loosely areolate, ovate-acuminate bracts. Plants small, prostrate, in rather thin mats, yellowish green above, brownish beneath, sparingly radiculose, irregularly branched; branches short, horizontal. Leaves erect-spreading and somewhat homomallous when dry, widely spreading when moist, oblong-ovate, rather long-acuminate, concave, 0.6 to 0.7 mm. long, the margin entire or very faintly sinuate toward the apex, plane; costa short and double or none; leaf cells smooth, linear, prosenchymatous, 6 or 8 at the basal angles, subquadrate; perichaetial leaves erect, the outer about 1 mm. long, ovate-lanceolate, slenderly acuminate, loosely areolate in the lower half; seta slender, reddish below, paler above, about 8 mm. long, twisted to the right when dry; capsule about 1 mm. long, horizontal, contracted under the mouth and lightly striate when dry, short-ovoid when moist; exothecal cells short-rectangular, with rather thick, yellowish, pellucid walls; peristome teeth pale yellow, projecting about 0.25 mm. above the rim, closely cross-striate below, pale and coarsely papillose at the apex, cilia two; lid and calyptra unknown.

Type: In dense nut palm woods, Túxpan, State of Jalisco, Mexico, altitude about 20 meters, November 3, 1926, Mrs. Ynes Mexía, no. 1028a.

The plane-margined leaves distinguish this plant from both *I. miradoricum* and *I. cordovense*. It is nearer *I. tenerum* (Sw.) Mitt., but is smaller, with broader leaves less slenderly pointed and with a larger area of quadrate alar cells. Exactly the same plant occurs in a collection of Mexican mosses received from Mr. C. R. Orcutt, collected in the vicinity of Alzada, State of Colima, November 4, 1910, no. 4645.

POGONATUM BREVICAULE Brid.

Rocky stream bank, in damp clay soil, San Sebastian, Arroyo Seco, Jalisco, 1,500 meters, Jan. 15, 1927, no. 1494. Near stream at bottom of canyon, growing on rocks, trail from San Sebastian to Arroyo Seco, Jalisco, 1,500 meters, Jan. 8, 1927, no. 1436.

The occurrence of this species in Mexico is rather surprising, but I can find no excuse for separating these collections from the familiar type of the eastern United States. This is apparently the first time it has been recorded from Mexico.

POGONATUM CAMPYLOCARPUM (C. M.) Mitt.

Shady, north bank of stream, Real Alto, Poso Hedionda, Jalisco, 2,500 meters, Feb. 20, 1927, no. 1723a.

POGONATUM LIEBMANNIANUM Schimp.

Steep damp stream bank, San Sebastian, east of Arroyo Santa Gertrudis, Jalisco, 1,500 meters, Jan. 18, 1927, no. 1511. Near stream, on bare gullied hillside, growing in damp red clay, San Sebastian, Hacienda del Cura, Jalisco, 1,425 meters, Jan. 2, 1927, no. 1352 (?).

BOTANY.—*The identification of* Polypodium triangulum L.[1] WILLIAM R. MAXON, National Museum.

Among the ferns, one of the most distinctive groups is the widespread genus *Polystichum*. The species are commonly regarded as highly polymorphic, yet really are less notably so than has been thought, in many cases occupying (when critically segregated) comparatively narrow but natural, well defined areas of distribution; this has been shown to be true for Jamaica and the West Indies generally.[2]

The present notes relate to the historic misidentification of the Linnaean *Polypodium triangulum*, described originally from Hispaniola. Recent ample collections from that island show it to be a very distinct but rare endemic species, related closely not to the abundant Greater Antilles plant commonly called *Polystichum triangulum* (which must be known in future as *Polystichum echinatum*), but to *P. mucronatum* (Swartz) Presl, a Jamaican species of similar habit and essentially non-spinulose character. Historical and descriptive notes upon the three species, with principal synonymy, are given herewith.

Polystichum triangulum (L.) Fée, Gen. Fil. 279. 1852. FIG. 1. *Polypodium triangulum* L. Sp. Pl. **2:** 1088. 1753.

The original description of *Polypodium triangulum* L., 1753, reads as follows: "Polypodium frondibus pinnatis: pinnis triangularibus, dentatis," and is based upon the "Trichomanes folio triangulo dentato" of Petiver, illustrated at plate 1, figure 10. This illustration is obviously redrawn from Plumier's plate 72, depicting a plant from Hispaniola. There is no specimen of *Polypodium triangulum* in the Linnaean Herbarium. Plumier's plate 72 thus stands as virtual type.

So long as true material of this species was lacking from Hispaniola it was not unnatural to associate under this name other plants from the Greater Antilles which agreed only indifferently with the Plumier plate. Thus the name became fixed eventually upon a highly variable species of Jamaica, eastern Cuba, and Haiti (rare in Porto Rico and Guadeloupe), in which the pinnae are for the most part not merely "dentate" but serrate-spinescent. This latter species, taken up by Hooker, Jenman, and others as *Aspidium*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 31, 1928.

[2] Contr. U. S. Nat. Herb. **13:** 25–39. *pl. 2–9.* 1909; **16:** 49–51. *pl. 27.* 1912; **24:** 53, 54. *pl. 19, 20.* 1922.

Fig. 1. *Polystichum triangulum* (L.) Fée

triangulum Swartz, and by recent authors as *Polystichum triangulum*, must properly bear the name *Polystichum echinatum* (Gmel.) C. Chr.; it is discussed below.

The Hispaniola material at hand which now proves truly referable to *Polystichum triangulum* is as follows:

HAITI: Fonds Verettes, Mission; alt. 1000 meters or more; occasional in damp thickets; *Leonard* 3997. Furcy; alt. 1300–1500 meters; damp thickets and steep mossy ravine banks; occasional or locally common, *Leonard* 4278, 4281, 4284a, 4631, 4635; *Picarda* 256. Morne Brouet, Massif de la Selle; alt. 1600 meters, in shady places; *Ekman* 1103. Morne Formond, Torbec, Massif de la Hotte; alt. 1550 meters; on stony ridge, *Ekman* 7454.

As previously stated, the affinity of this species is with *P. mucronatum* (Swartz) Presl, of Jamaica, a species well known from Hooker's description and figure,[3] from Jenman's description,[4] and from notes and illustrations published by the writer.[5] As in *P. mucronatum*, the rachis bears a thick persistent covering of rigidly ascending or appressed-imbricate, hairlike, reddish scales, and the very numerous close-set pinnae are similarly clothed beneath. Plumier's descriptive notes, freely translated, are in part that the stipes or rachises are "all covered with reddish hairs;" that the pinnae are "so close to one another that the lower one always overlaps the other;" that the pinnae are always rather short, but broad at the base, not more than an inch long, "wholly of a brownish green, wrinkled on the upper surface, the lower surface being clothed with reddish hairs."

These characters apply to the plants in hand, rather than to the *P. triangulum* of authors. We may believe, too, that the spinulose margins and glabrate surfaces of the *P. triangulum* of authors would have been emphasized, if that plant had been intended. On the contrary, Plumier refers to the "pointed teeth" of the pinnae, a character which is not very obvious in all the specimens, though well shown in some.

Making every allowance for exaggeration of detail in Plumier's plate 72, it seems fairly certain, then, that the plant there figured is identical with the one here illustrated. Certainly the plants at hand are distinct specifically from all other West Indian species known, and they agree far better with the plate and description of Plumier than do any of the Hispaniola specimens here placed under *P. echinatum*, the *P. triangulum* of authors.

Polystichum echinatum (Gmel.) C. Chr. Ind. Fil. 83. 1905; 581. 1906.

Polypodium echinatum Gmel. Syst. Nat. 2[2]: 1309. 1791.

Polystichum falcatum Fée, Gen. Fil. 279. 1852; not Diels, 1899.

This is the common Greater Antilles species misidentified in the past as *Polystichum triangulum.*

[3] Sp. Fil. **4**: 9. *pl. 216*. 1862, as *Aspidium mucronatum;* not *A. mucronatum* Swartz, which is *Polystichum muricatum* (L.) Fée.

[4] Bull. Bot. Dept. Jamaica II. **2**: 266. 1895.

[5] Contr. U. S. Nat. Herb. **13**: 37. *pl. 8, A, B.* 1909; as *Polystichum struthionis* Maxon.

The original description of *Polypodium echinatum* reads as follows, "Pinnis falcato-lanceolatis subserratis sursum auritis base & anterius spinosis; stipite squamoso," with citation of Sloane's plate 36, figures 4 and 5, representing Jamaican plants. Gmelin's specimens (if any) have not been seen. The two Sloane specimens illustrated in figures 4 and 5 were examined recently at the British Museum, however; and although one of them is only scantily spinescent, both belong to the species ordinarily called (in error) *P. triangulum.* The specific name employed by Gmelin is in itself peculiarly indicative of this species, as opposed to *P. triangulum* (verum) and the Jamaican *P. mucronatum.*

Variation within *P. echinatum* is exceptionally wide. A narrow form is shown by Hooker in plate 33 of his Filices Exoticae (1858); but blades 4 to 6 cm. broad are not uncommon even in Jamaica, and in Hispaniola they reach a width of 8 to 10 cm., showing also marked variation in degree of serration. The Cuban plants are, in the main, intermediate, and it is possible to arrange the whole extensive series of Greater Antilles material in an almost unbroken line, showing every integradation not only in size but in less obvious characters. The margins are almost invariably serrate-spinescent, often very deeply and strongly so, and the blades always non-proliferous. As illustrative, the following specimens may be cited:

JAMAICA: *Clute* 170; *Hitchcock* 9506; *Underwood* 1167, 1822, 2838, 2839, 3295; *Maxon* 1201, 1337, 1489, 1873, 1883, 1884, 1887, 2207, 2555, 2591, 2788, 2827, 2968, 8752, 8754, 10087, 10150, 10400, 10462, 10482; *Maxon & Killip* 358, 998, 1034, 1413, 1453a, 1699.

CUBA: *Shafer* 8731; *Pollard & Palmer* 143; *Leon* 11179; *Maxon* 4243, 4260, 4267, 4459, 4461.

HISPANIOLA: Haiti, *Leonard* 3648, 3772, 3786, 4697, 4905, 4926, 7822, 8398, 8638, 9087; *Nash & Taylor* 1341, 1352; *Miller* 235; *Ekman* 1177, 3800, 7333. Dominican Republic, *Abbott* 1848, 1852, 1969; *Türckheim* 2933; *Fuertes* 1562.

PORTO RICO: Near Florida, on limestone, *E. G. Britton* 8535; *Britton, Britton & Boynton* 8189.

Polystichum mucronatum (Swartz) Presl, Tent. Pter. 83. 1836.

Polypodium muricatum Swartz, Prodr. Veg. Ind. Occ. 131. 1788; not L., 1753.

Aspidium mucronatum Swartz, Journ. Bot. Schrad. **1800**[2]**:** 30. 1801.

Polystichum echinatum C. Chr. Ind. Fil. 83. 1905; not *Polypodium echinatum* Gmel. 1791.

Polystichum struthionis Maxon, Contr. U. S. Nat. Herb. **13:** 37. *pl. 8, A, B.* 1909.

A well known, endemic Jamaican species, here regarded in the sense of Swartz, Hooker, and Jenman.

Relying too much upon Sloane's plate 36, figures 4 and 5, cited by Swartz as illustrating his *Polypodium muricatum* and again mentioned by him in proposing the substitute name *mucronatum,* the writer long ago misidentified this species and needlessly proposed for it the new name *P. struthionis;* the error might have been avoided by a critical reading of Swartz's later detailed description.[6] Recently, an examination of the Swartzian type at Stockholm showed it to be identical with Hooker's plate of *Aspidium mucronatum*[7] and

[6] Fl. Ind. Occ. **3:** 1649. 1806.

[7] Sp. Fil. **4:** 9. *pl. 216.* 1862.

the writer's illustration of *P. struthionis,* above cited. As previously stated, Sloane's figures 4 and 5 pertain to *P. echinatum,* and not to *P. mucronatum.*

The following specimens, showing relatively slight variation, are at hand:

JAMAICA: *Hart* 29, 209; *Clute* 68; *Eggers* 3763; *Underwood* 458; *Maxon* 1316, 1470, 1610, 1614, 2660, 8748, 10077, 10154, 10557; *Maxon & Killip* 608, 906, 1009.

PALEOBOTANY.—*An* Alethopteris *from the Carboniferous of Peru.*[1]

EDWARD W. BERRY, Johns Hopkins University.

In 1922 the writer described a few Carboniferous plants from the Paracas Peninsula in Peru, one of which he collected also on the Copacabanya peninsula at the Bolivian end of Lake Titicaca.[2] These were *Palmatopteris furcata* Brongn., *Eremopteris whitei* Berry, *E. peruianus* Berry, *Calamites suckowii* Brongn., *Calamostachys* sp., *Lepidodendron rimosum* Sternb., *L. obovatum* Sternb., *Lepidophyllum* sp., *Lepidostrobus* sp., *Stigmaria* sp., and *Knorria* sp.

Despite the absence of neuropterids, pecopterids, alethopterids and lonchopterids, this flora was considered to indicate a Westphalian age and not to represent the Dinantian as had been asserted by Steinmann.[3] This conclusion was based upon paleogeographic considerations, the nature of the plants found and their manner of accumulation, and their apparent close relations with marine sediments carrying a Uralian fauna (Stephanian stage in terms of the European continental section).

The Paracas plants have also been the subject of a short paper by Seward[4] who reported on a collection made by Douglas. I have heard of specimens of ferns from the Carboniferous of Titicaca Island—they are mentioned by Bandelier—but I have seen no actual specimens. The marine Carboniferous is widespread in South America, and carries an excellent fauna. A soft bottom facies of this was encountered in the Amotape Mountains in 1927, which is the most northwesterly known occurrence of rocks of this age in South America.

A small collection recently received from my friend, Professor Lisson of Lima, enables me to report the occurrence in Peru of a plant highly characteristic of the Westphalian stage in Europe, and inferentially supports my determination of the age of the Paracas plants.

[1] Received October 19, 1928.

[2] E. W. BERRY. Johns Hopkins University Studies in Geology **4**: 9–44. *pls. 1–8.* 1922.

[3] G. STEINMANN. Geol. Rundschau **1**: 50. 1912.

[4] A. C. SEWARD. Quart. Journ. Geol. Soc. Lond. **78**: 278–283. *tf. 1; pl. 13.* 1922.

The present material comes from Chuquibambilla in the province of Cotabamba, Department of Apurimac. Marine Carboniferous was reported from Apurimac, at Antabamba above Chuquibambilla, by Bowman,[5] who also collected fossils at Chuquibambilla, said by Schuchert[6] to represent *Pecten* near *quadricostatus*, a clypeasterid, etc., which are Cretaceous forms. I know nothing of the relations of the rocks in the vicinity of Chuquibambilla, but there can be no question of the identity of the present fossil plant or of its Westphalian age.

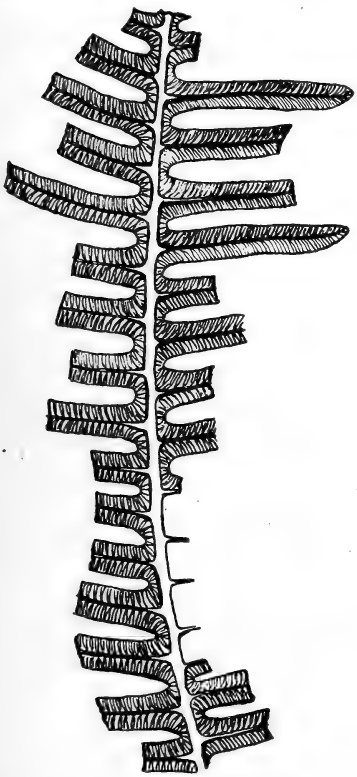

Figure 1.—*Alethopteris serlii* (Brongn.) Goeppert var., from Westphalian of Chuquibambilla, Apurimac, Peru.

The material submitted by Professor Lisson comprises two specimens the size of the one figured and several smaller fragments, all of a single species, preserved in a dark, considerably metamorphosed shale. These are identical with what is called *Alethopteris serlii* (Brongniart) Goeppert in the Northern Hemisphere. The question of the actual cosmopolitanism of a single botanical species is not so certain, although there are no known criteria for making a differentiation. Some of the alethopterids have been shown to be referable to the seed ferns (Pteridospermophyta) and the suspicion that all of them belong in that category appears to be warranted. What is now called *Alethopteris serlii* was figured by Parkinson in 1804, named by Brongniart in 1828, and described a few years later. The Peruvian material, one of the larger specimens of which is shown in Figure 1, may be briefly characterized as follows:

ALETHOPTERIS SERLII (Brongniart) Goeppert

Figure 1

Coriaceous. Pinnules not contracted toward the base. Midveins coarse, straight and prominent. Laterals at almost right angles, stout and very closedly spaced, usually acutely forked near the base, but sometimes simple

[5] I. BOWMAN. *The Andes of Southern Peru*, pp. 243–244. 1916.
[6] C. SCHUCHERT. Idem., p. 323.

and always simple toward the tips of the pinnules. The pinnules are linear, at right angles to the axis, long slender and bluntly pointed, very slightly ascending toward their tips; they are alternate, well spaced, decurring to join the one next below by an only slightly inequilateral sinus. In one specimen the pinnules are closely spaced and these taper slightly proximad.

This so-called species exhibits a great deal of variation, judging by the numerous figures of specimens which various authors have identified with it. And even on a single frond—which is large and quadripinnate—there is a great deal of variation in different regions of the frond. The Peruvian form is more like the variety described by White[7] from Missouri as var. *missouriensis* than it is like any of the figures of European specimens with which I have compared it.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY

720TH MEETING

The 720th meeting was held at the Cosmos Club, April 7, 1928, with President GOLDMAN in the chair and 57 persons present. New members elected: RICHARD JONES, HENRY S. KLAUSNER, W. E. MCINDOO, C. N. SMITH.

A. WETMORE stated that the insect collection of the late C. F. BAKER had been donated to the National Museum. He explained that this was one of the finest collections of Phillippine insects and had just arrived at New York. The collection is housed in 1,400 Schmidt boxes.

H. H. T. Jackson announced that the annual meeting of the American Society of Mammalogists would be held at the National Museum April 12–14, and that the art exhibit in the National Museum in this connection numbered about 150 colored drawings and about 50 technical drawings.

R. M. LIBBEY called attention to the arrival of purple martins on March 29.

A. WETMORE announced the receipt by the National Museum of a rare thrush donated by Mr. LOWE. He discussed briefly the structure and relationships of this rare bird.

W. P. TAYLOR: *The biology of forest range.*—The cutting or burning of vast tracts of timber means more than timber loss. The whole realm of nature is affected. Game birds, mammals, fur-bearing animals, and fishes are often reduced in numbers or even exterminated. The trend here, as in England, is definitely toward a reduction of the nation's basic resources and a lowering of living standards. No argument is needed to show the need for more facts. Forest and range are not gifts, they should be regarded as crops. While agricultural production generally has increased, forest and forage production has decreased. The only way to change this is through careful studies of all the important animals and plants in the woods and on grazing ranges and their climatic and other surroundings, and the rigorous application of the results of these studies in the management of forest and range lands and the improvement of forest and forage crops.

[7] D. WHITE. U. S. Geol. Survey Mon. **37**: 118. *pl. 37, fig. 2; pl. 42,5.* 1899.

W. H. RICH, of the U. S. Bureau of Fisheries, discussed the method of age determination of salmon, by means of the scales. This discussion of recent progress in determining structural and growth characteristics in the scales which made it possible to determine the age of specimens of certain species of salmon was illustrated by lantern slides.

W. B. BELL, *Secretary pro tem.*

721ST MEETING

The 721st meeting of the Biological Society was held at the Cosmos Club, April 21, 1928, with President GOLDMAN in the chair and 38 persons present. New member elected: PAUL S. GOLTROFF.

RAY GREENFIELD announced the capture of a specimen of a rare shrew, *Sorex fontinalis,* near Riggs Mill, Prince Georges County, Maryland, on April 6, 1928. This is said to be the seventeenth specimen taken in the District of Columbia and vicinity.

WALTER BALL reported his capture of a sick or injured live specimen of red-throated loon on the Tidal Basin, Washington, D. C., on April 17, 1928. The specimen, which is a very rare bird in the vicinity of the District of Columbia, has been presented to the National Zoological Park.

R. L. PIEMEISEL: *Types of vegetation of East Africa* (illustrated).—Three types of vegetation cover the major part of this area. The *Acacia* and desert grass type consisting of *Acacia* trees, tufts of bunch grasses and spaces of bare soil covers semi-arid lands adapted only for grazing. The drought period is long and the grasses are green for only a short time after the rains. The scrub tree and tall grass type, with *Acacia* or similar trees and a uniform growth of somewhat coarse grasses, covers the lower plains near Lake Victoria and the coast. These grasses are green for most of the year. The bulk of the sisal and cotton is grown here. The tall grass type, mostly pure grasslands, covers the higher plains. The length of the drought period is intermediate between those of the two preceding types but the temperatures here are lower than those of either of the other two. It represents the great grazing areas and the part near the border of the temperate rain forest produces most of the wheat of Kenya. Moreover, land of this and the preceding type together produces most of the maize of East Africa.

Interesting types covering but a small percentage of the total area are found on the mountain slopes and high plateaus; the temperate rain forest type of olives, cedar, *Podocarpus* and bamboo, the lower parts of which furnish the best coffee lands and meadows which are green practically the year around; the alpine shrub type of heaths and composites; and the alpine grassland, mostly sedges and coarse grasses. (*Author's abstract.*)

L. W. KEPHART: *Geography of East Africa* (illustrated).—(No abstract received.)

W. B. BELL, *Recording Secretary pro tem.*

722D MEETING

49TH ANNUAL MEETING

The 722d regular and 49th annual meeting was held at the Cosmos Club, May 5, 1928, with President GOLDMAN in the chair and 21 persons present.

Under suspension of the rules, the following new members were elected: MALCOLM DAVIS, C. C. SANBORN, G. S. WALLEY.

A resolution on the recent death of Dr. J. N. ROSE, a former President of the Society, prepared by Drs. HITCHCOCK and MAXON, was read by the

Secretary. On motion of Dr. OBERHOLSER, it was voted that it be spread on the minutes and a copy sent to the bereaved family.

The minutes of the previous annual meeting were read and approved. The reports of the Recording Secretary, Treasurer, and Publication Committee were read and ordered placed on file. Mr. C. E. CHAMBLISS, for the Auditing Committee, reported that the treasurer's accounts had been found correct. Dr. W. B. BELL gave an informal report for the Committee on Communications. The report of the Board of Trustees was read and accepted. The President then appointed Messrs. JACKSON and CHAMBLISS tellers and the election of officers took place, resulting as follows:

President, E. A. GOLDMAN; *Vice-presidents,* A. WETMORE, C. E. CHAMBLISS, H. H. T. JACKSON, C. W. STILES; *Recording Secretary,* S. F. BLAKE; *Corresponding Secretary,* W. H. WHITE; *Treasurer,* F. C. LINCOLN; *Members of Council,* H. C. FULLER, W. R. MAXON, A. A. DOOLITTLE, I. HOFFMAN, T. E. SNYDER.

S. F. BLAKE, *Recording Secretary.*

Obituary

DAVID SYLVANUS CARLL, a member of the ACADEMY, died at his home in Washington, November 5, 1928. He was born at Huntington, New York, March 21, 1855. He was a past president of the Washington Society of Engineers and of the Washington Chapter, American Society of Civil Engineers. Mr. Carll was chiefly interested in traction engineering, having had charge of construction and operation of street railways in Washington, D. C., since 1890.

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A † denotes the abstract of a paper before the Academy or an affiliated society. A § indicates an item published under the head Scientific Notes and News.

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Saturday, December 29.	The Biological Society.
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The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the eleventh and twenty-fifth day of each month.

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