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ERRATA

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Page 4, line 23: for "*Acetocina*" read "*Acteocina.*"
Page 4, line 32: for "*Noetica*" read "*Noetia.*"
Page 4, line 35: for "*mulrilineatus*" read "*multilineatus.*"
Page 4, line 36: for "*muricatus*" read "*muricatum.*"
Page 12, line 14: for "Dupoin" read "Duplin."
Page 63, line 48: delete "found."
Page 82, line 19: for "Birsson" read "Brisson."
Page 83, line 8: for "olarctic" read "Holarctic."
Page 128, line 39: for "MacCullum's" read "MacCallum's."
Page 381, line 7 from bottom: for "Mosoa" read "Mocoa."
Page 407, second letter from left in Fig. 1: for "F" read "B."
Contents, March 15 issue, line 8: for "Gyradactyloidea" read "Gyrodactyloidea."

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GEOLOGY.—*The Pleistocene Horry clay and Pamlico formation near Myrtle Beach, S. C.*[1] C. Wythe Cooke, U. S. Geological Survey.

In my recently published report on the geology of the Coastal Plain of South Carolina, the statement is made that late Pleistocene Pamlico time, during which the sea stood about 25 feet above its present level, was preceded by a time of lower sea level.[2] This statement was based on evidence that came chiefly from outside of South Carolina, for I had not seen a contact of the Pamlico formation with underlying beds within the State. Since that report went to press, the canal of the Intracoastal Waterway mentioned on page 125 has been completed through Horry County. The following instructive section on it yields evidence that corroborates that statement.

SECTION WEST OF THE RAILWAY BRIDGE ACROSS THE INTRACOASTAL WATERWAY $2\frac{1}{2}$ MILES NORTHWEST OF MYRTLE BEACH, S. C.

	Feet
Pamlico formation:	
3. Fine leached marine sand including a few thin beds of clay in the middle part and merging upward into clayey loam.......	12
2. Fine sand loaded with sea shells, many of which have both valves in juxtaposition. The upper part contains many oysters	6
Horry clay:	
1. Very dark brown clay containing comminuted plant fragments and woody tissues and diatoms. Cypress stumps and knees are rooted at the top. Some of the stumps extend a few inches above the clay into the overlying shell bed. The top of the clay is perforated by tubular holes, presumably made by boring creatures. Covered by water at high tide...........................	3

The presence of rooted tree stumps beneath a thick marine deposit that evidently accumulated in quiet water gives conclusive evidence that the sea stood lower on the land when they grew than in the immediately succeeding epoch.

The name Horry clay, here used for the first time, is proposed

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[1] Published by permission of the Director of U. S. Geological Survey. Received October 6, 1936.

[2] Cooke C. W., U. S. Geol. Survey Bull **867**: 157. 1936.

for bed 1. It is pronounced O-ree, with the accent on the last syllable, as in Horry County, S. C., from which it is adopted.

The Horry clay contains a large flora of diatoms. A small sample studied by Kenneth E. Lohman of the U. S. Geological Survey yielded the 53 species in the following list:

A—abundant; C—common; F—few; R—rare; *—now living in fresh or brackish water; species not preceded by an * are marine.

Melosira cf. *M. recedens* Schmidt (F), *M. sulcata* (Ehrenberg) Kützing (C), *Podosira stelliger* (Kützing) Mann (C), *Cyclotella striata* (Kützing) Grunow (F-C), *C. striata bipunctata* Fricke (F), *C.* sp. (F), *Coscinodiscus denarius* Schmidt (F), *C. excentricus* Ehrenberg (F), *C. nitidus* Gregory (F), *C. oculus-iridis* Ehrenberg (F), *C. radiatus* Ehrenberg (F), *Actinoptychus parvus* Mann (R), *A. splendens* (Shadbolt) Ralfs (R), *A. undulatus* Ehrenberg (F), *Polymyxus coronalis* Bailey (A), *Aulacodiscus argus* (Ehrenberg) Schmidt (F), *Eupodiscus* cf. *E. decrescens* Rattray (R), *Auliscus pruinosus* Bailey (R), *Actinocyclus ehrenbergii* Ralfs (F), *Triceratium favus* Ehrenberg (F), *T. reticulum* Ehrenberg (F), *Biddulphia* cf. *B. rhombus* (Ehrenberg) Wm. Smith (F), *B.* sp. (R), *Grammatophora* sp. (R), *Plagiogromma* sp. (R), *Rhaphoneis amphiceros* Grunow (C), *R. belgica* (R), *R.* aff. *R. angularis* Lohman (C), *R. surirella* Grunow (R), *Synedra investiens* Wm. Smith (R), *Leudugeria janischii* (Grunow) Van Heurck (R), **Eunotia monodon* Ehrenberg (R), *Cocconeis scutellum* Ehrenberg (R), **Diploneis elliptica* (Kützing) Cleve (R), *D. gründleri* (Schmidt) Cleve (R), *D. weissflogii* (Schmidt) Cleve (F), **Frickea lewisiana* (Greville) Heiden (R), *Trachyneis aspera* Ehrenberg (R), **Navicula peregrina* (Ehrenberg)Kützing (R), *N.* aff. *N. spectabilis* Gregory (R), *N.* sp. (R), **Caloneis formosa* (Gregory) Cleve (R), **Gyrosigma acuminatum* (Kützing) Rabenhorst (R), **G.* cf. *G. balticum* Ehrenberg (R), *G.* sp., *Pleurosigma* sp. (F), *Amphora pediculus* (Kützing) Grunow (R), **Epithemia zebra porcellus* (Kützing) Grunow (R), **E. zebra saxonica* (Kützing) Grunow (R), **Rhopalodia gibberula* (Ehrenberg) Müller (R), **Nitzchia granulata* Grunow (R), **N.* cf. *N. plana* Wm. Smith (R), **N. tryblionella* Hantzsch (R).

Mr. Lohman comments on this flora as follows:

"The facts that the fresh- and brackish-water species are all rare in the Horry clay and that the marine species are abundant indicate a marine to slightly brackish environment at the time of deposition, such as would be found in the seaward part of an estuary or bay beyond the influence of any major fresh-water stream that may have emptied into it. The most abundant species, *Polymyxus coronalis,* is now known to be living only in the tropics, and this is true also of several of the others, strongly suggesting that the Horry clay was deposited under conditions at least as warm, and most probably warmer, than those existing in the same region today.

"*Polymyxus coronalis* occurs abundantly in the Pleistocene beds penetrated by a well drilled at Wildwood, N.J., at a depth of 78–180 feet. It also occurs sparingly in the "blue clay" at Philadelphia, which represents its northernmost known occurrence. This species is extinct along the Atlantic coast of North America, and so far as known is living only off the mouths of the Para and Amazon rivers. It has never been found in rocks older than Pleistocene. Another common species, *Triceratium favus*, has a known range of Pleistocene to Recent. Many other species in the assemblage also occur in Pleistocene beds in the Atlantic Coastal Plain, but most of them are long-ranging species having little significance for age determination."

The peaty appearance of the clay and the cypress stumps rooted in it would lead one to suppose that the clay had accumulated in a cypress swamp; but all the trees are rooted in the top of the deposit, and all the common species of diatoms are marine. It is therefore evident that the clay was deposited in salt water. Before the cypress trees could have taken root there must have been either a lowering of sea level or a freshening of the water due to other causes. The clay may represent the deposits of a salt marsh that eventually was changed into a fresh-water swamp by the building of barriers across the tidal inlets.

As the diatom flora includes several tropical species, it is hardly likely that the clay could have been deposited during a glacial stage. It more probably represents part of an interglacial stage, presumably the early part of that including Pamlico time, after sea level had risen from the low of the preceding glacial stage to approximately its present height but before it had attained its maximum of 25 feet above the present level. The trees may have grown in a flooded estuary freshened toward the end of a brief pause in the submergence.

Further flooding of the estuary in which the Horry clay was deposited widened it into a V-shaped bay opening towards the southwest. The bay was separated from the Atlantic Ocean by a low, narrow peninsula composed (at Myrtle Beach) of coarse reddish-brown sand containing disc-shaped, flat pebbles. In the "Geology of the Coastal Plain of South Carolina"[3] I interpreted this peninsula and the higher land across the bay as having been built above water by the waves and winds of Pamlico time. In the light of newer evidence it seems more likely that they are of Talbot age and that the Horry estuary occupied a valley in the Talbot plain.

A somewhat similar occurrence of diatomaceous clay and cypress stumps overlain by marine fossiliferous sand (Pamlico formation) is reported by Mansfield[4] on the Neuse River about 10 miles below New Bern, N. C. At this place, however, *Nitzschia scalaris*, a fresh-water species, predominates. The presence of at least two marine

[3] U. S. Geol. Survey Bull. **867**: 7, 153: pls. 1, 4, 17. 1936.

[4] MANSFIELD, W. C., U. S. Geol. Survey Prof. Paper **150**: 134. 1928.

species there indicates that the deposit was formed in an estuary to which salt water had occasional access. Although the incomplete list of the diatoms on the Neuse includes no species listed from the Horry clay near Myrtle Beach, the two deposits are probably contemporaneous, for both are estuarine, both underlie the marine Pamlico formation, and they stand at the same level. If they are contemporaneous, they yield further evidence that there has been no tilting of late Pleistocene deposits in the Carolinas.

The lower part of the Pamlico formation at the railroad bridge near Myrtle Beach (bed 2 of the section) is highly fossiliferous. Many of the fossils are well preserved and larger than the usual sizes that the same species attain along the Carolina coast today—an indication of warmer water. Among the organisms represented are unidentified corals; unusually large sand dollars (*Mellita quinquiesperforata*); and more than 60 species of mollusks, some of which (e.g. *Rangia cuneata*) no longer live in the Atlantic Ocean. For the identification of the mollusks listed below I am indebted to Dr. W. C. Mansfield. The collection is especially valuable because all of the specimens were found in place, without possibility of contamination from other beds. As many of the bivalves retain both shells in juxtaposition, it is unlikely that any of them were reworked.

Acetocina canaliculata (Say), *Terebra dislocata* (Say), *T. concava* (Say), *Mangelia cerina* Kurtz & Stimpson, *Marginella* sp. (immature), *Olivella nitidula* Dillwyn, *Oliva sayana* (Ravanel), *Busycon caricum* (Gmelin), *B. caniculatum* (Linnaeus), *Cantharus cancellaria* (Conrad), *Alectrion acuta* (Say), *A. trivittata* (Say), *Ilyanassa obsoleta* (Say), *Anachis avara* Say, *A. obesa* C. B. Adams, *Mitrella lunata* (Say), *Urosalpinx cinerius* (Say), *Odostomia* sp. *Turbonilla* sp., *Seila adamsii* (H. C. Lea), *Littorina irrorata* Say, *Crepidula fornicata* (Linnaeus), *C. fornicata ponderosa* H. C. Lea, *Polinices duplicatus* (Say), *Tectonica pusilla* (Say)?, *Sinum perspectivum* (Say), *Glycymeris* sp. (young), *Argina pexata* Say, *Arca transversa* Say, *Noetica ponderosa* Say, *Fossularca adamsi* Dall, *Ostrea virginica Gmelin*, *Pecten gibbus gibbus Linnaeus*, *Anomia simplex* d'Orbigny, *Modiolus* sp. (fragment), *Pandora trilineata* Say, *Venericardia tridentata* Say, *V. perplana* Conrad, *Phacoides mulrilineatus* Tuomey & Holmes, *P. radians* (Conrad), *P. trisculatus* Conrad, *Divaricella quadrisulcata* (d'Orbigny), *Rochefortia* sp., *Cardium muricatus* Linnaeus, *C. robustum* Solander, *Dosinia discus* Reeve, *Chione cancellata* (Linnaeus), *Venus mercenaria* Linnaeus, *Gemma purpurea* H. C. Lea?, *Tellina* sp. cf. *T. sayi* Deshayes, *Semele proficua* Poulteney, *Abra aequalis* (Say), *Donax variabilis* Say, *D.* sp., *Spisula similis* Say, *Mulinia lateralis* Say (very abundant), *Rangia cuneata* Gray, *Ervilia concentrica* Gould, *Corbula contracta* Say, *Barnea costata* Linnaeus.

The contact between beds 2 and 3 of the section near Myrtle Beach apparently marks the location of the top of the saturated zone before the canal was dug. The absence of shells above this level may be attributed to the leaching action of rain water that, in percolating downward, dissolved the shells. The absence of shells from terrace deposits higher than the Pamlico has been advanced as an argument against the marine origin of the higher terraces; but most of the higher terrace deposits are porous and have been subjected to leaching for a longer time than the Pamlico formation.

The sequence of late Pleistocene events that can be inferred from the sections near Myrtle Beach, on Neuse River, and from other evidence is as follows: First, a lowering of sea level from the 42-foot Talbot stage to a depth estimated by Stearns[5] as about 60 feet below the present level; next, a rise of sea level to approximately its present position and deposition of the Horry clay in estuaries filling valleys cut in the Talbot terrace during the preceding epoch; then, continued rise of sea level to a height of 25 feet, expansion of the Horry estuaries, and deposition of the Pamlico formation; next, fall of sea level to a depth at least 25 feet lower than the present, indicated by submerged channels in Pamlico Sound and elsewhere; finally, rise of the sea to its present level, drowning the valleys and lowlands of the preceding epoch to form the existing sounds and estuaries.

I have elsewhere[6] tentatively correlated the Pamlico formation with the last major interglacial stage, commonly called Peorian—a correlation that seems to be confirmed by the studies of MacClintock and Richards.[7] The Horry clay apparently represents the early part of the same stage.

PALEONTOLOGY.—*Pliocene and Pleistocene mollusks from the Intracoastal Waterway in South Carolina.*[1] W. C. MANSFIELD and F. S. MACNEIL.

In June, 1935, and again in April, 1936, the writers visited the Intracoastal Waterway at North Dam (Location Contract 195) about 3 miles west-southwest of Little River and about 15 miles northeast of Myrtle Beach, S. C. The canal here traverses a low plain, which as interpreted by Cooke,[2] is the southward continua-

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[5] STEARNS, H. T., Geol. Soc. Am. Bull. **46**: 1941. 1935.

[6] COOKE, C. W. *Tentative ages of Pleistocene shore lines.* This JOURNAL **25**: 333. 1935.

[7] MACCLINTOCK, PAUL, and RICHARDS, H. G. *Correlation of late Pleistocene marine and glacial deposits of New Jersey and New York.* Geol. Soc. Am. Bull. **47**: 317. 1936.

[1] Published by permission of the Director, U. S. Geological Survey. Received October 12, 1936.

[2] COOKE, C. W. *Geology of the Coastal Plain of South Carolina.* U. S. Geol. Survey Bull. **867**: 125–126. 1936.

Fig. 1.—Intracoastal waterway canal, June, 1935, at North Dam (Location contract 195) about 3 miles west-southwest of Little River and about 15 miles northeast of Myrtle Beach, S. C. The rock on which the senior author stands is referred to the Pliocene epoch (see No. 1 of section).

tion of the Pamlico terrace plain of North Carolina. The purpose of this paper is to record the species of mollusks collected at North Dam, both those in place from the different beds in the canal banks and those thrown out by the dredge along the spoil banks. These faunas are compared with those from other areas and certain species not heretofore recorded from this area are indicated.

The section exposed at this locality is as follows:

	Feet
Recent:	
6. Cross-bedded white to tan sand	8±
Pleistocene (Pamlico formation):	
5. Dark gray, rather fine clayey sand, carrying many fossils (U. S. Geol. Survey nos. 13424, 13813	3±
4. Sand (of dune origin?)	3±
3. Alternating layers of cross-bedded sand and peat, the peat in places grading laterally into sand	3±
2. Dark gray clayey sand, some of the sand grains large and irregular, carrying many individuals of *Mulinia lateralis*, *Ostrea virginica* and other shells; this bed changes laterally in character and thickness, being more clayey and fossiliferous where it occupies depressions in the underlying bed and more sandy and cross-bedded as it becomes thinner; in places the lower	

part of the carbonaceous bed (no. 3) rests directly on the Pliocene (bed 1) (U. S. Geol. Survey no. 13425)................. 0–3

Unconformity.

Pliocene (Waccamaw formation):

1. Indurated, light gray, highly calcareous marl with a minor amount of rather fine quartz sand, carrying fragmental and entire mollusks, corals, encrusting bryozoa and echinoderms (U. S. Geol. Survey no. 13426).....(above water level)..... 4±

The species collected from layers 1, 2, and 5, and from the spoil bank are listed below.

LIST OF SPECIES FROM LAYER 5

Aceteocina canalicula (Say), *Terebra dislocata* (Say), *Terebra concava* (Say), *Ilyanassa obsoleta* (Say), *Anachis avara* Say, *Epitonium angulatum* Say, *Melanella* sp., *Turbonilla,* 2 or more species, *Seila adamsii* (H. C. Lea), *Crepidula fornicata* (Linnaeus), *Nucula proxima* Say, *Arca transversa* Say, *Noetia ponderosa* (Say), *Argina pexata* (Say), *Ostrea virginica* Gmelin (?), *Anomia simplex* D'Orbigny, *Mytilus* sp., *Lyonsia* aff. *L. floridana* Conrad, *Phacoides multilineatus* Tuomey and Holmes, *Cardium robustum* Solander, *Cardium muricatum* Linnaeus, *Chione cancellata* (Linnaeus), *Venus* sp., *Venus mercenaria* Linnaeus, *Gemma purpurea* H. C. Lea, *Tellina* cf. *sayi* (Deshayes) *Dall*, *Semele proficua* Pulteney, *Cumingia tellinoides* (Conrad), *Tagelus gibbus* (Spengler), *Tagelus divisus* Spengler, *Mulinia lateralis* Say, *Anatina canaliculata* (Say), *Barnea* (*Scobina*) *costata* (Linnaeus).

This fauna is of very late Pleistocene age. Of the 26 species all, or nearly all, are now living somewhere along the Atlantic coast.

LIST OF SPECIES FROM LAYER 2

Acteocina canaliculata (Say), *Cylichnella bidentata* (D'Orbigny), *Terebra* sp., *Mangelia cerina* Kurtz and Stimpson, *Olivella nitidula* Dillwyn, *Marginella apicina* Menke, *Marginella* sp., *Busycon caricum* (Gmelin), *Busycon perversum* (Linnaeus), *Cantharus tinctus* Conrad, *Alectrion acuta* Say, *Alectrion trivittata* (Say), *Ilyanassa obsoleta* (Say), *Anachis obesa* C. B. Adams, *Mitrella lunulata* Say, *Urosalpinx cinerius* Say, *Eupleura caudata* Say, *Epitonium* sp., *Turbonilla,* 2 or more sp., *Semicassis inflata* Shaw, *Ficus papyratia* Say, *Triphora nigrocincta* C. B. Adams, *Cerithiopsis subulata* Montagu, *Vermicularia spirata* (Philippi), *Turritella* sp., *Crepidula fornicata* (Linnaeus), *Crepidula plana* Say, *Calyptraea centralis* Conrad (?), *Polinices* (*Neverita*) *duplicatus* (Say), *Diodora alternata* (Say), *Nucula proxima* Say, **Glycymeris americana* Defrance, **Arca lienosa* Say, *Arca transversa* Say, *Argina pexata* (Say), *Noetia ponderosa* (Say), "*Fossularca*" *adamsi* Dall, *Ostrea virginica* Gmelin, **Pecten eboreus solariodes* Heilprin, **Plicatula marginata* Say, *Cardita* sp. (young), **Cardita arata* (Conrad), **Venericardia granulata* Say, *Chama* sp., **Phacoides* cf. *P. waccamawensis* Dall, *Diplodonta semiaspera* Philippi, **Diplodonta acclinis* Conrad, *Bornia* cf. *B. triangulata* Dall, *Dosinia elegans* (Conrad), *Chione latilirata athleta* Conrad, *Venus* sp., *Tellina sayi* (Deshayes) Dall, *Cumingia tellinoides* (Conrad), *Abra aequalis* (Say), *Tagelus gibbus* (Spengler), *Spisula* cf. *S. similis* Say, *Mulinia lateralis* Say, *Anatina canaliculata* (Say), *Corbula barrattiana* C. B. Adams, *Corbula contracta* Say, Coral.

The sediments of layer 2 were probably deposited during Pleistocene time. Of about 62 species listed, 8 are believed to have lived during Pliocene time (marked in the list with an asterisk*) and to have been redeposited in the Pleistocene sediments.

The water level in the canal was about 4 feet higher during our last than during our first visit and consequently the lower part of layer 2, seen during our first visit, was under water. All of the presumably reworked Pliocene species were collected during our first visit from depressions in the underlying Pliocene bed and at the time were thought to have been in place in the base of layer No. 2. However, the possibility that they may have slipped down the bank from overlying dredged material, is recognized.

The following species are not known to have lived earlier than Pleistocene time: *Busycon caricum* (Gmelin), *Cantharus tinctus* Conrad, *Alectrion trivittata* (Say), *Ilyanassa obsoleta* (Say), *Urosalpinx cinerius* Say, *Semicassis inflata* Shaw, *Argina pexata* (Say), *Noetia ponderosa* (Say), *Cumingia tellinoides* (Conrad), *Anatina canaliculata* (Say) and others.

LIST OF SPECIES FROM THE UPPER PART OF THE PLIOCENE, LAYER NO. 1

Olivella mutica Say, *Fusinus* cf. *F. carolinensis* Dall, *Ilyanassa porcina* Say, *Nucula proxima* Say, *Glycymeris americana* (DeFrance), *Pecten eboreus senescens* Dall, *Crassinella lunulata* (Conrad), *Venericardia abbreviata* Conrad?, *Phacoides multilineatus* (Tuomey and Holmes), *Diplodonta acclinis* (Conrad), *Cardium* sp., *Laevicardium mortoni* Conrad, *Venus* sp., *Tellina sayi* (Deshayes), *Mulinia lateralis* Say, *Poromya* sp., *Corbula barrattiana* C. B. Adams, *Corbula contracta* Say.

LIST OF SPECIES FROM THE SPOIL BANK

Terebra dislocata (Say), *Terebra* aff. *dislocata* (Say), *Terebra concava* (Say), *Conus adversarius* Conrad, *Conus floridanus* Gabb (C), "*Drillia*" *ebenia* Dall (C), "*Drillia*" aff. *pagodula* Dall (C?), *Cymatosyrinx lunata* (H. C. Lea), *Mangilia* sp., *Cancellaria* cf. *C. carolinensis* Emmons, *Oliva sayana* (Ravenel), *Olivella nitidula* Dillwyn, *Marginella* aff. *M. limatula* Conrad, *Scaphella* (*Aurinia*) *floridana* (Heilprin) (C), *Aurinia obtusa* Emmons, *Fasciolaria sp.* (N), *Fasciolaria apicina* Dall, *Busycon carica* Gmelin (P?), *Busycon perversum* (Linnaeus), *Busycon pyrum* Dillwyn, *Busycon* sp. (N), *Fusinus carolinensis* (Dall), *Fusinus* sp., *Alectrion acuta* (Say) (P), *Alectrion vibex* (Say) (C), *Ilyanassa obsoleta* (Say) (P), *Ilyanassa irrorata* Conrad, *Ilyanassa isogramma* Dall, *Alectrion* aff. *ambigua antillarum* D'Orbigny (C), *Anachis avara caloosaensis* Dall, *Ocinebra alta* Dall (C), *Eupleura caudata* Say (P), *Murex pomum* Gmelin, *Murex rufus* Lamarck, *Purpura fluvi-*

ana Dall (C), *Coralliophila lepidota* Dall, *Urosalpinx cinerius* (Say) (P), *Urosalpinx* sp. (N), *Ficus papyratia* (Say), *Petaloconchus irregularis* D'Orbigny (P), *Turritella subannulata* Heilprin, *Turritella* sp. (P?), *Crepidula fornicata* (Linnaeus), *Crepidula cymbaeformis* Conrad, *Crepidula plana* Say, *Polinices* (*Neverita*) *duplicata* (Say), *Natica canrena* Linnaeus, *Diodora* cf. *D. alternata* (Say), *Nuculana acuta* (Conrad), *Glycymeris americana* (DeFrance), *Glycymeris pectinata* (Gmelin), *Acar reticulata* Gmelin (C), *Arca plicatura* Conrad?, *Arca transversa* Say (P), *Arca lienosa* Say, *Arca rustica* Tuomey and Holmes (N), *Arca* (*Cunearca*) *incongrua* Say (P), *Argina pexata* Say (P), *Navicula umbonata* Lamarck (P?), *Navicula wagneriana* (Dall) (C), *Fossularca adamsi* Dall, *Noetia ponderosa* (Say) (P), *Ostrea sculpturata* Conrad, *Ostrea virginica* Gmelin (P), *Ostrea* aff. *O. trigonalis* Conrad, *Pecten eboreus senescens* Dall, *Pecten evergladensis* cf. *charlottensis* Mansfield (C), *Pecten eboreus solarioides* Heilprin (W), *Pecten ernestsmithi* Tucker (N), *Amusium mortoni* Ravenel, *Plicatula marginata* Say, *Anomia simplex* D'Orbigny, *Modiolus* cf. *M. gigantoides* Olsson (W), *Astarte concentrica* bella Conrad, *Crassinella dupliniana* Dall, *Crassinella lunulata* (Conrad), "*Eucrassatella*" *gibbesii* (Tuomey and Holmes), "*Eucrassatella*" *mansfieldi* MacNeil (C, N,W), *Cardita arata* (Conrad), *Venericardia granulata* Say, *Venericardia tridentata* Say, *Chama striata* Emmons, *Echinochama arcinella* (Linnaeus), *Phacoides radians* (Conrad), *Phacoides anodonta* (Say), *Diplodonta acclinis* Conrad, *Laevicardium sublineatum* (Conrad), *Cardium* cf. *isocardia* Linnaeus, *Cardium muricatum* Linnaeus (P), *Chione latilirata* Conrad, *Chione cribraria* (Conrad), *Chione cancellata* (Linnaeus), *Venus campechiensis permagna* Conrad, *Venus mercenaria* Linnaeus, *Macrocallista reposta* Conrad, *Tellina* cf. *T. propetenella* Dall, *Macoma balthica* Linnaeus (P), *Semele bella-striata* Conrad (C), *Semele proficua* Pulteney (P), *Semelina nuculoidea* Conrad (P?), *Tagelus gibbus* Spengler (P), *Spisula* aff. *similis* Say, *Mulinia lateralis* Say, *Corbula inaequalis* Say, *Barnea costata* Linnaeus (P).

The capital letters used in the preceding list are explained as follows: (P) probably Pleistocene; (C) present also in the Caloosahatchee marl (Pliocene) of western Florida but not previously reported from the Waccamaw formation in the adjacent area to the west of the canal; (N) present also in the Pliocene at Neills Eddy Landing, 5 miles N. E. of Acme, N. C.; (W) present also in the Pliocene in the upper bed at the north shore of Lake Waccamaw, N. C. Most of the species not followed by a letter probably came from the Pliocene as many of the specimens are incrusted with a hard matrix.

The close relationship of the Pliocene fauna or faunas dredged from the canal, to that of the Caloosahatchee marl of western Florida, to that at Neills Eddy Landing on Cape Fear River, N. C., and to that in the uppermost bed on the north shore of Lake Waccamaw, N. C., is indicated by the common occurrence at those localities of certain of the species as indicated in the list. The presence of *Navicula wagneriana* (Dall) is of particular interest as it has been known heretofore only in the Caloosahatchee marl.

No specimens of the genus *Rangia* were collected from the spoil banks. The apparent absence of this genus, which inhabits shallow water, may indicate open and moderately deep water conditions for this area, during Pliocene and Pleistocene time.

Three species of mollusks (identified by W. C. Mansfield)—*Pecten ernestsmithi* Tucker, *Pecten eboreus senescens* Dall, and *Scaphella* (*Aurinia*) *floridana* (Heilprin), and one species and three specifically unnamed genera of echinoids—*Rhyncholampus evergladensis* (Mansfield), a *Clypeaster*, an *Encope* and a *Coelspleurus*, are recorded by Cooke[3] from this locality.

PALEONTOLOGY.—*A new subspecies of* Pecten *from the upper Miocene of North Carolina.*[1] W. C. MANSFIELD, U. S. Geological Survey.

In April, 1936, F. S. MacNeil and the writer obtained additional specimens of *Pecten*, among other material, from exposures along the Chowan River in Bertie and Hertford Counties, eastern North Carolina. The *Pecten* from certain localities, as noted below, was referred by the writer[2] to *P.* (*Chlamys*) *eboreus eboreus* Conrad, but he now believes, after procuring better specimens for comparison, that it should be referred to a new subspecies—*P. eboreus bertiensis*, described as follows:

Pecten (Chlamys) eboreus bertiensis Mansfield, n. subsp. Figs. 1–3

Shell large, thin, ovate, inequilateral; hinge line rather short; left valve much more inflated than right; ornamented with 24 to 25 ribs. Right valve of cotype low, ornamented with 25 flat ribs, which are medially shallowly incised over the middle part of the disk and separated by shallow interspaces which are a little narrower than the ribs. The concentric lamellae are moderately coarse. Right ear shallowly insinuated and marked with 5 rather strong radials, those near the hinge line being the stronger; left ear with 11 moderately strong radials. Left valve of cotype with 25 ribs, narrower than interspaces and medially sulcated over the middle part of the disk and nearly flat ventrally. Both ears with about 7 radials.

Dimensions of cotypes (U.S.N.M. no. 496224): Right valve, length 86 mm; height 80 mm; convexity 11 mm; length of hinge line 44 mm. Left valve, length 95 mm; height 88 mm; convexity 24 mm; length of hinge line 50 mm.

Type locality: Station 11999, from bed exposed at beach to 10 feet above in right bank of Chowan River, three-fourths of a mile below Mount Gould Landing, Bertie County, North Carolina.

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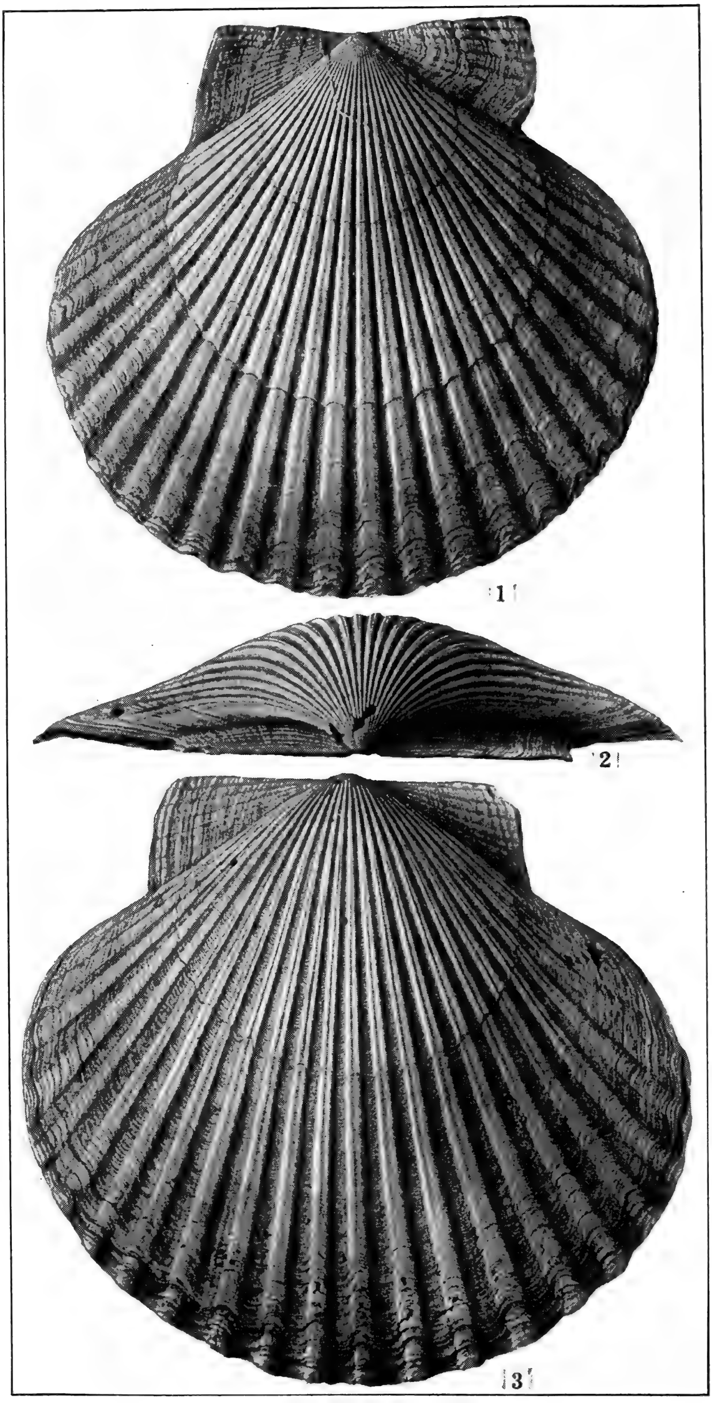
[3] COOKE, C. W. *Geology of the Coastal Plain of South Carolina.* U. S. Geol. Survey Bull. **867**: 126. 1936.

[1] Published by permission of the Director of the U. S. Geological Survey. Received December 2, 1936.

[2] MANSFIELD, W. C. *Stratigraphic significance of Miocene, Pliocene, and Pleistocene Pectinidae in the southeastern United States.* Jour. Paleontology **10** (3): 175, stratigraphic position 17, 1936.



Figs. 1–3.—*Pecten* (*Chlamys*) *eboreus bertiensis* Mansfield. n. subsp. Cotypes. 1, right valve. 2, 3, left valve. Slightly reduced.

The new subspecies intergrades with *Pecten eboreus eboreus* Conrad and *P. eboreus darlingtonensis* Dall, but it is more closely related to the former than to the latter. The left valve of the new subspecies is more inflated than the same valve of either of the above subspecies, and it is marked with incised ribs which neither one possesses.

Other occurrence in North Carolina: Station 12035 (lower bed), station 13814 (upper bed), Colerain Landing, Bertie County; station 1/1230, Tar Ferry, Wiccacon Creek, Hertford County; station 13798, upper bed at Beaver Dam Creek, Martin County; station 12004, Poplar Landing, Martin County.

The beds in which the new subspecies occurs are placed in the uppermost Miocene of North Carolina and are believed to have been deposited at a little later time than the Suffolk beds in Virginia at the north and about the same time as the Dupoin marl at the south.

ZOOLOGY.—*Notes on Chinese spiders of the families Salticidae and Thomisidae.*[1] IRVING FOX. (Communicated by C. F. W. MUESEBECK.)

The following notes and descriptions of new species represent continuation of a report on several collections of Chinese spiders in the possession of the United States National Museum. These spiders were collected chiefly by Dr. D. C. Graham in Szechwan Province, China, during the years 1923 to 1930. Several others taken by Mr. N. Gist Gee at Soochow, Kiangsu Province, are also considered in this paper.

Family SALTICIDAE

Myrmarachne grahami, n. sp. Figs. 1, 2

Female.—Total length, 7.13 mm. Chelicerae, .72 mm long. Carapace, cephalic part, 1.39 mm long, 1.29 mm wide, thoracic part, 1.29 mm long, 1.09 mm wide. Pedicel, .59 mm long. Abdomen, 3.97 mm long, 1.98 mm wide. Dorsum of the carapace dark brown, sides with a blackish tinge. The furrow that separates the two parts bears white wedge-shaped marks. Chelicerae brown, much lighter than the carapace. Endites orange with fringes of dark hair anteriorly, labium dark basally, whitish distally. Sternum dark brown contrasting strongly with the coxae which are yellowish. Legs orange; upper portion of the femora, the patellae, and tibiae of legs I with distinct dark longitudinal bands at the lateral surfaces; legs II having much less distinct lateral bands; legs III without lateral bands but with the coxae and femora darker at their distal ends. Dorsum of the abdomen blackish with numerous golden hairs, basally with an indistinct transverse stripe. At the basal third clear transverse light bands, one on each side, extend laterad from the dorsum, broaden at the sides and finally are lost in the light

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[1] Received April 11, 1936.

venter. The venter bears a broad dark longitudinal band extending from the epigastric furrow to the spinnerets.

First row of eyes recurved, the eyes more or less contiguous, the median twice as large as the lateral. Ocular quadrangle wider than long (31/28), occupying about one-third the total length of the carapace. The eyes of the second row very small, closer to the anterior laterals than to the posterior laterals. Upper margin of the chelicerae armed with six teeth of which five are robust while the basal is weak, lower margin armed with seven teeth of which the basal five are close together while the other two are separated.

First pair of legs with 2-2-2-2 spines on the tibiae below, and 2-2 on the metatarsi below. Second pair of legs with 2-2-2 spines on the tibiae below and 2-2 spines on the metatarsi below. The third and fourth pairs are without spines. Legs, I, 4.18 mm; II, 2.96 mm; III, 3.52 mm; IV, 5.16 mm. For the structure of the epigynum see Fig. 2.

Type Locality.—China: female holotype from Suifu, Szechwan, Province 1000 ft., April 25, 1930 (D. C. Graham). Female paratype from Soochow, Kiangsu, Province (N. Gist Gee). *Type:* U.S.N.M. Cat. No. 1163.

This spider is related to *M. japonica* (Karsch) and resembles it in general coloration. It differs from that species, however, in the structure of the epigynum.

Myrmarchne gisti, n. sp. Figs. 4, 9, 12, 14

Female.—Total length, 8.02 mm. Chelicerae, .8 mm long. Carapace, cephalic part, 1.20 mm long, 1.16 mm wide, thoracic part, 1.36 mm long, .92 mm wide. Pedicel, 1.12 mm long. Abdomen, 3.86 mm long. 2.57 mm wide. Dorsum of the carapace dark and reddish brown, the cephalic part much darker than the thoracic and contrasting strongly with it. In the furrow that separates the two parts is found a wedge shaped mark on each side. Chelicerae concolorous with the thoracic part being reddish brown. Palpi with the basal joints brown while the distal have a bluish tinge and are distinctly iridescent. Labium and endites brown, sternum somewhat darker. Legs I clear whitish yellow above and below, with distinct bands on the prolateral surfaces of the basal portion of the femora, the patellae, tibiae, and metatarsi. Legs II the same as I except that the lateral bands are less distinct. Legs III with the coxae, trochanters, and femora dark brown above and below, the other joints concolorous with legs I and II except for a dark spot at the junction of the patella and tibia above. Legs IV with the coxae and trochanters clear whitish yellow above and below but darker at the sides; the femora, distal portions of the patellae, tibiae, and metatarsi brown. Basal third of the abdomen whitish or buff, giving off posteriorly a more or less triangular mark which is bifurcate at the broad side. Middle third of the abdomen dark brown, outlined anteriorly by the whitish basal third and posteriorly by a broad buff portion which is as wide as the dorsum at that place (Fig. 4). Distal portion of the abdomen dark brown, concolorous with the middle third. Venter of the abdomen with a wide median dark band that begins at a point farther than usual below the epigastric furrow and extends to the spinnerets. The space between the epigastric furrow and the beginning of the median band is clear white in color.

First row of eyes slightly recurved, the median eyes contiguous and more than twice as large as the lateral. Ocular quadrangle wider than long (32/25), wider behind than in front (32/29), and occupying about one-third the total length of the cephalothorax. Eyes of the second row very small, closer to the anterior lateral than to the posterior lateral. Upper margins of the chelicerae armed with seven well separated teeth of which the basal three are diminutive while the distal four are robust; the animal's left chelicera armed with eight teeth on the lower margin of which the basal five are close together, animal's right chelicera armed with seven teeth. Legs, I, 4.08 mm; II, 3.32 mm; III, 3.68 mm; IV, 5.60 mm.

First pair of legs with 2-2-2-2 spines on the tibiae below, and 2-2 on the metatarsi below. Second pair of legs with 2-2-2 spines on the tibiae below, and 2-2 spines on the metatarsi below. The third and fourth pairs are without spines. For the structure of the epigynum see Fig. 14.

Male.—Total length, 8.71 mm. Chelicerae, 2.02 mm long, Carapace, cephalic part, 1.70 mm long, 1.50 mm wide, thoracic part, 1.32 mm long, 1.14 mm wide. Pedicel, .35 mm long. Abdomen, 3.07 mm long, 1.06 mm wide. Carapace light brown above, the cephalic part somewhat darker than the thoracic, the eyes on dark spots. Sides lighter, bearing at the furrow that separates the two parts a wedge-shaped mark consisting of white hairs. Chelicerae light brown, concolorous with the thoracic part of the carapace. Sternum and endites light brown, the labium darker, these parts contrasting strongly with the coxae and trochanters of the anterior pairs of legs which are almost white. Dorsum of the abdomen like the female in its coloration having a broad buff portion distally and a dark brown middle third, the design at the basal third not so distinct as in the female (Fig. 9). Abdomen constricted anteriorly and bearing light bands which run laterad in the margin of the constriction. Venter lightest at the epigastric furrow, thereafter darkening posteriorly, bearing evidences of a median longitudinal dark band.

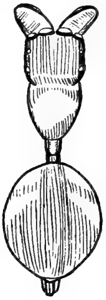
First row of eyes recurved, the anterior median closer to each other than to the anterior lateral and about twice the size of the latter. Eyes of the second row very small, closer to the anterior lateral than to the posterior lateral being removed from the former by a distance about five-sevenths as large as that which separates them from the latter. Ocular quadrangle wider than long (30/24), occupying more than one-third the total length of the cephalothorax, about as wide in front as behind. Chelicerae roughly wedge shaped, without a distinct lower margin, upper margin armed with ten teeth, of which the most distal points foward while the others are directed inward. For further details regarding the arrangement of the teeth see Fig. 12. The first pair of legs lacking, the second bears 1r-1r spines on the tibiae below. Legs, II, 3.27 mm; III, 4.10 mm; IV, 5.86 mm.

The palpal organ is characteristic of the genus, and presents little or no distinguishing features.

Type Locality.—China: female holotype and male allotype from Soochow, Kiangsu Province (N. Gist Gee). *Type:* U.S.N.M. Cat. No. 1164.

The unique design on the dorsum of the abdomen of this spider will serve to distinguish it from other oriental species of the genus.

Fig. 1.—*Myrmarachne grahami*, n. sp., female, dorsal view. Fig. 2.—*Myrmarachne grahami*, n. sp., epigynum. Fig. 3.—*Xysticus ephippiatus* Simon, epigynum. Fig. 4.—*Myrmarachne gisti*, n. sp., female, dorsal view. Fig. 5.—*Xysticus sicus*, n. sp., epigynum. Fig. 6.—*Myrmarachne vehemens*, n. sp., male, dorsal view. Fig. 7.—*Plexippus optabilis*, n. sp., epigynum. Fig. 8.—*Thomisus transversus*, n. sp., epigynum. Fig. 9.—*Myrmarachne gisti*, n. sp., male, dorsal view. Fig. 10.—*Myrmarachne vehemens*, n. sp., male, right chelicera. Fig. 11.—*Xysticus croceus*, n. sp., epigynum. Fig. 12.—*Myrmarachne gisti*, n. sp., male, left chelicera. Fig. 13.—*Rhene candida*, n. sp., male palpus. Fig. 14.—*Myrmarachne gisti*, n. sp., epigynum. Fig. 15.—*Rhene ipis*, n. sp., male palpus.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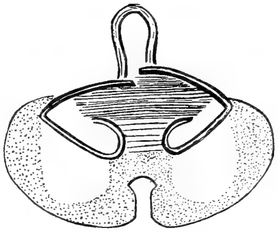
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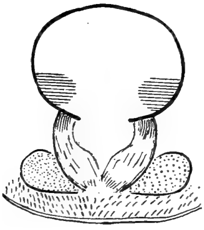
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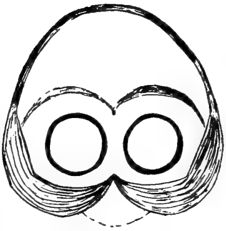
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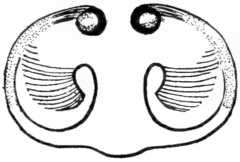
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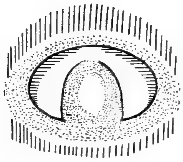
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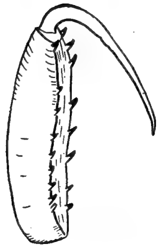
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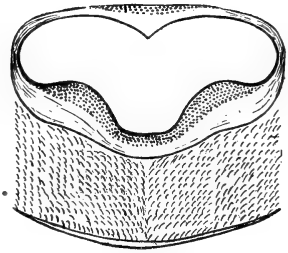
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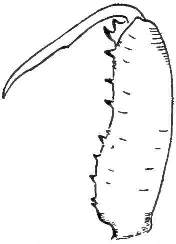
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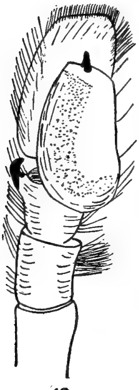
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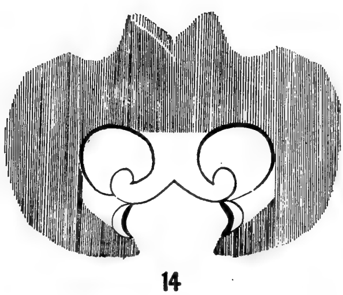
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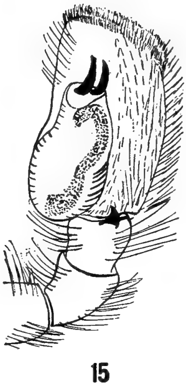
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For explanation of Figs. 1–15, see bottom of opposite page.

Myrmarachne vehemens, n. sp. Figs. 6, 10

Male.—Total length, 7.62 mm. Chelicerae, 2.48 mm long. Carapace, cephalic part, 1.54 mm long, 1.63 mm wide, thoracic part, 1.19 mm long, 1.45 mm wide. Pedicel, .13 mm long. Abdomen, 2.90 mm long, 1.45 mm wide. Carapace uniform dark brown above, the sides and the suture separating the two parts somewhat lighter. Eyes on dark spots, the spaces between those of the anterior row and the clypeus densely clothed with white hairs. Chelicerae lighter, of a reddish-brown hue, oblong and parallel extending directly forward. Sternum, coxae, and endites light brown, labium somewhat darker. Legs light brown above, the tibiae of the first and last pairs darker than the other joints. Abdomen dark brown above and at the sides, anteriorly with a well defined constriction whose margins are much lighter than the dorsum and the sides. Venter with a broad longitudinal dark band extending from the epigastric furrow to the spinnerets.

First row of eyes recurved, the anterior lateral separated from the anterior median, which are subcontiguous, by about three-fourths their diameter and much smaller than the latter (5/8). Eyes of the second row very small, closer to the anterior lateral than to the posterior lateral being removed from the former by a distance about five-eighths as large as that which separates them from the latter. Ocular quadrangle wider than long (32/27), somewhat wider behind than in front (32/30), occupying more than one-third the total length of the carapace. Upper cheliceral margin armed with eight robust teeth, lower margin armed with nine smaller teeth (Fig. 10). The legs are without spines below. Legs, I, 5.24 mm; II, 3.66 mm; III, 4.40 mm; IV, 6.42 mm.

Palpus characteristic of the genus presenting no important distinguishing features; in general it is similar to that of *M. lugubris* (Kulcz.).

Type Locality.—China: male holotype from Soochow, Kiangsu Province. (N. Gist Gee). *Type:* U.S.N.M. Cat. No. 1165.

This species is allied to *M. patellata* Strand, but differs from it in the dental armature and in lacking spines on the first tibiae below.

MYRMARACHNE INNERMICHELIS Bösenberg and Strand

Myrmarachne innermichelis Bösenberg and Strand. Abh. Senckenb. Ges. **30:** 329 pl. 9, fig. 128, pl. 14, fig. 382, 1906.

Record.—China: Kiangsu Province, Soochow, male (N. Gist Gee).

MYRMARACHNE 7-DENTATA STRAND

Myrmarachne maxillosa var. *7-dentata* Strand. Zoologischer Anzeiger **31:** 568, 1907.

Record.—China: Szechwan Province, Suifu, 1000 ft. October, 1930, male (D. C. Graham).

Plexippus optabilis, n. sp. Fig. 7

Female.—Total length, 7.32 mm. Carapace, 3.27 mm long, 2.38 mm wide. Abdomen, 3.76 mm long, 2.47 mm wide. Dorsum of the carapace blackish for about a third of the length where the black region ends in an inverse triangle which provides an apex for a much lighter portion at the middle third. In this lighter portion are indications of a longitudinal line which gives off several branches on each side. The basal third of the carapace dark brown, expanding laterad along the sides giving them a brownish color. Clypeus light with numerous long hairs. Chelicerae, sternum, and endites light brown, labium darker; coxae concolorous with the sternum but bearing dark markings at the sides. Legs orange, more or less annulate at the distal ends of the femora, patellae, and tibiae above; femora of the third and fourth pairs of legs with broad dark longitudinal bands on the prolateral surfaces. Dorsum of the abdomen with a median light band having anteriorly a longitudinal dark line, and breaking posteriorly into four large spots. Sides of the abdomen black and white, the white forming three more or less distinct stripes. Venter light with a distinct longitudinal dark band which is herringbone in pattern posteriorly.

First row of eyes slightly recurved, the medians closer to each other than to the laterals and about twice their size. Eyes of the second row midway between the anterior lateral and posterior lateral. Ocular quadrangle wider than long (43/32), about twice as wide before as behind, occupying more than one-third the total length of the carapace. Posterior lateral eyes about as large as the anterior lateral. Clypeus narrow, one-third the diameter of an anterior lateral eye. Each chelicera armed with a robust black tooth on the lower margin.

Tibiae I and II with 2-2-2 spines below, 1-1 on the prolateral surfaces, none above, metatarsi I and II with 2-2 spines below, none elsewhere; tibiae III and IV with 1-2 spines below, 2-2-2 above, metatarsi III and IV with 2-2 spines below, 2-2 above and 1 apical spine on each lateral surface. Legs, I, 5.00 mm; II, 4.24 mm; III, 5.56 mm; IV, 5.44 mm. For the structure of the epigynum see Fig. 7.

Type locality.—China: female holotype from Suifu, Szechwan Province, 1000 ft., October, 1930 (D. C. Graham). *Type:* U.S.N.M. Cat. No. 1166.

This species is referred to *Plexippus* because of its resemblance to *P. setipes* Karsch in general character. It differs from that species in the structure of the epigynum which is wider than long.

PLEXIPPUS CRASSIPES Karsch

Plexippus crassipes Karsch. Berliner Entom. Zeitschrift. **25**: 38. 1881.

Record.—China: Szechwan Province, Gongoshien, August 1, 1934, female (D. C. Graham).

PLEXIPPUS SETIPES Karsch

Plexippus setipes Karsch. Verh. Ver. Rheinl. **36**: 89. 1879.

Record.—China: Kiangsu Province, Soochow, 6 females (N. Gist Gee).

PLEXIPPUS PAYKULLI (Audouin)

Attus paykulli Audouin in Savigny, descr. Egypte **22**: 172. 1827.

Hyllus mimus Chamberlin. Proc. United States Nat. Mus. **63**: 33, pl. 7, fig. 50, 1924.

Records.—China: Szechwan Province, Suifu, 1000, ft., June 1925, female; Kiating, June, 1924, female (D. C. Graham). Kiangsu Province, Soochow, male (N. Gist Gee).

TELAMONIA BIFURCILINEA Bösenberg and Strand

Telamonia bifurcilinea Bösenberg and Strand. Abh. Senckenb. Naturf. Ges. **30**: 331 pl. 9, fig. 153, pl. 13, fig. 357, 1906.

Record.—China: Szechwan Province, Chungking, 2000 ft., May 6, 1930, female (D. C. Graham).

EVARCHA ALBARIA (L. Koch)

Hasarius albarius L. Koch. Verh. Zool-Bot. Ges. Wien **27**: 780 pl. 16, fig. 39, 1877.

Record.—China: Szechwan Province, South of Suifu, March 25, 1930, male (D. C. Graham).

Rhene ipis, n. sp. Fig. 15

Male.—Total length, 5.74 mm. Carapace, 2.38 mm long, 2.87 mm at the widest place. Abdomen, 3.37 mm long. 2.47 mm wide. Dorsum of the carapace with a median dark brown portion which is as wide as the first row of eyes anteriorly, and which tapers thereafter to the third eye row where it expands again so that it has almost its anterior width at the caudal end of the carapace. The regions about the posterior eyes are reddish. Surrounding all the eyes but present most thickly at the anterior row are numerous white hairs. Sides of the carapace dark brown with white hairs. Clypeus thickly covered with white hairs. Sternum, basal portion of the endites, and labium dark brown, distal portion of the labium and endites light brown. Legs more or less concolorous with the sternum below, the coxae are somewhat lighter. First pair of legs much heavier and darker than the others. Femora of the posterior legs contrasting strongly with the other joints which are lighter. Abdomen light brown above, with three pairs of large dark pits, posteriorly are indications of lateral white hairs. Sides of the abdomen with white hairs, more concentrated anteriorly. Venter light brown, sparsely clothed with white hairs.

First row of eyes recurved, the medians closer to each other than to the laterals and more than twice their size. Eyes of the second row small, very close to the anterior lateral eyes being removed by about a diameter of the latter. Third row of eyes slightly smaller than the width of the carapace at that place, the eyes somewhat larger than the anterior lateral. Ocular quadrangle wider than long (56/42), much narrower in front than behind (40/56), occupying about four-fifths of the entire length of the cephalothorax. Clypeus equal in height to about one-half the diameter of an anterior lateral eye. Chelicerae with a single dark robust tooth on the lower margins. Anterior tibiae and metatarsi with 2-2 spines below. Legs, I, 6.60 mm; II, 3.92 mm; III, 4.00 mm; IV, 4.56 mm.

The tibia of the palpus bears a small black apophysis distally. The bulb itself is provided with two processes anteriorly which are arranged so as to be pincer-like. For further details regarding the structure of the palpus see Fig. 15.

Type locality.—China: male holotype from between Kiating and Yachow, Szechwan Province, July 29, 1929; male paratype from Suifu, Szechwan Province, September, 1929; two male paratypes from Mupin, Szechwan Province, 3500 ft., July, 1929 (D. C. Graham). *Type:* U.S.N.M. Cat. No. 1167.

This species is allied to *R. atrata* (Karsch), but differs from that species in lacking a distinct and conspicuous design on the dorsum of the abdomen.

Rhene candida, n. sp. Fig. 13

Male.—Total length, 5.44 mm. Carapace, 2.67 mm long, 2.67 mm wide. Abdomen 2.97 mm long, 2.28 mm wide. The coloration of the carapace is similar to that of the previous species, *R. ipis,* but the central portion is not so clearly demarcated from the lateral. In general the dorsum bears much fewer hairs, and in the alcoholic specimen these are not white. Sides of the carapace with distinct marginal stripes of white hairs. Each chelicera bears at its basal third a broad transverse band of white hairs. Sternum, coxae, labium and endites dark brown, labium with the distal portion lighter. The first pair of legs much darker and heavier than the others which are light brown below. The tarsi lighter, with black spots at the basal and distal ends. Dorsum of the abdomen light brown with indications of characteristic dark pits. The caudal end of the abdomen bears a pair of white bars on each lateral surface. Venter light brown with a white pubescence.

First row of eyes recurved, the medians closer to each other than to the laterals and about twice their size. Eyes of the second row very small, removed from the anterior lateral eyes by a distance greater than the diameter of the latter (6/5). Third row of eyes as wide as the carapace at that place, the eyes the same size as the anterior lateral. Ocular quadrangle wider than long (55/42), much narrower in front than behind (37/55), occupying about two-thirds the total length of the cephalothorax. Clypeus equal in height to three-fifths the diameter of an anterior lateral eye. Chelicerae with a single dark robust tooth on the lower margins. Tibiae and metatarsi I with 2-2 spines below. Legs, I, 5.20 mm; II, 3.80 mm; III, 3.68 mm; IV, 4.32 mm.

The bulb of the palpus is similar to that of *R. ipis*, but differs in the possession of a single, poorly defined process anteriorly rather than two processes. The tibial apophysis is pronounced and hook-like. For further details regarding the palpus see Fig. 13.

Type Locality.—China: male holotype from Suifu, Szechwan Province. September, 1929, (D. C. Graham). *Type:* U.S.N.M. Cat. No. 1168.

This species is readily identifiable by the broad, transverse bands of white hairs on the chelicerae.

Family THOMISIDAE

Xysticus croceus, n. sp. Fig. 11

Xysticus ephippiatus Bösenberg and Strand. Abh. Senckenb. Naturf. Gesell. **30**: 261, pl. 10, fig. 161, 1906 (not *Xysticus ephippiatus* Simon).

Female.—Total length, 7.92 mm. Carapace, 3.36 mm long, 3.17 mm wide. Sternum, 1.56 mm long, 1.16 mm wide. Abdomen, 4.65 mm long, 4.55 mm wide. Carapace with a median longitudinal light band about one-third its width which encloses two reddish brown parallel lines that originate between the posterior median eyes and extend to the middle of the cephalothorax. Sides of the carapace reddish brown, interrupted by a light submarginal stripe on each side. Sternum yellow with reddish maculations, labium and endites concolorous with the sternum, maculations on the coxae more dense except for clear basal and median portions. Femora of the anterior legs heavily punctate with reddish brown, those of the posterior legs much lighter, with large red spots on the preaxial surfaces; nearly all the joints with reddish brown spots at their distal ends. Each leg bears above a more or less distinct light stripe extending its length. The abdomen, which is in poor condition, is reddish brown with thin indistinct stripes at the edges, the venter and sides are lighter.

Eye rows strongly recurved, the first narrower than the second (40/45). Ratio of eyes: ALE:AME:PLE:PME = 5.5:3:4:3. Anterior median eyes separated by more than three times their diameter, twice their diameter from the laterals. Posterior median eyes removed from each other and from the posterior lateral eyes by more than three diameters. Median ocular area slightly wider than long (17/16), as wide in front as behind. Clypeus about two and one-half times the diameter of an anterior median eye.

Legs heavily spined; tibiae I with 2–1p–2–2–2–1p–2–2–2 spines of various sizes below; tibiae II with six pairs of spines below; metatarsi I and II with 2–2–1r–2–2–2 spines below. Legs, I, 9, 12 mm; II, 9.12 mm; III, 5.88 mm; IV, 6.36 mm.

Epigynum broader than long, transverse, the sides heavily chitinized. There is no chitinized portion extending caudad almost to the epigastric furrow.

Type locality.—China: Female holotype from Suifu, Szechwan province, 1922 (D. C. Graham). *Type:* U.S.N.M. Cat. No. 1169.

This species was regarded as *X. ephippiatus* Simon by Bösenberg and Strand, the differences in the epigyna and spinal armature being explained on the basis of injury and technique of handling. The discovery of a Chinese spider that corresponds closely with the description of Simon's species together with another that appears to be identical with that of Bösenberg and Strand makes it apparent that two species are involved. These two spiders, *X. croceus*, new species, and *X. ephippiatus* Simon differ greatly in the structure of the epigyna, and are readily distinguished by these characters alone. Below *X. ephippiatus* Simon is redescribed, and details regarding the two epigyna are shown in Figs. 3 and 11.

XYSTICUS EPHIPPIATUS Simon Fig. 3

Xysticus ephippiatus Simon. Ann. Soc. Ent. France **10** (Ser. 5): 107, pl. 3, fig. 6, 1880.

Female.—Total length, 9.40 mm. Carapace, 3.46 mm long, 3.46 mm wide. Sternum 1.36 mm long, 1.16 mm wide. Abdomen, 6.14 mm long, 6.44 wide. Carapace reddish with the characteristic median light band bearing three reddish streaks that originate between the posterior median eyes and extend to the thoracic groove. From the groove a reddish bar extends obliquely cephaled on each side. Sides of the carapace reddish with lighter submarginal stripes and darker marginal ones. Clypeus and chelicerae with robust black hairs of various size projecting forward. Sternum reddish brown, the labium, endites, and coxae much lighter being yellowish. Legs concolorous with the sternum, the posterior pairs lighter than the anterior, all the legs lighter below than above. Abdomen dark reddish brown above, venter somewhat lighter.

Eye rows recurved, the first narrower than the second (39/46). Ratio of the eyes ALE:AME:PLE:PME = 6:3:4:3. Anterior median eyes removed from each other by more than three and one-half diameters, from the anterior lateral by two diameters. Eyes of the second row equidistant, separated by less than four times the diameter of a posterior median eye. Median ocular quadrangle wider than long (17/15), as wide in front as behind. Clypeus equal in height to about three times the diameter of an anterior median eye.

Legs heavily spined with the spinal armature irregular. The animal's right tibia I with 2–2–1p–2–2–2, right metatarsus I with 1p–2–2–1p–2–2–2 spines below, the animals left tibia I with 2–2–1p–2–2–2–2, left metatarsus I with 1p–2–2–2–2–2 spines below. Tibiae II with 2–2–2–2–2 spines below, right metatarsus II with 2–2–2–2–2–2, left metatarsus II with 1p–2–2–1p–2–2–2 spines below. Legs, I, 9.88 mm; II, 9.88 mm; III, 5.96 mm; IV, 6.20 mm.

Epigynum oval, with a chitinous extension extending caudad about half the distance to the epigastric furrow. For further details regarding the epigynum see Fig. 3.

Record.—China: Szechwan Province, Yao- Gi, Mupin, 8000 ft., July 14, 1929, female (D. C. Graham).

Xysticus sicus, n. sp. Fig. 5

Female.—Total length, 7.62 mm. Carapace, 2.67 mm long, 2.77 mm wide, 1.62 mm wide in front. Abdomen, 5.04 mm long, 4.95 mm wide. Carapace with a broad median whitish band beginning at the anterior median eyes, expanding to include the lateral eyes, narrowing behind them, and then expanding again making the anterior portion shield-like. Posteriorly the band gives off wings so that the caudal border of the carapace is provided with a broad submarginal stripe; at the junction of each lateral wing with the central band is a large black spot above and below. The cephalic portion of the band with a complex design consisting of a reddish lanceolate of dagger-shaped mark on a brownish shield-shaped background. Sides of the carapace reddish with white spots. Clypeus brown below the lateral eyes, but whitish below the median. Chelicerae tan with whitish spots basally, much lighter distally. Labium and endites reddish brown lighter at the centers. Sternum whitish, maculate with red. Legs white and reddish, with the reddish predominating, distal portion of the femora with noticeable black spots above. Abdomen whitish, densely provided with red spots and markings.

First row of eyes recurved, the median much closer to the lateral than to each other, about half as large as the lateral. The posterior row recurved, the median eyes nearer to each other than to the laterals, and about two-thirds as large. Anterior and posterior eyes on well developed tubercles. Median ocular quadrangle broader than long (15/12), slightly wider in front than behind, the eyes subequal. Clypeus much higher than the diameter of an anterior lateral eye (8/5).

Legs spinose, although there are absences due to injury the arrangement seems to be as follows: the first two tibiae armed below with five pairs of robust spines, the last two with three pairs of weak ones, the first two metatarsi with five pairs beneath, the last two with two pairs of spines of which one pair is apical. Legs I, 8.71 mm; II, 8.71 mm; III, 5.88 mm; IV, 7.15 mm. For the structure of the epigynum see Fig. 5.

Type locality.—China: female holotype from Mupin, Szechwan Province, 3500 ft., July, 1929. *Type:* U.S.N.M. Cat. No. 1170.

This species is closely allied to *Xysticus lateralis atrimaculatus* Bösenberg and Strand, but differs from that species in having the epigynum provided with a pair of heavily chitinized orifices that almost completely fill the basal half of the atrium.

XYSTICUS TUNICATUS Bösenberg and Strand

Xysticus tunicatus Bösenberg and Strand. Abh. Senckenb. Naturf. Ges. **30:** 263, pl. 10, fig. 176, 1906.

Record.—China: Szechwan Province, Summer, 1930, 3 females (D. C. Graham).

XYSTICUS SAGANUS Bösenberg and Strand

Xysticus saganus Bösenberg and Strand. Abh. Senckenb. Naturf. Ges. **30:** 261 pl. 10, fig. 155, 1906.

Record.—China: Szechwan Province, between Kiating and Yachow, 1200 ft. July 29, 1929, male (D. C. Graham).

Thomisus transversus, n. sp. Fig. 8

Female.—Total length, 8.91 mm. Carapace, 3.86 mm at the widest place, 2.28 mm wide in front, 3.56 mm long. Abdomen, 6.04 mm long, 10.00 mm wide. Carapace reddish with a longitudinal median white band which diverges anteriorly giving off a thin stripe on each side of which is a semicircular mark. Sides of the carapace with indications of lighter stripes. Sternum, labium and endites yellowish brown. Legs concolorous with the sternum except for the tibiae of the posterior pairs which are dark brown contrasting strongly with the other joints. Abdomen yellowish white, darker at the anterior edges, with a dark median stripe. The five characteristic spots are present, one at the anterior edge of the dark median stripe and two on each side. Venter somewhat darker than the dorsum, bearing two longitudinal rows of three spots in the space between the epigastric furrow and the spinnerets.

First row of eyes recurved, narrower than the second row, which is also recurved, in the ratio of 5:6. Anterior median eyes two-thirds as large as the anterior lateral, and removed from each other by a distance eleven-fifteenths as great as that which separates them from the anterior lateral. Posterior median eyes two-thirds as large as the posterior lateral, and removed from each other by a distance greater than that which separates them from the posterior lateral (24/15). Median ocular quadrangle wider than long (28/16), narrower in front than behind (17/28). Clypeus slightly less in height than the length of the median ocular quadrangle (13/16).

Legs sparsely spinose; tibia I with 1p–1p–1p–2–1p spines below, Tibiae II with 1p–2 spines below. Legs, I, 10.74 mm; II, 10.64 mm; III, 6.37 mm, IV, lacking.

Epigynum small, resembling that of *T. onustoides* Bösenberg and Strand, but differing in the possession of a narrower septum which arises at the caudal border rather than the anterior. For further details regarding the epigynum see Fig. 8.

Type locality.—China: female holotype from Shin kai Shi, Szechwan province, 4000 ft., July 6, 1934 (D. C. Graham). U.S.N.M. Cat. No. 1171

THOMISUS ONUSTOIDES Bösenberg and Strand

Thomisus onustoides Bösenberg and Strand Abh. Senckenb. Naturf. Ges. **30:** 251, pl. 10, fig. 166, 1906.

Record.—China: Szechwan Province, between Suifu and Kiating, June 2, 1930, male (D. C. Graham).

MISUMENA TRICUSPIDATA (Fab.)

Aranea tricuspidata Fabricius. *Systema entomologia,* p. 433, 1775.

Records.—China: Szechwan Province, Suifu, 1000 ft. May 25, 1930, 2 females; October, 1930, one male; Chungking, 2000 ft., May 6, 1930, 2 females (D. C. Graham).

ZOOLOGY.—*Polychaetous annelids collected by Captain Robert A. Bartlett in Greenland, Fox Basin, and Labrador.*[1] A. L. TREADWELL, Vassar College. (Communicated by WALDO L. SCHMITT.)

This report is based on the polychaetous annelids collected by Captain Robert A. Bartlett on the east and west coasts of Greenland, Fox Basin, and the coast of Labrador. It has earlier been noted (Moore 1902) that the Greenland polychaets have been thoroughly studied by European investigators and, as was to be expected, few new species appear in the present collection. Many species of the regions visited occur on both the east and west shores of the Atlantic, as recorded in the elaborate monographs on the British Annelids by Wm. C. McIntosh. For most of the species listed below I have attempted to give only the references to the original description and to McIntosh's account. The collection comprises sixteen families, twenty-five genera, and twenty-nine species, of which four, *Harmothoe levis, Oophylax minuta, Nereis* (*Cerantonereis*) *bartletti* and *Pista groenlandica* are new to science.

Because of the presence of numerous setae in the stomach of a bearded seal, *Erignathus barbatus,* from Fox Basin a portion of the contents was submitted to me for examination. This material contained a good deal of what in land mammals we would call "hair balls," composed in this case chiefly of agglomerated setae. Of these the larger number are identical with the setae of *Eunoe nodosa* and undoubtedly belong to that species. There are also a few large black setae characteristic of the Aphroditacea, but I am uncertain of the species. Half of a *Nereis* jaw, badly corroded, was also noted in the material. I do not know that worms in the considerable quantities indicated by this sample have ever been reported as the food of marine animals before. The saved contents of the stomach of this seal totalled a full three-quarters of a gallon of similarly matted and setae-filled material, intermingled with one or two dozen gasteropod mollusk feet and operculae, several large shrimp, *Sclerocrangon boreas,* and the remains of perhaps six holothurians, *Cucumaria frondosa,* two to three inches long.

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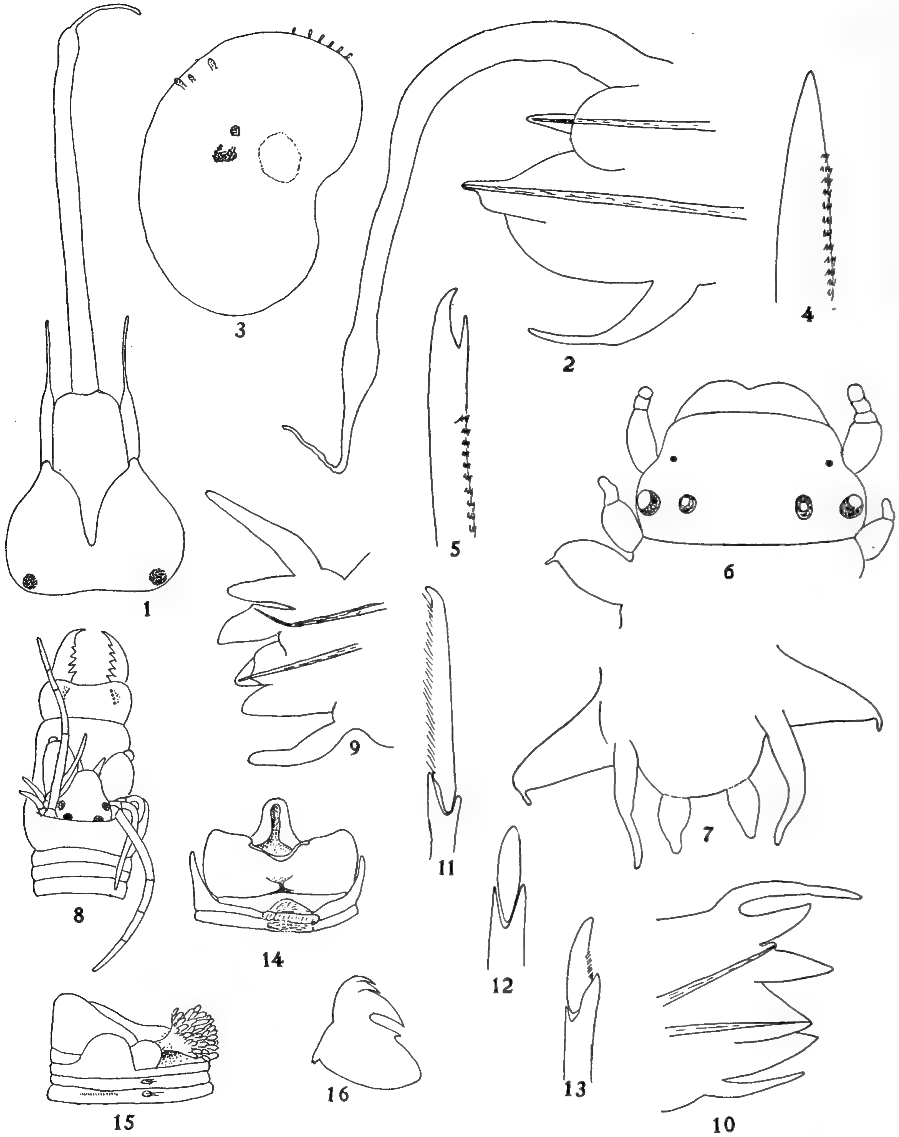
[1] Received October 16, 1936.



Figs. 1–5.—*Harmothoe levis*. 1, prostomium ×28. 2, parapodium ×35. 3, elytron ×12. 4, seta ×250. 5, seta ×250.

Figs. 6–7.—*Oophylax minuta*. 6, anterior end ×280. 7, posterior end ×280.

Figs. 8–13.—*Nereis* (*Ceratonereis*) *bartletti*. 8, anterior end ×10. 9, anterior parapodium ×100. 10, median parapodium ×100. 11, heterogomph neuroseta ×500. 12, posterior notoseta ×500. 13, posterior falcigerous neuroseta ×500.

Figs. 14–16.—*Pista groenlandica*. 14, ventral view anterior end ×7.5. 15, lateral view anterior end ×7.5. 16, uncinus ×250.

Family AMPHINOMIDAE

SPINTHER Johnston

SPINTHER CITRINUS (Stimpson)

Cryptonota citrina Stimpson 1854. p. 36.
Spinther citrinus Verrill 1873–74, p. 502.

A rare species. Stimpson's species came from Grand Manan, Verrill's from the Gulf of Maine, and the U. S. National Museum has some taken in the Bay of Fundy. The Bartlett specimen was taken at Fox Basin.

Family EUPHROSYNIDAE

EUPHROSYNE Savigny

EUPHROSYNE BOREALIS Oersted

Euphrosyne borealis Oersted 1843, p. 18, pl. 2, figs. 23–27.

A fairly common species in the region covered by the collections. It was recorded by Wesenberg-Lund (1934, p. 24) as a new record for East Greenland. In the Bartlett collection it was taken at E. end of Cobourg Id., Baffin Bay, 75°40′N., 78°50′W., Aug. 1935.

Family POLYNOIDAE

GATTYANA McIntosh

(*Nychia* Malmgren name preoc.)

GATTYANA CIRROSA (Pallas)

Aphrodita cirrosa Pallas 1766, p. 95, pl. 8, figs. 3–6 (teste McIntosh).
Nychia cirrosa Malmgren 1865, p. 58, fig. 1.
Gattyana cirrosa McIntosh 1900, pp. 285–291, pl. 25, fig. 3; pl. 27, fig. 5; pl. 31, fig. 1; pl. 37, figs. 16–19; pl. 42, fig. 27.

Collected S. of Cape Martineau, Melville Peninsula, Aug. 9, 1933; Fox Basin (N & B) 1933; E. end of Cobourg Id., Baffin Bay, 75° 41′N., 78° 20′W., Aug. 3, 1935; Murchison Sd., N. Greenland, Aug. 20, 1926.

EVARNELLA Chamberlin

(*Evarne* Malmgren name preoc.)

EVARNELLA IMPAR (Johnston)

Polynoe impar Johnston 1839, p. 463, pl. 22, figs. 3–9 (teste McIntosh).
Evarne impar McIntosh 1900, pp. 353–358; pl. 27, fig. 13; pl. 30. fig. 7; pl. 32, fig. 18; pl. 39, figs. 20–22.

Collected E. end of Cobourg Id., Baffin Bay, 75° 40′N., 78° 50′W., Aug. 3 and 4, 1935; 4 mi. east of Cape Dorchester, Fox Channel, Aug. 4, 1927; 3 mi. S. from Salisbury Id., Hudson Strait (N & B)[2] July 25, 1933; Duckett Cove, Hurd Channel, Aug. 11, 1933; between Hurd Channel and Melville Peninsula, Aug. 7, 1933; S. of Cape Martineau, Melville Peninsula, Aug. 9, 1933; 66° 30′N., 80°W., Aug. 10, 1927.

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[2] Norcross-Bartlett Expedition, 1933.

HARMOTHOE Kinberg

HARMOTHOE IMBRICATA (Linnaeus)

Aphrodita imbricata Linnaeus 1766, p. 1084 (teste McIntosh).

Harmothoe imbricata Malmgren 1865, p. 66, pl. 9, fig. 8; McIntosh 1900, pp. 314–327, text figs. 25–30; pl. 25, fig. 6; pl. 30, fig. 1; pl. 32, fig. 10; pl. 38, figs. 14–16; pl. 26a, figs. 1, 3–8, 12.

A very widely distributed species showing a considerable degree of variability. Collected at Bight, Shannon Id., N.E. Greenland, July 29, 1930; N. Omenolu, North Star Bay, N. Greenland, July 28, 1932; Cape Alexander, Smith Sound, N. Greenland, Aug. 26, 1932; Cape York, N. Greenland, in dredge "between glacier and bill of Cape," 76° 50′N., July 21, 1926; Cape York, N. Greenland, 76° 0′N., July 21, 1926; Parker Snow Bay, N. Greenland, July 17, 1935; S. part of Fox Basin, 66° 43′N., 80° 07′W., Aug. 27, 1927; 3 mi. from Southampton Id., Hudson Strait, July 31, 1933; Sturges Bourne Strait, W. end of Hurd Channel, Melville Peninsula (N & B), Aug. 18, 1933; Duckett's Cove, Melville Peninsula, Aug. 11, 1933; N.E. end of Melville Peninsula, entrance to Fury and Hecla Straits, Aug. 5, 1933 (N & B); N.E. of Cape Dorchester, Fox Channel, Aug. 4, 1927; between Hurd Channel and Melville Peninsula, Aug. 7, 1933; E. end of Cobourg Id., Baffin Bay, 75° 40′N., 78° 50′ and 45′W., Aug. 3 and 4, 1935; Cove, N. shore of Lyon Inlet, Melville Peninsula (N & B), Aug. 24 and 25, 1933; S. of Cape Martineau, Melville Peninsula, Aug. 9, 1933; 66° 30′N., 80°W., Aug. 10, 1927; Labrador, no year given; Saglek Bay, Labrador, Sept. 25, 1925; Coast of Labrador, summer 1925.

Harmothoe levis n. sp.

The type specimen is 15 mm long and, measured from the outer borders of the elytra on opposite sides, 5 mm wide. The elytra overlap on the dorsal surface and extend laterally so as to cover the basal third of the dorsal cirri. In the type the protruded pharynx is 4 mm long. Under low magnification the elytra have a smooth appearance, tinted faintly-pinkish gray, each being marked near the center (fig. 3) by a group of brown pigment granules. To the naked eye this smooth surface with the prominent pigment is the most characteristic feature of the animal. In the type the pigment is present on all elytra, smallest anteriorly and gradually increasing in size in the following ones. In others the color may be absent in the most anterior elytra.

The prostomium is characteristic of the genus in that each half terminates anteriorly in a peak beneath which, and invisible from above, are the large anterior eyes. The posterior eyes are also large and lie near the posterolateral angle of the prostomium. The cirrophore of the median tentacle is large and fills the dorso-median prostomial cleft. Its length is about equal to that of the prostomium (fig. 1). The median tentacular style is about two and one half times as long as the cirrophore, very faintly swollen near the tip, and terminates in a slender filament. The prostomium is colored like the elytra, the cirrophore of the median tentacle is a darker brown, the basal half of the style is colored like the cirrophore, beyond this there is a lighter area, then a darker one of about the same length, then the slight swelling which is colorless. At the base of the filament is a dark spot, the remainder being colorless. The lateral tentacles are scarcely longer than the cirrophore of the median and are colored like it. Their slender apical regions are about as long as the stouter basal portions. The palps are of moderate size and taper uniformly to their apices, their general coloration being like that of the median tentacle, the apices white. The tenacular and dorsal cirri are like the median tentacle in form and color but in general are somewhat smaller. The last three pairs of dorsal cirri are very long. Anal cirri had been lost.

The protruded pharynx has dorsally ten and ventrally nine soft marginal papillae. The teeth are very sharp pointed and light-brown in color with darker margins.

The first two pairs of elytra are nearly circular in outline, the others kidney-shaped (fig. 3). The pigment patch is located postero-dorsally to the elytrophore scar. Except for a very few clavate cilia on the posterior border, the margin is smooth. Near the outer lateral margin are a few larger stout spines and the whole surface is densely studded with minute spines not shown in the figure.

A parapodium from the middle of the body (fig. 2), has a very long dorsal cirrus, both dorsal and ventral cirri lying near the posterior parapodial border, while the notopodial lobe is a little anterior to the neuropodial. The notopodium is composed of a broadly rounded anterior and a very narrow sharp-pointed posterior lip, with a fan-shaped row of heavy setae arising between them. The acicula extends into the posterior lip. The neuropodium is considerably longer and larger than the notopodium. It has a rounded posterior lip, posterior to which the setae arise. The anterior lip is almost rectangular in outline but has a narrow dorsal prolongation into which the acicula extends.

The notopodial setae vary in size, the one at the ventral end of the series being hardly one-half as wide or one-eighth as long as the dorsalmost one. They are all (fig. 4) heavy, blunt-pointed, and have rows of toothed plates extending nearly to the ends. The neuropodial setae have long slender stalks widened toward the outer ends. Distally they gradually narrow again so that the apices are about half as wide as the narrowest portion of the stalk. Each (fig. 5) terminates in a terminal hook and a subterminal tooth. Toothed plates extend nearly to the base of the tooth.

The type, No. 20222 U.S.N.M., was taken at Angmagssalik, E. Greenland, on Aug. 31, 1931. Another specimen was secured between Capes Martineau and McLaren, at the south end of Melville Peninsula on Aug. 19, 1933, and a third at 66° 30′ N., 80° W., Aug. 27, 1927.

This species is closely related to *Harmothoe imbricata* Linn.

EUNOE Malmgren

EUNOE NODOSA (Sars)

Polynoe nodosa Sars 1860, p. 59.

Eunoe nodosa Malmgren 1865, p. 64, pl. 8, fig. 4; McIntosh 1900, pp. 291–296, pl. 27, fig. 9; pl. 32, fig. 3; pl. 37, figs. 20, 22, 24, 26, 27; pl. 42, fig. 28.

Collected at Clavering Fiord, N.E. Greenland, Aug. 2, 1930; 66° 30′N., 80° W., Aug. 10, 1927; Fox Basin, Aug. 26, 1927; Center of Fox Basin, Aug. 24 and 25, 1927; S. part of Fox Basin, 66° 43′ N., 80° 07′ W., Aug. 12, 1927; coast of Labrador, Sept.–Oct. 1925; Fox Basin (N & B), 1933.

EUNOE OERSTEDI Malmgren

Eunoe oerstedi Malmgren 1865, pl. 8, fig. 3.

A species related to *E. nodosa* and considered by Fauvel (1914, p. 51) as synonymous with it. One important distinction in the specimens in the Bartlett collection is that *E. oerstedi* has very prominent spines on the elytra which are not found in *E. nodosa.*

Collected at Cape Alexander, Smith Sound, N. Greenland, Aug. 26, 1932; Hurd Channel between Bushman Id. and Melville Peninsula, Aug. 17, 1933; S. end of Cobourg Id., Baffin Bay, 75° 40′N., 78° 58′W., Aug. 4, 1935; 66° 36′N., 78° 58′W., Aug. 10, 1927.

Family NEPHTHYDIDAE

Nephthys Cuvier

Nephthys ciliata (Müller)

Nereis ciliata Müller 1789, p. 114, pl. 89, figs. 1–4 (teste McIntosh); Malmgren 1865, p. 104, pl. 12, fig. 17; McIntosh 1908, pp. 24–27, pl. 66, fig. 9; pl. 77, figs. 6, 7.

Collected between Capes Martineau and McLaren, S. end of Melville Peninsula, Aug. 19, 1933; Duckett's Cove, Hurd Channel, Aug. 11, 1933; King Francis Joseph Fiord, N.E. Greenland, Aug. 4, 1936; North Fiord, N.E. Greenland, Aug. 2, 1936.

Family PHYLLODOCIDAE

Phyllodoce Savigny

Phyllodoce groenlandica Oersted

Phyllodoce groenlandica Oersted 1842–43, p. 121 (teste McIntosh); McIntosh 1908, pp. 86–88, pl. 58, fig. 5; pl. 68, figs. 4, 5, 6; pl. 78, fig. 7.

Collected at Clavering Fiord, N.W. Greenland, July 29, 1930; Disco Id., July 17, 1935 (this specimen is badly macerated and is recorded as taken from a cod's stomach); at entrance to Straits of Fury and Hecla, Sept. 3, 1933. One bottle, marked simply "Labrador" contained a much injured specimen too badly broken for identification. It possibly is of this species.

Family SYLLIDAE

Syllis Savigny

Syllis armillaris (Müller)

Nereis armillaris Müller 1776, p. 217 (teste McIntosh).

Syllis armillaris Oersted 1842–43, p. 118 (teste McIntosh); McIntosh 1908, pp. 188–191, pl. 60, fig. 1; pl. 70, fig. 14; pl. 80 (1910), figs. 8, 8a.

Collected at 70° 04′N., 17° 58′W. (N & B); 66° 30′N., 80°W.; and at S. part of Fox Basin, 66° 43′N., 80° 07′W., Aug. 12, 1927.

Polybostrichus Oersted

Polybostrichus (Autolytus) longosetosus Oersted

Polybostrichus longosetosus Oersted 1843, p. 183, pl. 5, figs. 62, 67, 71 (teste Quatrefages).

Collected at S. part of Fox Basin, 66° 43′ N., 80° 10′ W., Aug. 27, 1927.

OOPHYLAX Ehlers

Oophylax minuta n. sp.

The type and only specimen is very small, hardly 2 mm in length. It was found clinging to another annelid, but this association evidently was accidental. The prostomium has a width of nearly twice its length (fig. 6), and near its posterior border are four large eyes, the lateral ones being slightly the larger. The lenses of the median eyes are directed dorsally, those of the lateral ones dorso-laterally. Anterior to these on either side is a much smaller eye. The palps are short and are fused nearly to their ends, this fusion being more complete dorsally than ventrally. Focussing below the level shown in the figure shows a definite cleft between them. The tentacles are heavy, each having a swollen basal portion which abruptly narrows into a cylindrical terminal region, the latter ringed in such a way as to resemble articulations.

The first somite is rather short and has on either side a tentacular cirrus which is slightly smaller than the tentacle but is otherwise similar to it in shape. There are twenty-five pairs of parapodia, all prominent, the first one rounded in outline but later ones become gradually more sharp pointed toward the ends. In anterior somites the dorsal cirri are larger than the tentacular but similar to them in form. Beginning at about the sixth parapodium, these begin to narrow toward their bases and throughout the greater part of the body they are cylindrical and extend beyond the ends of the parapodia. There is one pair of short, thick, anal cirri (fig. 7). I was unable to see clearly the anterior ventral cirri but posterior ones are slender and cylindrical and reach about half way to the ends of the parapodia. The parapodia are conical, each having at its apex a small, colorless, posteriorly directed cirrus (see figs. 6, 7). The setae are all compound and prominent, the largest reaching beyond the parapodium to a distance equal to the length of the latter. The basal joint is slender, expanding noticeably at the heterogomph outer end. There are two kinds of terminal joints in each somite differing from one another only in length. Their ends are curved to sharp hooks. I was unable to decide whether their concave margins are merely roughened or carry excessively minute hairs. The pharynx has anteriorly a single median tooth and extends as far as the posterior border of the third setigerous somite. The crop extends through four somites.

The unique type, No. 20223 U.S.N.M., was collected four miles east of Cape Dorchester in Fox Channel on Aug. 4, 1927.

Oophylax is diagnosed by Ehlers (1864, p. 252) as having "four paired head appendages and eyes, palps more or less fused, seta-bearing parapodium of the first somite similar to later ones." Chamberlin (1919, pp. 166, 167) stated that *Oophylax*, with some other genera, is synonymous with *Exogone*, which he defined (p. 165) as having palps completely fused and rudimentary tentacular cirri, with all tentacles and cirri cylindrical. The specimen agrees more closely with Ehlers' than with Chamberlin's diagnosis and I have therefore described it as *Oophylax*.

Family NEREIDAE

NEREIS Linnaeus

NEREIS PELAGICA Linnaeus

Nereis pelagica Linnaeus 1746, p. 2096; McIntosh 1910, pp. 267–280, pl. 52, figs. 1, 2; p. 160 (1908), figs. 6–6b; pl. 71, figs. 7–7i; pl. 80, figs. 25, 25b.

A very widely distributed species but no great number of specimens appeared in the Bartlett collections. Collected at 63° 16′ 09″ N., 84° 21′ 15″ W., Aug. 1, 1933; 3 mi. S. of Salisbury Id. (N & B), July 27, 1933; mouth of Bay of Gods Mercy, Southampton Id., Hudson Bay (N & B), Aug. 5, 1933; a much mutilated specimen in epitokous condition was taken at Duckett's Cove, Melville Peninsula, Aug. 13, 1933; Coast of Labrador, 1925; 74° 04′ N., 17° 58′ W. (N & B), July 30, 1931.

NEREIS ARCTICA Oersted

Heteronereis arctica Oersted 1843, p. 179. pl. 4, figs. 50, 51; pl. 5, figs. 65, 68, 69–70* (teste Quatrefages).

Collected at S.E. corner of Fox Basin, 66° 46′ N., 79° 15′ W., Aug. 13,1927.

NEREIS (CERATONEREIS) Kinberg

Nereis (Ceratonereis) bartletti,[3] n. sp.

The type and only specimen is 28 mm long and 0.75 mm wide at the prostomium. The prostomium is colorless. On the peristomium is a faint dusting of brown pigment which becomes slightly more intense in the following somites and noticeably so on the region from the sixth to the thirtieth, being densest from the fifteenth to the twentieth. Behind the thirtieth this pigmentation continues in a gradually decreasing intensity to nearly the posterior end of the body. Except where it is more intense it is limited to a transverse dorsal band in each somite as long as one half the dorsal body-diameter and leaving uncolored the intermediate regions. In more deeply pigmented somites there are lateral patches on the parapodial bases separated from the dorsal ones by a distinct colorless line.

The prostomial length is about equal to its breadth (fig. 8), rather broadly rounded on the anterior border. The tenacles are relatively rather heavy and are well separated from one another. The basal joints of the palps are heavy and extend well beyond the tentacle ends, the terminal joints being mere knobs. Two pairs of prominent eyes are situated well toward the posterior border. In the preserved specimen the posterior eyes are about one half covered by the overlapping margin of the peristomium. The posterior dorsal tentacular cirrus reaches to the anterior border of the seventh somite, the anterior dorsal to the anterior border of the fourth, the ventral ones are hardly longer than the prostomium. The dorsal ones are more slender than the ventral and show a small amount of jointing. All dorsal cirri are slender, unjointed, and not especially long. The two anal cirri are as long as the last ten body somites.

In the protruded state of the pharynx the peristomium is much wider than the prostomium. In the mid-dorsal line it is about twice as long as somite 2. The following somites increase in length and width as far as the region of the twentieth, while posterior to that they gradually decrease toward the posterior end.

The protruded pharynx (fig. 8) has large teeth, each with a terminal fang and five heavy denticulations. The paragnath formula is I, absent; II, not more than ten, in two rows, the larger lying on the inner row; III, a few obscure denticles rather widely separated; IV, on either side a roughly triangular patch whose apex extends as two rows nearly to the bases of the jaws; V, VI, VII and VIII absent.

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[3] In honor of the discoverer, Capt. R. A. Bartlett.

Anterior parapodia (fig. 9) have a heavy dorsal cirrus extending for about one-third its length beyond the end of the dorsal lobe. This dorsal lobe is an elongated oval in outline, its outer half only slightly narrower than its inner. The setal lobe is a small elevation on the dorsal surface of the ventral lip and the acicula ends in it. The ventral lip of the notopodium is roughly triangular in outline, its base extending beyond the end of the dorsal lobe. In the neuropodium the setal lobe has a vertical posterior and a conical anterior lip, the large acicula ending in the latter. The ventral lip is heavy and shorter than the setal lobe. A parapodium from the middle of the body (fig. 10) has much the same structure as the anterior ones, except that the lobes are more pointed. This general structure persists posteriorly, the only change being that the lobes become still more pointed.

In anterior parapodia there are few notopodial setae (three in the parapodium drawn, fig. 9), each having a very slender homogomph basal portion, the terminal joint long and slender and finely toothed along one margin. The neuropodial setae are in two tufts, one above and one below the acicula. In each tuft are two kinds of setae, one form being like those of the notopodium, the other having heterogomph basal joints, the terminal joint a flattened blade that narrows regularly from base to apex which is rounded and slightly curved. Along one margin is a row of bristles (fig. 11). On the second and third parapodia in front of the pygidium are setae not found farther forward. On the specimen examined there is in the notopodium one shown in figure 12. This has homogomph basal joint. The terminal joint is elongated-oval in outline, one end being inserted in the notch at the end of the basal. In the neuropodium are two like figure 13. The basal joint is heterogomph, the terminal short and thick, curved slightly and has a row of bristles for about half its concave margin. Both of these forms of setae are much larger than any in anterior somites and have much darker basal joints.

Type, No. 20224, U.S.N.M., was taken in a dredge at 129 fathoms at 74° 04′ N., 17° 58′ W., on July 30, 1931.

Family LEODICIDAE

LUMBRINEREIS Blainville

LUMBRINEREIS FRAGILIS (Müller)

Lumbricus fragilis Müller 1788, p. 22, pl. 22, figs. 1–3.

Lumbriconereis fragilis Audouin et Edwards 1833, vol. 28, p. 244; McIntosh 1910, pp. 372–376, pl. 62, figs. 1, 1a; pl. 72, figs. 8–8c; pl. 82, figs. 2–2b.

All of the specimens in the collection were badly macerated and the identification was made mostly through the structure of the jaws.

Collected in summer of 1925, coast of Labrador; Saglek Bay, Labrador, Oct. 1, 1925; Coast of Labrador, Sept.–Oct. 1925.

ONUPHIS Audouin et Edwards

ONUPHIS CONCHYLEGA Sars

Onuphis conchylega Sars 1835, p. 61, pl. 10, figs. 28 a–e; McIntosh 1910, pp. 410–413, pl. 63, fig. 9; pl. 64, figs. 1–1a; pl. 75, fig. 7; pl. 84, figs. 5–5c.

In the identification I have followed McIntosh's description. The only differences I could find are that the frontal tentacles are more prominent and the nuchal cirri longer than in his statement. There is much variation in the coloration from practically no color at all to a dense brown dorsal pigmentation.

Collected at 74° 04′ N., 17° 58′ W., July 30, 1931 (N & B); 74° 21′ N., 16° 30′ W., July 29, 1931; E. end of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 50′ W., Aug. 3, 1935; 75° 40′ N., 78° 55′ W., Aug. 3, 1935.

Family GLYCERIDAE

GLYCERA Savigny

GLYCERA LAPIDUM de Quatrefages

Glycera lapidum de Quatrefages 1865, pp. 187, 188; McIntosh 1910, pp. 477–481, pl. 55, fig. 4; pl. 64, figs. 9–9a; pl. 76, figs. 1–1b; pl. 85, figs. 3–3b.

Collected at S. end of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 58′ W., Aug. 4, 1935.

Family OPHELIDAE

OPHELIA Savigny

OPHELIA LIMACINA Rathke

Ophelia limacina Rathke 1843, p. 190, pl. 10, figs. 4–8 (teste McIntosh); McIntosh 1915, pp. 9–14; pl. 88, fig. 1; pl. 95, figs. 1, 1d.

Collected at Hakluyt Id., Whale Sound, 77° 26′ N., 72° 30′ W., July 30, 1935; E. end Cobourg Id., Baffin Bay, 75° 40′ N., 78° 56′ W., Aug. 4, 1935; and at latter locality but at 58′ W. on Aug. 4, 1935.

Family CHLORHAEMIDAE

BRADA Stimpson

BRADA GRANOSA Stimpson

Brada granosa Stimpson 1854, p. 32.

E. end Cobourg Id., Baffin Bay, 75° 40′ N., 78° 50′ W., Aug. 3, 1935; King Francis Joseph Fiord, N.E. Greenland, Aug. 4, 1936.

Family AMPHICTENIDAE

PECTINARIA Lamarck

PECTINARIA GRANULATA (Linnaeus)

Sabella granulata Linnaeus 1766, p. 1268.

Cistenides granulata Malmgren 1865, p. 359.

Collected at Angmagssalik, E. Greenland, Aug. 28, 1931; Parker Snow Bay, off Cape York, July 17, 1935; N. Omenolu, near North Star Bay, N. Greenland, July 28, 1932; Cape York, N. Greenland, Aug. 28, 1932; 5 mi. S. of Cape Chalon, N. Greenland, July 27, 1932; between Capes Martineau and McLaren, Aug. 19, 1933; cove N. shore Lyon Inlet, Melville Peninsula, Aug. 24 and 25, 1933; Duckett's Cove, Hurd Channel, Aug. 11 and 12, 1933; Hurd Channel, between Bushman Id. and Melville Peninsula, Aug. 17, 1933; S. of Cape Martineau, Melville Peninsula, Aug. 19, 1933; King Francis Joseph Fiord, N.E. Greenland, Aug. 4, 1936.

Family AMPHARETIDAE

AMPHARETE Malmgren

AMPHARETE GROENLANDICA Grube?

Ampharete groenlandica Grube 1860, vol. 26, pp. 106–107, pl. 5, figs. 3, 3a, 3b.

A single female with eggs. All of the tentacles have been lost and I have provisionally identified it as above.

Collected at 66° 30′ N., 80° W., Aug. 27, 1927.

Family TEREBELLIDAE

THELEPUS Leuckart

THELEPUS CINCINNATUS (Fabricius)

Amphitrite cincinnata Fabricius 1780, p. 286.

Thelepus cincinnata Malmgren 1865, p. 387, pl. 22, fig. 58.

Thelepus cincinnatus Verrill 1874, vol. 7, p. 499; McIntosh 1922, pp. 170–177, pl. 120, fig. 1; pl. 126, figs. 6–6d (var. *andreneae*).

Abundant in the collections associated with *Pista groenlandica.* The tubes differ from those of *P. groenlandica* in that *Thelepus* uses larger and a more heterogeneous collection of pebbles to cover the surface than does *Pista*.

Collected at 74° 04′ N., 17° 58′ W. (N & B), July 30, 1931; 74° 21′ N., 16° 30′ W. (N & B), July 29, 1931; North Omenolu, North Star Bay, N. Greenland, Aug. 26, 1932; 5 mi. S. from Cape Charles, N. Greenland, July 27, 1932; E. end of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 40′ W., Aug. 3, 1935; at entrance to Strait of Fury and Hecla, Sept. 3, 1933; 3 mi. S. from Salisbury Id. (N & B), Hudson Strait, July 25, 1933; cove to windward of Cape Charles, W. side of Lyon Inlet, Melville Peninsula, Aug. 18, 1933; between Capes Martineau and McLaren, S. end of Melville Peninsula, Aug. 19, 1933; S. of Cape Martineau, Melville Peninsula, Aug. 19, 1933; 66° 30′ N., 80′ W., Aug. 10, 1927.

PISTA Malmgren

PISTA FLEXUOSA (Grube)

Terebella flexuosa Grube 1860, vol. 26, pp. 102–103, pl. 5, figs. 2 and 2a.

Scione flexuosa Wesenberg-Lund 1934, p. 29.

The arrangement of the gills puts this species in the genus *Pista*.

Collected at E. end of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 58′ W., Aug. 3, 1935.

Pista groenlandica n. sp.

Common in the collection in association with the commoner *Thelepus cincinnatus* Fabricius. Their tubes may be distinguished by the fact that they are somewhat smaller than are those of the latter species and the surfaces of the tubes are covered with sand grains which are smaller and more uniform in size than is the case with *T. cincinnatus*.

The type is 70 mm long and has a prostomial width of 3 mm. So far as can be determined on preserved material the body width is fairly uniform throughout except that there is a noticeable narrowing at the posterior end.

The cephalic margin is not very pronounced and on its latero-ventral side is largely covered by a large latero-ventral lobe of the first somite. Ventrally it is separated by a notch from the high and rather narrow supraoral fold. None of the specimens had been preserved outside of the tube and it was found quite impossible to remove them from the tubes without injuring the tentacles and only a few of these remain on the type. They occur in a dense tuft and when contracted show grooving. No eyes were visible. Dorsally the first somite is very short, its two halves separated in the mid-dorsal line by a forward expansion of the second somite that carries the gills. A prominent lateral lobe is present on either side of the first somite. Ventrally the two lobes are united by a transverse bridge (fig. 14), and posterior to this each lobe sends out a rounded process, the two nearly meeting in the mid-ventral line. The second somite is very short on the mid-ventral line but widens laterally and is continued dorsally as a larger area carrying the gills. The third somite carries ventrally the first shield which extends over the second somite and is divided into two by a transverse line. Laterally the third somite carries a free lobe which extends forward nearly as far as the anterior border of the first somite (fig. 15). There is one pair of gills situated on the dorsal surface of the second somite. Each (fig. 15) has a heavy base and divides into five (in the one figured) branches which subdivide toward the ends. There is no indication of a spiral arrangement such as has been described in other species of this genus.

On the type are twelve well defined ventral shields and behind them a row of very much smaller ones that at about the twentieth somite fade away into a deep groove. A row of ten cirri, of which the two ventral ones are the largest, surround the anus.

The first seta tuft is on the fourth somite and there are sixteen pairs. The setigerous ridges increase in size from anterior to posterior ones, the later ones being prominent. The uncini begin on the fifth somite, the tori being very low as far as the setae extend and behind this they protrude considerably from the body. They continue to the posterior end of the body, the latest ones being smaller. The setae are all long and slender, very fine-pointed, and gently curved at the ends. They are bilimbate, the wings being noticeably striated. An uncinus (fig. 16) has a broadly rounded base and one large hook. At the apex there is a much smaller hook and on either side one larger than the apical one. A hook-like projection lies between the uncinal base and the largest hook. In anterior tori the uncini are in single rows but at about the tenth the rows become double with alternate uncini facing in opposite directions.

The type, No. 20225, U.S.N.M., and a paratype deposited in the American Museum of Natural History were collected at the east side of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 40′ W., Aug. 3, 1935. Others were taken 5 miles S. of Cape Charles; at entrance to Straits of Fury and Hecla; at Duckett's Cove, Hurd Channel; at 74° 04′ N., 17° 58′ W.; and at 74° 21′ N., 16° 30′ W.

Pista cristata O. F. Müller appears in a number of lists of polychaetous annelids collected from the northeastern coast of North America and McIntosh (1922, p. 160) lists the species from Canada (Whiteaves), New England and Atlantic coast (Verrill), and Virginia (Webster). In his diagnosis of the species, McIntosh (p. 158) states that the gills arise from the anterior border of the fourth somite, but later (p. 161) he locates them on the third. In *P. groenlandica* they are on the third. Other differences are that in *P. cristata* there are three pairs of lateral lobes on the second, third, and fourth somites, respectively, while *P. groenlandica* has only one pair on the second. The arrangement of anal papillae is quite different, as is the structure of the uncini. Verrill (1882, pl. 11, fig. 2) figures *P. cristata*, but his figure seems to correspond more closely to *P. groenlandica*, and McIntosh does not record any personal observations on any American forms, basing his descriptions solely on the European. It seems to me quite possible that the ones described from North America are *P. groenlandica*. I cannot find that the papers show anything more than a relisting of the species without any critical examination. The relationship between the two species is close.

TEREBELLIDES Sars

TEREBELLIDES STROEMI Sars

Terebellides stroemi Sars 1835, p. 48, pl. 13, fig. 31 (teste McIntosh); McIntosh 1922, pp. 209–215, pl. 127, figs. 5, 5′, 5″, 5a, 5a′, 5b.

A single entire specimen which agrees in all respects with the description given by McIntosh, except that it has only one pair of gills on the second somite, while McIntosh describes two pairs on somites 2 and 3. His figure, however (pl. 120, fig. 3), shows only one pair.

Collected at Cove, N. shore of Lyon Inlet, Melville Peninsula, Aug. 24, 1933.

Family SABELLIDAE

CHONE Kroyer

CHONE DUNERI Malmgren

Chone duneri Malmgren 1867, p. 116, pl. 13, fig. 75; McIntosh 1923, pp. 295–297, pl. 130, figs. 3–3c.

Distinguished from *C. infundibuliformis*, which is much commoner in this region, by the fact that in *C. duneri* the thoracic spatulate setae have long sharp points, while in *C. infundibuliformis* they have rounded ends.

Collected at E. end of Cobourg Id., Baffin Bay, 75° 40′ N., 78° 40′ W., Aug. 3, 1935.

Family SERPULIDAE

SPIRORBIS Daudin

SPIRORBIS SPIRILLUM (Lamarck)

Serpula spirillum Linnaeus 1758, p. 786.

Spirorbis spirillum Lamarck 1818, p. 359; McIntosh 1923, pp. 391–396, pl. 122, figs. 9–9b; pl. 132, figs. 6–6f.

Collected in considerable numbers on floating sea weed at mouth of Bay of Gods Mercy, Southampton Id., Hudson Bay, Aug. 5, 1933 (N & B).

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ZOOLOGY.—*Resistance to intestinal trichinosis in experimental animals induced by feeding metabolic products of encysted trichinae.*[1]

L. A. SPINDLER, Bureau of Animal Industry, U. S. Department of Agriculture (Communicated by BENJAMIN SCHWARTZ).

Administration of vaccines by mouth has been found to be of value in some cases in the treatment of certain diseases, and in view of this, it occurred to the writer that metabolic products elaborated by trichina larvae might be used in a similar manner to produce a resistance to intestinal infestation with this parasite. Attempted immunization by injection of trichina proteins has yielded negative results.[2] In order to determine, therefore, whether the ingestion of metabolic products of trichina larvae would pro-

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[1] Received October 7, 1936.

[2] McCoy, O. R. Amer. Jour. Hyg. **21**: 200. 1935.

tect animals against infection with this parasite, carcasses of rabbits containing encysted trichinae were digested in artificial gastric juice thus liberating into the digestive fluid possible metabolic products of the larvae present within the capsules.

The digestive fluid was prepared and the digestive process carried out as outlined by Ransom.[3] The fluid obtained following the digestion of trichinous meat was filtered through a Mandler filter to remove all trichina larvae and coarse undigested particles; before administering the fluid, it was neutralized with decinormal sodium hydroxide, using phenolphthalein as an indicator. Rats, rabbits and guinea pigs were the host animals used in the experiments.

TABLE 1.—RESULTS OF FEEDING METABOLIC PRODUCTS OF ENCYSTED TRICHINAE

Test No.	No. of animals used	No. of trichinae given per animal	Neutralized digestive fluid per animal (cc)		Days duration of infection	Average No. of trichinae per animal		Percentage of trichinae in test animals as compared to controls
	test and control	test and control	test	control	test and control	test	control	
1	4 rats	1,850	8 to 12	0	3	663	1,100	60.3
2	4 rats	5,200	10 to 15	0	3	3,910	4,630	84.4
3	4 rats	10,150	6 to 8	0	6	3,560	4,950	71.9
4	4 rats	10,000	50 to 70	0	4	1,750	3,300	53.0
5	4 rats	500	140 to 200	0	3	128	400	32.0
5a	2 rats	500	95 to 100[1]	0	3	170	398	42.7
5b	2 rats	500	90 to 110[2]	0	3	395	400	98.8
6	2 rabbits	25,000	110 to 125	0	6	5,075	12,950	39.1
7	2 rabbits	26,375	65 to 80	0	4	7,470	18,522	40.3
8	2 rabbits[3]	4,000	30 to 60	0	3	200	1,200	16.6
8a	2 rabbits[3]	4,000	30 to 60	0	3	187		15.6
9	4 guinea pigs[4]	555	100 to 125	0	3	220	400	55.0
9a	4 guinea pigs[4]	555	120 to 130	0	3	175		43.8
9b	4 guinea pigs[4]	555	115 to 145	0	3	400		100.0
10	3 guinea pigs[5]	800	60 to 80	0	3	325	600	54.2
10a	3 guinea pigs[5]	800	50 to 85	0	3	563		93.8

[1] Digestive fluid heated before feeding.
[2] Fluid obtained after artificial digestion of carcass of trichina-free rabbit.
[3] Two control rabbits were used in these tests.
[4] Four control guinea pigs were used in these tests.
[5] Three control guinea pigs were used in these tests.

Both test and control animals were infected with equal numbers of trichina larvae, and the test animals were given the neutralized digestive fluid by mouth throughout the duration of the experiment; the control animals received distilled water instead of the digestive fluid.

A post-mortem comparison, made 3 to 6 days after infection, of the number of adult trichinae in the test animals with those present

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[3] Ransom, B. H. Jour. Agric. Res. 5: 819. 1916.

in the controls was the criterion for determining whether or not a resistance had been brought about by ingestion of the digestive fluid. The technic involved in these examinations was the same as that outlined by McCoy.[4]

To determine whether animals would be protected from an experimental infection with trichinae by ingesting artificial gastric juice in which trichina-free rabbit meat had been digested, animals in tests 5b, 9b, and 10a were fed fluid obtained by artificially digesting uninfected rabbit carcasses. It will be noted that these animals were not protected, since they harbored practically as many trichinae as the controls that received no digestive fluid.

Ten tests were carried out and the results are summarized in Table 1. These data show that the test animals were protected to a greater or lesser extent against experimental intestinal trichinosis, since the test animals harbored only from 15.6 to 84.4 percent of the numbers of trichinae present in the controls. In tests 5a and 9a the digestive fluid was heated at 50°C for 30 minutes, and in test 8a it was heated at 60°C for 30 minutes, before administering it to the animals. As shown in Table 1, the animals which received the heated digestive fluid harbored from 15.6 to 43.8 percent of the number of trichinae harbored by the controls, showing that the immunizing principle was not destroyed by heating at these temperatures.

From the tests reported in this paper, it may be concluded that artificial gastric juice in which trichinous meat has been digested contains a substance capable of protecting to a certain extent, rats, rabbits, and guinea pigs from an experimental intestinal infection with trichinae. This protective substance is associated with the presence of trichinae, and is not destroyed by moderate heating. Additional investigations of this problem are in progress.

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[4] McCoy, O. R. Amer. Jour. Hyg. **21**: 200. 1935.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

270TH MEETING

The 270th regular meeting was held in the assembly hall of the Cosmos Club, January 7, 1936, President **John W. Roberts** presiding; attendance 100. **Mary Elizabeth Pierce**, **Arthur F. Sievers**, and **Jesse D. Diller** were elected to membership.

Notes and reviews.—**Charles Thom** called attention to a very complete *Medical Mycology* by C. W. Dodge. **C. R. Ball** called attenton to the diamond willows and passed around an interesting example from Alaska.

Program.—Notes on the annual meetings of the American Association for the Advancement of Science at St. Louis were given by: **H. A. Edson** for pathology; **Alice M. Andersen** for physiology; **S. L. Emsweller** for genetics; **Neil E. Stevens** for general botanical matters; **W. J. Zaumeyer** for virus diseases.

N. R. Smith gave notes on the bacteriological meetings at New York City, and **E. A. Hollowell** on the agronomy meetings at Chicago.

271ST MEETING

The 271st regular meeting was held in the assembly hall of the Cosmos Club, February 4, 1936, President **John W. Roberts** presiding; attendance 93. **Thora N. Plitt** and **Dewey Stewart** were elected to membership.

Notes and reviews.—**George M. Darrow** called attention to a new book, entitled *Gardens of Color* by Henslow, head of Kew Gardens.

Program.—**Miriam L. Bomhard**: *Leaf venation—a useful criterion for distinguishing the poisonous water hemlocks from the harmless angelicas.* Publish in this Journal **26**: 102–107. 1936.

Shio Sakanishi: *Japanese flower arrangement.*

Mrs. Herbert H. Gregor: *Demonstrations of Japanese flower arrangement.*

272ND MEETING

The 272nd regular meeting was held in the assembly hall of the Cosmos Club, March 3, 1936, President **John W. Roberts** presiding; attendance 137. **Otto Brown**, **F. J. Crider**, **Guy C. Fuller**, **Ernest G. Holt**, **Walter V. Kell**, **William R. Van Dersal**, and **Robert L. Weintraub** were elected to membership.

Notes and reviews.—**C. R. Ball** called attention to the use of willow trees as roosting places for blackbirds. **M. A. Raines** gave a description of sheet culture technique for growing young plants.

Program.—**Charles R. Enlow**: *The agronomy program of the Soil Conservation Service.* In the United States, 300,000,000 acres are affected by soil erosion. Of this acreage, 50,000,000 are essentially destroyed, 50,000,000 practically destroyed, 100,000,000 almost depleted of topsoil, and another 100,000,000 now eroding. The Soil Conservation Service has at present 141 projects in operation in 41 states, covering 46,600,000 acres of land. Of this acreage, 39,700,000 are Federal land, and 6,900,000 agricultural farm lands. The extent of the agronomic work on this acreage is well illustrated by the fact that 65% of the land on the projects in seven southeastern states is in crops and pastures, and the percentage is still larger in other sections of the country.

The difficulty encountered in developing a national agronomic policy is well illustrated by the varying conditions in Region 7 (Nebraska, Kansas and Oklahoma). This region has a rainfall of from 14 to 50 inches; soils ranging from alkaline to acid; has both water and wind erosion; dryland agriculture, wheat growing, cotton growing, corn production, and general farming. The method of erosion control in use at present by the Agronomy Section consists of rearranging the farm lands to retain soil and moisture. In attempting erosion control, proper rotations, strip cropping, contour farming, pasture management, winter and summer cover crops, change in tillage methods, contouring of pastures, and reseeding of abandoned land, blow land and gullies with commercial and native grasses and other plants, are some of the principal methods of attack. Results of experiments in strip cropping and contour farming from the soil erosion Experiment Stations at Temple, Texas, Tyler, Texas, and Guthrie, Oklahoma, show these practices save much soil and water. At Guthrie, Oklahoma, cotton lost eleven times as much water by runoff as Bermuda grass and 670 times as much soil.

Burton F. Kiltz: *Native grasses of the prairies and plains.* A recent need has appeared requiring much of the land that has been plowed in the plains states to be returned to grass. Since ordinary introduced grasses are not adapted, a study was started to determine the possibilities of the native species already present. Most of these species, contrary to popular belief, produce viable seed and have great promise for such purposes. Seed has already been collected in considerable quantities, sufficient at least to permit rather extensive tests next year. Tests already made indicate that the seed of most species can be planted successfully. The important native species that show promise are: Blue grama (*Bouteloua gracilis*), Buffalo (*Buchloe dactyloides*), Little bluestem (*Andropogon scoparius*), Big bluestem (*Andropogon furcatus*), Western wheat (*Agropyron smithii*), and Switch grass (*Panicum virgatum*). Various machines are being given a trial in the collection of seed of these grasses. Machinery ordinarily used in collecting tame grass seed appears to be satisfactory when used on native grasses.

Wm. R. VanDersal: *Moving pictures of seed collecting in the northeastern states.*

273RD MEETING

The annual banquet and 273rd regular meeting of the Botanical Society was held in the ball room of the Kennedy-Warren Hotel, April 14, 1936; attendance 142.

Program.—H. H. **Bartlett** gave an address entitled *Experiences of a plant collector in Oceania.* He also showed two movie films of Sumatra scenes.

A special meeting of the Botanical Society was held jointly with the Washington Academy of Sciences in the assembly hall of the Cosmos Club April 16, at which E. D. **Merrill** gave an address entitled *Plants and Civilizations.*

274TH MEETING

The 274th regular meeting was held May 5, 1936, at 8 p.m., at George Washington University, in connection with its 4th Annual Spring Wild Flower Show; attendance 142.

Program.—**Everett F. Davis**: *Some aspects of black walnut toxicity, its cause and effects.*

P. L. Ricker: *Wild flower cultural preferences.* The majority of wild flowers grow in neutral soil and many do equally well in a slightly acid or alkaline soil. A number of species require an acid soil if they are to succeed. Azaleas, Trailing Arbutus and Pink Ladyslipper are the best examples. Most plants found in oak or pine woods require acid soil and a partially shaded condition. Most native plants must be transplanted to the same growing conditions in which they are found but a number of plants like Oswego Tea, almost always found in wet places, do equally well in dry places. The Fringed Gentian prefers a wet, gravelly, acid soil covered with grass so the seedlings will be shaded the first year. It is a biennial and sowings must be made two successive years. It is difficult to transplant unless pot-grown, and then, if its taproot is broken, it will not live. The bluebonnet is an annual, prefers a sandy, acid soil and disturbing the roots seems to be fatal to it, as is the case with the northeastern Lupine, which is a perennial. The American Pasque-flower must have a very light, well-drained soil to succeed, and this should preferably be slightly acid.

PAUL W. BOWMAN: *Remarks on the 4th Annual Spring Wild Flower Show at George Washington University.*

The formal meeting was followed by a visit to the flower show in another room.

275TH MEETING

The 275th regular meeting was held October 6, 1936, in the assembly hall of the Cosmos Club; attendance 125. **EDWARD P. CARTER** was elected to membership.

Notes and Reviews.—W. W. **DIEHL** reported on the summer Mycological Foray at Mountain Lake, Va., which took place Sept. 3–5, 1936. M. B. **WAITE** reported that some cherry trees around Haines Point had root injury due to flood and some showed winter injury. C. R. **BALL** called attention to two new books: *Wild flowers of California* by Thurston, and *Pollen Grains* by Wodehouse.

Program.—W. A. **DAYTON**: *The range plant handbook of the Forest Service.* Now in page-proof. Consists of 339 write-ups, 58 generic and 281 specific, including brief notes on 651 other species of western range plants; illustrated by 294 pictures, mostly original. A novel feature is the lining up of the simple botanical descriptions of the key characters with the appropriate parts of the illustration, so as to be usable by persons without botanical training. Chief purpose is to evaluate for busy field administrative men of the Service the relative importance of these range plants as regards grazing, watershed protective, recreational, and other uses, and to enable ready field identification. The looseleaf feature facilitates selection and arrangement of material, as well as possible later revision and extension.

R. **KENT BEATTIE**: *The Dutch elm disease in Europe.* The Dutch elm disease was found in the United States for the first time in 1930. It was brought in elm logs imported from Europe. The U. S. Bureau of Plant Industry in cooperation with the Bureau of Entomology and Plant Quarantine maintains a Dutch elm disease laboratory at Oxford, England.

The elm disease was first noted in England in 1927 though it had been present for several years. It was soon found to be widespread and all efforts to eradicate or control it were soon abandoned. No research is being conducted by the British other than an annual survey to determine its rate of intensification. Serious losses have occurred. The disease has invaded the mile-long elm rows at Windsor Castle. Eighty per cent of the beautiful trees at Buxted Deer Park are dead or dying. Roadside rows in the Worcester region are rapidly going. Southeast of Cambridge the disease has already imparted a more or less treeless appearance to the region. The disease has moved north to within 30 miles of the Scottish border. All this destruction is in spite of the fact that the English elm is not as susceptible as the American elm.

The Dutch began research on the elm disease when it was first found southeast of Rotterdam in 1919, but have made no serious effort to eradicate it. An extensive and somewhat successful program aimed at the slowing down of the disease was begun 5 years ago. This will permit more economical utilization of the dead timber.

Belgium is carrying on no research and is doing nothing to control the disease, although it is widespread in the long roadside rows of elms.

The disease was found in France in 1919 near Chalons-sur-Marne northeast of Paris. It has spread over the whole country. It is very noticeable from the railroad trains in northwest France. It is rapidly destroying the fine old elm rows at Versailles. Little research and no control measures are being undertaken in France.

276TH MEETING

The 276th regular meeting was held in the assembly hall of the Cosmos Club Nov. 4, 1936, President JOHN W. ROBERTS presiding; attendance 108. GEORGE Y. YOUNG was elected to membership.

Notes and reviews.—R. F. GRIGGS showed specimens of a sensitive plant (*Leptoglottis nuttalli* D C) new to the flora of Washington. D. H. ROSE, J. B. S. NORTON and G. H. SHULL called attention to plants blooming in the fall.

Program.—GEORGE M. DARROW: *Berry breeding.* A report was given of the progress of the raspberry and blackberry breeding work at Corvallis, Oregon, which is under the direction of George Waldo of the U. S. Department of Agriculture. The object of the work is particularly to obtain much hardier and larger and firmer red raspberries and much higher flavored blackberries.

In red raspberry crosses hardiness was found to be dominant and nearly all of the seedlings were hardier than the standard variety grown in the Northwest. In size of berry, over half of some crosses were larger than the standard variety of the Northwest and some more than twice as large. Data on inheritance of resistance to "streak" virus disease and other inherited characteristics were presented. Some discussion was given on crosses with Asiatic raspberries and a rather full discussion of crosses with the Logan and its wild relative, which has a higher flavor than all other blackberries. Inheritance of thorniness was also discussed.

KENNETH B. RAPER: *Why study a slime mold. Dictyostelium discoideum* is a member of the Acrasiales, a group of slime molds characterized by pseudoplasmodia into which great numbers of myxamoebae aggregate but do not fuse. *Dictyostelium discoideum* is unique in possessing migrating pseudoplasmodia that typically form bacteria-free fruiting structures, or sorocarps, outside the limits of the bacterial colonies in which the myxamoebae vegetate and in which the pseudoplasmodia originate. Because of the ease with which bacteria-free spores may be obtained this species is particularly well adapted for studies upon the inter-relation between slime molds of this group and the bacteria which accompany them.

Employing pure spores and pure cultures of bacteria, *D. discoideum* was grown upon hay infusion agar in pure-mixed culture with forty-eight different species of bacteria including saprophytic forms and some plant and animal pathogens. Upon richer media containing peptone the growth of the slime mold was dependent upon a favorable H-ion concentration in the colonies of "host" bacteria, the optimum reaction being approximately pH 6.2±. The manner in which this favorable reaction is obtained is unimportant and can be attained by incorporating in the medium a sugar which the host bacterium can ferment, or by buffering and adjusting the reaction of the culture medium prior to inoculation with bacteria.

Fractions of pseudoplasmodia of different origin can be grafted together and by employing pseudoplasmodia of different color (e.g., red pseudoplasmodia produced in cultures grown upon *Serratia marcescens* and white pseudoplasmodia produced with *Escherichia coli*) the organization of the pseudoplasmodium was studied. The organization center of the pseudoplasmodium was found to reside in the apical region; it was likewise from this region that the supporting stalk of the mature fruiting structure was formed. (*Author's abstract.*)

277TH MEETING

The 277th regular meeting was held in the assembly hall of the Cosmos Club December 1, 1936, President John W. ROBERTS presiding; attendance 68. H. A. JONES, H. A. BORTHWICK, KARL C. HAMNER, LAWRENCE A. SCHAAL, LAWRENCE PAUL BATJER, JOHN W. MCKAY, ALFRED E. CLARKE, and E. V. JOTTER were elected to membership.

Program.—Address of retiring President, JOHN W. ROBERTS: *The spraying of plants, botanically considered.* Spraying for the control of plant diseases became practical only after botanists had worked out the life histories of fungi causing the diseases. Much of this work was done by members of the Botanical Society of Washington. It was pointed out that while valuable work is being done on how sprays kill fungi and the effect of sprays on higher plants, much remains to be done. In work on fungicides there are many interesting and difficult problems that are strictly botanical in nature.

36TH ANNUAL MEETING

The 36th annual meeting was held immediately following adjournment of the 277th regular meeting, JOHN W. ROBERTS presiding.

MRS. AGNES CHASE read an obituary for A. S. HITCHCOCK. E. H. WALKER, C. L. SHEAR, and J. R. SWALLEN gave additional information regarding Dr. Hitchcock and his work.

E. O. WOOTON was elected to honorary membership.

The following officers were elected for 1936: President, GEO. M. DARROW; Vice-President, G. F. GRAVATT; Recording Secretary, H. H. MCKINNEY; Corresponding Secretary, ALICE ANDERSEN; Treasurer, ANGIE BECKWITH.

Nominated for Vice-President Washington Academy of Sciences, JOHN W. STEVENSON.

G. F. GRAVATT, *Recording Secretary*

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 27 FEBRUARY 15, 1937 No. 2

GEOLOGY.—*The emergence of ideas as illustrated from geology.*[1]

GEORGE H. ASHLEY, State Geologist of Pennsylvania. (Communicated by ROLAND W. BROWN.)

Geologic ideas emerged slowly because primitive man was curious only in matters affecting his personal welfare; because the earth's major features seemed too permanent to suggest that they had evolved from other forms or conditions; and because some peoples held the concept of a God able to create the heavens and the earth and to control or change them at will—a concept not yet extinct.

On the other hand the Greeks, Romans, and some others, worshipped a galaxy of gods until they tired of them. These gods, like the genii of the Arabian Nights, had magical but limited powers which did not include creating stars or upheaving continents. So, thrown on their own resources, the Greeks and Romans began to observe nature and theorize on her ways. As a result many ideas of vast import today first emerged over 2,000 years ago. As early as the sixth century B.C. Xenophanes finding sea shells far inland saw evidence that the sea had once covered that area. Aeschylus in 525 B.C. glimpsed the idea of progress when in *Prometheus Bound* he described primitive man as living "like silly ants beneath the ground in hollow caves unsunned." Before 400 B.C. Herodotus, Democritus, and others were arguing that the earth was round, the center of a revolving universe, composed of atoms and subject to natural law. They recognized changes produced by erosion and sedimentation. Later Plato, Aristotle, Pliny, and others added their bit although all their contributions made only a slight beginning.

Then came the Dark Ages. The Greco-Roman world was conquered from the northeast by the barbarians and from the southeast by the Christians. The Christian concept of an all-powerful God did not encourage the study of earth forces and laws. For a time culture passed to the Arabs, and in Europe the partly formed ideas concerning the earth awaited a more auspicious time for further development. Starting with their rebirth let us trace the evolution of a few of these ideas.

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[1] Address delivered before a joint meeting of the Washington Academy of Sciences and the Geological Society of Washington, November 19, 1936. Received December 15, 1936.

EROSION AND THE EARTH'S SURFACE

That rivers dig their own valleys is one of the large and useful concepts of modern geology. As with other ideas I shall take up, this has not yet completely emerged, and 100 years ago Benjamin Silliman, of Yale, one of America's great scientists, refused to accept it. The Greeks recognized more than two thousand years ago that valleys were silting up, deltas were extending, that floods produced minor changes along stream-channels and so on. These ideas though lost sight of in Europe, were preserved among the Arabs of North Africa. Thus in 1000 A.D. Avicenna, an Arab, translated Plato into Arabic and seems to have been the first to recognize that while some mountains were upthrust to the accompaniment of earthquakes, some were left in relief as erosion etched away the softer rocks surrounding them. Europe was not then reading Arabic.

The Crusades brought a change. The forest dwellers of western and middle Europe saw in the East a civilization superior to their own, some of which they brought back. Trade with the East developed and wealth accumulated, especially in Italy. Then came the Renaissance. Men began to explore the earth. The classics of Greece were restudied. Outstanding at that time was Leonardo da Vinci, born in 1452, who to his other accomplishments added a study of the earth. Thus he recognized that the river Po was building the plain of the Po valley; that high-level gravels were deposited when the river ran at that elevation long ago.

The idea that valleys were carved by the rivers in them encountered two almost insurmountable obstacles: first, the earth's obvious stability and lack of change as far back as man's memory or traditions went; and second, the concept of a six-day creation dating about 4000 B.C. Specifically the Mediterranean and the lands around it had not changed materially in the memory of man. Roman bridges 1,500 years old revealed no change in the river banks. The individual man saw no change in his landscape.

Two hundred years passed before the idea began to make headway that rain and rivers might produce major changes in the earth's surface. Nicholas Steno and John Ray saw that, given time enough, these forces would ultimately reduce the land to sea level. But lack of available past time still handicapped a proper concept of the origin of the earth's present features. Only catastrophic events would serve. Another century passed before observers here and there saw and recorded changes going on before their own eyes. De Saussure in

Switzerland, Guettard in France, and others began to realize that erosion gradually modifies the face of the earth.

Then Buffon broke the chains of time and finally James Hutton in 1785 boldly declared that given time enough the forces at work about us were adequate to account for all we could read in the rocks. Even then another half century passed before many leading geologists completely accepted the idea.

Hutton clearly pointed out that not only was erosion molding the face of the earth today but that rocks revealed many previous periods of long erosion followed by sinking and the laying down of thousands of feet of additional sediments. At the beginning of the twentieth century W. M. Davis recognized that sometimes, after a long period during which the earth's surface was reduced almost to a plane or "peneplane," uplift instead of sinking might follow, with the gradual destruction of the plane, which however might still be recognized in flat mountain tops or in other flat highlands bevelling rocks of different hardnesses. Then for a time every flat surface anywhere and at many elevations was called a peneplane until there was a veritable plague of peneplanes.

Within recent years came a clearer recognition that though erosion works slowly it takes no vacations and slights no parts of the earth's surface, even peneplanes. It was recognized that flat mountain tops often coincide with flat-lying resistant strata, or with upturned strata so uniform in character, thickness and structure that though reduced hundreds of feet they may still reflect a former peneplane. Evidence is clear that some monoclinal mountains have retreated many miles without losing their level summits. So most of the peneplanes have faded out, though many parts of the earth still reveal one or more.

Coming to the present. What next? Next we must reduce our qualitative knowledge of erosion to quantitative. The history of a river is revealed in the contours of its valley. At present we are content to name the changes that have taken place. The next logical step is to measure them. That will require care in the selection and evaluation of the criteria but offers no insurmountable obstacles. In particular we need to study the differential effect of erosion. If we say that, based on studies in the Mississippi, the surface of that basin is lowered one foot in 4,000 years, we do not mean that the whole surface is lowered that much. Flat, gravel-covered areas may be lowered very little, a fraction of an inch; intermediate areas may be lowered a foot; areas of high relief may be lowered several feet and river channels in areas of recent uplift may be cut down many feet; as in the San Juan Mountains where 2,500 foot canyons were formed between two uplifts, both of Pleistocene age. As another example, Sir Arthur Keith makes the Piltdown skull a million years old. It was found in plateau gravels 80 feet above the Ouse River cut in rocks of Cretaceous age. If that is a region of recent uplift, it is conceivable that the Ouse River might have deepened its valley 80 feet in 20,000 to 100,000 years, depending on all the factors involved. The matter should be completely solvable, as should be any other questions in which erosion is involved. But the answer demands vastly more facts than we now have.

FOSSILS AND WHAT THEY TELL

Passing the Greeks and Romans who correctly interpreted fossil shells as the remains of past life and as indicating the former presence of the sea where they were found, and skipping the succeeding Dark Ages, we come again to Leonardo da Vinci in the fifteenth century, who recognized the true organic nature of fossils. To account for sea shells hundreds of miles inland involved changes in the earth's face contrary to all human experience and tradition; and so for several hundred years a royal battle raged between those standing for their organic character and those finding other explanations, some even charging that the devil put them there to confound the pious. But as knowledge of fossils grew, there could be only one outcome of such a battle and by the end of the eighteenth century their organic origin was acknowledged by all except Werner, a mineralogist, and his disciples.

Meanwhile Guettard and others had found that fossils commonly characterized certain rocks, that they revealed the climate and physiographic conditions under which the rock was laid down, and, using fossils, they began to make geologic maps showing the outcrop of the strata. William Smith thus made a geologic map of England; but American geologists, many of them influenced by Werner, were slow to take advantage of fossils until the New York State Survey was established.

But fossils were leading down other roads. They revealed the former existence of plants and animals now extinct. Soon the outlines of the long ascent of life began to emerge. As vast numbers of fossils were found and men noted that in places the whole fauna changed from one layer of rock to the next, they began to speculate on the origin of these new and later forms. Some saw successive faunas and floras wiped out by catastrophies, followed by a wholesale creation of new faunas and floras. Others, like Lamarck, felt that somehow the later faunas had evolved from the earlier. The idea was not new. By the middle of the nineteenth century that idea had become dominant, though as yet no one had suggested how it could be brought about. Then Darwin and Wallace offered a mechanism that seemed adequate to account for the origin of the new species.

I need not tell you of the quick acceptance of that idea by the few and its general rejection by the many even to this day. We come to the present. What next? You know the tremendous importance of fossils today in all stratigraphic work, but I believe that they may perform another large service. I may be stepping on the toes of some if I suggest that biologists experimenting with fruit flies or other living forms miss entirely the fundamental factors in evolution, one of which is time. Marble is not flexible in the laboratory but I have seen thin marble slabs in cemeteries bend under their own weight—with time. In the laboratory time may be simulated for some things by "speeding up" processes, but not for others. Recent biological studies are valuable for a better knowledge of heredity; but the evidence is clear that while all life tends to adjust itself to its environment, it reveals no tendency to advance toward man. It is suggested that the steps in the ladder to man have been unique, each step occurring only at one place and at one time. It is not clear yet whether these steps were large, by mutations, or small and infinite in number. In either instance the question naturally arises as to their cause. Chance or purpose? Any attempt to get help from science on the answer to that question demands more knowledge of fossil life. It alone reveals the full play of time. Again we need more facts.

GEOLOGIC TIME

One of the astounding ideas given the world by geology is that of the enormous duration of earthly time. This was the missing factor in all early thinking about the earth. First estimates were based on supposed genealogic records, traditions and what not. All early peoples reckoned human history as very short, a few thousand years at most, and earth history as still shorter. The two periods were like the time it takes a man to build his house and the time he lives in it. The earth was built for man; the sun and stars were its exterior decorations. Even in the seventeenth century when Nicholas Steno, followed by others, first began to read successive events in the rocks, they felt impelled to compress them into the accepted span of earth history. Descartes and Leibnitz, who postulated the earth as derived in molten condition from the sun and as having cooled since, seem not to have committed themselves to time figures. Apparently that remained for Buffon, in the eighteenth century, after testing the rate of cooling of cast iron balls. He frankly declared that the six days of Scripture meant periods, to be as long as the facts demanded. He estimated 75,000 years from the beginning of the earth. Probably James Hutton was the first to realize that his interpretation of the rocks demanded vast stretches of time. As Playfair wrote, after seeing a cliff section with Hutton and Sir James Hall in a boat: "The mind grows dizzy looking so far into the abyss of time."

From then on an increasing number of people grasped the idea of geologic time, as illustrated by Lamarck's statement: "For nature time is nothing." While most geologists contented themselves with pointing out the evidence of vast time, a few dared to make estimates in years. As far back as 1715, Halley suggested determining the age of the Caspian sea by noting its increased saltiness over a period of years and computing its age from the total saltiness. As such an experiment might take centuries, it was not tried. In 1860 John Phillips started off with 38 million to 96 million years. But about the same time Lord Kelvin, Tait, and others, calculating the rate of the earth's radiation of heat, argued for 5 to 10 million years. Lyell had estimated the time required to lay down the Joggins coal measures in Nova Scotia at from 375,000 to 2,000,000 years. Later he estimated or guessed at 240 million years as necessary for historic geologic time. For a generation the dispute raged, estimates by geologists in the 1890's ranging as a rule under 100 million years, though Geikie in 1899 estimated from 100 to 400 million years.

In the early 1900's new means of estimates came from two directions, Sollas, Becker, and others, using the salt of the sea, contented themselves with small numbers, 30 to 80 million years; while Rutherford, using an entirely new method, in 1908 announced 500 million years as the time from the beginning of the Cambrian. The new method was based on studies of radioactive minerals and is today too well known to require more than reference here. As continued research appears to give concordant results, there is today a tendency to accept the general figures supplied by these studies, which indicate an age of roundly 500 million years from the beginning of Cambrian time.

Today, however, we are asking for more accurate measures for geologic time, especially, as previously suggested, in matters bearing on the antiquity of man. While many methods have been used in these studies, most satisfactory results are being achieved by correlating records of rhythmic sedimentation. These are of several kinds: the simplest and most satisfactory are varves or the annual layers of sediments deposited in ponded waters. Varves reveal not only the number of years represented by any such deposit but may reveal a seasonal record from year to year that permits correlating the varves of one area with those of another. Similar studies are now being made of fine deposits of all geologic ages and are not only yielding time estimates but in some instances are helping to identify key horizons in stratigraphic sections otherwise apparently homogeneous. In highly folded strata, the detection of such key horizons is essential to eliminate re-counting beds repeated by the folding.

Recently attempts have been made to identify larger cycles. Thus the four or more glacial advances suggest some kind of rhythmic series. The large number of coal beds usually found in coal measures accompanied by the underclay and other beds has suggested a cycle of events, climatic perhaps or of rhythmic earth movements. These are being studied to determine, if possible, the cause of the seemingly rhythmic movements. Efforts are also being made to determine if there may not be some cause for those still larger movements that result in geosynclines with heavy sedimentation, followed by apparent contraction with rock folding and mountain making.

Few results have yet appeared except with varves. But there is a growing feeling that more knowledge will reveal the interaction of great forces, perhaps astronomic in character and therefore measurable as to time, that will ultimately permit us to refer all geologic history to a definite and complete time scale, much as we do human history since man began to keep records of his comings and goings. But here again our crying need is for facts.

GLACIERS

Let us turn for a moment to something lighter. One reason why many early geologists refused to accept the idea that rivers had cut their valleys, was the presence over all of northern Europe and northern America of great bodies of debris called "The Drift" or "Diluvium," sand, gravel, clay and rock, piled helter-skelter over the land. The only plausible explanation was a vast flood. Why should not such a flood also have gouged out the valleys? True, Playfair in 1802 suggested ice; but the drift covered hills and mountains as well as valleys. Ice was inconceivable as a cause. But about 1830 two Frenchmen, Venetz and Charpentier, traced the tracks of ancient

Alpine glaciers from the Alps far out over the Swiss plains. In 1836 Louis Agassiz went over the ground with them and at once noted the resemblance of these deposits to the drift of other areas. Visiting England he was convinced that ice—glacial ice—had once pushed over all the British Isles. Von Buch, it is said, "could hardly contain his indignation" at the idea. But once delivered, the idea would not down. Agassiz persuaded Buckland, the English geologist, to visit the Swiss area with him and Buckland returned converted. Lyell followed. But it took many years to convert all geologists to the idea.

Then came the question: Whence and why the ice? Two theories arose; one that the drift had been deposited by floating icebergs while the drift-covered land was submerged beneath the sea. The other that from whatever cause, ice had accumulated at centers of distribution to such depth that it flowed outwards hundreds of miles over land and sea. Lyell in 1845 suggested a compromise that islands of floating ice had encroached on sinking lands. He assumed that from some cause glacial cold existed all over the northern hemisphere. Many theories were offered to account for this condition, from land changes affecting the Gulf stream and other oceanic currents to Croll's theory relating it to the shifting of the polar axes or variations in the heat of the sun. Obviously the localized character of the centers of ice accumulation, both in the recent Ice Age and in previous ice ages, ruled out any theory that affects the earth as a whole. On the other hand the existence of great mountain glaciers in the Alps, Sierras and other mountains outside the glaciated areas during the Ice Age rules out purely local causes. Recent physiographic studies revealing 10,000-foot canyons of Pleistocene age off our coasts and elsewhere, growing knowledge of other tremendous earth movements in Pleistocene time, as revealed in the Himalayas, Andes, Atlas, and other mountains, evidences that between the several glacial advances our coasts were flooded, are all throwing new light on the problem and may lead to its solution. But in the meantime we need more facts.

THE STRUCTURE OF THE EARTH

Finally, for I do not want to keep you here until the opening of the Quinternary Age, it may be of interest to trace briefly the emergence of present ideas about the structure of the earth. Early man took the earth for granted as it was. If he stumbled over the protruding edge of a layer of rock he probably swore in Egyptian, Hebrew or Greek as the case may be and let it go at that. Just when men began to observe layers of rock, other than layers of sand and gravel, is unknown. When they did they took them for granted as we probably do the mechanism of our new radio. If the rocks stood up on end, men assumed that they were made that way.

But the finding of fossils in certain rock layers suggested that these rocks had been deposited as sediments in the sea. At first it was thought that these beds and their enclosed life remains were laid down by the Flood. Apparently it was not until Nicholas Steno in 1669 published his treatise on the rocks of Tuscany describing six episodes in the geologic history of that area that men began to realize that the rocks were the result of earth forces and revealed a story. This idea made headway slowly. Here and there men began to observe distinctions in rocks and in the eighteenth century Peter Pallas, noting granite and schists in the center of the Urals, flanked by highly dipping rocks and those in turn by other rocks having low dips, distinguished the three series as primary, secondary and tertiary. Still it was commonly held that steeply dipping strata were formed that way. A theory to account for the many layers of rock at all elevations assumed that in the beginning an ocean as deep as the highest mountains covered the earth. As its surface gradually sank layers of rock were deposited. Where the water went to nobody knew, but presumably into the earth to form vast reservoirs as a source of springs. Steno held that the collapse of these reservoirs turned the overlying rocks on end, as they were often observed to be. But though this explanation was wrong, Steno had insisted that the upturned strata had been turned up by earth forces and, though generally denied, the idea slowly took hold, until Hutton in 1785, 150 years ago, presented clear evidence that granite and other igneous rocks had pushed their way up through the overlying beds, and not only penetrated them but turned them up on end and even exerted such a tremendous side thrusting effect as to fold them some distance from the upthrust.

As Rogers in Pennsylvania, Heim in the Alps and others began to describe and figure wide areas of highly folded beds many thousands of square miles in extent, often with overturned folds or thrust faults driven many miles over the tops of the other rocks, it became obvious that other factors besides igneous intrusion were involved. This led to the theory that, due to loss of heat from the interior, the earth's core was shrinking while its crust, maintained at a constant temperature was not, and that therefore it must in time buckle on the interior as does the skin of a dried apple.

Meanwhile, however, the discovery of tillites or ancient glacial deposits, some of Pre-Cambrian age, upset the idea of continuous cooling. Then came the discovery of radioactivity and the conclusion that radioactivity would not only explain the slow cooling of the sun but also the slow cooling of the earth and suggested that the earth was not actually cooling at any such rate as had been assumed. Calculation had indicated that, cooling by heat radiation alone, the sun should have become chilly long ago and that the earth could not be over ten or twenty million years old. Other difficulties also arose, such as enormous thrust folds in the Alps, and evidence of crustal extension or stretching, as indicated in rift valleys.

Then isostasy came into the picture—the idea that there is an isostatic balance between sectors of the earth's crust, so that light rocks in elevated areas are balanced by heavier rocks in relatively low areas, as under the sea bottom. The only way such a balance can be maintained under changing surface load is by the transfer of rock below the surface from one area to another. Thus, as a mountainous area is lowered by erosion, its weight is reduced, while the area receiving the sediments has its weight increased. According to isostasy, a flow of deep seated plastic rock from the area of sedimentation to the area of erosion, will not only maintain the balance but will account for the gradual and continued elevation of the area of erosion and the gradual, continued sinking of the area of sedimentation. But which movement came first and what started it?

Recently isostasy has been criticized from many angles. All through past time shores have advanced and retreated; but an advancing shore means uplift in the region of loading and a retreating shore means sinking in the region of unloading. Furthermore our growing knowledge of stratigraphy has shown tremendous gaps in the sedimentary record during which the area of sedimentation either stood stationary over long periods and received no sediments or was lifted above sea level and actively denuded. These facts raise questions as to whether surface loading and unloading is a primary or secondary factor. Isostasy does not seem to account for the vast surface overthrusts such as the 75-mile Alpine thrust, the 35-mile or more Bannock overthrust of Idaho and Wyoming, the overthrusts of Glacial National Park, and many others.

I will not attempt to lead you through the mazes of the "undation" theory of Stille and others, in which, starting with a variable differentiation of the acidic from the basic rocks in a subsurface gabbrolike mixture, there follows a theoretic succession of events producing the surface features we observe, even to the great overthrust faults. It is certainly an ambitious attempt to explain the earth's major crustal features but it needs more study of all the facts involved, not overlooking the factor of friction. According to this theory the medial ridge of the Atlantic is the beginning of a new continent.

Recently Alfred Wegener, struck by the resemblance of the east shore line of the Americas to that of the west shore line of Europe and Africa, suggested that at sometime in the past these continents were united, but subsequently drifted apart. He found some resemblances in the direction and age of the mountains on both sides of the Atlantic. This theory helped to explain how in many ages animals and plants living on the east side of the Atlantic could have left their remains on the west side also, before the days of arks or other boats, and obviated the building of land bridges. The physicists, however, raised questions of friction and other mechanical difficulties so that the theory has not been widely accepted.

Tokuda, of Japan, noting chains of islands or chains of mountains, making great arcs, as in the Aleutian islands, has been experimenting to show that these might have been formed by great sliding crustal fans. Imagine an old land bridge between Alaska and Asia taking a slide southward, pushing up the Aleutian Islands at its toe and leaving a depression behind now filled by the Behring Sea. The Okhotsk Sea, Sea of Japan, East China Sea, South China Sea and Philippine Sea, are each thought to fill the voids left by other great slides, not to mention the Caribbean Sea and others. It may be true but at first it takes your breath away.

No other field of geological investigation is today more active in producing new ideas, many quite startling and upsetting to old conclusions. One of the old ideas now before the court of inquiry is that great periods of mountain building were of limited duration. It is generally recognized today that most of our mountains are not simple mountains of folding, but are due to subsequent and recent uplift, sometimes with faulting, of old areas of land, underlain or not by folded rocks. Nearly all the high ranges bear traces of past peneplanation on their shoulders.

But back of that, evidence of persistence of structures is accumulating all over the world. We have long known that the Cincinnati Arch, as we call it, was not a single uplift. The Himalayas began to form in Cretaceous time at the north, continued to form in Eocene and lower Miocene time and have reached their present height only recently. In England we find Cretaceous folding in places following the underlying Carboniferous folding, with peneplanation between. In the Appalachians, evidence is accumulating that folding began in Ordovician time or earlier, and it begins to look as though the eastern Appalachians had largely been folded by the beginning of Silurian time or continued to be folded during Post-Ordovician time and thus became the source area for the later Paleozoic rocks. Finding Devonian fossils in "Pre-Cambrian" schists in New England is only one of the disturbing new facts.

This is not the time or place to go into details. I only mention some of the new theories, to show how ideas on orogeny are struggling to emerge. These studies are revealing new patterns or a framework in the earth's major features. New facts are complicating old problems, but they also serve to define more clearly those problems, until, as C. F. Kittering would say, "Some day we will have defined our problems so exactly that we shall have solved them."

Without pursuing the matter further, we realize today that our urgent need in every geological field is for facts and more facts. Our knowledge of the earth is just about where the knowledge of the body was two or three hundred years ago. Unfortunately our efforts to penetrate the mysteries of the earth's interior are comparable to attempting to make an autopsy of a man's body with his clothes on.

PALEONTOLOGY.—*A specimen of* "Crassatellites" *from the St. Marys formation of Maryland.*[1] W. C. MANSFIELD.

Dr. S. F. Blake, U. S. Department of Agriculture, recently collected a left valve of the genus "*Crassatellites*" from the St. Marys formation at Chancellor Point, St. Marys River, Maryland, and kindly turned it over to me for identification. The bluish sandy clay deposit at Chancellor Point was referred by Shattuck[2] to zone 24, or the highest zone, of the St. Marys formation of Maryland.

The specimen in hand is interesting because no species or subspecies of "*Crassatellites*," to my knowledge, has heretofore been identified from the St. Marys formation of Maryland, although two subspecies —"*C.*" *meridionalis surryensis* Mansfield and "*C.*" *undulatus urban-*

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[1] Published by permission of the Director, U. S. Geological Survey. Received December 24, 1936.

[2] SHATTUCK, G. B., Maryland Geol. Survey, Miocene, p. lxxxv, 1904.

naënsis Mansfield (formerly called a subspecies of *meridionalis*), have been obtained from the St. Marys formation of Virginia, the former taken from the basal bed consisting of a blue sandy clay exposed in the right bank of the James River, 1½ miles below Claremont Wharf; and the latter from a stratigraphically higher sandy deposit at Urbanna.[3] The Maryland specimen, though slightly corroded in the umbonal region, appears either to be *"C." meridionalis surryensis* Mansfield or a closely related form. The slight differences observed between the Maryland form and the Virginia subspecies is that the Maryland form is smaller, thinner, more quadrate, and the nepionic undulations extend radially about 3 mm farther. The dimensions of the Maryland specimen are: length, 70 mm; height, 50 mm; distance of umbo to the anterior end, 30 mm.

With only one specimen in hand from the St. Marys formation at Chancellor Point, I do not think a new subspecific name is warranted unless more specimens are collected from this horizon that show the assumed differences to be constant.

A right valve of a *"Crassatellites,"* so far unidentified, was taken a number of years ago from a well at a depth of 130 feet at Crisfield, Sommerset County, Maryland. This specimen is corroded in the umbonal region; however, relying on the other better preserved parts of the shell, it appears to be the same as the subspecies from Virginia—*"C." meridionalis surryensis*. The base of the St. Marys formation in this well is estimated to be at a depth of about 240 feet.

At present the following species or subspecies of *"Crassatellites"* are represented at different horizons of the Chesapeake group: *"C." melinus* (Conrad), Calvert formation; *"C." turgidulus* (Conrad), Choptank formation, zone 17; *"C." marylandicus* (Conrad), Choptank formation, zone 19; *"C." meridionalis surryensis* Mansfield, St. Marys formation, Maryland (?) and Virginia; *"C." undulatus urbannaënsis* Mansfield, uppermost St. Marys formation, Virginia; *"C." undulatus cyclopteras* Dall, Yorktown formation, zone 1 and later; *"C." undulatus* (Say), Yorktown formation, zone 1, to Duplin marl (uppermost Miocene).

The name *"Crassatellites"* is placed in quotation marks here as the nature of this name has been indicated by Iredale (Mal. Soc. London Proc., vol. 14, p. 206, 1921) to be unsatisfactory. Consequently, the correct generic names to be applied to the east coast Miocene forms cannot be given until a study of the family Crassatellidae is made.

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[3] MANSFIELD, W. C., U. S. Nat. Mus. Proc., vol. 74, art. 14, pp. 8–9, 1929.

STRATIGRAPHY.—*The stratigraphic significance of* Kummelia, *a new Eocene bivalve genus from New Jersey.*[1] LLOYD W. STEPHENSON, U. S. Geological Survey.

The tube of a boring bivalve mollusk from the Vincentown sand (Rancocas group, Eocene) was described by Gabb (1) in 1860, under the name *Gastrochaena americana.* At that time the Vincentown was classed as Upper Cretaceous, and it was not until 1928 that Cooke and Stephenson (2) reassigned the formation, together with the underlying Hornerstown marl of the Rancocas group, and the overlying Manasquan marl, to the Eocene. Tubes of boring mollusks found in beds of undoubted Upper Cretaceous age, in the Atlantic and Gulf Coastal Plain, were referred to Gabb's species by Gabb himself and by Weller and others, but, as shown below, this identification was erroneous.

In 1861 Gabb reassigned his *Gastrochaena americana* to his new genus *Polorthus* in the belief that the tube was a conch and pertained to a gastropod near *Vermetus.* In 1872 Gabb reassigned *Polorthus americanus* to the Cephalopoda and made it the type of a new family, Polorthidae; this was done because he had come to believe that the suture-like grooves separating the annulations on the exterior of the tube indicate a chambered, septate conch.

That Gabb was mistaken in both of these reassignments, and that his *Polorthus americanus* is an external, protective calcareous tube secreted by a boring bivalve mollusk, can now be demonstrated. The present author has had the good fortune to find in the tubes specimens of the bivalve mollusks responsible for the construction of the tubes, both those in the Vincentown sand and those in the Upper Cretaceous sediments; the evidence afforded by these shells demonstrates clearly that the animal that secreted the Eocene tubes is both generically and specifically distinct from the one that built the Cretaceous tubes. The differences which serve to separate the two kinds of shells and tubes are indicated in the formal description given below. The Cretaceous shells and their tubes are strikingly like those of the true *Gastrochaena* Spengler, a Recent bivalve inhabiting the waters of the Indian and West Pacific Oceans, whereas both the Eocene shell and its tube are essentially different from *Gastrochaena.* Although the shells found in the tubes from the Eocene are similar in form to *Roscellaria* Blainville, a Recent shell, the Eocene tube is

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[1] Published by permission of the Director, U. S. Geological Survey, Washington, D. C. Received December 18, 1936.

strikingly different from that of *Roscellaria,* for which reason, and also because of the great separation in time, it seems reasonable to assign the Eocene shell to a new genus. The name proposed is *Kummelia.*

One incomplete tube of a boring mollusk, found by Dr. John B. Reeside, Jr., September, 1931, in the Piscataway member of the Aquia formation (Eocene), in a road cut just east of the West Branch of Patuxent River three fourths of a mile west of Oak Grove, 2.6 miles west of Leeland, Prince Georges County, Maryland (3), is essentially like that of *Kummelia americana* (Gabb); the shell itself was subsequently uncovered within the tube and it confirmed the identification. The shell and tube are shown in Figures 6–8. The road cut exposes about 15 feet of greensand, several layers of which are indurated. The tube was found in a loose fragment of one of the indurated layers; associated with the tube in the same piece of rock were several shells of *Terebratula harlani* Morton.

The finding of *Kummelia americana* (Gabb) in the Aquia formation of Maryland affords further confirmatory evidence of the Aquia (Eocene) age of the Rancocas group of New Jersey. The Oak Grove locality is stratigraphically well below a zone in the Paspotansa member of the Aquia formation (3) from which 23 species of Bryozoa have been recorded by Canu and Bassler (4); 6 of the 23 species are common to the Vincentown sand. Since the Vincentown has yielded 85 species of Bryozoa, this relatively small number of common species does not necessarily indicate exact age equivalency of the containing beds in Maryland and New Jersey; but there is a reasonable presumption that they do not differ greatly in age, and the position of the Oak Grove locality below the bryozoan zone suggests that it is of Hornerstown age.

In the summer of 1936, Mr. P. E. Cloud of the U. S. National Museum, made a collection of fossils from the Hornerstown marl in a pit of the Zeolite Chemical Company, 2 miles north of Medford, Burlington County, N. J. The fossils are mainly in the form of internal molds and include: An unidentified coral (common); an unidentified sponge (numerous); *Cucullaea* sp. (numerous); *Venericardia* (of the *planicosta* group); *Meretrix*?; *Polinices* sp.; *Pleurotomaria*?, and several unidentified gastropods. Of the forms mentioned the *Venericardia* may be accepted as satisfactory evidence of the Eocene age of the Hornerstown marl. The *Cucullaea,* though specifically indeterminate, has a form suggestive of *C. macrodonta* Whitfield from the Midway group (Eocene) of the Gulf region.

In recording this new evidence of the Eocene age of the Rancocas group, it is appropriate to call attention to evidence presented in three papers that have appeared since the publication by Cooke and Stephenson (2).

In 1930, Wetmore (5) critically reviewed the stratigraphic occurrence of eight species of fossil birds from supposed Cretaceous beds in New Jersey. He found that all came from the Hornerstown marl, the lower of the two formations composing the Rancocas group, and he concludes:

> From what has been said above it is evident that all of the supposed Cretaceous birds of the New Jersey marl beds are in reality from Tertiary deposits since they appear to come from the Eocene. They will be so indicated in the list of fossil birds to be included in the fourth edition of the "A.O.U. Check-List" now in course of preparation. With these forms allocated in the Eocene there is more logic in including them under families of birds with species existing today, procedure that to the writer has seemed dubious while they were considered of Cretaceous age since it is his present belief, based on what is known of the Hesperornithiformes and the Ichthyornithiformes, the only Cretaceous birds in which the skulls have been found, that all Cretaceous birds possessed teeth, and were for this and other reasons not so closely allied to living species as to permit their inclusion in living families.

In 1935 Miller and Thompson (6) discussed the significance of *Aturoidea* in the Hornerstown, Vincentown and Manasquan formations of New Jersey as follows:

> Although representatives of the genus *Aturoidea* have been found in beds which are clearly Upper Cretaceous in age, the Upper Cretaceous and the so-called Danian forms from India and northern Africa are very much more primitive than are the definitely Eocene forms, *A. parkinsoni* and *A. spathi*. As can be seen by comparing the figures on plates 65 and 66, *A. paucifex* and *A. pilsbryi* are strikingly similar to *A. parkinsoni* of the London clay (Yprésien), which has been correlated by some authors with the Aquia formation of Maryland and the upper portion of the Wilcox group of the Gulf Coastal Plain. *Aturoidea spathi* of the Eocene Ranikot series of India also appears to be very closely related, and although these four species came from three widely separated localities, the fact that they are very closely similar indicates that the beds which yielded them are probably not greatly different in age.

Jennings' (7) conclusions (1936), based on the microfauna of the Monmouth group and of the Hornerstown marl of the Rancocas group, add confirmatory evidence of the Eocene age of the Hornerstown.

Kummelia Stephenson, n. gen.

Type species: *Gastrochaena americana* Gabb.

The proposed new genus *Kummelia* is a sand-boring pelecypod that secreted an inclosing, long, tapering, more or less irregular tube characterized by rather widely spaced annular grooves of somewhat irregular trend around the tube. The spacing of the grooves ranges from 2 to 7 millimeters, and the angle of divergence of opposite sides of the tube is approximately 6 degrees. The small end of the tube is not complete in any of the available material. The large end of the tube is sealed over in adults. The shell found within the tube is elongated, subtrigonal in outline, and is widely gaping posteriorly, ventrally and anteriorly. In form it closely resembles the shell of the Recent genus *Roscellaria* Blainville, whose tube in contrast is short, irregular, roughly bottle- or jug-shaped, and is rendered even rougher in appearance by the adherence to its outer surface of sand grains, fragments of shells, and other extraneous matter.

In its habit of growth this bivalve began at a young stage to bore in the sand and to construct a protecting tube of calcium carbonate around itself. As it bored deeper and grew larger it gradually increased the size of its tube and eventually reached a size such that it could not escape backward out of its self-constructed prison; however, it maintained connection with the outer world, that is with the water above the small end of the tube, by means of an elongated siphon. As shown by the position of the shell in the large incomplete tube illustrated in Figures 6–8, the animal was able to back up a distance of at least 34 millimeters from the basal, or large end. In other tubes the shell is at the base. In all cases observed the forward end of the shell is directed toward the large end of the tube.

For further details see the following description of the type species, *Kummelia americana* (Gabb).

The genus is named in honor of Dr. Henry B. Kummel, Director of the Department of Conservation and Development of New Jersey.

Kummelia americana (Gabb), n. comb. Figs. 1–8

1860. *Gastrochaena americana* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 393, pl. 68, fig. 20.

1861. *Polorthus americana* Gabb, Acad. Nat. Sci. Philadelphia Proc., vol. 13, p. 367. (In part.)

1872. *Polorthus americanus* Gabb, Acad. Nat. Sci. Philadelphia Proc., vol. 24, p. 259, pl. 8, fig. 8. (In part.)

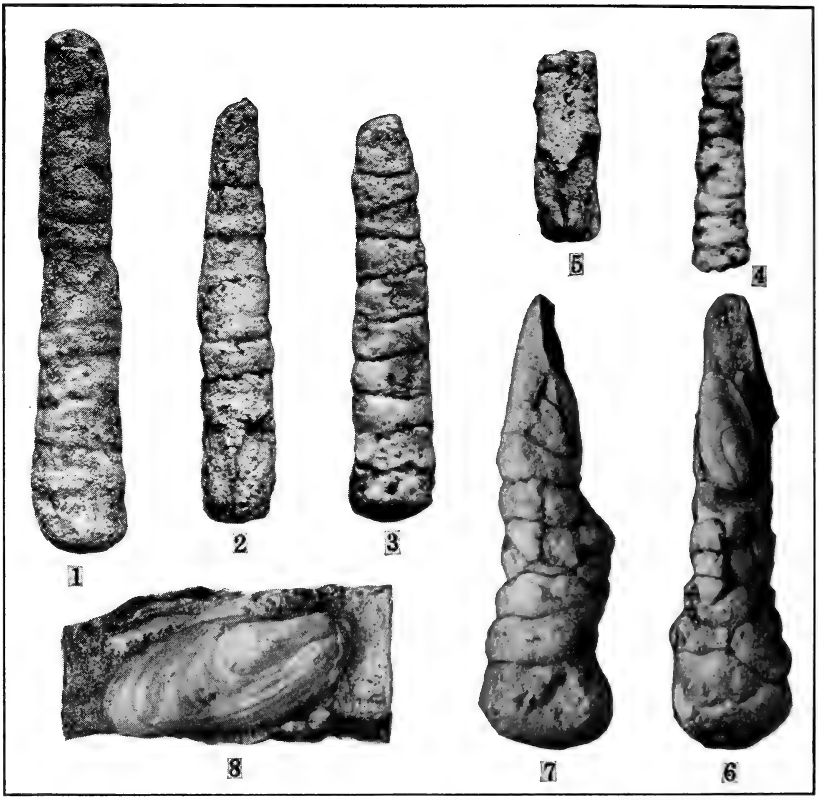
1885. *Gastrochaena americana* Gabb. Whitfield, U. S. Geol. Survey Mon., vol. 9, p. 203, pl. 26, figs. 17, 18 (in part). (New Jersey Geol. Survey, Paleontology, vol. 1, p. 203, pl. 26, figs. 17, 18, 1886.)

1905. *Gastrochaena americana* Gabb. Johnson, Acad. Nat. Sci. Philadelphia Proc., vol. 57, p. 18.

1907. *Gastrochaena americana* Gabb. Weller, Geol. Survey New Jersey, Paleontology, vol. 4, p. 649, pl. 73, fig. 13.

The following is Gabb's original brief description of the tube of this species: "Elongated conical; transversely wrinkled; termination of widest end, round. Length 2.5 in., greatest diameter 0.5 in. Common in the yellow limestone [Vincentown] of Timber Creek, and found with the above species [*Teredo irregularis*] in the brown marl [Hornerstown] of Burlington Co., N. J."

In the collection of the Academy of Natural Sciences of Philadelphia is a tray containing 8 incomplete internal molds of tubes apparently representing as many individuals, labeled *Gastrochaena americana* Gabb (A.N.S.



Figs. 1–8.—*Kummelia americana* (Gabb). 1, a tube, the largest among the 8 cotypes (A.N.S.P. no. 13403); this is probably the specimen which served as the principal basis for Gabb's original drawing, which, however, appears to have been partly restored at the small end on the basis of the smallest cotype. 2, one of the cotypes (A.N.S.P. no. 13403), a tube with impressions of the two valves of the shell, uncovered at the large end. 3, 4, tubes from the Vincentown sand of New Jersey (U.S.G.S. Coll. 17282), showing the characteristic annulations (U.S.N.M. 496382). 5, a tube in the same lot as the preceding, showing impressions of the two valves of the shell, uncovered at the large end. 6, 7, an incomplete tube and shell from the Aquia formation ¾ mile west of Oak Grove, Prince Georges County, Md. (U.S.G.S. Coll. 16014); just prior to the animal's death it had backed up a distance of 34 mm from the large end of the tube (U.S.N.M. 496381). 8, an enlarged view of the shell, a right valve, in the tube shown in the two preceding figures.

No. 13403). I am indebted to Dr. Henry A. Pilsbry for the privilege of examining and redescribing Gabb's types. The largest of the specimens, marked "type" in faded ink, is 69 mm long, 12.5 mm in greatest diameter, and 7 mm in least diameter (Fig. 1); this tube is shorter than the original figure, which is 76 mm long, but is longer than the dimensions (2.5 inches) given by Gabb. The small end appears to be freshly broken and the tube may have met with an accident subsequent to the drawing of the original figure, which appears to represent a tube more symmetrical and smoother than the supposed type; however, the drawing may have been somewhat generalized. A small label in the tray in Gabb's handwriting reads: "*Gastro-*

chaena americana Gabb, Timber Creek, N. J. Types." The word *Gastrochaena* has been crossed out in pencil and the word *Polorthus* written below it, apparently in the same handwriting. All the specimens have the characteristic annular rings more or less clearly impressed upon them. The large end of the tube marked "type" bears indistinct markings which appear to pertain to the forward end of the inclosed shell. On the large end of another specimen in the lot the forward end of the shell was unmistakably exposed and was subsequently uncovered by the present author (Fig. 2); it is rather poorly preserved. These evidences of the presence of shells within the tubes were not recorded by either Gabb or Whitfield.

The following description is based on the type material, supplemented by 7 specimens in the U. S. National Museum labeled "Vincentown sand" (without further locality description), one specimen collected by the writer from the Vincentown sand on Crosswicks Creek, N. J., and one specimen from the Aquia formation near Oak Grove, Md.; the shell is best preserved on the last mentioned specimen.

Tube long, slender, tapering, circular in cross section, with sides diverging downward at an angle of approximately 6 degrees. The tubes vary from nearly straight to slightly and irregularly sinuous, and are marked by a series of transverse, irregularly spaced, suture-like grooves, at vertical intervals of 2 to 7 mm; the outer surface is more or less rough and irregular. The tubes have a maximum measured diameter of 18 mm and an undetermined minimum diameter of less than 4 mm. Complete adult tubes may have exceeded a length of 120 mm. The large end of the tube of adults is sealed over with a layer of calcium carbonate; it is broadly rounded, becoming more sharply rounded on its perimeter. On corroded specimens the grooves are seen to mark the edges of transverse septum-like walls similar to the convex calcitic layer sealing the large end of the tube; these walls may have sealed the tube at the successive growth stages indicated by the grooves, and were centrally resorbed or mechanically removed sufficiently to permit the animal to advance during each new growth stage.

In the incompletely labeled lot in the National Museum the large end of a small tube contains the impression of a bivalve shell with both valves intact in a fair state of preservation (Fig. 5), and a better preserved shell is contained in the tube from near Oak Grove, Md. (Figs. 6–8). The shell is elongated subtrigonal in outline; although the valves appear to be partly spread apart ventrally, the shell was obviously widely gaping posteriorly, ventrally and anteriorly. The beaks are situated about 1.5 mm back of the sharply rounded anterior extremity; they are small, incurved, and prosogyrate. The umbonal region is broad and only moderately prominent, descending steeply in front; it forms a broadly rounded inflation which extends backward and slightly downward, broadening and fading out toward the lower posterior extremity.

Hinge line long and straight, antero-dorsal margin short, slightly descending; anterior margin sharply rounded above, curving less sharply into the long, broadly rounded, slightly sinuous ventral margin; posterior margin sharply rounded below, curving broadly into the dorsal margin above. The dorsal margins of the two valves found form a keel of moderate prominence toward the posterior end of the hinge. Hinge and interior features not uncovered. Surface of shell marked by irregularly developed, low, moderately coarse, concentric wrinkles which are strongest anteriorly below the umbonal inflation.

The incomplete tube from near Oak Grove, Md., is larger than any of the available New Jersey specimens. It measures: Length 61+ mm, maximum diameter at the large end 18 mm. The right valve of the shell in this tube has been uncovered in a fair state of preservation; at the time of the animal's death it had backed up until the front end of its shell was 34 mm above the large end of the tube. The shell is 17 mm long and 9 mm high. The tube exhibits the same sort of irregular annulations as those on the tubes from the Vincentown sand; although the Maryland specimen is incomplete and imperfectly preserved, both the tube and shell characters are essentially like those of the New Jersey specimens, and there is no reasonable doubt of their specific identity.

The shell of *Kummelia americana* lacks the square anterior truncation of *Gastrochaena* and has a broadly rounded ventral margin instead of a nearly straight one. The tubes of the two genera are also markedly different. *Gastrochaena* has a straight, regularly tapering tube marked by numerous closely-spaced, regular annulations; the tube of *Kummelia* has a rougher exterior, is more or less sinuous, and is characterized by much wider annulations separated by grooves of irregular spacing, which pass around the tube in an irregularly sinuous trend. The genotype of *Gastrochaena* is *G. mumia* Spengler, a Recent species.

The known material of *K. americana* includes the following:

A.N.S.P. no. 13403 (types). Vincentown sand on Timber Creek, N. J.; this creek forms the boundary between Camden and Gloucester Counties.

U.S.N.M. 496380 (U.S.G.S. Coll. 17279). Vincentown sand on a small east-flowing branch of Crosswicks Creek 0.7 mile north by west of New Egypt, Ocean County, N. J.; fragment of the large end of a tube 33 mm long, from within 10 feet of the base of the formation. Collected by the author, October 10, 1936.

U.S.N.M. 496382 (U.S.G.S. Coll. 17282). Three figured specimens labeled "Vincentown sand," with no additional information as to locality; the material doubtless came from New Jersey. U.S.N.M. 496383 (U.S.G.S. Coll. 17282). Four unfigured specimens from the preceding lot.

U.S.N.M. 496381 (U.S.G.S. Coll. 16014). Aquia formation in a road cut on the west-facing slope of the valley of the West Branch of Patuxent River, 3/4 mile west of Oak Grove, 2.6 miles west of Leeland, Prince Georges County, Md. Collected by J. B. Reeside, Jr., 1931.

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3. Clark, W. B., and Martin, G. C. *The Eocene deposits of Maryland.* Md. Geol. Survey, Eocene: 1–92 (esp. 74–81). 1901.
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ENTOMOLOGY.—*The bees of the genera* Augochlora, Augochloropsis, *and* Augochlorella (*Hymenoptera; Apoidea*) *occurring in the United States.*[1]

GRACE A. SANDHOUSE, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

This study of the brilliant, blue-green halictine bees of the genera *Augochlora, Augochloropsis,* and *Augochlorella* occurring in the United States was undertaken to facilitate their identification. The collections representing these genera in the United States National Museum have served as a basis for this revision and were supplemented by loans from other institutions and private collections.

I am greatly indebted to Mr. Robert B. Benson, of the British Museum, for comparison of specimens with the types of Smith's species; to Dr. C. R. Jones for information about the types in the collection of the Colorado Agricultural College; and to Messrs. Pierre-Georges Roy and Noel Comeau of the Musée de la Province de Quebec for comparisons of material with Provancher's types.

These genera may be separated by the following key:

1. First and second abdominal tergites each with apical fringe of simple bristles (if the fringe is worn off, an apical row of punctures visible); pubescence of tergites uniform and directed posteriorly; tegula large, metallic blue-green, caudal margin nearly truncate, inner margin emarginate; carinae on posterior-lateral angles of propodeum parallel, extending almost to dorsal surface. Female: Apical portion of labrum semicircular; posterior calcar of hind tibia pectinate. Male: Labrum with a median basal groove; first three abdominal segments more strongly developed than the others, the caudal segments usually partially retracted within the third; fourth sternite concealed under third, posterior-lateral angles extending into long processes, caudal margin with median projection, margin of fifth emarginate.. *Augochloropsis* Cockerell

   First and second abdominal tergites each without apical fringe of simple bristles, apical margins impunctate; tergites with long hairs directed posteriorly and short hairs laterally; tegula small, oval, brown or testaceous, usually without metallic tints; carinae on posterior-lateral angles of propodeum converging below, extending less than half way to dorsal surface. Female: Apical portion of labrum narrowly triangular; posterior calcar of hind tibia serrulate. Male: Labrum without a median basal groove; abdominal segments more uniformly developed, caudal segments not retracted; fourth sternite without posterior-lateral processes, caudal margin truncate or emarginate, margin of fifth usually truncate...2

2. Head broad, ocellocular line one and one-half times as long as postocellar; vertex gradually declivous behind postocellar line to the sharply defined occipital carina, the carina extending to hypostomal carinae;

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[1] Received December 28, 1936.

mesopleura punctate; metapleural suture carinate; apex of radial cell truncate, with appendiculate vein. Female: Mandible apically bidentate, the teeth subequal; first sternite usually with median carina or tooth, sixth with median triangular polished area; inner surface of hind femur with single row of long pinnately branched hairs. Male: Second flagellar joint distinctly longer than first; sides of propodeum deeply, nearly contiguously punctured; caudal margin of fourth sternite truncate . . . . *Augochlora* Smith

Head narrow, ocellocular line subequal to postocellar; vertex abruptly declivous behind postocellar line to the more weakly defined occipital carina, the carina obsolescent some distance from hypostomal carinae; mesopleura irregularly foveolate, indistinctly punctured; metapleural suture not carinate; apex of radial cell pointed. Female: Mandible with large rounded inferior tooth and smaller superior tooth separated by narrow emargination; first sternite without carina or tooth, sixth without triangular polished area; inner surface of hind femur with several rows of short unilaterally branched hairs. Male: First and second flagellar joints subequal; sides of propodeum indistinctly and rather sparsely punctured; caudal margin of fourth sternite usually emarginate . . . . *Augochlorella*, n. gen.

Augochlorella, n. gen.

Augochlora F. Smith, Cat. Hym. Brit. Mus., **1**: 73. 1853 (part).—Provancher, Natur. Canad., **13**: 205. 1882 (part).—Petit, Faun. Ent. Canad., p. 705, 1883 (part).—Robertson, Trans. Amer. Ent. Soc., **20**: 147. 1893 (part).—Dalla Torre, Cat. Hym., **10**: 93. 1896 (part).—Cockerell, Canad. Ent., **29**: 4. 1897 (part).—Robertson, Canad. Ent., **29**: 64. 1897 (part).—Cockerell, Trans. Amer. Ent. Soc., **24**: 162. 1897 (part).—Ashmead, Trans. Amer. Ent. Soc., **26**: 91. 1899 (part).—Cockerell, Proc. Acad. Nat. Sci. Phila., p. 374, 1900 (part).—Trans. Amer. Ent. Soc., **31**: 356. 1905 (part) (new synonymy).

Oxystoglossa Robertson, Canad. Ent., **34**: 244. 1902 (part) (new synonymy).

Halicti falcati groupe *Oxystoglossa* Vachal, Misc. Ent., **19**: 14. 1911 (part).

Genotype: Augochlora gratiosa Smith.

This genus is similar in general appearance and color to *Augochlora*, and the species assigned here were previously placed in that genus. The characters of the genus follow:

Head: In facial view nearly triangular, with angles rounded. Eyes large and bare, with their inner margins weakly emarginate, forming the lateral boundaries of the head for most of its length. Front slightly convex, contiguously punctured, occupying about half the space between anterior ocellus and apex of clypeus; a fine median carina on lower half. Vertex sparsely punctured, rather abruptly declivous to occipital carina. Postocellar line subequal to ocellocular. Occipital carina moderately well developed, obsolescent some distance from hypostomal carinae. Clypeus as broad as long in female, narrower in male, extending about half its length beyond lower margin of eye, apical margin truncate; clypeus and postclypeus strongly convex, with large punctures separated by more than their diameter; postclypeus shorter than clypeus. Basal portion of labrum of female broadly subrectangular, medially tumescent, apical portion narrowly triangular, medially sharply carinate, margins fringed with simple bristles. Labrum of male broadly subrectangular, convex, apical margin slightly curved and fringed, the bristles shorter than in the female. Gena obsolete.

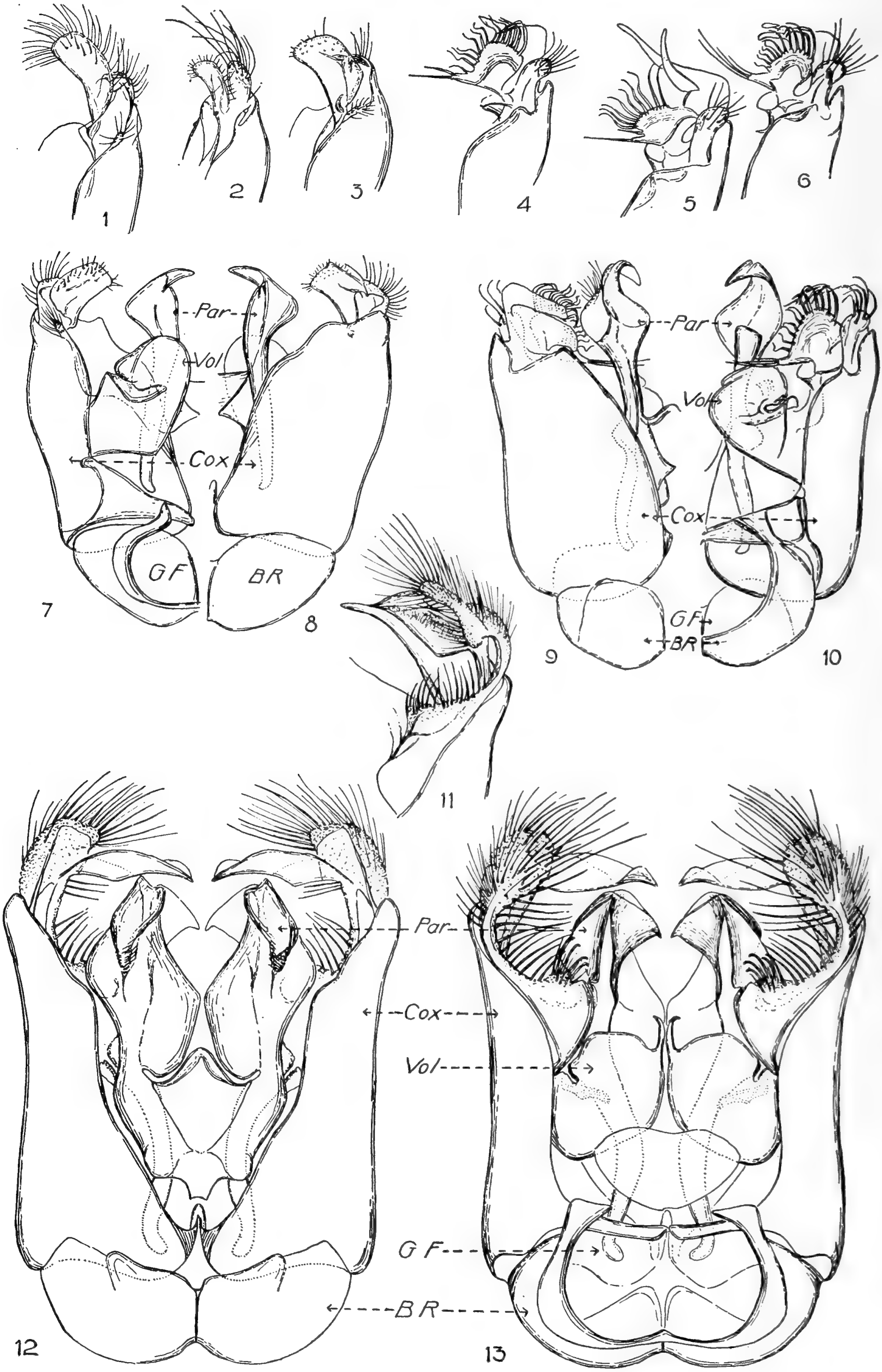
Post-gena declivous from outer margin of eye to occipital carina, striatopunctate above, finely tessellate and nearly impunctate below. Hypostomal carinae well developed, nearly parallel, without modifications. Mandible rather strongly curved; of female, with large rounded inferior tooth and smaller superior tooth separated by narrow emargination; of male edentate, tapering to pointed apex. Maxillary palpi six-jointed, labial palpi four-jointed. Antennae inserted about half way between apical margin of clypeus and postocellar line; scape of female about one-third length of antenna, flagellar joints progressively longer to apex; scape of male subequal to combined length of flagellar joints 4 to 6, joints 3 and 4 subequal, distal joints progressively longer.

General structure of thorax similar to that of related genera, more robust in female. Pronotum not modified. Mesoscutum broader than long, punctation usually varying specifically; parapsidal furrows as long as tegula, parallel; mesoscutellum nearly twice as long as metanotum, punctation similar to that of scutum. Mesopleuron, metanotum, and metapleuron irregularly foveolate-punctate. Propodeum extending horizontally for a short distance, then abruptly declivous to attachment of abdomen; dorsal surface or "disk" subcrescentic, the sculpture varying specifically; posterior-lateral angles carinate on lower third; posterior and lateral surfaces irregularly foveolate-punctate. Tegula small, oval, anteriorly with fine setiferous punctures.

Wings hyaline, yellowish infumate, veins brownish testaceous; venation of the usual type for the Halictinae; radial cell pointed at apex; second cubital cell higher than wide, always narrower in males. First recurrent nervure antefurcal or interstitial with second transverse cubital nervure. Legs typical for the subfamily and constant within the genus. Female: Inner surface of hind femur with several rows of short, unilaterally branched hair (similar to *Augochloropsis*); outer surface with long, pinnately branched hairs; knee-plate of hind tibia subovate, not so sharply defined as in *Augochlora;* inner tibial calcar serrulate. Male: Inner margin of hind basitarsus with fringe of hairs, which sometimes vary in length specifically.

Abdomen of female broadly ovate, of male more slender; tergites rather uniformly punctured except that the caudal margins are impunctate; shorter hairs directed laterally, longer ones posteriorly. Female: Fifth tergite with median rima, laterally densely pubescent; pygidial area of sixth narrow, sides parallel, apex truncate, apical-lateral angles rounded. Male: Sternites unmodified except the median emargination of caudal margin of fourth, which varies specifically.

Male genitalia: Basal ring cupuliform dorsally, much narrower ventrally and extending posteriorly as two processes which are attached to the bases of the coxopodites, instead of meeting medially. Coxopodites broad, shorter than the parameres, the distal ends with modifications which are constant for the species. On the ventral surface and near the distal end of the coxopodite is a flat, somewhat plate-like process, the caudal margin of which bears ribbon-like processes. Volsellae nearly flat, lying between the coxopodites distad of their ventral basal processes. Parameres narrow at bases, rather broadly expanded just before bending ventrally, apices pointed; on the ventral surface and just basad of the expanded portion is a slender projection with truncate apex. A figure of the entire genitalia of only one species (*gratiosa* (Smith)) is given and for the other species, a ventral view of the distal portion of the coxopodite, as that portion varies most between the species. (See Figs. 4, 5, 6, 9, 10.)



For explanation of Figs. 1–13, see bottom of opposite page.

Species brilliant blue-green, with sternites and legs largely brown; tarsi of male sometimes paler. Pubescence inconspicuous, white or yellowish.

KEY TO SPECIES OF THE UNITED STATES

1. Disk of propodeum carinate to caudal margin, median apical portion slightly depressed, median length subequal to that of metanotum, or slightly less, carinae longitudinal, radiating slightly. Mesoscutum anteriorly and laterally rugose-punctate............................2

   Disk of propodeum not carinate to caudal margin, median apical portion not depressed, median length always distinctly greater than that of metanotum, carinae very irregular. Mesoscutum closely and uniformly punctured..3

2. Disk of propodeum with many fine, slightly irregular carinae. Male: Hairs at base of hind basitarsus distinctly more than half its length; caudal margin of fourth sternite with deep median emargination.... ....*gratiosa* (Smith)

   Disk of propodeum with few coarse, regular carinae. Male: Hairs at base of hind basitarsus distinctly less than half its length; caudal margin of fourth sternite with shallow median emargination................ ....*striata* (Provancher)

3. Tegula testaceous; caudal portion of disk of propodeum polished; caudal margins of abdominal tergites testaceous; species 5.5 to 6 mm long. Male: Caudal margin of fourth sternite with rather shallow median emargination; flagellum and tarsi testaceous; second flagellar joint hardly longer than first, shorter than third..........*aurata* (Smith)

   Tegula dark brown; caudal portion of disk of propodeum dull, microscopically tessellate; caudal margins of abdominal tergites narrowly margined with black; species 9 to 10 mm long. Male: Caudal margin of fourth sternite subtruncate; flagellum and tarsi dark brown; second flagellar joint distinctly longer than first, subequal to third........ ....*pomoniella* (Cockerell)

Augochlorella gratiosa (Smith), n. comb.

Augochlora gratiosa F. Smith, Cat. Hym. Brit. Mus., **1:** 80. 1853.—Dalla Torre, Cat. Hym., **10:** 95. 1896.

Augochlora austrina Robertson, Trans. Amer. Ent. Soc., **20:** 147. 1893.—Dalla Torre, Cat. Hym., **10:** 94. 1896 (new synonymy).

Fig. 1.—*Augochlora nigrocyanea* Cockerell. Distal portion of coxopodite, ventral view. Fig. 2.—*A. aztecula* Cockerell. Distal portion of coxopodite, ventral view. Fig. 3.—*A. transversalis* Sandhouse and Cockerell. Distal portion of coxopodite, ventral view. Fig. 4.—*Augochlorella striata* (Provancher). Distal portion of coxopodite, ventral view. Fig. 5.—*A. pomoniella* (Cockerell). Distal portion of coxopodite, ventral view. Fig. 6.—*A. aurata* (Smith). Distal portion of coxopodite, ventral view. Fig. 7.—*Augochlora pura* (Say). Male genitalia, ventral view of right half. Fig. 8.—*A. pura.* Male genitalia, dorsal view of right half. Fig. 9.—*Augochlorella gratiosa* (Smith). Male genitalia, dorsal view of left half. Fig. 10.—*A. gratiosa.* Male genitalia, ventral view of left half. Fig. 11.—*Augochloropsis cuprea* (Smith). Distal portion of coxopodite, ventral view. Fig. 12.—*A. caerulea* (Ashmead). Male genitalia, dorsal view. Fig. 13.—*A. caerulea.* Male genitalia, ventral view.

BR, Basal Ring; *GF,* Genital Foramen; *Cox.,* Coxopodite; *Vol.,* Volsella; *Par.,* Paramere. The illustrations were made by Mrs. Eleanor A. Carlin of the Bureau of Entomology and Plant Quarantine.

Augochlora festiva Graenicher (not Smith), Ann. Ent. Soc. Amer., **23**: 157. 1930 [erroneous determination].

Type: Female, from Georgia, in the British Museum, where it was compared with material submitted by the writer. The type of *austrina* is in Robertson's collection. The species can be distinguished by the characters of the disk of the propodeum and the hairs on the basitarsus of the male.

Distribution: Apparently limited to the southeastern part of the United States. Specimens have been seen from the following States: New Jersey, North Carolina, South Carolina, Georgia, Florida, and Alabama.

Augochlorella striata (Provancher), n. comb.

Augochlora striata Provancher, Addit. Faun. Canad. Hym., p. 317, 1888.—Dalla Torre, Cat. Hym., **10**: 96. 1896.

Augochlora pura Robertson (not Say), Trans. Amer. Ent. Soc., **20**: 146. 1893 [erroneous determination].

Augochlora matilda Robertson, Trans. Amer. Ent. Soc., **20**: 147. 1893.—Dalla Torre, Cat. Hym. **10**: 95. 1896 (new synonymy).

Augochlora confusa Robertson, Trans. Acad. Sci. St. Louis, **7**: 324. 1897 (new synonymy).

Oxystoglossa confusa (Robertson), Canad. Ent., **34**: 247. 1902.

Augochlora (Augochlora) coloradensis Titus, Canad. Ent., **33**: 133. 1901 (new synonymy).

Augochlora confusa coloradensis Cockerell, Ann. Mag. Nat. Hist., (7), **12**: 442. 1903.

Halictus asaphes Vachal, Misc. Ent., **19**: 49. 1911 (new synonymy).

Halictus (Oxystoglossa) purus Vachal, Misc. Ent., **19**: 50, 53, 111. 1911 (new synonymy).

Augochlora pseudopurella Strand, Archiv. Naturg., Abt. A., **80**: 163. 1914. (Proposed for *Halictus purus* Vachal, not Say) (new synonymy).

Halictus (Oxystoglossa) confusus Viereck, Conn. Geol. & Nat. Hist. Surv., **22**: 705. 1916.

Augochlora coloradensis Hicks, Canad. Ent., **63**: 176. 1931.

Types: Female and male, from Quebec, Canada, in the Musée de la Province de Quebec, where through the courtesy of M. Roy they were compared with material submitted by the writer. The types of *confusa* and *matilda* are in Robertson's collection. The type of *coloradensis* is in the collection of the Colorado Agricultural College. The female is sometimes rather difficult to separate from that of *gratiosa,* as the regularity of the carinae on the disk of the propodeum varies somewhat, but these are always much coarser in *striata;* the males are readily separated by the characters of the hind basitarsus and fourth sternite.

Distribution: United States east of the Rocky Mountains, from Maine to Florida and from South Dakota to New Mexico. Specimens have been seen from the following States: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, South Dakota, Nebraska, Kansas, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas, Colorado, and New Mexico. The species is also known to occur in Ontario and Quebec, Canada.

Augochlorella aurata (Smith), n. comb.

Augochlora aurata F. Smith, Cat. Hym. Brit. Mus., **1**: 82. 1853.—Dalla Torre, Cat. Hym., **10**: 94. 1896.

Augochlora similis Robertson, Trans. Amer. Ent. Soc., **20**: 146. 1893.—Dalla Torre, Cat. Hym., **10**: 96. 1896 (new synonymy).

Augochlora confusa Cockerell (not Robertson), Bull. New Mex. Expt. Sta., **24**: 25. 1897 [erroneous determination].

Augochlora neglectula Cockerell, Bull. New Mex. Exp. Sta., **24**: 43. 1897 (new synonymy).

Oxystoglossa similis (Robertson), Canad. Ent., **34**: 247. 1902.

Halictus (*Augochlora*) *auratus* Viereck, Rept. New Jersey State Mus., p. 688, 1910.

Halictus (*Oxystoglossa*) *persimilis* Viereck, Rept. New Jersey State Mus., p. 688, 1910. (Proposed for *Halictus similis* (Robertson), not Smith) (new synonymy).

?*Halictus* (*Oxystoglossa*) *xystris* Vachal, Misc. Ent., **19**: 50. 1911 (new synonymy).

Type: Female, from St. John's Bluff, eastern Florida, in the British Museum, where it was compared with material submitted by the writer. The type of *similis* is in Robertson's collection. The type of *neglectula* is in Cockerell's collection; a "cotype" (paratype) is in the U. S. National Museum. The present location of the type of *xystris* is unknown to the writer. This species differs from *pomoniella* in size, color of tegulae and caudal margins of abdominal tergites, and sculpture of disk of propodeum.

Distribution: Apparently limited to the United States east of Rocky Mountains and south of the forty-second degree of latitude. Specimens have been seen from the following States: Maryland, Virginia, District of Columbia, North Carolina, Georgia, Florida, Indiana, Illinois, Minnesota, Iowa, Missouri, Kansas, Arkansas, Louisiana, Oklahoma, Texas, Colorado, and New Mexico.

Augochlorella pomoniella (Cockerell), n. comb.

Augochlora pomoniella Cockerell, Pomona Jour. Ent. & Zool., **7**: 232. 1915. —Pan-Pac. Ent., **3**: 162. 1927.

Type: Female, from Aliso Canyon, California, is in the U. S. National Museum. Of the species included in this genus, *pomoniella* approaches most nearly to *Augochlora* by the slightly wider head, dark caudal margins of the abdominal tergites, and shape of the fourth sternite of the male. It can be separated from *aurata* by the characters mentioned under that species.

Distribution: Apparently limited to the extreme southwestern part of the United States. Specimens have been seen from the following States: Arizona, Utah (southwestern part), and California (southern half).

Augochloropsis Cockerell

Augochlora (*Augochloropsis*) Cockerell, Canad. Ent., **29**: 4. 1897.—Proc. Acad. Nat. Sci. Phila., p. 374, 1900. *Genotype:* (*Augochloropsis subignita* Cockerell) = *Augochloropsis ignita* (Smith) (original designation).

Augochlora F. Smith, Cat. Hym. Brit. Mus., **1**: 73; pl. 3, fig. 10, 1853 (part). —Robertson, Trans. Amer. Ent. Soc., **20**: 147. 1893 (part).—Dalla Torre, Cat. Hym., **19**: 93. 1896 (part).—Robertson, Canad. Ent., **29**: 64. 1897 (part).—Cockerell, Trans. Amer. Ent. Soc., **24**: 162. 1897 (part).—Robertson, Canad. Ent., **29**: 176. 1897 (part).—Ashmead, Trans. Amer. Ent. Soc., **26**: 91. 1899 (part).—Robertson, Canad. Ent., **34**: 245. 1902.—Cockerell, Trans. Amer. Ent. Soc., **31**: 356. 1905 (part).

Halicti vibrissati groupe *Augochlora* Vachal, Misc. Ent., **11**: 126. 1903.—Misc. Ent., **19**: 13. 1911.

Augochloropsis (*Paraugochloropsis*) Schrottky. Zeit. Syst. Hym. Dipt., **6**: 312. 1906. *Genotype: Augochloropsis* (*Paraugochloropsis*) *lycorias* Schrottky (monobasic).

Tetrachlora Schrottky, Deut. Ent. Zeit., p. 481, 1909. *Genotype: Augochlora* (*Tetrachlora*) *multiplex* Vachal (monobasic).

Augochoropsis Schrottky, Deut. Ent. Zeit., p. 540, 1910.

This genus can be separated from the other genera of the Halictinae in the Nearctic fauna by the fringes of hair on the caudal margins of the first and second abdominal tergites (not to be confused with the preapical fasciae in *Halictus* s. str.) and by the large tegulae with truncate caudal margins. In general structure similar to *Augochlorella*, but differing in that the inner margins of the eyes are more deeply emarginate; labrum of female with basal portion broad, medially with longitudinal furrow, apical portion subsemicircular with high median carina, labrum of male with median furrow on basal portion; scape of male subequal to combined length of flagellar joints 3 to 6, fourth as wide as long, distal joints a little longer than wide. Pronotum laterally laminately produced, varying specifically. Posterior-lateral angles or propodeum with carinae extending nearly to caudal margin of disk. Female with knee-plate of hind tibia obsolete, inner calcar pectinate. Pubescence of abdominal tergites uniform and directed posteriorly; caudal margins of first and second tergites each with a single row of punctures and a fringe of coarse simple bristles; caudal segments of male usually retracted; posterior-lateral angles of fourth sternite produced into long processes.

Male genitalia: In general structure similar to those of *Augochlorella* but differing as follows: Volsella with slender process on inner caudal angle. Coxopodites longer than parameres, distal ends tapering and strongly convergent, ventral surface without a plate-like process. Apices of parameres broader. An illustration of the entire genitalia is given for *A. caerulea* (Ashm.), but for the others only a ventral view of the distal portion of the coxopodite, as that portion varies the most between the species. (See Figs. 11, 12, 13.)

Only two species are known to occur in the United States. They may be separated as follows:

Humeral angles of pronotum prominently developed, especially anteriorly; thoracic and abdominal tergites dull and microscopically tessellate between punctures; punctures on pleura and sides of propodeum contiguous; disk of propodeum dull, with fine irregular carinae; vertex elevated behind ocelli; postocellar line less than ocellocular; species usually 12 to 13 mm long; wings strongly infumated. Male: Fourth sternite with median caudal projection apically truncate, caudal margin of third truncate, of fifth with shallow emargination; tarsi dark brown .... *caerulea* (Ashmead)

Humeral angles of pronotum less prominently developed; thoracic and abdominal tergites shining between punctures; punctures on pleura and sides of propodeum separated by at least the diameter of a puncture; disk of propodeum shining, without carinae; vertex not elevated behind ocelli; postocellar line greater than ocellocular; species usually about 10 mm long; wings slightly infumated, yellowish. Male: Fourth sternite with median projection apically pointed, caudal margin of third broadly convex, of fifth with broad deep emargination; tarsi yellow.......... .... *cuprea* (Smith)

Augochloropsis ignita (Smith), n. comb.

Augochlora ignita F. Smith, Jour. Entom., **1**: 147. 1861.—Dall Torre, Cat. Hym., **10**: 95. 1896.

Augochlora subignita Cockerell, Trans. Amer. Ent. Soc., **24**: 145. 1897 (new synonymy).

Augochlora (*Augochloropsis*) *subignita* Cockerell, Canad. Ent., **29**: 145. 1897.

?*Augochlora fulvfimbriata* Friese, Stett. Ent. Zeit., **77**: 315. 1916, male only (new synonymy).

Type: Female, from Mexico, in the British Museum, where it was compared with specimens submitted by the writer. The type of *subignita* is in the Academy of Natural Sciences of Philadelphia; a paratype, in the U. S. National Museum. This synonymy is based on a study of material compared with the type of *ignita* and a part of the type series of *subignita.* The synonymy of *fulvofimbriata* which is tentatively suggested is based upon the study of a male specimen identified by Friese. Reference to *ignita,* which does not occur in the United States, is included only to give the synonymy of the genotype.

Augochloropsis caerulea (Ashmead)

Augochlora humeralis Patton, Bull. U. S. Geol. & Geogr. Surv., **5**: 365. 1879. —Dalla Torre, Cat. Hym., **10**: 95. 1896.—J. B. Smith, Jour. New York Ent. Soc., **9**: 52–72; text-figs. 1–3, pls. 3–5, 1901 (new synonymy).

Agapostemon caeruleus Ashmead, Bull. Colo. Biol. Assoc., **1**: 7. 1890.—Dalla Torre, Cat. Hym., **10**: 97. 1896.

Augochlora (*Augochloropsis*) *humeralis* Cockerell, Canad. Ent., **29**: 5. 1897.

Augochlora (*Augochloropsis*) *caerulea* Titus, Canad. Ent., **33**: 136. 1901.

Augochlora caerulea Crawford, Proc. Nebr. Acad. Sci., **7**: 165. 1901.

Halictus (*Augochlora*) *pattoni* Vachal, Misc. Ent., **11**: 132. 1903; **12**: 12. 1904. (Proposed for *Halictus* (*Augochlora*) *humeralis* Patton, not *Halictus humeralis* Sichel) (new synonymy).

Augochlora sumptuosa bolliana Cockerell, Ann. Mag. Nat. Hist., (8), **4**: 31. 1909 (new synonymy).

Halictus (*Augochlora*) *humeralis* Viereck, Rept. New Jersey State Museum, p. 688. 1901.

Augochlora lacustris Cockerell, Proc. U. S. N. M., **60** (18): 14. 1922 (new synonymy).

Augochlora floridica Cockerell, idem, 1922 (new synonymy).

Augochlora fulgida Graenicher, (not Smith), Ann. Ent. Soc. Amer., **23**: 157, 167. 1930 [erroneous determination].

Type: Male [not a female, as designated in the original description], labeled "Col." [although the type locality is cited as Denver, Colorado], in the U. S. National Museum. The types of *humeralis* are in the Academy of Natural Sciences of Philadelphia, where they were seen by the writer. The types of *sumptuosa bolliana, lacustris,* and *floridica* are in the U. S. National Museum, where they have been compared with *caerulea* and found to be identical. The name *humeralis* is a secondary homonym only in *Halictus,* but it has seemed best to follow the International Rules strictly in this matter. This species varies considerably in color, but is usually more bluish than *cuprea;* specimens from Florida are frequently deep purplish blue, as are also representatives of other species. In an account of the nesting habits (J. B. Smith, 1901) it is said to make deep and complicated burrows in the ground. It may be readily distinguished from *cuprea* by the characters given in the key, particularly the angles of the pronotum, the more strongly elevated vertex, and the brown tarsi of the male.

Distribution: Apparently limited to the southeastern and central parts of the United States, extending from New Jersey south to the tip of Florida and west to South Dakota and Texas. Specimens have been seen from the following States: New Jersey, Virginia, North Carolina, South Carolina, Georgia, Florida, Illinois, Minnesota, South Dakota, Nebraska, Kansas, Tennessee, Alabama, Mississippi, Texas, and Colorado.

Augochloropsis cuprea (Smith), n. comb.

Augochlora cuprea F. Smith, Cat. Hym. Brit. Mus., **1**: 79. 1853.—Dalla Torre, Cat. Hym., **10**: 94. 1896.—Graenicher, Ann. Ent. Soc. Amer., **23**: 157, 167. 1930.

Augochlora fulgida F. Smith, Cat. Hym. Brit. Mus., **1**: 79. 1853.—Dalla Torre, Cat. Hym., **10**: 95. 1896 (new synonymy).

Augochlora viridula F. Smith, Cat. Hym. Brit. Mus., **1**: 81. 1853.—Cresson, Trans. Amer. Ent. Soc., suppl. vol., p. 293, 1887.—Dalla Torre, Cat. Hym., **10**: 97. 1896.—Cockerell, Ann. Mag. Nat. Hist., (7), **19**: 533. 1907 (new synonymy).

Augochlora fervida F. Smith, Cat. Hym. Brit. Mus., **1**: 81. 1853.—Robertson, Trans. Amer. Ent. Soc., **22**: 118. 1895.—Dalla Torre, Cat. Hym., **10**: 95. 1896.—Robertson, Canad. Ent., **29**: 64. 1897.—Cockerell, Canad. Ent., **38**: 162. 1906. (new synonymy).

Augochlora lucidula F. Smith, Cat. Hym. Brit. Mus., **1**: 81. 1853.—Dalla Torre, Cat. Hym., **10**: 95. 1896 (new synonymy).

?*Augochlora sumptuosa* F. Smith, Cat. Hym. Brit. Mus., **1**: 82. 1853.—Dalla Torre, Cat. Hym., **10**: 96. 1896.—Cockerell, Canad. Ent., **29**: 5. 1897 (new synonymy).

Augochlora (*Augochloropsis*) *lucidula* Cockerell, Canad. Ent., **29**: 4. 1897.

Augochlora (*Augochloropsis*) *cleomis* Titus, Canad. Ent., **33**: 135; fig. 6, 1901 (new synonymy).

?*Halictus* (*Augochlora*) *chorisis* Vachal, Misc. Ent., **11**: 136. 1903; **12**: 13. 1904 (new synonymy).

?*Augochlora chorisis* Cockerell, Trans. Amer. Ent. Soc., **31**: 361. 1905.

Halictus (*Augochlora*) *cupreus* Viereck, Rept. New Jersey State Mus., p. 688, 1910.

Halictus (*Augochlora*) *fervidus* Viereck, Rept. New Jersey State Mus., p. 688, 1910.

Halictus (*Augochlora*) *viridissimus* Viereck, Rept. New Jersey State Mus., p. 688, 1910. (Proposed for *Halictus* (*Augochlora*) *viridulus* F. Smith, not *Halictus* (*Agapostemon*) *viridulus* Fabricius) (new synonymy).

Augochlora fulvofimbriata Friese, Stett. Ent. Zeit., **77**: 315. 1916, female only (new synonymy).

Augochlora anonyma Cockerell, Proc. U. S. N. M., **60** (18): 15. 1922 (new synonymy).

Augochlora (*Augochloropsis*) *fervida* Cockerell, Univ. Colo. Studies, **16**: 101. 1928.

Type: Female, from North America, in the Oxford Museum, where it was seen by Mr. Benson and its identity confirmed by comparison of specimens submitted by the writer. The types of *fulgida, viridula, fervida,* and *lucidula* are in the British Museum; their synonymy with *cuprea* was confirmed by comparisons in connection with notes and specimens submitted. The type of *sumptuosa* could not be located, but the synonymy tentatively made is based on a specimen in the British Museum identified by Smith. The type of *anonyma* is in the U. S. National Museum. The type and allotype of *cleomis* are in the collection of the Colorado Agricultural College, but the species can be identified with certainty from characters given in the description. A specimen of *fulvofimbriata,* labeled "typus" by Friese and in the National Museum, is identical with *cuprea.* The present location of the type of *chorisis* is unknown to the writer. This species varies in color in a manner similar to *caerulea* but is usually more golden green; it also differs in the angles of the pronotum, the less strongly elevated vertex, and the yellow tarsi of the male.

Distribution: In so far as is known, occurring throughout the eastern and central parts of the United States from New Hampshire to Florida and from South Dakota to Texas. It also occurs in Ontario, Canada, and the following Central American countries: Mexico, Honduras, Costa Rica, and Panama; but the distribution in these countries is yet inadequately known. Specimens have been examined from the following States: New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Ohio, Indiana, Illinois, Minnesota, Iowa, Missouri, South Dakota, Nebraska, Kansas, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas, Colorado, and Arizona.

Augochlora F. Smith

Augochlora F. Smith, Cat. Hym. Brit. Mus., **1**: 73, pl. III, fig. 10, 1853 (part) —Jour. Entom., **1**: 146. 1861.—Provancher, Natur. Canad., **13**: 205. 1882.—Petite Faun. Ent. Canad., p. 705, 1883 (part).—Robertson, Trans. Amer. Ent. Soc., **20**: 147. 1893 (part).—Dalla Torre, Cat. Hym., **10**: 93. 1896 (part).—Cockerell, Canad. Ent., **29**: 4. 1897 (part).—Robertson, Canad. Ent., **29**: 64. 1897 (part).—Cockerell, Trans. Amer. Ent. Soc., **24**: 162. 1897 (part).—Robertson, Canad. Ent., **29**: 176. 1897 (part).—Ashmead, Trans. Amer. Ent. Soc., **26**: 91. 1899 (part).—Cockerell, Proc. Acad. Nat. Sci. Phila., p. 374, 1900 (part).—Trans. Amer. Ent. Soc., **31**: 356. 1905 (part). *Genotype: Augochlora pura* (Say). (By designation of Cockerell, Ann. Mag. Nat. Hist., (9), **11**: 448. 1923).

Oxystoglossa F. Smith, Cat. Hym. Brit. Mus., **1**: 83, pl. III, figs. 8–9, 1853. —Robertson, Canad. Ent., **34**: 244. 1902 (part).—Schrottky, Deut. Ent. Zeit., p. 482, 1909. *Genotype: Oxystoglossa decorata* Smith (monobasic).

Odontochlora Schrottky, Rev. Mus. La Plata, **16**: 14. 1909.—Deutsch. Ent. Zeit., p. 482, 1909. *Genotype: Augochlora muelleri* Cockerell (original designation) (new synonymy).

Halicti falcati, groupe *Oxystoglossa* Vachal, Misc. Ent., **19**: 14. 1911 (part).

The synonymy of *Oxystoglossa* was first proposed by Ashmead (1899), and although I was unable to examine the genotype, *decorata* Smith, Mr. Benson verified the presence of certain diagnostic characters and confirmed this synonymy. Through the designation by Cockerell of *pura* as the genotype of *Augochlora,* both *Oxystoglossa* and *Odontochlora* become direct synonyms and can no longer be used, even as subgenera.

This genus is similar to *Augochlorella* in general appearance and color, but differs as follows: Head broader, more gradually declivous to occipital carina, the carina strongly developed and continued to hypostomal carinae. Mandible of female apically bidentate, teeth subequal; inferior margin convex apically, varying specifically. Flagellum of male with joints beyond fourth progressively longer. Transverse suture of metapleuron carinate. Apex of radial cell truncate, with appendiculate vein. Lateral surfaces of propodeum deeply, contiguously punctured. Female: Inner surface of hind femur with a single row of long, curled, pinnately branched hairs (as in *Halictus*); first sternite usually with median carina or tooth, sixth with median triangular polished area. Male: First sternite with median furrow or carina, caudal margins of second to sixth truncate.

Male genitalia: In general structure similar to those of *Augochlorella*, but differing as follows: Coxopodites about as long as parameres. Distal portion of coxopodite with a subrectangular process which is directed medially, ventral surface without a plate-like process. An illustration of the entire genitalia is given for *A. pura* (Say), but for the others, only a ventral view of the distal portion of the coxopodite, as that portion varies the most between the species. (See Figs. 1, 2, 3, 7, 8).

KEY TO SPECIES OF THE UNITED STATES

1. Caudal margins of abdominal tergites black or tergites strongly melanic; wings somewhat fuscous, not at all yellowish; species bluish green, frequently with tendency to melanism also on head and thorax. Female: First sternite with median tooth; first tergite microscopically aciculate; mesoscutum anteriorly and laterally with contiguous punctures, posteriorly microscopically tessellate; median carina of labrum low, without basal notch. Male: Abdominal sternites 2 to 6 dull brown or black . 2

   Caudal margins of abdominal tergites brownish; wings yellowish infumate; species golden or yellowish green with no tendency to melanism. Female: First sternite with median longitudinal carina or furrow; first tergite polished; mesoscutum and mesopleuron shining; median carina of labrum apically strongly elevated, basally notched. Male: Third and fourth abdominal sternites shining, strongly tinged with green . . 4

2. Transverse carina of metapleural suture strongly produced into a lamelliform process. Female: Tooth on first sternite, from lateral view, tapering but slightly to broadly rounded apex. Male: Labrum and mandibles reddish brown; clypeus unicolorous; third flagellar joint longer than broad, one and one-half times as long as second; first tergite apically with sides parallel, then narrowed rather abruptly to base, caudal margin constricted, punctures distinct, separated by about their diameter . . . . *transversalis* Sandhouse & Cockerell

   Transverse carina of metapleural suture not produced into a lamelliform process. Female: Tooth on first sternite, from lateral view, tapering to narrow apex. Male: Labrum and mandibles yellow; apical margin of clypeus yellow; third flagellar joint broader than long, subequal to second; first tergite narrowed gradually to base, caudal margin not constricted, punctures rather indistinct, separated by at least twice their diameter 3

3. Disk of propodeum longitudinally carinate. Female: First tergite indistinctly punctured; mesoscutum medially with some scattered punctures nearly twice as large as the others. Male: Third flagellar joint and those distad distinctly longer than wide, apical joint nearly twice as long as

wide; first sternite with low median carina; caudal margins of second and third slightly convex medially; first tergite finely aciculate; tarsal joints dark brown............................*nigrocyanea* Cockerell

Disk of propodeum laterally with longitudinal, medially with very irregular carinae. Female: First tergite distinctly punctured; mesoscutum uniformly punctured. Male: Unknown..............*azteca* (Vachal)

4\. Mesoscutum finely, uniformly punctured, the punctures separated by more than their diameter, interspaces strongly polished; disk of propodeum laterally and basally with longitudinal carinae, median apical portion with carinae nearly transverse, extreme apex not carinate, polished. Female: Median carina of first sternite obsolescent; angle of hypostomal carina strongly produced; flagellum distinctly paler beneath. Male: Third flagellar joint subequal to fourth, the joints distad as wide as, or wider than long, except that the apical joint is distinctly longer; abdominal sternites obscurely tinged with green..*aztecula* Cockerell

Mesoscutum more coarsely punctured, the punctures laterally nearly contiguous, medially separated by about their diameter, interspaces dull; disk of propodeum with slightly irregular longitudinal carinae reaching to apex. Female: Median carina of first sternite well developed; angle of hypostomal carina not produced; flagellum uniformly dark brown. Male: Third flagellar joint nearly one and one-half times as long as fourth, joints distad distinctly longer than wide; third and fourth abdominal sternites strongly tinged with green.....*pura* (Say)

Augochlora pura (Say)

Halictus purus Say, Boston Jour. Nat. Hist., **1**: 395. 1837.—Le Conte, Writ. Thomas Say, **2**: 773. 1859.

Augochlora pura F. Smith, Cat. Hym. Brit. Mus., **1**: 80. 1853.—Provancher, Natur. Canad., **13**: 206. 1882.—Faun. Ent., Canad., Hym., p. 706. 1883.—Dalla Torre, Cat. Hym., **10**: 96. 1896.—Robertson, Trans. Acad. Sci. St. Louis, **7**: 323. 1897.—Crawford, Proc. U. S. N. M., **45**: 243. 1913.—Blackman & Stage, Tech. Publ. 17, New York State Coll. For., Syracuse Univ., **24** (22): 198. 1924.—Graenicher, Ann. Ent. Soc. Amer., **23**: 157, 167. 1930.

Augochlora labrosa Robertson (not Say), Trans. Amer. Ent. Soc., **20**: 146. 1893.

Augochlora robertsoni Cockerell, Canad. Ent., **29**: 69. 1897.

Oxystoglossa pura Robertson, Canad. Ent., **34**: 246. 1902.

Augochlora banksiella (*pura* subsp. ?) Cockerell, Ann. Mag. Nat. Hist., (7), **19**: 533. 1907.

Halictus (*Oxystoglossa*) *purus* Viereck, Rept. New Jersey State Mus., p. 688, 1910.

Halictus (*Oxystoglossa*) *muelleri* Vachal, Misc. Ent., **19**: 45. 1911 (part) (new synonymy).

Halictus (*Oxystoglossa*) *astios* Vachal, Misc. Ent., **19**: 44. 1911.

Halictus (*Oxystoglossa*) *astios* var. (?) *fuscatipes* Vachal, Misc. Ent., **19**: 45. 1911 (new synonymy).

Augochlora mosieri Cockerell, Proc. U. S. N. M., **60** (18): 15. 1922 (new synonymy).

Augochlora palmarum Cockerell, idem, 1922 (new synonymy).

Types: Female and male, from the United States, probably destroyed, but the species can be placed with certainty from the description and the account of its habits. The type of *festiva* is in the British Museum, where it was compared with specimens of *pura* submitted by the writer. The types of *banksiella, mosieri*, and *palmarum* are in the U. S. National Museum and have been found to be identical with *pura.* The present location of the types of *astios* and its variety *fuscatipes* are unknown to the writer, but the characters given by Vachal definitely place them here. This species nests under the bark in decomposing sapwood of hickory and oak. It is the only species of the genus found in the United States outside of Texas. From other species of similar appearance the female may be readily distinguished by the median carina on the first sternite, the male by the strongly punctured sides of the propodeum and the truncate caudal margin of the fourth sternite.

Distribution: This species is distributed in the eastern and central parts of the United States from Massachusetts west to Minnesota and south to Texas and Florida. Specimens have been seen from the following States: Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, and Texas. It is also known to occur in Quebec and Ontario, Canada.

Augochlora aztecula Cockerell

Augochlora aztecula Cockerell, Ann. Mag. Nat. Hist., (7), **19:** 534. 1907.

Type: Female, from Tlacotalpam, Vera Cruz, Mexico, in Cockerell's collection. It can be separated from the other species of the genus occurring in the United States by the following: Apex of disk of propodeum polished; mesoscutum rather sparsely punctured, with interspaces strongly polished; carina of first sternite obsolescent in female; angle of hypostomal carina strongly produced.

Distribution: The only specimens taken in the United States that have been seen are from the region near Brownsville, Texas; the species apparently belongs to the Neotropical rather than to the Nearctic fauna.

Augochlora azteca (Vachal)

Halictus (*Oxystoglossa*) *azteca* Vachal, Misc. Ent., **19:** 45, 110. 1911.

Augochlora (*Odontochlora*) *azteca* Cockerell, Proc. U. S. N. M., **63** (8): 4. 1924.

Type: Female, from Mexico, is probably in the Musée National d'Histoire Naturelle, Paris. The female may be distinguished from *pura* and *aztecula* by the tooth on the first sternite and the black caudal margins of the tergites, from *transversalis* by the weaker carina on metapleural suture, and from *nigrocyanea* by the punctation of the tergites and the differences in the carinae on the disk of the propodeum.

Distribution: Apparently similar to that of *aztecula.* Reference to the occurrence of *azteca* in Lower California by Sandhouse and Cockerell (1924) was erroneous; the specimens mentioned there belong to *transversalis.*

Augochlora transversalis Sandhouse & Cockerell, new status

Augochlora azteca var. *transversalis* Sandhouse & Cockerell, Proc. Calif. Acad. Sci., (4). **13:** 338. 1924.

Augochlora azteca Sandhouse & Cockerell (not Vachal), Proc. Calif. Acad. Sci., (4), **13**: 339. 1924 [erroneous determination].

Type: Female, from La Paz, Lower California, is in the Museum of the California Academy of Sciences. In both sexes it can be readily separated from the other species of the genus by the lamelliform process on the metapleural suture.

Distribution: Although apparently limited to Lower California, the species is included here in order to show its relationship to *azteca* and to correct the distributional records for that species.

Augochlora nigrocyanea Cockerell

Augochlora nigrocyanea Cockerell, Trans. Amer. Ent. Soc., **24**: 144. 1897.
Augochlora (Odontochlora) nigrocyanea Schwarz, Amer. Mus. Novit., **722**: 6. 1934.

Type: Female, from San Rafael, Vera Cruz, Mexico, in the collection of the U. S. National Museum. It can be separated from the other species occurring in the United States by the following characters: From *transversalis* by the weaker carina on the metapleural suture, from *azteca* by the greater tendency to melanism and the more weakly punctured abdominal tergites; the female, from those of *pura* and *aztecula* by the toothed first sternite; the male, from *pura* by the dark abdominal sternites and from *azteca* and *aztecula* by the larger size and more slender flagellum.

Distribution: Apparently similar to that of *aztecula.*

SPECIES NOT RECOGNIZED

Augochlora obliqua Provancher

Type: Female, from Vancouver, in the Musée de la Province de Quebec. Upon comparison by M. Comeau with material submitted by the writer, it could not be recognized as belonging to any of the known species of the genera considered in this paper; nor are these known to occur in that region. It may be referable to *Agapostemon,* but further information on the type is necessary before a definite assignment can be made.

MALACOLOGY.—*A new species of* Melania *from Szechuan Province, China.*[1] Sui Fong Chen. (Communicated by Paul Bartsch.)

In a collection of Chinese fresh water mollusks received by the U. S. National Museum from the Rev. D. C. Graham is an undescribed species which is here named.

I wish here to express my appreciation to the authorities of the U. S. National Museum and to Dr. Paul Bartsch, the Curator of the Division of Mollusks, for the privilege of studying the Chinese Melanias in their collection.

Melania (Plotiopsis) grahami, n. sp. Figs. 1–7

Shell thin, elongated, ovate, turreted, greenish yellow with more or less irregularly interrupted reddish brown axial bands which are most conspicu-

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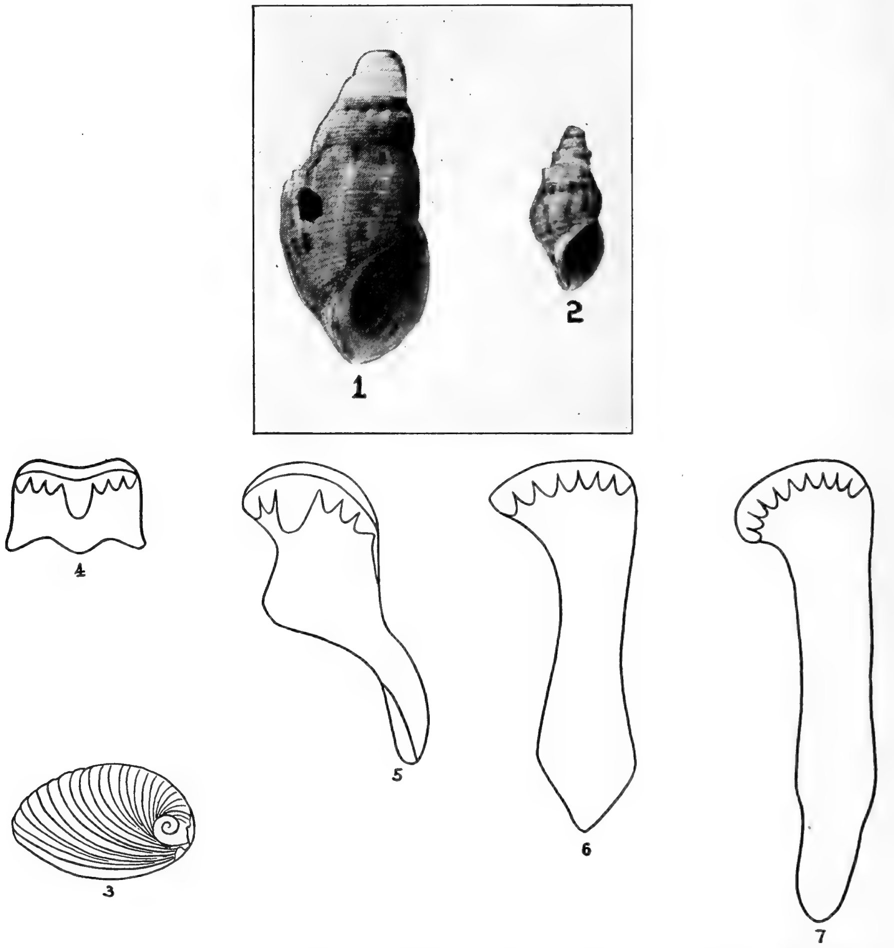
[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 16, 1936.

ous on the last whorl and the base, and may be seen in the aperture. Nuclear whorls eroded in all the specimens before me. The type has 4.5 whorls remaining, which are moderately convex and angulated at the anterior end of the concave shoulder. Thirteen axial ribs are present on all the postnuclear whorls. They are most prominent on the last and the penultimate whorls,



Figs. 1–7.—*Melania* (*Plotiopsis*) *grahami*, n. sp. 1, holotype, 2, young specimen, ×3; 3, operculum, ×7; 4, rachidian tooth, 5, lateral tooth, 6, inner marginal tooth, 7, outer marginal tooth, ×500.

evenly spaced, and project conspicuously at the shoulder as spinose tubercles continuing feebly across the shoulder to the summit. The spiral sculpture consists of lirations, of which 6 are present on the shoulder between the suture and the summit; 13 between the shoulder and the periphery on the last whorl and 10 on the base. Those on the base are the strongest, next to this are those between the shoulder and the periphery, while those between the suture and the summit are the least strong. Suture strongly constricted. Periphery of the last whorl well rounded. The aperture is elliptical; the peristome thin, slightly expanded, and adnate to the preceding turn at the parietal wall, which is glazed with a thin callus. The columella is arched, and calloused almost to the base with a grayish white deposit. The operculum is thin, elliptical with 2.5 turns and with subcentral nucleus. The radula has the formula: 3–1–3 : 2–1–3 : 7 : 10.

The type, U. S. N. M. Cat. No. 467600, was collected by Rev. D. C. Graham at Me-wang, Lam-ping, Szechuan Province, China, and gives the following measurement: No. of whorls, 4.5; height 14.2 mm; diameter 7.0 mm; length of aperture 6.1 mm.

Thirty-eight specimens derived from the same source from which the type was obtained, yield the following additional information: They have an average number of 4.8 whorls; the greatest number of whorls is 5.9, and the least 3.7. They present an average height of 9.7 mm; the greatest height is 12.2 and the least 7.1 mm. Their average diameter is 5.0 mm; the largest 6.2 and the least 3.5 mm. The length of the aperture averages 4.2 mm; the largest length of aperture is 5.3 and the least 2.9 mm.

This species most nearly resembles *Melania balonnensis* Conrad, from southeastern Australia. It differes from it in being a little smaller and more ovate.

ORNITHOLOGY.—*A new genus for* Pseudoptynx solomonensis *Hartert.*[1] JAMES L. PETERS, Museum of Comparative Zoology, Harvard University.

The name *Pseudoptynx* was proposed by Kaup in Oken's *Isis*, 1848, col. 770 for the segregation of *Syrnium philippense* Gray. However the generic name was without diagnosis and the name of its single included species was a nomen nudum, hence *Pseudoptynx* is not nomenclaturally available from this citation. In the Archive für Naturgeschichte, **17,** Bd. 1, 1851, p. 110, Kaup validated both his own generic name and Gray's nude specific name; *Pseudoptynx philippensis* therefore dates from 1851 and the authority is Kaup.

Tweeddale described *Pseudoptynx gurneyi* (Proc. Zool. Soc. London, 1878, p. 940, pl. 58) from Mindanao; Hartert named *Pseudoptynx solomonensis* (Bull. B. O. C., **12,** 1901, p. 25) from Ysabel Island, Solomon Islands; and lastly Ogilvie-Grant added *Pseudoptynx mindanensis* (Bull. B. O. C., **16,** 1906, p. 99) with type locality southeastern Mindanao. *P. mindanensis* is conspecific with *P. philippensis;* Hachisuka has proposed *Mimizuku* (Bds. Phil. Ids., pt. 3, 1934, p. 50) as a monotypic genus for *P. gurneyi* and in this paper I advocate the generic separation of the Solomon Island bird. *P. philippensis* and *M. gurneyi* belong to the subfamily Buboninae in which the external ear opening is small, dermal ear flaps absent and ear opening not crossed by a ligamentous bridge.

Hachisuka was quite right not only in removing *Pseudoptynx gur-*

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[1] Received January 27, 1937.

neyi Tweedd. from *Pseudoptynx*, but also in creating a monotypic genus for it. The bird is not at all closely related to *P. philippensis*, but is far more closely related to *Otus*. In diagnosing *Mimizuku*, Hachisuka gave only the characters that could immediately distinguish it from *Pseudoptynx*. Compared with *Otus*, *Mimizuku* stands out by reason of its larger size; bill with culmen strongly rounded, upper mandible decidedly convex in lateral outline (viewed from above) with distinct festoon or tooth on cutting edge; feet and claws relatively and absolutely larger and stronger than in even the largest species of *Otus;* wing very much rounded, longest primaries exceeding secondaries by little more than one-half the length of tarsus; outermost primary shorter than 10th, 2nd shorter than 9th, 5th longest; frontal feathers, ear tufts, emargination of primaries and tarsal feathering as in *Otus*. *P. solomonensis* on the other hand is not a bubonine owl at all, but belongs to the Striginae, characterized by a large auricular opening with well developed dermal ear flaps and crossed by a ligamentous bridge. It may be called

Nesasio, n. gen.

A medium sized strigine most nearly allied to *Asio* Birsson, but body plumage more decomposed and silky; feet and claws extremely large and powerful; tarsi feathered; toes naked; middle toe three-fourths length of tarsus (about one-half in *Asio*); claw of inner toe longer than claw of middle toe (reverse in other species of *Asio* except *madagascariensis*); bill very stout and heavy with culmen arched and strongly decurved; nostril more rounded less oval; wing much rounded; the longest primaries exceeding the tips of the secondaries by less than 20 mm; 4th? primary longest (by a strange coincidence the distal portion of 5th primary is missing in both wings of the single specimen available); outer primaries weakly emarginated; bristles at base of bill strong, though relatively not as well developed as in *Asio;* no trace of ear tufts. Two other characters noted may be due to the preparation of the skin, namely, facial disc not clearly defined; eyes much larger.

Type, *Pseudoptynx solomonensis* Hartert.

This genus is probably derived from an offshoot of *Asio flammeus* stock, the underlying color pattern of both suggesting this probable ancestry; its sedentary habits and insular habitat have resulted in a considerable shortening of the primaries, at the same time there has been a development in size of bill and feet, these members greatly exceeding in strength the corresponding parts of those representatives of the genus *Asio* characterized by strong bill and feet, namely *abyssinicus*, *madagascariensis* and *helvola*. *A. madagascariensis*, which is undubitably an offshoot of *A. asio*, also exhibits a tendency towards larger bill and feet and more rounded wing, but the characters are not sufficiently marked in this instance to warrant generic separation. An even closer parallelism is found in *Pseudoscops*, a monotypic genus confined to the Island of Jamaica. This bird, originally of *A. asio* stock, also has the increased size of bill and feet coupled with much shorter wing tip and weakly emarginated primaries.

In concluding I feel that a word of explanation is in order concerning feathering on tarsi and toes as a generic character in owls. Especially as regards the toes, my feeling is that this character is of subspecific importance, but no more. Of the genera confined to the tropics, practically not a single species has feathered toes, though in many cases the dense tarsal feathering ends abruptly at the base of the toes. On the other hand all the olarctic genera invariably have feathered toes, *Nyctea* being an example of extreme development in this direction. Where a genus is widely distributed with representatives in both temperate and tropical regions the feathering on the toes of the tropical forms varies from sparse to bristly and in some species of *Otus* for instance, the toes are quite bare. Among the Strigidae it therefore seems best to drop the feathering of the toes as a generic criterion, since it not only is of no generic significance, but its use in the past has resulted in the wrong allocation of species in their systematic position.

Thanks are due to Dr. Witmer Stone of the Academy of Natural Sciences for the loan of a specimen of *Mimizuku gurneyi* (Tweedd.) and to Dr. Ernst Mayr for the loan of a specimen of *Nesasio solomonensis* (Hart.).

Obituary

FREDERICK VERNON COVILLE, botanist in the U. S. Department of Agriculture since 1888, and an ex-president of the Academy, died of coronary thrombosis at his home, 1836 California Street, on January 9, 1937, after a brief illness. Dr. Coville was born at Preston, N. Y., on March 23, 1867. He received his A.B. at Cornell University in 1887, and the honorary degree Doctor of Science from George Washington University in 1921. After serving as instructor in botany at Cornell in 1887–88, he entered the U. S. Department of Agriculture as assistant botanist in 1888, becoming botanist in 1893 on the death of Dr. George Vasey, senior botanist in 1924, and principal botanist in 1928. When the present Bureau of Plant Industry was established in 1901, he became the head of the Office of Botanical Investigations and Experiments (later, after various transient changes in title, the Office of Economic and Systematic Botany, still later the Division of Botany), a position he held until the office was merged in 1934 into the Division of Plant Exploration and Introduction. He became curator of the National Herbarium in 1893, and so continued after its transfer to the custody of the Smithsonian Institution in 1896. He was active in promoting the establishment of a National Arboretum, and was acting director from 1929, when the project took definite form.

Dr. Coville's first professional field work was as botanical assistant in the Arkansas Geological Survey in 1887, resulting in the publication of *A List of the Plants of Arkansas* (by J. C. Branner and F. V. Coville) in 1891, which is still the only list of the plants of that state. His most important field work was as botanist of the Death Valley Expedition in 1891, the results of which were published in 1893 as *Botany of the Death Valley Expedition.* For several years prior to his death he had again been active, in cooperation with M. French Gilman, in the collection and study of the plants of Death Valley, and was preparing a popular flora of that region. In 1899 he and Dr. T. H. Kearney were botanists of the Harriman Expedition to Alaska. Although he described new plants in many other families, his taxonomic interests were primarily in the Juncaceae, in which he was the recognized American authority, and the Grossulariaceae, of which, in collaboration with Dr. N. L. Britton, he prepared the treatment for *North American Flora.* From almost the beginning of his career he was interested in the useful plants of the North American Indians, and he published several papers on this subjects.

Through his position in the Department of Agriculture from an early date, and through his association with the National Geographic Society and the Carnegie Institution, Dr. Coville's influence in practical problems of agriculture and forestry was extensive. The foundation, in 1903, of the Desert Botanical Laboratory of the Carnegie Institution at Tucson, Arizona, was largely due to his efforts. As Chairman of the Research Committee of the National Geographic Society for many years, he was influential in its choice of fields for exploration. In the Department of Agriculture he was instrumental in the formation of the Seed Laboratory with its seed investigations and in the initiation of grain-grading investigations. He formulated the policy for the use of National Forests as grazing lands which, with minor changes, is in effect today.

Dr. Coville's most important recent work in economic botany was concerned with the blueberry, which he developed from a wild fruit into a cultivated crop of commercial significance in the acid, sandy soils of our eastern coast. The largest berries produced by his plants, after 30 years of cultivation and hybridization, reached 25.9 mm in diameter, contrasting with the 12–15 mm maximum of their wild progenitors. In connection with his cultivation of blueberries, he demonstrated that this group and many other Ericaceae require acid soils for proper development. His work with cultivated plants led also to the scientific recognition of the importance of a period of chilling temperature for the normal flowering and fruiting of plants of the temperate zone. With assistance from members of his office, particularly W. F. Wight, he prepared or rewrote the botanical definitions in the supplementary volumes and the revised edition of the *Century Dictionary;* he had also taken an active part, under Dr. Lester F. Ward, in the preparation of the definitions in the first edition. With F. L. Olmsted and H. P. Kelsey, he was coauthor of *Standardized Plant Names,* a work which sought to establish standard names, both scientific and vernacular, for the plants in the North American nursery trade.

Dr. Coville was president of the Biological Society of Washington in 1899–1900, of the Botanical Society of America in 1903–04, of the Washington Academy of Sciences in 1912, of the Cosmos Club in 1915, of the Washington Biologists' Field Club in 1919–21, and of the Arts Club of Washington in 1927–29. In 1903 he was vice-president of the American Association for the Advancement of Science. He received the George Robert White Medal of Honor from the Massachusetts Horticultural Society in 1931, in recognition of his outstanding work with blueberries.

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HYDROLOGY.—*Our water supply.*[1] Oscar E. Meinzer, U. S. Geological Survey.

GENERAL CONSIDERATIONS

Water in relation to physical processes.—In the physical and biological evolution that has taken place on the face of the earth, water has had a unique function as the principal vehicle for the transfer of matter and energy. It appears that all evolution, whether physical or biological, requires, on the one hand, sufficient rigidity to supply a degree of stability and permanence, and on the other hand, sufficient fluidity or plasticity to permit more or less gradual change in response to applied energy. In the physical evolution of the earth there have been two major complimentary processes. One has been the repeated raising of parts of the solid exterior of the earth to considerable elevations above sea level through deformation and the intrusion or extrusion of fluid or plastic rock material; the other has been the reduction and modification of the raised parts, chiefly though not exclusively, through the agency of the water acting in its role as the transporter of matter and energy. Thus the development of the geologic structure of the outer part of the earth and the creation and recreation of the land areas in all their characteristic detail, have been accomplished chiefly because the earth is surficially rigid but fundamentally plastic, and because there is a supply of water which has served as the principal agent in mechanical weathering, as the carrier of oxygen and other elements that are active in chemical weathering, and as the transporter of the weathered materials in suspension or solution with subsequent deposition of these materials and forming of the sedimentary deposits.

Although the poet may regard mountains as the symbol of eternal permanence, the geologist knows that they are ephemeral features which stand majestically for but a brief period, only to disappear under the erosive work of the water. To the geologist the work of the

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[1] Address of the retiring president of the Washington Academy of Sciences delivered January 21, 1937. Received January 23, 1937.

water is almost everywhere in evidence—in the sculpture of the land, in the character of the soil and subsoil, in the vast succession of sedimentary formations with their numerous unconformities witnessing to repeated cycles of uplift and erosion, in the texture of the rocks, and even in the mineral deposits within the rocks.

Water in relation to life.—The work of water is no less evident in the evolution of the plant and animal kingdoms. The Cambrian strata contain the record of abundant marine life. In the half billion years that have elapsed since the Cambrian period both plant and animal kingdoms have undergone vast evolution, with extensive and effective adaptation for life on the land and even in the most arid regions. However, in this long process of radical adaptation to different environments no species of plant or animal has escaped from the fundamental requirement of a water supply in order to carry on its life processes. Deprived of water, all plants and animals would perish. Deprived of water, the human race, with all its thought and emotion and spiritual aspiration, would come to prompt oblivion.

When consideration is given to the narrow range of temperature and other conditions that are required to provide a utilizable supply of water to living creatures, it seems evident that relatively few heavenly bodies are adapted to support life as it is known to us. Nevertheless, in the inconceivably large multitude of heavenly bodies there may be, in the aggregate, many that have the proper conditions for a water supply and that support living creatures comparable with those that exist on this earth, or that existed in the Cambrian period, or that will exist in ages yet to come. Moreover, it seems reasonable to believe that there is a spiritual character to the universe which has a reality and means of expression that are not limited by the special physical conditions found on this earth. But, however incidental water may be in the ultimate plan of the universe, for life on our own earth its need is fundamental and inescapable.

As the plant and animal kingdoms moved in large part from the sea to the land, radical adaptations to their changed water supply resulted. Thus it became necessary for both the land plants and the land animals to adapt themselves to the use of fresh water instead of salt water, and this adaptation has become so thorough that now salt water means death to nearly all land life. Thus also was developed the constant-temperature adaptation of the warm-blooded animals, operated by means of water acting as the medium for transporting energy in the form of heat, and this has led to parental care and prolonged adolescence, and ultimately to the fruition of intellectual and social evolution in the human race.

Water in relation to human activities.—With advancing civilization the human race has found water to be a most convenient substance for a large and ever enlarging list of uses. Indeed, its several properties, such as its solvent properties, its high specific heat, its occurrence in the solid, liquid, and gaseous states within convenient temperature intervals and with high latent heat in passing from one state to another, lend themselves so remarkably to the needs of civilized man in his multitudinous domestic and industrial operations, recreational activities, and therapeutic applications that it seems as if these properties had been providentially designed for the benefit of man. It is an interesting exercise to make a list of the uses to which water is put by man, many of which are analogous to the physiological uses of water by living organisms, as for example, the conveyance and storage of material and energy, often with resultant chemical changes, the regulation of temperature, and the elimination of waste. It will be noted that in most of these uses, water serves as the vehicle for conveying either matter or energy. It is not surprising that water has acquired a unique religious significance as the symbol, in the rite of baptism, of spiritual cleansing and regeneration by the washing away of all sin.

The average per capita consumption of water in the cities and towns of the United States amounts to more than 100 gallons a day. Some of this water is wasted but most of it is used for beneficial purposes. In the future the volume so used will be increased and new uses will be developed. Thus, the rapid advance in air conditioning of buildings is producing an almost alarming increase in the demand upon our public water supplies. It may therefore be expected that, even with reduction in waste, the consumption of water will increase with advancing civilization. One of the truly great achievements of civilized man is that of providing, for human use, abundant, convenient, and reliable supplies of water of good quality. Indeed, the improvement of the quality of the water supplies has been a major factor in increasing the average length of human life. However, considering the less advanced countries of the world and the rural sections of our own country, it is evident that the task is still far from being completed.

The ultimate water supply.—The great residual reservoir of water is the ocean, which contains all except a small percentage of the external water of the earth, the rest being on the surface of the land, or in the interstices of the soil and rocks, or in the atmosphere. It is necessary to distinguish between the external and the internal water, for there is evidence that water is one of the constituents of the magma that forms the interior of the earth, and the total quantity of this internal magmatic water may be very great. The supply of external water is apparently being augmented by the extrusion of internal water and possibly by acquisition from outer space. There are also processes in operation which release water from chemical combination, but these are compensated more or less by processes which tie up some of the existing external water. Any attempt to evaluate these several processes would be quite academic. It appears that any changes which may have occurred in the total quantity of external water have not had effects of major importance within the period of definite geologic record. It also appears that no changes are in prospect that will affect appreciably the future affairs of man. Although the total quantity of external water has apparently not changed significantly, fluctuations in sea level, probably due to other causes, have been of primary importance throughout geologic history, including relatively recent time. Indeed, many of the large cities of the earth are at present situated below the levels of strands that have been washed by the sea since the human race began to live on the earth.

The hydrologic cycle.—The water that is of principal concern to man is the land water—the water in the lakes and ponds and in the brooks and rivers, the water that forms the soil moisture, the water in the rocks that supplies the springs and streams and wells. Any natural or artificial change that increases the supply of land water where it is needed, eliminates it where it is destructive, improves its quality, or increases its availability is a distinct human gain; any change in the opposite direction is human impoverishment.

The land water is not a stationary supply but forms a part of an ever-recurring circulation of great complexity and variation, which is known as the hydrologic cycle. The prime mover in this cycle is the sun, which, in the last analysis, furnishes the energy that evaporates water from the sea and conveys it as vapor to higher elevations on the land, where it is precipitated, chiefly as snow or rain, with potential energy that tends, through the force of gravity, to carry it back to the sea. The solar energy is also applied in causing evaporation from the lakes, ponds, swamps, and streams, from the land surface, from objects on the surface, from the soil, and, by transpiration, from the leaves of growing plants, including the native and cultivated trees, shrubs, and herbs. Indeed, the records of precipitation and run-off show that only about a third of the water that falls as rain or snow in the United States reaches the sea—about one-half in the eastern part of the country, only a small percentage on the Great Plains, and virtually none in the Great Basin.

In its return course, the water flows over the land surface and through the stream channels and percolates through the interstices of the soil and the water-bearing formations. In its course it performs work of great variety, some of which is beneficial and some injurious to man, and much of which has been modified for better or worse by the intelligent or unintelligent activities of civilized man.

Thus the hydrologic cycle consists of two phases—one phase including evaporation, atmospheric movement of the water vapor, and ultimately its condensation and precipitation upon the land; the other phase including the movement and temporary storage of the precipitated water upon or under the land surface while on its way to the sea or to points of re-evaporation on the land. Both phases are very complicated.

FIRST PHASE OF THE HYDROLOGIC CYCLE

Natural fluctuations in humidity and aridity.—Let us consider the first of these two phases of the hydrologic cycle. The terms *aridity* and *humidity,* as the opposite of *aridity,* are difficult to define in precise terms. In a widely accepted sense, however, the term *aridity* relates to the deficiency of the precipitation in a given area for the normal growth of mesophytic vegetation that is otherwise adapted to the conditions of that area. In this sense the aridity of an area is intensified by decrease in the amount of precipitation and also by increase in the evaporativity of the area—that is, in the potential rate of evaporation. Both precipitation and evaporativity vary radically from place to place and from time to time, largely because of temperature variations, which are produced by a complex of different causes.

The geologic record, covering some hundreds of millions of years, seems to show that long ages of relatively warm and equable climate, perhaps with a general tendency toward aridity, were at several times interrupted by shorter periods of more variable climate including some cold, humid stages. The latest of these variable periods began, perhaps a million years ago, with the first of the Quaternary glacial stages and is apparently still in progress. The geologic record shows that the Quaternary, and perhaps also older periods of the same sort consisted of several major glacial stages alternating with distinct interglacial stages, and that the glacial stages, or at least the last one, consisted of two or more substages involving considerable climatic fluctuations. The greater humidity of the glacial stages was in large part caused by decrease in evaporation. From biological evidence and the evidence of marine terraces, it appears that we are at present in an intermediate position, having receded only part of the way from the last glacial stage. From intensive study of geologic, archeologic, and historical records it is, however, evident that recent time has not consisted of a gradual change from glacial to inter-glacial conditions, but rather of complicated fluctuations of climate, in part regional rather than world-wide, between periods that were more humid and periods that were more arid than the present.

All about us we have impressive evidence of climatic change, such as the great sheets of glacial drift and trains of outwash gravel, the scores of desiccated or partly desiccated lakes, including the extensive Lakes Bonneville and Lahontan, and the great mantle of loess or wind-blown silt that covers much of the interior of this country and is largely responsible for its great fertility. Looking more closely at the evidence of fluctuations furnished by existing lakes, glaciers, tree rings, etc., and the available records of measured precipitation and stream flow, we stand impressed by the great and irregular climatic variations of the immediate past.

Thus at the end of the disastrous drought year of 1936, we in this country look into the future somewhat bewildered and almost afraid, the more so because we recognize that much of the productive part of our country is not very far from the margin of semiaridity. We must frankly admit that in spite of all our investigation we do not know in which direction we are trending—toward greater humidity or more severe droughts—in the ensuing year, decade, or century. We can, however, make some predictions, which are in part reassuring and in part otherwise. It is virtually certain that drought conditions are not permanent but will be followed by years of abundant rainfall and bounteous crops; on the other hand, it is almost equally certain that the recent droughts are not abnormal but that in the course of time other droughts of equal and even greater severity may be expected.

It is believed that the climatic fluctuations of the past have been the underlying cause of much turmoil in human history. But it is significant that the human race has not only managed to live through the times of drought and the intervening cold and wet times, but also that it has had its notable evolution in this Quaternary Period of strongly fluctuating climate. The climate of the present, as the climate of the past, challenges man to greater effort and achievement.

The possible influence of artificial changes upon precipitation.—When during periods of wet years the settlers moved into the semiarid region of our country and found to their delight that they could raise good crops, they fondly developed the faith that rainfall follows the plow. Now, after a series of years of drought and crop failure, this faith has been sorely tried, and we are tormented with the fear that on account of the acts of man in plowing and draining, our country is rapidly becoming a desert. In the presence of such intense public concern it is difficult to maintain a wholly judicial attitude. It is reasonable to expect that fluctuations in humidity such as are known to have characterized the past, should also occur, through wholly natural causes, in the present and future. This logical inference, however, does not afford any reason for assuming that the very extensive and radical changes which have been made by the white men on the face of our country have produced no effects toward greater humidity or aridity. Neither may it be assumed that such effects can be of no practical consequence if they are obscured by natural fluctuations.

If the average annual contribution to the precipitation upon a continent from water evaporated out of the sea remains the same, then the drainage of swamps should reduce the average annual precipitation because some of the swamp water that would normally be evaporated and reprecipitated is drained away into the sea. On the other hand, the diversion of water from streams that flow into the sea and the use of this water for irrigation should tend to increase the precipitation. Moreover, any changes incident to cultivating and cropping the land or to grazing the land should decrease or increase the precipitation according as they increase or decrease the run-off into the sea. It is generally believed that these artificially produced changes in run-off cannot be quantitatively competent to produce appreciable changes in precipitation. However, it is pertinent to inquire whether they may have significant effects in some critical areas. It would seem that the subject deserves serious investigation.

SECOND PHASE OF THE HYDROLOGIC CYCLE

Return flow and storage en route.—The other phase of the hydrologic cycle consists of the flow of the precipitated water toward the sea or toward places of re-evaporation from the land, and its storage en route, chiefly as ice and snow, as surface water in the lakes, ponds, and swamps, as moisture held by molecular attraction in the soil, and as ground water in the subterranean reservoirs formed by the porous rocks. To the extent that the storage facilities are inadequate, the precipitated water is rapidly discharged into the sea through the natural drainage channels as direct run-off. This direct run-off is of little value to man and it produces most of the destructive floods and most of the destructive erosion and sedimentation. If there were no natural storage facilities there would be virtually no springs, no perennial streams, and no trees, grass, or crops, and all stream channels would be subject to sudden and violent floods.

Near the close of the last century it became evident in this country that accurate continuous records of stream flow were essential for efficient utilization of the water resources and for effective flood control. Since that time a large amount of systematic stream gaging has been done, with accuracy increasing from year to year. Intensive studies have also been made to differentiate between the direct run-off and the run-off derived from the several kinds of storage, and to determine the laws of each and their relation to precipitation. In some of the coastal regions large quantities of ground water are also discharged into the sea without appearing at the surface, such discharge being controlled by the geologic structure, the permeability of the water-bearing formations, and the balance between the head of the ground water and the back pressure of the heavier sea water.

Civilized man has made a notable achievement by supplementing the natural storage facilities with many artificial reservoirs, both great and small. Unfortunately, this achievement is likely to prove less substantial in the long run than is popularly supposed, chiefly because of the rapid accumulation of sediment brought to the reservoirs by the turbid waters of the direct run-off. Much careful study has already been given and much more is needed to determine the rates of sedimentation under different conditions and to devise feasible methods of prolonging the life of reservoirs by by-passing the most turbid waters, by sluicing out the sediments, or by other means. Much progress has recently been made in the appreciation of the great value of the natural storage facilities and the importance of conserving and utilizing them. The whole complex subject affords a large field for future study and constructive effort.

Ice and snow storage.—Ice and snow have recently come into the scientific limelight in different ways. One of these relates to the interest of geologists in the relation of the Quaternary and older glacial stages to fluctuations of sea level and to the cyclic character of some of the stratified rocks of marine origin. Thus it is now believed that in some of the glacial stages enough water was locked up as glacial ice to depress the sea level as much as several hundred feet, and that, on the other hand, many of the ancient sea terraces, such as occur on the Atlantic and Gulf Coastal Plain, were formed during interglacial stages when there was even less ice than at present. It has been estimated that if all the ice that exists at present in the polar regions were melted it would raise the sea level at least 100 feet and perhaps 200 feet or more. The advance and retreat of existing European glaciers have long been recorded, but systematic observations on North American glaciers have only recently been undertaken. Interest in snow relates chiefly to the snow in the mountains, which supports the summer flow of many streams, and to recently developed methods of estimating the annual snowfall and predicting the resultant stream flow.

Storage of water in the soil.—A soil may be regarded as a water reservoir, its water being in the form of moisture adhering to the soil particles. This water is under complicated stresses produced by combinations of the molecular attraction of the soil, the downward pull of gravity, the absorptive energy of the plants, and the energy involved in the relation between the soil moisture and the atmospheric vapor. The slow movements of the soil moisture in response to these stresses are of much importance in plant growth and in recharge of the water-bearing formations, and they have properly been the subject of much study.

The value of a soil for producing crops depends largely on its capacity to hold its water supply against the pull of gravity and yet to yield this retained water to the roots of the plants. A clean dune sand retains so little water that even in a humid region it may support only cactus and other drought resistant plants; on the other hand, a clay soil has a large water-retaining capacity but may hold most of its water in dead storage in so far as the roots of the plants are concerned. Between these extremes are the productive soils of intermediate texture, such as the loams formed from the loess, which hold considerable water against the pull of gravity and yield it freely to the plants.

Dry farming methods consist largely in utilizing the reservoir capacity of a soil by storing in it the rain and snow water of one or more years and making it available to a crop that is grown in a much shorter period. Unfortunately, soils do not generally have the capacity to store the quantity of water that is needed to produce a crop without replenishment by rains or irrigation at more or less frequent intervals during the growing season. In the eastern and especially the southeastern part of this country it frequently happens that the soil moisture is fully replenished early in the winter and that for many weeks thereafter water from the rain and snow percolates through the soil without adding to its water content. In the ensuing summer, however, the soil moisture may become depleted long before the crops have matured, and severe drought damage may result.

Agriculture is, from the viewpoint of this discussion, one of the greatest of all achievements of man in the utilization of our water supply, but soil erosion, like a dread disease, gnaws at its roots. The erosion of the soil removes a part of the water reservoir that it utilized in crop production, and especially the upper part, which generally has the greatest capacity for holding water available to plants. Thus the measures undertaken to check soil erosion are measures of water conservation.

Storage of water in the rock formations.—The systems of rocks that form the outer part of the solid earth are the products of all the diverse and variable geologic processes that have been operative through the ages. The description and interpretation of these rock systems, with their almost infinite complexity, is the task of the geologists. The rock systems constitute natural systems of waterworks with many reservoirs of great variety, some of which have very large capacity. The study of these natural waterworks and their operation is a task of the hydrologists. It is a task that has required the development of a distinctive technique in the application of the science of fluid mechanics and hydraulic engineering to the geologic structure of the rocks.

The porous and permeable rock formations which constitute the underground reservoirs are saturated below a certain imaginary surface that is called the ground-water table. In other words, the underground reservoirs are filled to the level of the water table. In most places the roots of the plants do not extend downward to the water table or to the capillary fringe, which occurs directly above the water table, and there is therefore an intermediate belt between the root zone, or belt of soil moisture, and the zone of saturation.

Replenishment of the underground reservoirs.—The underground reservoirs are replenished, or recharged, with water from atmospheric sources. Nearly all hydrologists believe that the recharge is essentially all from rain and snow or from streams fed by rain and snow, but there are still a few hydrologists who believe that subsurface condensation is a substantial source. The amount of recharge from a given amount and kind of precipitation varies with the absorptive or intake capacity of the soil or other surficial material and inversely with the capacity of the soil to hold the water for plant use instead of allowing it to percolate downward to the water table.

The intake capacity constitutes a large subject with many ramifications. It includes questions as to the effects of the vegetable mold in the forested areas and of the natural sod, and, on the other hand, the effects of grazing and of the cultivation of the soil. It includes also the problems of artificial recharge by spreading stream water or by other means, and of the silting up of the natural recharge channels by surface storage or other manipulation. The surface conditions of both forests and sod-covered prairies are favorable to intake by keeping the rain and snow water clean and thus permitting it to percolate downward through the available ducts and pores without clogging them, whereas under some conditions the cultivation of the soil tends to decrease the intake capacity, especially in heavy and prolonged rains, by puddling the top layer of soil and choking the intake openings. However, forests consume large quantities of water by transpiration, which tends to offset their large intake. The conflicting results obtained by different investigators as to the effects of forests on the water table and on the flow of springs and streams, as compared to the effects of cleared or cultivated land, are in part due to the fact that in some places and at some times the balance is actually on one side and in others on the other side. Relatively little investigation has as yet been made of transpiration on the sod-covered prairies and of the effects of breaking up and cultivating the prairie lands. It appears probable that there is a basis in fact for the prevalent belief that the advent of the white men in this country was attended by a certain amount of lowering of ground water levels and of decrease in the flow of springs and streams.

It appears that artificial recharge by water spreading, by impounding of surface water and regulation of stream flow, and perhaps by drainage into wells, has large possibilities for increasing the perennial supply of ground water in certain specific areas of heavy consumption in which the natural conditions are favorable. On the other hand, for the country as a whole, recharge by such means will remain small in comparison to the total natural recharge and the total discharge of ground water through stream flow and through evaporation and transpiration. Greater aggregate increase in recharge is likely to result from general improvements in agricultural practice and from structures designed to retard soil erosion.

Great as are the variations in precipitation from place to place and from year to year in the same place, the variations in ground-water recharge are still greater. It is now known, for example, that perennial supplies amounting to many millions of gallons a day are available to wells through natural recharge of the sand and gravel in the fill of the coastal valleys and the Great Valley of California, the glacial outwash sands and gravels of Long Island, the Rhine Valley and the plain of northern Germany, the dune sands of Holland, the creviced limestone in the Roswell artesian basin in New Mexico, the broken lava rocks of the Snake River Plain in Idaho and the Islands of Oahu and Maui, and the water-bearing rocks of various other areas. On the other hand, there are areas in which ground-water recharge is extremely small, either because the surface terrane is impermeable or because the water absorbed from scant precipitation is nearly all evaporated or utilized by plants before it reaches the bottom of the root zone. Large areas in the arid and semi-arid parts of this country have only very meager recharge because the precipitation is light and occurs largely in the growing season. Yet many of these areas are underlain by water-bearing formations that contain large stores of accumulated water which they will yield freely to wells so long as the supply lasts. In the coastal region of California and in the Great Valley the soil normally becomes desiccated during the long dry summers. In winters of subnormal precipitation the precipitated water is here largely required to restore the soil moisture, and there may be little ground-water recharge; in exceptionally wet winters, however, the water-retaining capacity of the soil is satisfied long before the end of the rainy season and very large quantities of water percolate to the water table, either locally through the soil or through the channels of the influent streams. In the relatively humid eastern part of the United States there is normally considerable recharge not only in winter and spring but also in wet periods in summer, but in the drought of 1930–31 some localities were devoid of recharge for nearly a year. In cold regions with only moderate precipitation nearly all the recharge may occur in a very short time in the spring when the snow melts and the frost leaves the soil. In such regions there are also great differences in the annual crop of ground water.

Relation of the water table to the plant kingdom.—It has already been pointed out that in most places the roots of the plants do not obtain their water supply from the zone of saturation. Throughout the greater part of the extensive and productive interior agricultural region of our country, the staple crops depend on the soil moisture derived directly from the rain and snow and fail if that supply becomes exhausted, regardless of the quantities of water that are stored below the water table. On the other hand, however, water from the zone of saturation is utilized, either habitually or in times of drought, by native and cultivated plants in many low places, including large parts of the Atlantic and Gulf Coastal Plain, the glaciated region, and the stream valleys and structural valleys in other parts of the country. Thus the relation of the water table to forest and fruit trees, staple crops such as wheat, corn, and alfalfa, garden truck, and native grasses is a subject of great consequence.

It is estimated that in the eastern part of the United States at least one-third of the water discharged from the zone of saturation is discharged by transpiration or evaporation, the rest being discharged as stream flow. In some of the summer months the discharge by transpiration and evaporation may greatly exceed the discharge by stream flow. In going toward the less humid parts of the country the total annual supply of ground water decreases but the proportion discharged by plants increases, until in some of the arid sections virtually all the water discharged from the zone of saturation is through plants, and the phreatophyte vegetation, which taps the zone of saturation, stands in striking contrast to the other desert plants.

Probably the greatest deficiency in hydrologic knowledge, especially in this country, is in the important practical subject of the relation of the native and cultivated plants to the water table. Not enough attention has been given to the water table by botanists, silviculturists, or agronomists, and adequate information is not available on such important subjects as the phreatophytic habits of trees and their relation to forestation in the arid and semiarid regions, the depth to which different cultivated plants will extend their roots to reach the water table, the optimum depth to the water table, and the increase in crop production resulting from use by the plants of water from the zone of saturation. The intensive drainage developments that have been made in this country have been based too largely on the concept that the water table is a detrimental feature, and not enough consideration has been given to the value of the water table to plants under proper conditions. On the other hand, the inadequacy of specific information on this subject is largely responsible for exaggerated statements that are made from time to time as to the disastrous results to agriculture from general lowering of the water table.

Relation of underground storage to stream flow and to water supplies *from wells.*—The principal function of a reservoir is to store water for future use. The underground reservoirs function naturally like lakes and ponds in equalizing the stream flow, but they are more effective because of the retardation of the ground water by the friction of the rock interstices. Underground reservoirs of some sort are almost universally present and are chiefly responsible for the sustained flow of streams. The ground-water run-off carried by the streams is relatively constant as compared with the very erratic uncontrolled direct run-off, but it is nevertheless sensitive to various weather conditions and is generally greatly reduced by severe drought. Streams differ greatly in the quantity and fluctuation of their ground-water run-off according to the geology and other natural conditions of the drainage basins. A subject that has received little investigation but is of much scientific and practical interest is the relation of geology to stream flow.

The underground reservoirs function like artificial reservoirs with controlled outlets only when they are tapped by wells that extend considerably below the water table. Shallow wells that merely skim off ground water from the top of the zone of saturation are likely to fail when the water table is lowered by drought, but the wells that extend deeper into the water-bearing formations and have access to their great stores of water are not appreciably affected by drought. Reports of failure of such wells are commonly due to mechanical defects in the wells or pumps, or to attempts made in times of drought to increase the rate of pumping beyond the normal capacities of the wells. By drawing water from wells in proper amounts the storage facilities of the underground reservoirs are utilized and ground-water recharge is increased.

Yield of the artesian reservoirs.—A problem of great practical significance relates to the perennial yield of the underground reservoirs. To what extent is the water that is annually being drawn from pumped or flowing wells derived from annual recharge and to what extent is it taken out of storage, with the prospect of ultimate serious depletion? From which of the water-bearing formations can additional perennial water supplies be developed and where can these developments be made? These questions are more intricate for the artesian formations, which are under confining covers, than for the water-bearing formations that have water-table conditions and hence have their wells in or near their intake areas. They are also more intricate for the extensive artesian sands and sandstones, which transmit their water through small inter-granular interstices and exhibit considerable volume elasticity, than for the artesian limestones and lava rocks, which have much larger water conduits and are more rigid.

Among the large artesian sandstones of the United States are the Cambrian sandstones of the interior, the St. Peter sandstone, the Dakota sandstone, and the series of thick sands or sandstones of the Atlantic and Gulf Coastal Plain. In these sandstones centuries may be required for water to percolate from the intake areas to the localities of the wells. The total quantities of water that they hold in storage are indeed very large, and the quantities that they will yield from storage merely through the compression that results from the release of artesian pressure of the confined water apparently may amount to millions of gallons a day for many years. It is believed that the phenomenon of compression with decrease in artesian pressure has been demonstrated to be of primary importance in the study of the perennial yield of these artesian sandstones, but the mode of compression has not been given much investigation. Presumably compression occurs largely in the strata of relatively fine grain which feed into the strata of coarser grain that supply the wells. The phenomenon of reexpansion with increase in artesian pressure is also known to occur to a considerable extent. It is more difficult to explain than the compression but is probably also more characteristic of strata of relatively fine grain than of the most productive water-bearing beds.

It appears that the spectacular discharge of artesian water from the Dakota sandstone for more than half a century has been supplied to a great extent from storage, largely as a result of the elastic or compressive properties of the system. It remains to be determined whether the more moderate withdrawals that are likely to be made in the future will be replaced by recharge or will result in further progressive depletion. The 800-foot sand in the Atlantic City area has yielded water freely for several decades and is currently yielding several millions of gallons a day. It shows encouraging recovery of head whenever the rate of pumping from wells is diminished. However, a thirteen-year record obtained by the investigators in that area seems to show that the regional cone of depression is still expanding, and that with the resulting compression some water is still being taken from storage. Other great artesian sandstones, such as those which for many years have furnished the water supplies of Memphis and Houston, are known to have large annual recharge, but nevertheless further records are needed to determine definitely the source of the current pumpage—to what extent the pumped water is replaced by recharge and to what extent it is derived from storage by the further development of the regional cones of depression.

About 6,500 public waterworks in this country are supplied from wells. Many of these obtain their water from surficial formations with true water-table conditions and many others from recognized artesian formations. However, there is another large group of waterworks that are supplied from aquifers, largely in the glacial drift, that are not usually regarded as artesian and yet underlie more or less effective confining beds and are recharged by somewhat devious percolation of the ground water. More attention ought to be given to the problems of depletion and safe yield of these aquifers of intermediate character.

EMERGENCE OF HYDROLOGY AS A RECOGNIZED SCIENCE

The hydrologic cycle, being of major scientific and practical interest, has received the study of a large number of scientists, most of whom have not called themselves hydrologists. In this country the Weather Bureau long ago established a comprehensive and systematic program that has resulted in the accumulation of a great amount of base data on precipitation and other weather conditions, the value of which is beyond estimation. The Geological Survey has developed a thorough technique for gaging streams and has accumulated a remarkable body of systematic and exact data on stream flow. By systematic work through many years it has also made substantial achievements in the chemical analysis of the natural waters, in a general survey of the ground-water conditions, and in the development and application of quantitative methods in ground-water investigation.

In addition to the work of these two scientific bureaus of the Federal Government, there has been a vast amount of work by a great number of governmental and private agencies and individuals that has contributed in many ways to the base data and to the methods and principles of hydrology. Thus many hydraulic engineers have devoted much of their time not to engineering work at all but to scientific research relating to the natural waters; thus, also, many other scientists, such as soil scientists, agronomists, geologists, botanists, and foresters, have made distinct contributions to hydrology. There has, however, been a lack of coordination, and developments have been made which have had unfavorable effects that were not foreseen because the scientists and engineers concerned did not have an adequate appreciation of the unity and complexity of the hydrologic cycle.

In recent years there has arisen a wholesome recognition of hydrology as a comprehensive science, and a general effort has been made to correlate the different aspects of the subject. This trend has found expression and stimulus in the organization, six years ago, of the Section of Hydrology of the American Geophysical Union. More recently an attempt has been made through the efforts of the Mississippi Valley Committee, the National Resources Committee, the State Planning Boards, and other agencies to evaluate objectively the manifold works of man that have affected the hydrologic cycle at some point and to attain a clearer perspective for the future. Thus progress has been made in an appreciation of the sensitivity of our water supply to many complex controls. Looking to the future, we must insist that engineering works or other developments shall be undertaken only after their hydrologic consequences have been fully studied, and we must resolutely set ourselves the task of building a science of hydrology that will be adequate for the responsibilities that are involved.

CHEMISTRY.—*Hydrogen ion concentration and the formation of copper complexes.*[1] K. J. MURATA, U. S. Geological Survey. (Communicated by R. C. WELLS.)

The exact function of the alcoholic hydroxyl groups of hydroxy acids in the formation of complex compounds with metals has become clarified in recent years by the physico-chemical investigations of Smythe and Schmidt (1) and of Smythe (2). Although several chemists working with these substances still ignore the role of the hydroxyl groups, there can be little doubt that the metal atoms displace hydrogen from them, especially from those in the alpha position, and establish covalent links between themselves and the remaining oxygens. The present trend in the interpretation of most of these substances is to consider them as chelated complex compounds, the "innere Komplexe" of Werner. Wark and Wark (3) who have made extended researches on the copper complexes are inclining toward this view. The modern electronic theory of valency provides a physical basis for Werner's coordination number, and emphasizes the importance of this secondary valence in complex formation. Other viewpoints are held by Mathieu (4) and by Dumanski and Chalisev (5).

As discussed by Smythe, the metal atoms in displacing hydrogen from the hydroxyl groups are merely enhancing a tendency toward acidic dissociation already possessed by the latter. Two interesting studies of the acidic nature of polyols (sugars) which have been

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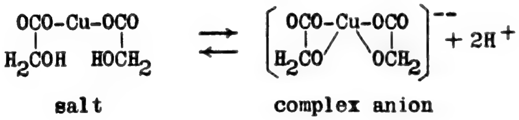
[1] Published by the permission of the Director, U. S. Geological Survey. Received January 15, 1937.

recently reported are those of Urban and Shaffer (6) and of Ambler (7).

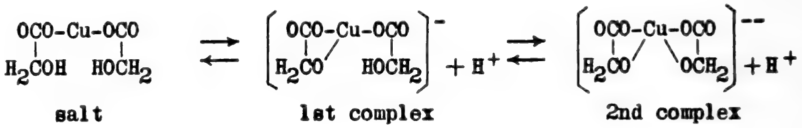
Inasmuch as hydrogen ions are liberated when complexes of this type are formed, the pH of the medium would be expected to have a profound influence on the progress of the reaction. Smythe and Schmidt explored the lower and upper pH limits of stability of different iron complexes. But there is evidence that the pH has an even more intimate action than merely setting these boundary conditions. The mechanism of complex formation outlined by these investigators can be represented for the cupric glycollate complex by equation (a). The bond between copper and the carboxyl groups in the parent salt is very likely one capable only of slight dissociation, like that found in copper malonate by Riley and Fisher (8) and in several tartrates of the transition elements by Mathieu (4). When a certain threshold pH is attained, according to the scheme of Smythe and Schmidt, the two hydrogens of the hydroxyls are simultaneously ejected, and a quadricovalent copper complex anion is formed.

The object of this paper is to discuss evidence indicating that the two alpha hydroxyls are not dissociated simultaneously but successively, thus giving rise to two different complexes which are stable in different pH ranges. See equation (b).

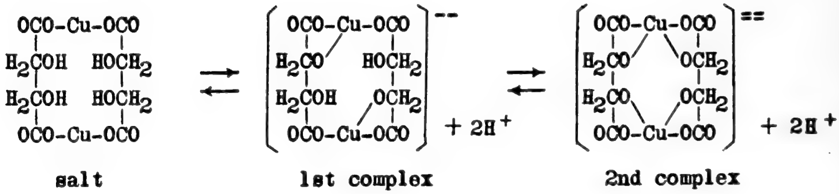
(a)



(b)



(c)



The instant that one of the hydroxyls loses a hydrogen ion, the symmetry of the molecule is lost and a stepwise dissociation becomes a possibility.

The report by Pickering (9) of a monopotassium cupriglycollate complex from a faintly alkaline solution and a dipotassium compound from a strongly alkaline solution favors this view. However, a more satisfactory proof is to be found in certain cupritartrate complexes, which will next be briefly discussed.

THE CUPRITARTRATE COMPLEXES

Of the great number of different compounds of copper and tartaric acid that have been reported, attention will be confined to those which contain one atom of copper per mole of tartrate radical. These comprise a series which has been most recently examined by Gabiano (10) and by deMallemann and Gabiano (11), who studied their remarkable optical properties.

The first of two different complexes is formed when a sufficient base is added to the salt, cupric tartrate, to just dissolve a given quantity of it. On the basis of partial analyses, Gabiano has assigned to it the formula, $NaCuC_4H_4O_6 \cdot 2H_2O$.

The second complex is obtained in crystalline form from solutions containing larger amounts of the base than required for the first complex. deMallemann and Gabiano, by partial analyses, have fixed its composition as $Na_2CuC_4H_4O_6 \cdot 2H_2O$. It has a deeper bluish color than the first complex.

Copper tartrate differs from the tartrates of other divalent metals studied by Mathieu in that it does not yield an insoluble basic compound as the alkali is added to it. In this respect it behaves like chromium tartrate investigated by him (12) and by Hakamori (13).

Packer and Wark (14), several years prior to the researches of Gabiano, studied in great detail what has been called in this paper the first complex. They made complete analyses of their crystalline compound, and found the composition to be $(NaCuC_4H_3O_6)_3CuO \cdot 11H_2O$. Though this work has been criticised by Dumanski and Chalisev (5), subsequent checks (15) indicate that the result is essentially correct. The 1:1:1 ratio of Na:Cu:T seems to hold both here and in Gabiano's formula, though the discrepancy of $\frac{1}{3}$ CuO cannot be accounted for satisfactorily. It is highly desirable that the refractive indices and other optical properties of such synthesised materials be recorded so as to facilitate their identification by later workers. The findings of Packer and Wark are of special theoretical importance however, because they demonstrate that, in a certain pH range, one of the two alpha hydroxyl groups of the tartrate radical is dissociated while the other is still intact. This fact offers strong support to the hypothesis of stepwise dissociation for these hydroxyls briefly outlined above.

The molecular weight determinations carried out by Kahlenberg (16) show that the first complex is a double molecule. This work has not received the attention that it deserves.

The extensive researches of Bullnheimer and Seitz (17) on the second complex present at higher alkalinities seem to have successfully avoided the sources of error which arise from the instability of this substance, and which have been clearly set forth by deMallemann and Gabiano. Complete analyses by them gave $Na_2CuC_4H_2O_6 \cdot 2H_2O$. This differs from the formula given by deMallemann and Gabiano to the extent that the two hydrogens of the hydroxyl groups are lacking, a result to be expected on the basis of chelate ring structures for these complexes, and one which the partial analyses of the latter workers could not reveal. A mechanism for the formation of these complex copper tartrates, which emphasizes the successive dissociation of the hydroxyl groups, is outlined in equation (c) above.

When one adds the base to cupric tartrate in increasing amounts, he notes the color changes that appear as the first and the second complexes form. But beyond a certain amount there is no further deepening of the blue color. This is seen to be a consequence of the second complex, which forms through the dissociation of the second alpha hydroxyl, attaining a stable and ultimate quadricovalent structure. Any excess of a base is without effect, at least so far as the chromophoric copper atoms of the complex are concerned.

The concern of the chemist when he adds an alkali to the solid cupric salts of these hydroxy acids or to solutions of them to form the complexes should not be the molecular ratio between the alkali and copper, but rather the pH of the system. The value of some of the stoichiometric equations used to account for the formation of complexes is doubtful. The role of the base is not to take a direct part in the synthesis of a complex but to alter the nature of the medium and the reactants so that the synthesis may proceed.

Whether or not the copper atoms in the first complex are manifesting the unusual covalency of three or whether the fourth covalency is satisfied by a molecule of water cannot be decided until more reliable means of determining coordinated water of this kind are established, and the hydration of the other constituents becomes known. That the quadricovalent copper of the second complex has a planar configuration becomes very probable in the light of recent researches of Cox and coworkers (18). The different cis and trans arrangements which the isomeric tartrates can form may account for the marked differences in their stability.

A survey of the cupric complexes of several alpha hydroxy acids indicates that the stepwise dissociation of the hydroxyl groups is a general characteristic. For example, Pickering's (19) "Potassio-cupric Hydrogen Citrate" containing 5 atoms of potassium and 1 of copper is very likely the first complex, and his "Potassium beta-Cupricitrate" with 6 atoms of potassium and one of copper the second complex for this acid. Any study of the equilibrium constants of complex substances of this sort must therefore discriminate between the two kinds that occur in the different pH ranges. Potentiometric pH titration curves usually fail to show any distinct breaks however, and manifest a smooth slope characteristic of weak polybasic acids.

CONCLUSION

Evidence pointing to a stepwise dissociation of the hydroxyl groups in complex formation between copper and alpha hydroxy acids is discussed. In general, as a result of this behavior two different simple cupric complexes may exist, each in a different pH range.

A modification of the mechanism for complex formation outlined by Smythe and Schmidt is proposed.

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PALEONTOLOGY.—Clistocrinus, *a new Carboniferous crinoid genus*.[1]

EDWIN KIRK, U. S. Geological Survey.

Through the kindness of Dr. G. H. Girty, of the U. S. Geological Survey, I have been given the opportunity of studying and describing an interesting new crinoid genus from the Carboniferous of South-

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[1] Published by permission of the Director, U. S. Geological Survey. Received January 28, 1937.

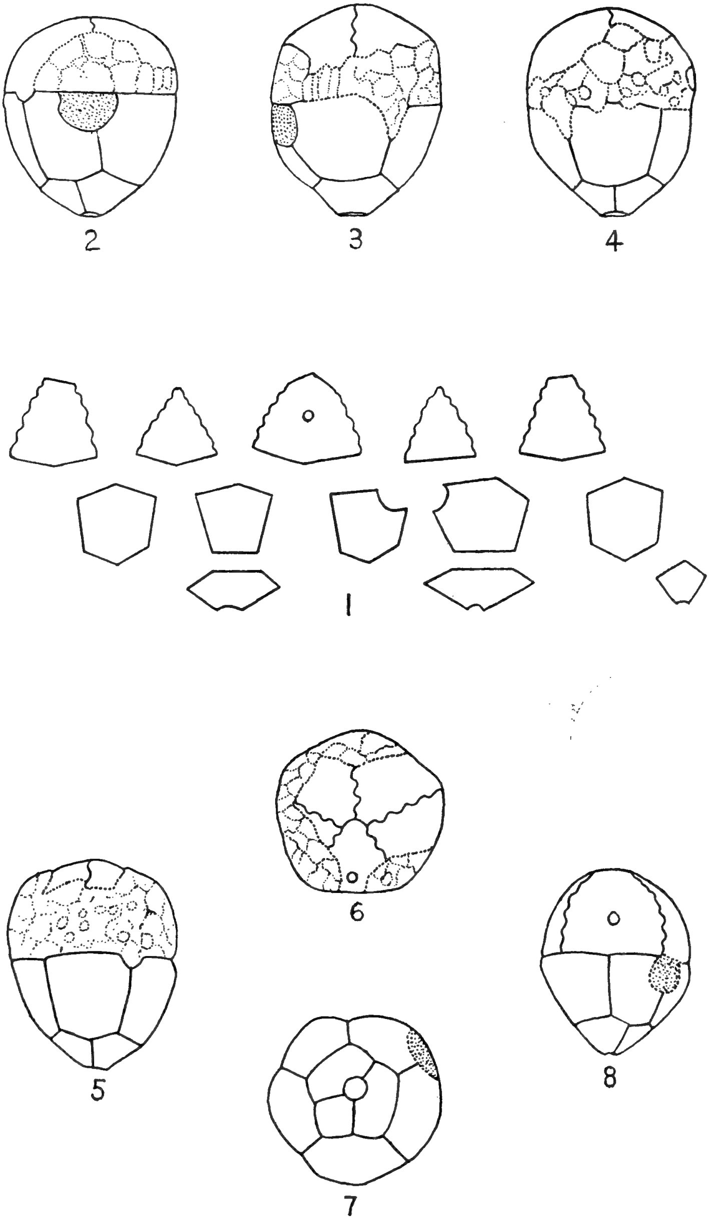
eastern Alaska. This genus, for which the name *Clistocrinus* is here proposed, belongs to a group of small crinoids of anomalous structure which in recent years has been found to have a wide geographical distribution and to range throughout the Carboniferous and up into the Permian. As now known, these crinoids have been found in the Visean (Lower Carboniferous) of Belgium and England, and the upper Mississippian of the United States, the Pennsylvanian (essentially the European Upper Carboniferous) of the United States and Alaska, the Permo-Carboniferous of Russia, and the Permian of Timor and the United States. *Clistocrinus,* coming as it does from the lower Pennsylvanian of Alaska, is of very great interest both on account of its geographic and stratigraphic position. Structurally *Clistocrinus* furnishes an intermediate form in the series of these crinoids as known.

Clistocrinus, n. gen.

The genotype is *Clistocrinus pyriformis,* n. sp.

Before giving a description of the crinoid, certain points of terminology and orientation will briefly be considered in order to avoid confusion. The theca is composed of three circlets of plates. According to Wanner's usage these would be named, as in a dicyclic crinoid, infrabasals, basals, and orals, the radials being absent. For convenience in the present case I prefer treating the form as a monocyclic crinoid, calling the same circlets of plates basals, radials, and orals, respectively. According to Wanner's thesis, such a form as this is derived from a dicyclic crinoid with four circlets of plates by the elimination of one circlet, the radials. I believe the reverse is true and that the four-circlet type is derived from the three circlet by an intercyclic interpolation of a fourth ring of plates which become known as radials. Were this the only evolutionary possibility, Wanner's terminology would still be applicable. I think, however, that the median circlet of plates of the three-circlet type is potentially either a basal or a radial ring and feel that it is less confusing to use a nomenclature based on monocyclic structure in such crinoids as have the orals alternating with the plates of the second range. To all intents and purposes, irrespective of potential dicyclic structure, these crinoids are monocyclic. In orienting the theca I call the large hydropore-bearing oral the posterior and arrange the other plates accordingly. Wanner also calls this oral posterior, but according to his interpretation it then would have a radial position in this form as in *Acaraiocrinus,* and the orientation of the dorsal cup would be arbitrary, his posterior "basal" being 36° out of line with the posterior oral. The difference of orientation between Wanner and myself must be borne in mind when reading his descriptions. The large lateral opening lying in the radial-oral plane which has universally been called the anal opening may be such, but I doubt it. The opening piercing the posterior oral, which is probably the anal opening, I shall call the hydropore, a somewhat equivocal term but in conformity with current and past usage.

The following brief diagnosis of the genus will give the salient features of the form, the more detailed description being found under the description of the type species.



Figs. 1–8.—*Clistocrinus pyriformis*, n. sp. 1, plate diagram. 2, view from right posterior interradius showing the lateral opening. 3–5, views of same specimen revolving the specimen progressively to the left. 6, tegminal view. 7, basal view. 8, another somewhat smaller specimen, posterior view showing the position of the hydropore. Figs. 2–8 are approximately ×6.

The basal units are three in number, two large and of approximately equal size, the third much smaller. The small unfused basal is the left anterior, a normal position for monocyclic crinoids. The radials are five in number and vary somewhat in relative size. The right posterior and right anterior radials are invaginated to form the lateral opening. The posterior oral is the largest and is pierced by a hydropore. Although not clearly seen, the posterior oral and the right and left anterior orals alone meet at the center of the tegmen. This is a condition common to other genera of this group. The sutures between the orals are sinuous, very like *Embryocrinus.* The right posterior oral instead of holding a median position between the right posterior and right anterior radials does not touch the right posterior radial, the common suture between the posterior and right posterior orals falling directly above the lateral opening. The lateral opening lies in the right posterior interradius, unequally notching the right posterior and right anterior radials. The superjacent orals are not invaginated.

Clistocrinus pyriformis, n. sp.

Of this species three adult specimens and three or possibly more younger individuals are available for study. The specimens are calcified and were found in a richly fossiliferous crystalline limestone. The sutures show clearly in the larger specimens.

The species is a small one, the holotype measuring 4.7 mm in height by 4.2 mm in diameter. The theca is subpyriform in shape. The sides of the dorsal cup diverge fairly rapidly to about two-thirds the height of the radials and then constrict somewhat at the plane of the radial-oral contact. The tegmen is a rounded dome, with a height about one-third that of the theca. The orals are somewhat flattened, giving the tegmen an obscurely facetted appearance, with the angles falling along the inter-oral sutures. The plates are finely punctate.

The basal units are three in number, the small unfused pentagonal basal being the left anterior. The other two are hexagonal in outline and subequal in size. The height of the basal cup of the largest individual is 1 mm and its maximum diameter 2.3 mm. The radials are subequal in size. They have a uniform height looking straight down upon them of 2.2 mm, except the anterior, which gives a measurement of 2 mm. The breadth of the plates at their upper margin is variable. The right posterior is the narrowest with a width of 1.8 mm, estimating the width by projecting the right posterior-right anterior suture upward through the lateral opening. The right anterior radial is the widest at the upper margin, with a breadth of 2.7 mm. Measurements for the other radials read as follows: ant., 2.3 mm; l. ant., 2 mm; l. post., 2.2 mm. The width of the radials at the base is more uniform, the r. post., r. ant., and ant. radials measuring 1.5 mm. In the l. ant. the width is 1.4 mm, and in the l. post. it is 1.2 mm. The orals are difficult to measure owing to curvature and indistinct sutures. The width of the plate at the base can be measured with fair accuracy, however. This dimension on the r. ant., l. ant., and l. post. orals is the same, 2.7 mm. The posterior oral is by far the largest, with a width of 3.3 mm, while the r. post. oral is narrower than the first three noted, with a width of but 2.5 mm. The apposed faces of the orals are coarsely crenulate, as in *Embryocrinus* and *Coenocystis.* The hydropore cannot be located with certainty in the larger specimen illustrated, but its probable situation is indicated in figure 6 and was drawn in mainly to identify the hydropore-oral. The hydropore shows clearly in the specimen illustrated as figure 8 and in one other. In the specimen not figured the hydropore is much nearer the apex of the oral. The hydropore shows as a pit, rather than as elevated pimple, as is often the case. In the larger specimen the pit is surrounded by a smoothly rounded ridge.

The lateral opening is of relatively large size, having a maximum height of 0.9 mm and a width at the oral-radial plane of 1.2 mm. It lies in the right posterior interradius, unequally cutting into the right posterior and right anterior radials. Of the total width, approximately 0.8 mm lies within the right posterior radial and 0.4 mm within the right anterior radial. The opening does not cut into the superjacent orals as is the case in several genera. One would expect the lateral opening to be covered entirely by the right posterior oral. Such is not the case, however. The posterior oral extends beyond the median line of the right posterior radial and meets the right posterior oral at a point about midway of the lateral opening.

On the surface of the tegmen of the largest individual are irregular superimposed raised areas. When first seen these areas were thought to be extraneous growths. Being restricted almost entirely to the tegmen, apparently having the structure of crinoid stereom, and similar but smaller areas being found on other specimens, it seems probable that they are structures of the crinoid itself. As seen the surface of these areas is covered with irregularly disposed suboval to subcircular depressions. In general appearance the depressions are similar to the pits for the reception of epithecal brachioles in some of the more primitive cystids, but the resemblance is probably superficial. There would appear to be no reason for calcified exothecal extensions on crinoids of this type. The pits are sometimes thickly clustered and sometimes fairly well separated. It is difficult to render the structures in a drawing, even to the extent of delimiting the areas themselves. The outline shown in figures 2 to 6 are intended only approximately to give the general size and distribution of the areas. In general these patches of stereom are most numerous near the periphery of the theca and along the inter-oral sutures.

The areal distribution of the epithecal structures in the largest specimen shows an almost continuous peripheral band at the base of the orals, with the greatest development along the inter-oral sutures. A large patch lies directly above the lateral opening, extending on both sides of the post.-r. post. oral contact. It extends upward along the suture to about one-half the height of the orals. From this patch a narrow band extends to the right horizontally and just above the radial-oral plane to another large patch on the r. ant.-l. ant. oral contact. This patch is clearly defined, and its surface rises well above that of the orals. It extends upward to about two-thirds the height of the orals. From this patch a broad irregular band extends across the l. ant. and l. post. orals to slightly beyond the l. post.-post. oral suture. The band broadens somewhat at both the l. ant.-l. post. oral and l. post.-post. oral contacts. This band lies at times somewhat above the radial-oral plane.

In two other somewhat smaller individuals the surface of the theca is not as well preserved, but structures suggesting similar epithecal deposits can be seen. As shown the areas are discontinuous and much smaller than in the largest specimen. Here again the main concentration of superficial stereom is along inter-oral sutures. In two small specimens the plate sutures cannot be seen, and the separation of tegmen and dorsal cup must be made arbitrarily. The pits in these specimens are relatively large, and apparently the epithecal areas extend onto the dorsal cup.

The stem cicatrix is round and has a diameter of 0.5 mm.

Picked out of the broken limestone fragments, and associated with the large specimens of *Clistocrinus pyriformis*, are five small subovate to capsule-shaped specimens that appear to be the young of the crinoid. Broken out of a dark crystalline limestone and not subjected to weathering, it is not possible to see plate sutures in all of them. One can be reasonably certain of at least three of the specimens, however. The tegmen and dorsal cup can be recognized, and the lateral opening and the columnar attachment can be identified with a fair degree of certainty. A fourth specimen is so similar to the other three as to render its identification reasonably sure. The fifth and smallest specimen is of uncertain placement. All the specimens agree in having a height in excess of the diameter. In the smaller specimens the diameter is approximately 0.8 the height. With increasing age the diameter approaches 0.9 the height, and this appears to hold as an average for the larger specimens. The proportions of tegmen and dorsal cup appear to be reasonably constant. In the younger specimens the base is more rounded, however, and it is difficult to distinguish one end of the theca from the other.

Horizon and locality.—The locality as given by the collector, A. F. Buddington, is "Northwest end of large island at head of Saginaw Bay, Kuiu Island, on east side; 40-foot bed of limestone intercalated in series of interlayered chert, slaty quartzite, and cherty limestone." Girty[2] gives an extensive faunal list of the associated fossils and on page 116 gives his opinion as to the age of this and similar faunas. His conclusion was tentatively to make the fauna upper Mississippian in age, though recognizing strong Pennsylvanian affinities. At my suggestion, L. G. Henbest examined the foraminifera from this locality, and his general conclusion[3] is that these fossils favor an assignment of the fauna to the Pennsylvanian. Girty[4] holds that although the evidence for a Pennsylvanian age does not appear much stronger than in 1929, the evidence for a Mississippian assignment seems somewhat weaker. His general conclusion is "The Alaskan fauna, I am inclined to believe, will prove to be of Pottsville age, or at least early Pennsylvanian, but I cannot say that the proof is at present extant." There are two other crinoid genera in the material. *Synbathocrinus* is indeterminate as to age. The other is a small crinoid which, though not typical, would be referred to *Delocrinus*, a Pennsylvanian genus. On the whole it would appear best to consider the fauna lower Pennsylvanian in age.

Types.—The cotypes and other specimens studied are in the collections of the U. S. National Museum, No. 94441.

Structurally we see in *Clistocrinus* an intermediate evolutionary stage between the Mississippian *Lageniocrinus* and the Permo-Carboniferous (Russia) and Permian (Timor) *Acariaiocrinus* (*Streptostomocrinus*). In another paper I am redescribing *Lageniocrinus*, based on a study of de Koninck's type specimen of *L. seminulum*. In *Lageniocrinus* there is a lateral ("anal") opening notching the upper corners of the two plates of the second range, one below the hydropore-oral and the one to the right. The orals are in alignment with the plates of the second range. In *Clistocrinus* we find the orals shifted to the left relative to the plates of the dorsal cup, becoming

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[2] Girty, G. H., in Buddington, A. F., and Chapin, Theodore, *Geology and mineral deposits of southeastern Alaska:* U. S. Geol. Survey Bull. **800:** 113. 1929.

[3] Personal communication, August 29, 1936.

[4] Personal communication, November 11, 1936.

"interradial" in position. The lateral opening is larger and has migrated somewhat to the left. In *Acariaiocrinus* the orals are "interradial" in position, and the lateral opening has migrated still further to the left, holding a median position on the right posterior "radial."

In some of the genera of this group of crinoids it has been assumed that the orals could be opened and closed. There has been no evidence for this, but anyone handling the material would, I think, come to this conclusion. I have very good evidence in the case of *Coenocystis.* Here there are five suboval pits, each at the center of the distal face of a plate of the second range ("radial"). Above each pit is a cavity excavated in the superjacent orals and equally shared by them. At the proximal angles of the orals are apophyses that project downward and bear against the inner wall of the dorsal cup when the orals are closed. It is obvious that we have here an articulating structure of rather complex type. In the case of *Clistocrinus* we have two difficulties. One is that the inter-oral suture between the posterior and right posterior orals is in line with the large lateral opening, and the proximal corners of these orals involved have no bearing surface. Obviously with the corners lacking support and the total bearing surface cut down these plates would have poor but perhaps adequate articulating surfaces. The other difficulty is the presence of the patches of stereom partially covering the inter-oral sutures and effectively soldering the oral dome into an immovable unit. It is possible that these pitted areas of superimposed material were not laid down by the crinoid, but the evidence at hand seems in favor of such an explanation. An examination of 10 well-preserved specimens of *Embryocrinus* shows nothing comparable in that genus, nor has anything of the sort been seen in a number of specimens of *Coenocystis,* though here the preservation, owing to silicification, makes the evidence less satisfactory. The only thing to do is to await more material to confirm or disprove the apparent structure. It would be of great importance, however, to know that such a crinoid could function with its orals firmly closed. In such case it would appear necessary to consider the lateral opening as an oral opening. I favor this view.

Of great importance in the orientation of the crinoids of this group and the Allagecrinidae as well, and in some cases the only reliable criterion, is the evidence offered by the orals. This does not seem to have been recognized. The arrangement and shape of the orals seems to be invariable. The posterior oral is the largest. Often the hydropore can be recognized without doubt, but fortuitous pitting and secondary alteration of the surface of specimens as small as these may lead one astray. The posterior oral may, however, be recognized by its pentagonal outline, and careful examination will usually show its distal portion formed of two faces meeting at an obtuse angle. The right and left anterior orals are large, quadrangular in outline and make contact with the posterior oral with their obliquely truncated distal faces. The right and left posterior orals are relatively small, triangular in outline and do not reach to the center of the tegmen. A recognition of these facts should prevent the preparation of drawings and plate diagrams that show the orals as five subequal triangular plates or with the right and left anterior orals truncated in the wrong direction. A modification of this typical structure is found in *Embryocrinus* and possibly elsewhere. Here the apical portion of the posterior oral forms an obtuse re-entrant angle, with a median projection. The apical portions of the right and left anterior orals fit into the re-entrant and in this case are not obliquely truncated.

BOTANY.—*A new type of heterobasidiomycete.*[1] G. W. MARTIN, State University of Iowa.

The fungi included in the order Tremellales, in the wide sense, are of peculiar interest because they may be regarded as constituting the plexus from which has developed, on the one hand, the rusts and smuts, and, on the other, the homobasidiomycetes. For this reason, the finding of an undoubted member of the order possessing a characteristic suggestive of certain phenomena long known to occur in the smuts is worthy of more extended comment than might be justified were it merely an addition to the known genera and species of the group.

The fungus in question was found to be common in western Panama, growing on fallen trunks and stumps in the mountain forest bordering the upper Rio Chiriqui Viejo. In appearance it suggests a large, white and rather soft *Tremella*, but microscopic examination shows it to be a member of the Auriculariaceae, with unique basidia and spores. It is difficult to believe that so large, common and conspicuous a form has not been previously noted, but, if it has, I have been unable to find any recognizable description. As there seems to be no known genus into which it may be placed, it becomes necessary to erect one for it.

Syzygospora Martin, gen. nov.

Fructificatione sessile, gelatinosa; basidiis clavatis, transverse uniseptatis, loculis singulis monosporium gerentibus; sporis coalescentibus ante disjunctionem.

Basidiocarp sessile, gelatinous; hymenium covering entire exposed surface; basidia bluntly clavate, transversely septate into two cells, each cell producing a single basidiospore on a short sterigma; basidio-spores fusing in pairs before detachment. Type species, *S. alba.*

Syzygospora alba Martin, sp. nov.

Fructificatione sessile, late effusa, undulata vel subcerebriformia, alba, gelatinosa demum deliquescente, attingente 10×5×2.5 cm; sicca fulva, cornea; basidiis clavatis, 8–15×3.5–4μ, transverse uniseptatis, loculis singulis monosporium gerentibus; sporis subglobosis, coalescentibus ante disjunctionem, demum cylindraceis post fusionem, 5–6×2.8–3.2μ.

Basidiocarp sessile, broadly effused, undulate to subcerebriform, pure white, soft gelatinous, with long soaking becoming deliquescent, up to 10 cm long by 5 cm broad by 2.5 cm thick; dark brown and horny when dry; hymenium composed of basidia borne in fascicles at the tips of branching, radiating hyphae, forming a dense palisade layer covering the entire surface; basidia bluntly clavate, 8–15×3.5–4μ, becoming transversely septate into two cells, the distal cell blunt and approximately isodiametric, the basal cell longer and attenuated toward the base, each cell producing a globose

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[1] Received January 9, 1937.

basidiospore on a short sterigma, that of the distal cell borne at the basal end just above the septum, that of the basal cell borne at the distal end just below the septum and adjacent to the other, the two basidiospores fusing before attaining full size and finally breaking off as a single oval, cylindrical or slightly dumb-bell shaped spore 5–6×2.8–3.2μ.

Panama: Prov. Chiriqui. Valley of upper Rio Chiriqui Viejo, alt. 1600–1800 m., June–July 1935. G. W. M. 2449 (Type, in herb. State Univ. Iowa), 2167, 2517, 2547, 2575.

The generic name is derived from σύζυγος, *yoked together*, and σπορά, *spore.*

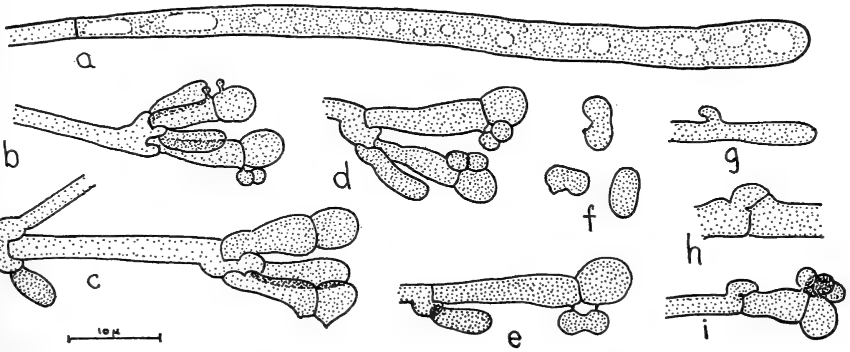

Fig. 1.—*Syzygospora alba*, n. gen. and sp. a, cystidium. b, cluster of four basidia, two bearing spores. c, tip of large axial hypha bearing cluster of three basidia, one preparing to produce spores, and two clamp connections, both proliferating, one to bear a single basidium, the other, a lateral branch which bore at tip a cluster of basidia similar to b, which was produced at the next lower septum. d, cluster of three basidia, the center one showing early stage of fusion of spores. e, two basidia, the larger one showing spores in late stage of fusion. f, three fused and detached spores two showing evidence of origin; the bulk of the spores resemble the third. g, tip of axial hypha showing beginning of clamp connection. h, clamp connection from basal region of axial hypha. i, basidium possibly bearing four spores. All drawings made with aid of camera lucida at magnification ×2436, and reduced in reproduction to ×1200.

When soaked, the fructifications become rather dingy white and waxy-gelatinous, then soft, but do not regain their original color and size. A microtome section through a portion of a soaked specimen, hardened in formalin and imbedded in paraffin, shows the hyphae aggregated into thin anastomosing strands separated by large open spaces, the whole suggesting a structure resembling that of a sponge. The internal hyphae are of two sorts, extremely irregular, tortuous hyphae of varying size, and large straight ones, 3–4μ in diameter, which radiate outward in all directions and by repeated branching give rise to the basidiophores, which are mostly 1. 5μ–2μ in diameter. Clamp connections are abundant, being visible at almost every septum, including those at the base of the basidia. The basidia themselves are borne singly, or in unilateral cymose tufts of two to four, the successive basidia after the first usually arising by proliferation from the clamp connection at the base of the next older basidium, essentially in the manner reported by Rogers[2] for *Sebacina prolifera.*

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[2] Mycologia **28**: 347–362. 1936.

A small number of basidia were observed which seemed to bear two pairs of spores. When carefully focussed, some of these resolved themselves into two superimposed basidia, others seemed to be instances where a loose spore had become attached to the side of the basidium, but in a very few instances there seemed to be four spores, fused or unfused, actually present. If this interpretation is correct, it is probably to be regarded as an aberration such as is characteristic of the Tremellales.

In addition to basidia, the hymenium includes a small number of clavate, hyphal tips with highly vacuolate and somewhat refringent contents, attaining 80μ in length and 5μ in diameter near the tips. They are borne on the same hyphae as the basidia. In some cases they represent the ends of the large axial hyphae bearing the basidiophores, while in others they originate amongst a cluster of basidia. They are evidently to be regarded as cystidia.

The fusion of the spores must result in the immediate restoration of the dicaryon phase. This phenomenon seems to be distinct from anything known heretofore in the Basidiomycetes in that fusion results in a distinct, diploid spore serving as a disseminule. It must, however, be regarded as homologous with the familiar fusion of sporidia either while still attached to the basidium ("promycelium") of many of the smuts or immediately after separation, first announced and illustrated by the Tulasnes[3] and later by DeBary, Brefeld and many others. It is perhaps even closer to the fusion between the cells of the basidium as demonstrated by Rawitscher for *Cintractia Montagnei.*[4] In the smuts, however, the smut spore, or probasidium, is the primary disseminule, and the fusion product either grows directly into a mycelium or proceeds to develop secondary basidiospores which are forcibly discharged and then function as disseminules.[5] The fusion of basidiospores in *Syzygospora* is significant as illustrative of a tendency in the group which may have been modified and developed in the smuts and adapted to their highly specialized ecological requirements.

ZOOLOGY.—*North American monogenetic trematodes. I. The superfamily Gyrodactyloidea.*[1] EMMETT W. PRICE, U. S. Bureau of Animal Industry.

The monogenetic or ectoparasitic trematodes comprise a wide variety of more or less bizarre flatworms occurring on fishes and other aquatic animals. These forms are most commonly encountered on the skin and gills of marine and fresh-water fishes. Several species occur in the mouth and upper respiratory tract of turtles and in the urinary bladder of turtles and frogs. A few have been found on crustaceans and cephalopods, and one species has been reported from the eyes of

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[3] Ann. Sci. Nat. Bot. IV **2**: 157–159. 1854.

[4] Ber. deut. bot. Gesell. **32**: 281–287. 1914.

[5] BULLER. *Res. on Fungi,* **5**: 207–278. 1933.

[1] Received January 29, 1937.

an aquatic mammal. The literature dealing with this group of trematodes is fairly extensive, although only a few papers have appeared which may be regarded as monographic in scope. The most important are those by Braun (1889–1893), Saint Remy (1891a and b, 1892, 1898), Goto (1894), Johnston and Tiegs (1922) and Fuhrmann (1928).

The first monogenetic trematode from a North American host was described as an "insect" by La Martinière (1787), and was found on the skin of a fish collected somewhere between Monterey Bay, California, and Nootka Island. The true nature of this "insect" was determined by Bosc (1811). Since that time more than 40 papers have appeared which deal either wholly or in part with North American representatives of the order Monogenea. The most extensive studies of these forms were made by the late Dr. G. A. MacCallum (14 papers appearing from 1913 to 1931), and by Stunkard (1917), Mueller (1934, 1936) and Mizelle (1936).

This paper, which is the first of several to appear under the general heading of *North American monogenetic trematodes*, is limited to the superfamily Gyrodactyloidea. Subsequent papers will deal with other major groups and will appear in sequence. In all of these papers will be given diagnoses and keys for all groups as far as genera, and when taken together these papers will represent a revision of the entire order Monogenea. Under each genus is given a list of all species known to belong to that group. However, no attempt has been made in each instance to pass judgment on the validity of the exotic representatives of these genera. The species of which detailed descriptions are given are those from this continent that have been inadequately characterized and those in which important characters have been overlooked or misinterpreted. A few new species have been included, but no particular effort has been made to obtain new forms since the mere describing of new species is regarded of minor importance as compared with redescriptions of imperfectly known old species.

This revision has been made possible through access to the extensive collections of MacCallum, Linton and others, which are deposited in the U. S. National Museum. The writer is indebted to Drs. J. E. Guberlet, University of Washington; Harold Heath, Stanford University; Edwin Linton, University of Pennsylvania; H. W. Manter, University of Nebraska; John D. Mizelle, University of Illinois; Justus F. Mueller, Syracuse University; H. S. Pratt, Haverford, Pa.; H. W. Stunkard, New York University; and H. J. Van Cleave, University of Illinois; as well as to Drs. P. D. Harwood, W. H. Krull, E. E. Wehr, and Mr. Allen McIntosh of the Zoological Division, U.

S. Bureau of Animal Industry, for supplying specimens not available in the U. S. National Museum Collections.

Order MONOGENEA Carus, 1863[2]

Synonyms.—Cryptocoela Johnston, 1865; Ectoparasitica Lang, 1888; Eterocotylea Monticelli, 1892; Heterocotylea Braun, 1893; Monogenetica Haswell, 1893; Heterocotylida Lahille, 1918.

Diagnosis.—Small to medium sized ectoparasitic flukes, with elongated to leaf-like bodies. Anterior end of body with or without haptors; posterior end always with a haptor, the haptor usually provided with hooks or suckers, or with both hooks and suckers. Mouth ventral or subterminal, at or near anterior end; pharynx always present, well developed; intestine single or double. Eyes present or absent. Excretory system double, opening dorsally through 2 symmetrically placed pores at or near level of genital aperture. Always hermaphroditic; genital apertures usually opening into a common sinus. Genito-intestinal canal present or absent. Uterus usually short; eggs few, frequently provided with polar prolongations. Development direct, i.e., without alternation of generations and without alternation of hosts; metamorphosis incomplete. Usually parasites of cold-blooded vertebrates or of crustaceans parasitic on vertebrates, rarely on cephalopods and mammals.

Odhner (1912) has proposed a division of the Monogenea into two suborders, Monopisthocotylea and Polyopisthocotylea, on the basis of the presence or absence of a genito-intestinal canal, and most authors have accepted Odhner's proposal. Fuhrmann (1928), however, recognizes three suborders, namely, Monopisthodiscinea, Monopisthocotylinea and Polyopisthocotylinea, the first two of these groups being the result of splitting Odhner's Monopisthocotylea into two suborders, while the third is equivalent to Polyopisthocotylea Odhner. The writer fails to see sufficient fundamental difference to warrant subdividing the Monopisthocotylea into two suborders, preferring to retain the groups as proposed by Odhner, and has proposed two superfamilies to replace the first two of Fuhrmann's suborders.

KEY TO THE SUBORDERS OF MONOGENEA

Genito-intestinal canal present	Polyopisthocotylea Odhner
Genito-intestinal canal absent	Monopisthocotylea Odhner

Suborder MONOPISTHOCOTYLEA Odhner, 1912

Synonyms.—Monocotylea Blainville, 1828; Tricotylea Diesing, 1850; Tristomeae Taschenberg, 1879; Oligocotylea Monticelli, 1903; Monopisthodiscinea Fuhrmann, 1928; Monopisthocotylinea Fuhrmann, 1928.

Diagnosis.—Anterior haptors present or absent, when present consisting of a weakly developed oral sucker, or of 2 lateral suckers not opening into oral cavity, or of 2 elongate depressions near anterior end of body with numerous small unicellular glands opening into them; when haptors absent, adhesive function supplied by cephalic glands opening singly at anterior

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[2] Most authors credit the name of this order to Van Beneden (1858), but this seems to be an error. Van Beneden proposed a division of the trematodes into two major groups, "monogénèses" and "digénèses," the names being in the vernacular form. The first to use the name Monogenea for the order appears to have been Carus (1863).

margin of body or through one or more pairs of head organs. Posterior haptor disc-like, usually well developed, its ventral surface with or without septa, never bearing distinct suckers or clamp-like attaching organs, usually armed with 1 to 3 pairs of large hooks and a number (2 to 16) of marginal hooklets; large hooks frequently supported by transverse cuticular bars. Eyes present or absent. Genito-intestinal canal absent, except possibly in Protogyrodactylidae. Vagina present or absent.

KEY TO SUPERFAMILIES OF MONOPISTHOCOTYLEA

Posterior haptor armed; large hooks with supporting bars . . . . Gyrodactyloidea. Johnston and Tiegs
Posterior haptor armed or unarmed; when armed, large hooks without supporting bars . . . . Capsaloidea Price

Superfamily GYRODACTYLOIDEA Johnston and Tiegs, 1922

Diagnosis.—Anterior haptors absent; cephalic glands present, usually in 2 groups, 1 group on each side of pharynx, with ducts opening to exterior through 1 or more pairs of head organs. Posterior haptor disc-like, sometimes wedge-shaped, bearing 1 to 2 pairs of large hooks, the hooks almost always supported by 1 to 2, rarely 3, cuticular bars. Intestine sac-like or consisting of 2 branches with or without diverticula, the later, when present, short. Genital aperture median or submedian. Cirrus simple, cuticular, frequently with complicated cuticular accessory structure. Vagina present or absent. Vitello-intestinal canal rarely present. Oviparous or viviparous.

Type family.—Gyrodactylidae Cobbold, 1877.

KEY TO FAMILIES OF GYRODACTYLOIDEA

1. Viviparous . . . . Gyrodactylidae Cobbold
   Oviparous 2
2. Vitello-intestinal duct present . Protogyrodactylidae Johnston and Tiegs
   Vitello-intestinal duct absent 3
3. Anterior end of body expanded to form head lappets . . . . Calceostomatidae Parona and Perugia
   Anterior end of body not expanded to form head lappets . . . . Dactylogyridae Bychowsky

Family GYRODACTYLIDAE Cobbold, 1877

Diagnosis.—Small, elongated Monogenea, with 2 head organs. Haptor well developed, usually bearing 1 pair of large hooks (absent in Isancistrinae) and 15 or 16 marginal hooklets. Intestine branched, the 2 limbs not uniting posteriorly. Eyes absent. Male copulatory organ armed with a row of minute spines and usually with a triangular cuticular plaque. Ovary V-shaped, or lobed, posttesticular. Vitellaria absent or united with ovary. Vagina absent. Viviparous. Parasites of fishes, amphibians and cephalopods.

Type genus.—*Gyrodactylus* Nordmann, 1832.

Many authors, including Johnston and Tiegs (1922), Fuhrmann (1928), Froissant (1930) and Bychowsky (1933), credit the name of this family to Van Beneden and Hesse (1863), but these authors used the name "Gyrodactylides" and not "Gyrodactylidae"; the first to use the correct form of the family name appears to have been Cobbold (1877).

KEY TO SUBFAMILIES OF GYRODACTYLIDAE

Haptor with 2 large hooks and 16 marginal hooklets	Gyrodactylinae Monticelli
Haptor without large hooks but with 15 marginal hooklets	Isancistrinae Fuhrmann

Subfamily GYRODACTYLINAE Monticelli, 1892

Diagnosis.—Anterior end bilobed, each lobe with a head organ. Haptor circular, with 1 pair of large hooks and 16 marginal hooklets. Parasites of fishes and amphibians.

Type genus.—*Gyrodactylus* Nordmann, 1832.

Genus GYRODACTYLUS Nordmann, 1832

Diagnosis.—Characters of the subfamily.

Type species.—*Gyrodactylus elegans* Nordmann, 1832.

The genus *Gyrodactylus* contains the following species: *G. elegans* Nordmann, 1832; *G. groenlandicus* Levinsen, 1881; *G. gracilis* Kathariner, 1894; *G. medius* Kathariner, 1894; *G. rarus* Wegener, 1910; *G. fairporti* Van Cleave, 1921; *G. japonicus* Kikuchi, 1929; *G. cobitus* Bychowsky, 1933; *G. latus* Bychowsky, 1933; *G. parvicopula* Bychowsky, 1933; *G. cylindriformis* Mueller and Van Cleave, 1932; *G. elegans* vars. A. and B. Mueller, 1936; and *G. gurleyi*, n. sp. Of these species, *G. fairporti*, *G. elegans* vars. A and B, *G. spathulatus* and *G. gurleyi* are from North American fish hosts. *G. elegans* Nordmann has been reported from fishes in Maine by Atkins (1901) and in Washington by Guberlet, Hansen and Kavanagh (1927) but whether these reports indicate the occurrence of the European species by that name is open to question. The report by Cooper (1915) of the occurrence of *G. medius* Kathariner from North America is likewise questionable, as the description and figure given by Cooper indicate that he was dealing with some species other than *G. medius*.

In addition to the species listed above, reports of species of *Gyrodactylus* from North American fishes have been given by a number of writers, including Davis (1929) and Hess (1930) but no evidence is given in these reports that would enable one to determine the species involved. Recently Stunkard and Dunihue (1933) reported the occurrence of a species of *Gyrodactylus* on tadpoles of *Rana catesbeiana*, constituting the first report of a species of this genus parasitizing an amphibian.

Gyrodactylus gurleyi, n. sp. Fig. 1

Description.—Body elongate, 435 to 510μ long by 60 to 76μ wide, width about uniform throughout length of body proper; anterior end bifid and provided with 1 pair of head organs; cephalic glands present on each side of pharynx. Haptor circular, about 76μ wide, armed with 1 pair of large hooks supported by a delicate dorsal bar and a similar ventral bar, and with 16 marginal hooklets; ventral bar at level of proximal ends of large hooks. Large hooks 45 to 49μ long; marginal hooklets about 23μ long. Oral aperture ventral, about 75μ from anterior end; esophagus very short; intestinal

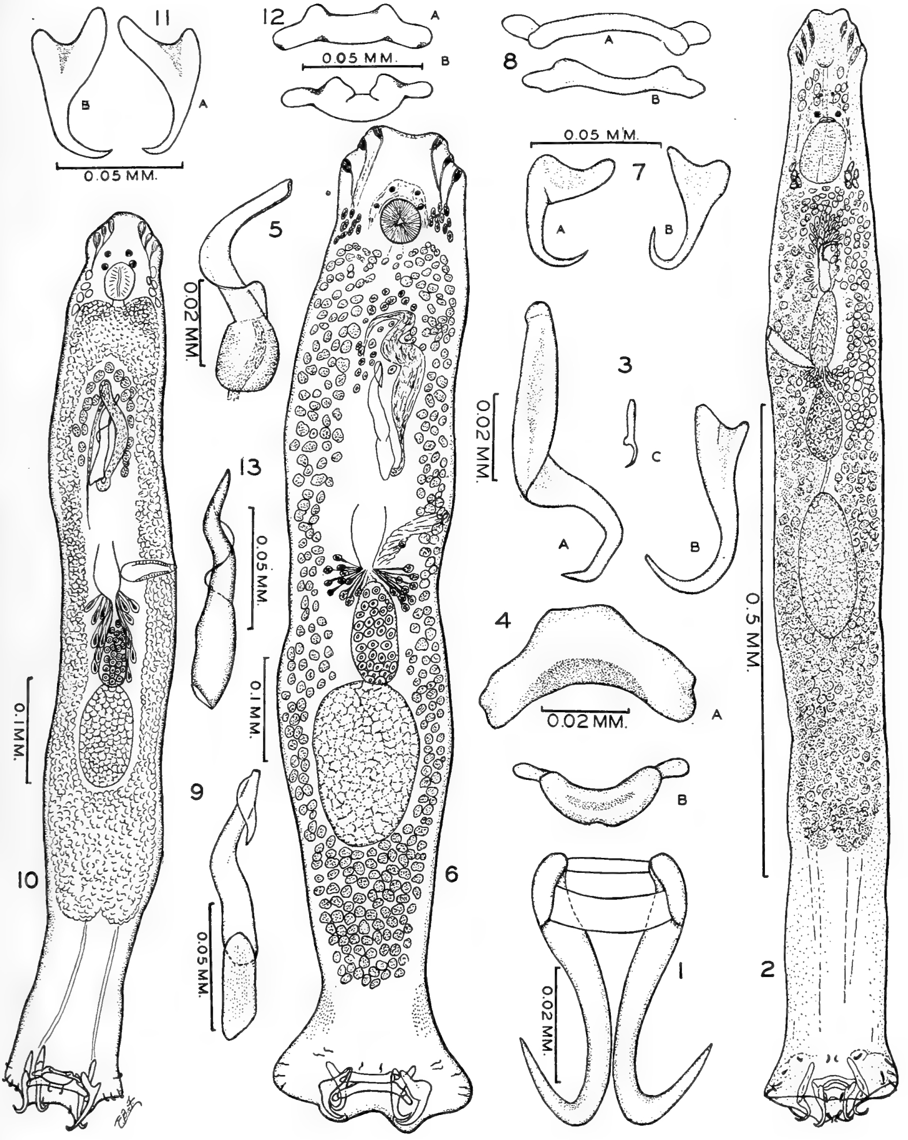

Fig. 1.—*Gyrodactylus gurleyi*. Large haptoral hooks, dorsal view. Figs. 2–5.—*Ancyrocephalus teuthis*. 2, Complete worm, ventral view; 3, haptoral hooks (A—hook of dorsal pair, B—hook of ventral pair, C—marginal hooklet); 4, haptoral bars (A—dorsal bar, B—ventral bar); 5, cirrus. Figs. 6–9.—*Ancyrocephalus lactophrys*. 6, Complete worm, ventral view; 7, large haptoral hooks (A—hook of ventral pair, B—hook of dorsal pair); 8, haptoral bars (A—ventral bar, B—dorsal bar; drawn to same scale as Fig. 7); 9, cirrus. Figs. 10–13.—*Ancyrocephalus similis*. 10, Complete worm, ventral view; 11, haptoral hooks (A—hook of ventral pair, B—hook of dorsal pair); 12, haptoral bars (A—ventral bar, B—dorsal bar); 13, cirrus.

branches simple. Genital apertures not observed. Testis oval, 20 to 38μ long by 20 to 25μ wide, median, about 155μ from posterior end of body proper. Ovary an indistinct mass occupying greater part of body width and extending from level of testis to near posterior end of body proper. Ovum about 23 to 27μ in diameter, lying immediately anterior to testis. Uterus in equatorial third of body, containing 1 to 2 developing embryos.

Host.—Gold fish ("Japanese fan-tail").
Location.—Fins.
Distribution.—United States (Texas).
Specimens.—U. S. N. M. Helm. Coll. No. 39584.

The above description is based on a slide mount of a portion of the fin of a gold fish to which were attached several specimens of gyrodactylids. The slide was labeled "*Gyrodactylus elegans*—Japanese fan-tail—Dr. Gurley, Sept. 1891." The locality was not given, but Dr. A. Hassall has informed the writer that these specimens had been collected in Texas. The specimens were not in good condition and a complete description is, therefore, impossible. The general appearance of the worms corresponds closely to that of *G. medius* as described by Kathariner (1895) and by Wegener (1910), but the ventral supporting bar of the large haptoral hooks is placed at the level of the proximal ends of the hooks while in *G. medius* this bar is placed much farther back. It is on the basis of the position of this bar that the species is considered new.

Subfamily ISANCISTRINAE Fuhrmann, 1928

Diagnosis.—Anterior end truncate, with 1 pair of head organs. Haptor without large hooks, with 15 marginal hooklets. Parasites of cephalopods.
Type genus.—*Isancistrum* de Beauchamp, 1912.

Genus Isancistrum de Beauchamp, 1912

Diagnosis.—Characters of subfamily.
Type species.—*Isancistrum loliginis* de Beauchamp, 1912.

The type and only species. *I. loliginis,* was described by de Beauchamp (1912) from specimens collected from *Loligo media* Linneaus; this parasite is not known to occur on North American hosts.

Family PROTOGYRODACTYLIDAE Johnston and Tiegs, 1922

Diagnosis.—Minute forms, about as broad as long; cephalic glands present, opening to exterior through well developed head organs. Haptor well developed, with 2 pairs of large hooks and with a number of relatively large marginal hooklets. Intestine branched, the two limbs may or may not unite posteriorly. Eyes present. Testis and ovary unbranched. Cirrus simple, cuticular, tube-like. Vitelline glands lateral, arranged in 2 groups, one preovarial and the other postovarial; transverse vitelline ducts connected by median longitudinal duct; posterior transverse vitelline duct with definite connection with intestinal limbs. Vagina absent. Parasites of fresh-water fishes.
Type genus.—*Protogyrodactylus* Johnston and Tiegs, 1922.

KEY TO GENERA OF PROTOGYRODACTYLIDAE

Posterior vitelline system double..........*Trivitellina* Johnston and Tiegs
Posterior vitelline system single.....*Protogyrodactylus* Johnston and Tiegs

Genus PROTOGYRODACTYLUS Johnston and Tiegs, 1922

Diagnosis.—Haptor broad, not sharply set off from body proper, strongly "padded," provided with 2 pairs of large hooks and 12 marginal hooklets, the latter relatively large. Intestinal branches not united posteriorly. Vitellaria consisting of a preovarial and a postovarial system; posterior transverse vitelline duct communicating with intestine.

Type species.—*Protogyrodactylus quadratus* Johnston and Tiegs, 1922.

The type and only species of this genus occurs on the gills of *Therapon carbo* Ogilby and McCulloch and *T. hilli* Castelnau in Australia.

Genus TRIVITELLINA Johnston and Tiegs, 1922

Diagnosis.—Haptor sharply set off from body, not strongly "padded," provided with 2 pairs of large hooks and 12 marginal hooklets as in *Protogyrodactylus*. Intestinal branches united posteriorly. Vitellaria consisting of 1 preovarial system and 2 postovarial systems, one of the latter connected with the intestine.

Type species.—*Trivitellina subrotunda* Johnston and Tiegs, 1922.

The type and only species of this genus is known only from Australia where it occurs on the gills of *Therapon fuliginosus* Macleay.

Family DACTYLOGYRIDAE Bychowsky, 1933

Synonyms.—Gyrodactylidae Cobbold, 1877, in part; Amphibdellidae Carus, 1885.

Diagnosis.—Anterior end with 2 or more pairs of head organs; cephalic glands lateral, or distributed throughout median, preoral area (Bothitrematinae). Haptor moderately to well developed, with or without accessory structures or squamodiscs, and with 1 or 2 pairs of large hooks and usually 14 marginal hooklets. Ovary globular, sometimes curved, pretesticular. Vitellaria well developed. Vagina present or absent. Oviparous. Parasites of fishes.

Type genus.—*Dactylogyrus* Diesing, 1850.

KEY TO SUBFAMILIES OF DACTYLOGYRIDAE

1. Haptor with 1 pair of large hooks..............................2
   Haptor with 2 pairs of large hooks..............................3
2. Haptor with a circle of heavily cuticularized, tubular structures........ ....Bothitrematinae Price
   Haptor without circle of tubular structures. Dactylogyrinae Bychowsky
3. Haptor with a pair (dorsal and ventral) of accessory structures or squamodiscs...............................Diplectaninae Monticelli
   Haptor without accessory structures or squamodiscs............... .... Tetraonchinae Monticelli

Subfamily DACTYLOGYRINAE Bychowsky, 1933

Synonyms.—Gyrodactylinae Monticelli, 1892, in part.

Diagnosis.—Haptor moderately developed, without squamodiscs, with 1 pair of large hooks supported by 1 or 2 heavily cuticularized clamp-like bars, and with 14 marginal hooklets. Intestine double, branches usually, if not always, united posteriorly. Eyes present. Testis and ovary rounded, the latter always pretesticular. Vagina present, with or without cuticular supporting structures.

Type genus.—*Dactylogyrus* Diesing, 1850.

Genus DACTYLOGYRUS Diesing, 1850

Diagnosis.—Characters of subfamily.

Type species.—*Dactylogyrus auriculatus* (Nordmann, 1832) Diesing, 1850.

The genus *Dactylogyrus* contains the following species: *D. aequans* Wagener, 1857; *D. affinis* Bychowsky, 1933; *D. alatus* Linstow, 1878; *D. amphibothrium* Wagener, 1857; *D. anchoratus* (Dujardin, 1845); *D. auriculatus* (Nordmann, 1832); *D. bini* Kikuchi, 1929; *D. chranilowi* Bychowsky, 1933; *D. cornu* Linstow, 1878; *D. crucifer* Wagener, 1857; *D. cryptomeres* Bychowsky, 1934; *D. kulwieći* (Bychowsky, 1931); *D. cyprini* Buschkiel, 1930; *D. difformis* Wagener, 1857; *D. dujardinianus* (Diesing, 1850); *D. extensus* Mueller and Van Cleave, 1932; *D. falcatus* (Wedl, 1857); *D. fallax* (Wagener, 1857); *D. formosus* Kulwieć, 1927; *D. fraternus* Wegener, 1910; *D. frisii* Bychowsky, 1933; *D. gracilis* Wedl, 1861; *D. haplogonus* Bychowsky, 1933; *D. intermedius* Wegener, 1910; *D. inversus* Goto and Kikuchi, 1917; *D. macracanthus* Wegener, 1910; *D. malleus* Linstow, 1877; *D. megastoma* Wagener, 1857; *D. minor*, Wagener, 1857; *D. minutus* Kulwieć, 1927; *D. mollis* (Wedl, 1857); *D. nybelini* Markevich, 1933; *D. parvus*, Wegener, 1910; *D. propinquus* Bychowsky, 1931; *D. puntii* Buschkiel, 1930; *D. siluri* Wagener, 1857; *D. similis* Wegener, 1910; *D. simplicimalleata* Bychowsky, 1934; *D. sphyrna* Linstow, 1878; *D. tenuis* Wedl, 1857; *D. tuba* Linstow, 1878; *D. uncinatus* Wagener, 1857; *D. vastator* Nybelin 1924 (syn. *D. crassus* Kulwieć, 1927); *D. wegeneri* Kulwieć, 1927; *D. wunderi* Bychowsky, 1931; and *D. zandti* Bychowsky, 1933. Only two of these species, *D. extensus* and *D. anchoratus*, are known to occur in North America, the former occurring on the gills of *Cyprinus carpio* and the latter on *Carassius auratus*.

Subfamily TETRAONCHINAE Monticelli, 1903

Diagnosis.—Body devoid of scales or spines. Haptor without squamodiscs, with 2 pairs of large hooks and (?) 2 to 16 marginal hooklets. Intestine single or double. Eyes present or absent. Testis usually without lobes. Ovary without lobes. Vagina present or absent.

Type genus.—*Tetraonchus* Diesing, 1858.

KEY TO GENERA OF TETRAONCHINAE[3]

1. One pair of head organs.........*Diplectanotrema* Johnston and Tiegs
   More than 1 pair of head organs..................................2

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[3] The recent genera by Mueller (1936, 1937) may not all be valid; they have been included in this key pending further study. *Dactylodiscus* Olsson is omitted from the key as it is too imperfectly known; it may belong to this subfamily and is appended as a genus inquirenda.

2. Intestine single.................................*Tetraonchus* Diesing
   Intestine double...3
3. Intestine uniting posteriorly..................................4
   Intestine not uniting posteriorly.............................15
4. Eyes absent........................*Tetrancistrum* Goto and Kikuchi
   Eyes present...5
5. Vitellaria not extending into posterior third of body..........6
   Vitellaria extending into posterior third of body..............7
6. Vagina present...................*Daitreosoma* Johnston and Tiegs
   Vagina absent...................*Empleurosoma* Johnston and Tiegs
7. Dorsal and ventral haptoral hooks dissimilar....*Aristocleidus* Mueller
   Dorsal and ventral haptoral hooks similar......................8
8. Haptor disc-like; haptoral bars articulate.......*Actinocleidus* Mueller
   Haptor wedge-shaped; haptoral bars non-articulate..............9
9. Large haptoral hooks unequal, ventrals about one-half as large as dorsals
   ....*Haplocleidus* Mueller
   Large haptoral hooks equal or nearly so.......................10
10. Large hooks each with flattened blade arising near angle.......
    ....*Pterocleidus* Mueller
    Large hooks without blades...................................11
11. Marginal hooklets relatively large, 6 pairs arranged around anterior edge of haptor, their points projecting forward...............
    ....*Onchocleidus* Mueller
    Marginal hooklets relatively small, mostly projecting backward...12
12. Cirrus long and slender, thrown into wide spiral; without movable accessory piece............................*Leptocleidus* Mueller
    Cirrus usually short, with movable accessory piece...........13
13. Vagina absent..................................*Urocleidus* Mueller
    Vagina present...14
14. Vagina dextral................................*Tetracleidus* Mueller
    Vagina sinistral..............................*Cleidodiscus* Mueller
15. Eyes present...16
    Eyes absent..18
16. Vagina absent..................*Anchylodiscus* Johnston and Tiegs
    Vagina present...17
17. Vagina aperture median; haptor with 3 bars.......*Murraytrema*, n. g.
    Vaginal aperture lateral; haptor with 2 bars...*Ancyrocephalus* Creplin
18. Haptor without bars............................*Amphibdella* Chatin
    Haptor with 1 or 2 bars......................................19
19. Haptor with 1 bar...........................*Amphibdelloides*, n. g.
    Haptor with 2 bars...............*Haliotrema* Johnston and Tiegs

Genus TETRAONCHUS Diesing, 1858

Synonym.—*Monocoelium* Wegener, 1910.

Diagnosis.—Cephalic glands opening to exterior through several pairs of head organs. Haptor more or less distinctly set off from body proper, with 2 pairs of large hooks supported by a single large transverse cuticular bar; 16 marginal hooklets. Intestine single, without diverticula. Eyes present. Testes and ovary in equatorial zone. Vagina absent.

Type species.—*Tetraonchus monenteron* (Wagener, 1857) Diesing, 1858.

The genus *Tetraonchus* contains two species, *T. monenteron* (Wagener, 1857), reported by Van Cleave and Mueller (1934) from *Esox lucius* from

Oneida Lake, New York, and *T. alaskensis* Price, reported by the present writer (1937) from the gills of *Salmo mykiss* Walbaum, *Salvelinus malma spectabilis* (Giard) and *Oncorhynchus kisutch* Walbaum from Alaska.

Genus ANCYROCEPHALUS Creplin, 1839

Synonyms.—Diplectanum Auct.; *Tetraonchus* Diesing, 1858, in part.

Diagnosis.—Head organs usually 3 pairs. Haptor indistinctly set off from body proper. Large hooks supported by 2 cuticular bars; 14 marginal hooklets. Intestinal branches not united posteriorly. Eyes present. Testis and ovary equatorial or postequatorial. Vitellaria usually extending into posterior third of body. Vagina present.

Type species.—Ancyrocephalus paradoxus Creplin, 1839.

The following species belong to the genus *Ancyrocephalus: A. atherinae* Price, 1934; *A. bassensis* Hughes, 1928; *A. lactophrys* (MacCallum, 1915); *A. manilensis* Tubangui, 1931; *A. paradoxus* Creplin, 1839; *A. similis*, n. sp.; *A. teuthis* (MacCallum, 1915); *A. tylosuri* (MacCallum, 1917); *A. vanbenedenii* (Parona and Perugia, 1890); and *A. vesiculosus* Murray, 1931. Of these species, *A. atherinae, A. lactophrys, A. similis, A. teuthis,* and *A. tylosuri* occur on North American fishes; descriptions of the forms from this continent except *A. atherinae* from *Atherina araea* Jordan and Gilbert, which was described by the present writer (1934), are given below.

Ancyrocephalus teuthis (MacCallum, 1915)
Johnston and Tiegs, 1922

Figs. 2–5

Synonym.—Diplectanum teuthis McCallum, 1915.

Description.—Body slender, 1.1 to 1.2 mm long by 96 to 114μ wide, sides parallel; anterior end slightly notched and somewhat narrower than remainder of body; cephalic glands present, in 4 groups, 1 group on each side of base of pharynx and 1 group on each side of median line anterior to oral aperture, opening to exterior through 3 pairs of head organs. Haptor 133μ wide, not set off from body proper, with 2 pairs of large hooks supported by 2 cuticular bars and with 14 marginal hooklets; 2 small crescentic bodies also present in median line, lying side by side at level of roots of dorsal hooks. Large hooks unequal and dissimilar; those of dorsal pair sickle-shaped, 57 to 58μ long, apparently with single, handle-like root and with angular blade; hooks of ventral pair simple 42, to 45μ long, with slightly biramous roots; dorsal supporting bar somewhat yoke-shaped, about 45μ long, ventral bar yoke-shaped, 43 to 49μ long; marginal hooklets 15μ long. Oral aperture ventral, at level of posterior pair of head organs; pharynx oval, 57μ long by 45μ wide; intestine not discernible. Eyes present, 2 pairs, anterior to pharynx. Genital aperture median, about 250μ from anterior end of body. Cirrus tubular, curved, about 57μ long, with delicate spiral ala. Testis oval, 133μ long by 57μ wide, equatorial. Ovary oval, median, pretesticular. Vitellaria extending from level of base of pharynx to about one-fourth of body length from posterior end. Vagina present, opening on right side of body about 325 to 245μ from anterior end. Ootype elongate, its base surrounded by unicellular glands. No eggs observed.

Host.—Acanthurus hepatus (Linnaeus).

Location.—Gills.

Distribution.—United States (New York Aquarium).
Specimens.—U. S. N. M. Helm. Coll. Nos. 35689 (cotypes), 35690 and 35691.

Three slides containing several specimens and representing collections made by Dr. G. A. MacCallum on May 22, 1914; March 17, 1915; and November 24, 1915, respectively, were available for study. The specimens were fairly well preserved and stained, but some structures figured by MacCallum (1915), such as the esophageal glands, seminal vesicle and seminal receptacle, could not be made out.

The most distinguishing feature of the species is the structure of the dorsal hooks of the haptor; these have relatively long, apparently uniramous roots and peculiarly curved blades.

Ancyrocephalus lactophrys (MacCallum, 1915) Johnston and Tiegs, 1922

Figs. 6–9

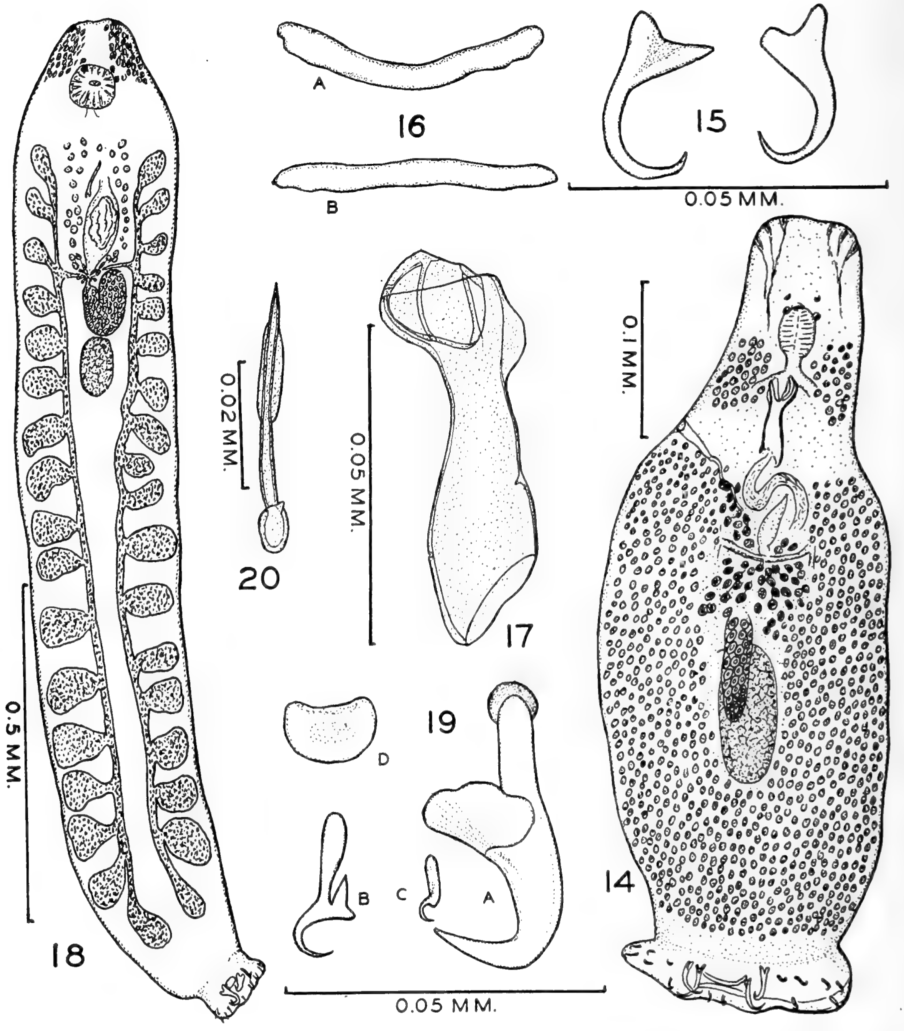
Synonym.—*Diplectanum lactophrys* MacCallum, 1915.
Description.—Body elongate, 650 to 950μ long by 150μ wide, slightly constricted at level of ootype. Cephalic glands in 2 groups, 1 on each side of pharynx, opening to exterior through 3 pairs of head organs; no esophageal glands observed. Haptor 170 to 190μ wide, with 2 pairs of large hooks separated by cuticular bars, and with 14 marginal hooklets. Large hooks biramous 49μ long; dorsal supporting bar 76μ long, ventral bar 68μ long; marginal hooklets 15μ long. Oral aperture ventral, about 80μ from anterior end of body; pharynx about 38μ in diameter; intestinal tract not observable. Brain antero-dorsal to oral aperture; eyes present, 2 pairs. Genital aperture median, about 200μ from anterior end of body. Cirrus tubular, about 105μ long, no accessory piece observed; seminal vesicle somewhat S-shaped, to right of cirrus; vas deferens extending from testis to seminal vesicle, passing to left of cirrus and curving anterior to genital aperture. Testis oval, about 150μ long by 95μ wide, postequatorial. Ovary elongate oval, 100μ by 57μ wide. immediately pretesticular. Vitellaria extending from level of base of pharynx to near junction of haptor with body proper. Vagina present, relatively large, with distinct cuticular lining, the lining presenting a twisted appearance at proximal end of vagina. Ootype oval, its base surrounded by long-necked unicellular glands. Eggs not observed.
Host.—*Acanthostracion quadricornis* (Linnaeus).
Location.—Gills.
Distribution.—United States (New York Aquarium).
Specimens.—U. S. N. M. Helm. Coll. No. 35692 (cotypes).

Several specimens of this species were collected by Dr. G. A. MacCallum, February 19, 1915, from the gills of *Lactophrys tricornis* (=*Acanthostracion quadricornis*). The above description is based on these specimens.

Ancyrocephalus similis, n. sp.

Figs. 10–13

Description.—Body elongate, 850 to 936μ long by 100 to 115μ wide, lateral margins almost parallel for entire length. Cephalic glands on each side of pharynx, opening to exterior through 3 pairs of head organs. Haptor not set off from body proper, with 2 pairs of large hooks supported by 2 cuticular bars, and with (?) 14 marginal hooklets. Large hooks 57 to 60μ



Figs. 14–17.—*Ancyrocephalus tylosuri*. 14, Complete worm, ventral view; 15, haptoral hooks; 16, haptoral bars (A—dorsal bar, B—ventral bar; drawn to same scale as Fig. 15); 17, cirrus. Figs. 18–20.—*Diplectanotrema balistes*. 18, Complete worm, ventral view; 19, haptoral hooks and bar (A—hook of ventral pair, B—hook of dorsal pair, C—marginal hooklet, D—bar); 20, cirrus.

long, roots biramous; dorsal supporting bar 42 to 57μ long, ventral bar 57 to 65μ long; marginal hooklets about 10μ long. Oral aperture ventral, about 40μ from anterior end of body; pharynx 40μ long by 30μ wide; intestinal tract not observed. Eyes present, 2 pairs, anterior to oral aperture. Genital aperture median, about 200μ from anterior end of body. Cirrus 76 to 95μ long, similar in shape to that of *A. lactophrys*. Testis oval, 75μ long by 55μ wide, postequatorial. Ovary elongate, median, pretesticular. Vitellaria as in *A. lactophrys*. Vagina short, without twisted cuticular lining as in *A. lactophrys*. No eggs observed.

Hosts.—Priacanthus arenatus Cuv. and Valenc. and *P. cruentatus* (Lacépède).
Location.—Gills.
Distribution.—United States (New York Aquarium).
Specimens.—U. S. N. M. Helm. Coll. Nos. 35693 (type and paratypes) and 35694.

This species is based on specimens collected by Dr. G. A. MacCallum. Two slides containing a number of specimens from each of the above-mentioned hosts were available; the specimens from *Priacanthus arenatus* had been collected June 20, 1915, and those from *P. cruentatus* on May 30, 1915.

Ancyrocephalus similis resembles *A. lactophrys* so closely that on casual examination the two forms appear to be identical. However, there are very significant differences in the morphology of the large hooks, supporting bars and cirri of the two species, which appear sufficient to warrant recognizing them as distinct.

Ancyrocephalus tylosuri (MacCallum, 1917) Johnston and Tiegs, 1922

Figs. 14–17

Synonym.—Diplectanum tylosuri MacCallum, 1917.
Description.—Body somewhat elliptical, 510 to 645μ long by 170 to 210μ wide, anterior end more or less abruptly constricted. Cephalic glands numerous, on each side of pharynx, opening to exterior through 3 pairs of head organs. Haptor disc-like, about 150μ wide, more or less sharply set off from body proper, with 2 pairs of large hooks supported by 2 cuticular bars, and with 14 marginal hooklets. Large hooks similar in shape, 23μ long, with slightly biramous roots; ventral bar slightly sinuous, about 38μ long; dorsal bar curved, about 38μ long; marginal hooklets about 12μ long. Oral aperture ventral, 50 to 55μ from anterior end of body; pharynx oval, 27μ long by 19μ wide; intestinal tract not observed. Eyes present, 2 pairs, anterior to pharynx. Genital aperture median, about 100μ from anterior end; cirrus 57μ long, tubular, expanded distally, without accessory piece; seminal vesicle S-shaped. Testis oval, about 75μ long by 40μ wide, postequatorial. Ovary linguiform, 75μ long by 20μ wide, partly overlapping testis. Vitellaria occupying greater part of body from level of base of cirrus to posterior end of body proper. Vagina present, cuticular, somewhat trumpet-shaped, opening at body margin immediately in front of anterior limit of left vitellarium. Ootype elongate, its base surrounded by numerous, relatively large, unicellular glands. Eggs not observed.
Host.—Strongylura marina (Walbaum).
Location.—Gills.
Distribution.—United States (New York Aquarium).
Specimens.—U. S. N. M. Helm. Coll. No. 35695 (cotypes).

This species was described by MacCallum (1917) from specimens collected May 4, 1916 from a silver gar at the New York Aquarium; this redescription is based on the original specimens. All of the specimens had been stained and mounted and were not in good condition, consequently very little could be added to the original description. *A. tylosuri* may be easily distinguished from all other species of the genus by the position of the vaginal aperture and by the structure of the cirrus.

Ancyrocephalus spp.

Undetermined species of *Ancyrocephalus* have been reported from fresh-water fishes in this country by Hess (1928, 1930) and by Van Cleave and Mueller (1934). In view of the fact that the genus *Ancyrocephalus, s. str.*, is composed of species from marine fishes, it appears safe to conclude that the forms reported by the above writers do not belong to that genus.

Genus HALIOTREMA Johnston and Tiegs, 1922

Diagnosis.—Body slightly constricted in equatorial region; 4 to 5 pairs of head organs. Haptor distinctly set off from body proper, with 2 pairs of large hooks supported by a pair of clamp-like bars, and with 14 marginal hooklets. Intestinal limbs not united posteriorly. Eyes absent. Testis and ovary in posterior third of mid-region of body. Cirrus large, complex. Vagina present, with heavily cuticularized lumen.

Type species.—Haliotrema australe Johnston and Tiegs, 1922.

This genus contains two species, *H. australe* Johnston and Tiegs from *Upeneus signatus* Gunther and *H. japonense* Yumaguti, from *Pseudupeneus chrysopleuron* (Tem. and Schl.), neither of which occurs in this country. So far as the writer has been able to ascertain this genus does not differ from *Ancyrocephalus* in any important character; the absence of eyes, if they are actually absent, seems to be the most important difference. Both Johnston and Tiegs (1922) and Yamaguti (1934) call attention to 2 pairs of gland cells in the vicinity of the oral cavity, but the arrangement of these cells suggests the possibility of unpigmented eyes having been mistaken for gland cells; however, until specimens of representatives of the genus are available for study this point cannot be settled and for the time being *Haliotrema* may be regarded as valid.

Genus DIPLECTANOTREMA Johnston and Tiegs, 1922

Diagnosis.—Body more or less uniform in width, 1 pair of head organs. Haptor cup-like, not distinctly set off from body proper, armed with 2 pairs of large hooks, the hooks of the 2 pairs markedly unequal and dissimilar, and with 14 marginal hooklets. Eyes present. Ovary and testis in anterior third of body; cirrus simple. Vitellaria consisting of very large discrete follicles arranged in linear series along sides of body, extending to near posterior end of body proper. Vagina apparently absent.

Type species.—Diplectanotrema balistes (MacCallum, 1915) new comb.

This genus was proposed as a subgenus of *Ancyrocephalus* by Johnston and Tiegs (1922) to contain *Diplectanum plurovitellum* MacCallum, 1916. This subgenus is regarded here as a distinct genus with *D. balistes* (MacCallum) as type, since, as will be shown later in this paper, MacCullum's *Diplectanum plurovitellum* and his *D. balistes* are identical, the latter having priority.

Diplectanotrema differs from *Ancyrocephalus* in having a single pair of head organs, in the marked dissimilarity of the large hooks of the haptor, and in the character of the vitellaria which are composed of large discrete follicles arranged in linear series along each side of the body instead of small irregularly arranged follicles as in *Ancyrocephalus*.

Diplectanotrema balistes (MacCallum, 1915), n. comb. Figs. 18–20

Synonyms.—*Diplectanum balistes* MacCallum, 1915; *Ancyrocephalus balistes* (MacCallum, 1915) Johnston and Tiegs, 1922; *Diplectanum plurovitellum* MacCallum, 1916; *Ancyrocephalus* (*Diplectanotrema*) *plurovitellum* (MacCallum, 1916) Johnston and Tiegs, 1922.

Description.—Body elongate, sides almost parallel, 850μ to 1.4 mm long by 150 to 220μ wide; cephalic glands present, prepharyngeal, opening to exterior through 1 pair of head organs. Haptor cup-like, 95μ wide, not distinctly set off from body proper, with 2 pairs of large hooks supported by a single heavily cuticularized bar, and with 14 marginal hooklets; large hooks of ventral pair relative large, 42μ long, with biramous roots; hooks of dorsal pair taenioid, 20μ long; supporting bar more or less rectangular, 10μ by 15μ; marginal hooklets about 10μ long. Oral aperture ventral, median, about 100μ from anterior end; pharynx globular, 57 to 75μ in diameter; esophagus very short; intestine not traceable in available specimens. Brain antero-dorsal to pharynx; eyes present, 2 pairs. Genital aperture median, about 200μ from anterior end of body. Cirrus slender, tubular, 40μ long; accessory piece apparently simple. Testis oval, 95μ long by 57μ wide, about one-third of body length from anterior end. Ovary somewhat U-shaped, about 95μ long by 68μ wide. Vitellaria lateral, consisting of large discrete follicles arranged in linear series, each series connected by means of a longitudinal vitelline duct. Vagina apparently absent. Ootype relatively large, its posterior end surrounded by unicellular glands; large gland cells also present in median field on each side of ootype. Egg oval, 75μ long by 45μ wide.

Hosts.—*Balistes capriscus* Gmelin, *Acanthurus* (*Teuthis*) *hepatus* (Linnaeus) and *Anisotremus virginicus* (Linnaeus).

Location.—Gills.

Distribution.—United States (New York Aquarium).

Specimens.—U. S. N. M. Helm. Coll. Nos. 35696 (cotypes), 35697 (cotypes of *Diplectanum plurovitellum*) and 35698.

Diplectanotrema balistes was originally described as *Diplectanum balistes* by MacCallum (1915) from specimens collected January 13, 1913, from the gills of a trigger fish, *Balistes carolinensis* (=*B. capriscus*), at the New York Aquarium. The next year MacCallum (1916) described under the name of *Diplectanum plurovitellum* a species from the gills of *Teuthis hepatus* and *Anisotremus virginicus;* specimens from the former host were collected November 27, 1915, and those from the latter on March 5, 1916, as a slide bearing that date was found in his collection. The specimens from the two last mentioned hosts appear to be the same as those collected from *Balistes carolinensis,* since a careful comparison of these specimens revealed no essential differences. The specimens were not in good condition as they had apparently been fixed under pressure of a cover slip and somewhat distorted; due apparently to improper fixation, the specimens stained unevenly, and it seems that the difference in staining was responsible for the failure of MacCallum to recognize that he was dealing with a single species instead of two species. Some structures described and figured by MacCallum could not be made out. The intestine which in his *D. balistes* is figured as consisting of 2 limbs, and which in his description of *D. pleurovitellum* is described as seeming "to join into a single tube posterior to the testis" could not be made out in any of the specimens; no vagina could be made out, although it is possible that a vagina may be present but so collapsed by pressure that it could not be located.

(to be continued)

MALACOLOGY.—*Two new land shells from Cuba.*[1] PAUL BARTSCH, U. S. National Museum.

Cuba is the malacologists' paradise, for nowhere else do we find such a differentiation and concentration of land shells as is found on the "Pearl of the Antilles." On this account the Island has attracted to it naturalists of fame from the early days of malacology. The scholarly Poey, as well as men like Pfeiffer, Otto, Gundlach, Sagra, Wright and Arango, have all left their impress upon this science. However, it seems as if the mantle of all these explorers and naturalists, who have furthered our science, had fallen upon Cuba's genial scientist and scholar, Dr. Carlos de la Torre, whose researches in the malacological field have fine-tooth-combed the Island and brought to our ken treasures far excelling the greatest expectation that the earlier explorers might have visioned.

Working over a huge collection of Cuban shells has brought to light two of the most exquisite forms known to science, and I take great pleasure in dedicating both of them to my friend, Don Carlos.

Chondropometes (Chondropometes) torrei, n. sp. **Fig. 2**

Shell rather large, turbinate, thin, semi-translucent, openly umbilicated. Nuclear whorls translucent, pale yellow, the succeeding turns orange buff with varicial streaks of deeper orange. Peristome flame colored. Nuclear whorls about 2, in perfect conformity in their coiling with the postnuclear turns. The first thin, translucent, appearing granulose under high magnification; the last marked by feeble, somewhat retractively slanting, closely spaced, incremental lines. The postnuclear whorls inflated, well rounded, marked by very regular, retractively slanting sublamellar axial riblets which are a little less wide than the spaces that separate them. These riblets extend over the periphery into the umbilicus of the last turn, remaining of about the same strength throughout. In addition to these, there are narrow orange streaks at more or less regular intervals, which are occasioned by the approximation of two or more riblets. These are a little lighter than the rest of the shell. The spiral sculpture consists of almost obsolete threads which are narrower than the spaces that separate them and which render the riblets slightly wavy and under high magnification feebly serrulate. They are best developed on the anterior half of the whorls. The spiral threads are obsolete

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 1, 1937.

on the base but become strengthened within the umbilicus on the parietal wall where they are heavier. Suture well impressed; periphery inflated, well rounded. Base inflated, well rounded. Aperture subcircular with a slight angulation at the posterior angle. The peristome is broadly expanded and reflected, about half as wide as that of *Chondropometes* (*Chondropometes*) *latilabre* d'Orbigny. It is appressed to the preceding turn at the posterior angle. Behind the peristome the last whorl is solute for about one-fifteenth of a turn. Operculum thin, multispiral, horny with a fine granulose, callus-like deposit, which is heaviest on the inner margin and thins out outwardly, vanishing a little beyond the middle of the turn. This deposit is laid down in a more or less corrugated pattern. The typical race of this species, for at least nine are known at this time which will be described later, was collected by Dr. de la Torre on Mogote Canalete, Abra de Bejarano, at the western end of the Sierra San Andrés, Pinar del Rio Province, Cuba. It is the most magnificent of all the members of the genus known today.

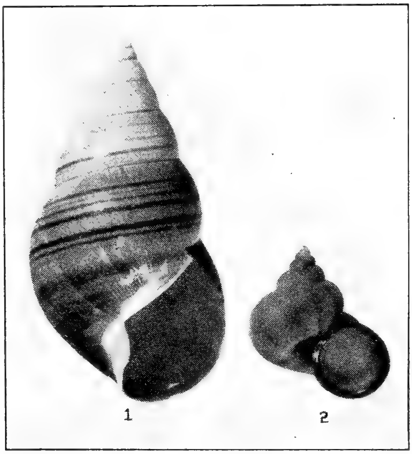

Fig. 1.—*Liguus crenatus caroli,* n. subsp. Fig. 2.—*Chondropometes* (*Chondropometes*) *torrei,* n. sp. Seven-eighths natural size.

The type, U.S.N.M. Cat. No. 428794, a perfect specimen, has 6.0 whorls and measures: Length 23.0 mm; greater diameter 22.3 mm; lesser diameter 15.9 mm.

This species stands midway in distribution between *Chondropometes* (*Chondropometes*) *vignalense* and *Chondropometes* (*Chondropometes*) *latilabre,* and its characters are midway between these two extremes. These are constant for all the races that we have seen, and we shall therefore assign subspecic rank to them in a subsequent paper.

Liguus crenatus caroli, n. subsp. Fig. 1

Shell large, turritid, covered with a thin periostracum. The early whorls ivory colored, which is soon succeeded by faint lemon yellow, which becomes intensified and eventually gives way to orange axial streaks and finally to an orange outer lip in young shells. The whorls in addition to this are marked by spiral bands and lines of olive green, which are a little paler on the base than on the spire, but on the last part of the base become much intensified and more or less confluent. The aperture is characteristically that of *Liguus*, the outer lip being thin, the pillar being slightly truncated anteriorly to form a somewhat tooth-like projection, the parietal callus extending down over the columella. The nucleus consists of about 3 whorls, which are in perfect alignment with the postnuclear spire. They are marked by fine, rather distantly spaced, spiral striations, which disappear on the early turn of the postnuclear spire.

This subspecies comes from Turiguano Island off the north coast of Camaguey Province. The type, U.S.N.M. Cat. No. 428810, has 8 whorls and measures: Length 56.9 mm; greater diameter 30.3 mm; lesser diameter 27.2 mm; length of aperture 26.0 mm; diameter of aperture 17.8 mm.

We collected this subspecies on the expedition which I made to Cuba under the Walter Rathbone Bacon Traveling Scholarship of the Smithsonian Institution in 1928. The specimens collected at that time were rather small, none having attained the full dimensions listed for the type. The red color in these young individuals was more brilliant than it is in the type, which was subsequently collected by Dr. de la Torre or some of his friends and donated by him to the National Museum.

U.S.N.M. Cat. No. 384712 contains 12 paratypes.

It is quite possible that this subspecies is responsible for the orange element that we find in the Floridian hybrid *Liguus* complex. This does not seem at all improbable because the Island of Turiguano is in the middle of the north coast of Cuba and hurricanes could easily carry young specimens across that distance, or they might in a hibernating state be tucked away in a knothole of some log and might then have drifted to Floridian shores.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

39TH ANNUAL MEETING

The 39th Annual Meeting of the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, January 21, 1937, with 32 members present. President **Meinzer** called the meeting to order at 9:30 P.M.

The minutes of the 38th Annual Meeting were read and approved. The Corresponding Secretary, **Nathan R. Smith**, submitted the following report on the membership and activities of the Academy:

Membership: During 1936, 13 were elected to resident and 7 to non-resident active membership. Of these, 12 qualified for resident and 3 for non-resident members, a total of 15 new members. Four were elected in recognition of their work in Chemistry; 4, in Forestry; 2, in Anthropology; 2, in Physics; and 1 each in Horticulture, Paleontology and Zoology. There were 7 resignations, 1.3% (2 resident and 5 non-resident), and 5 deaths. The net gain in membership was, therefore, 3.

The members of the Academy stood in respect as the Secretary read the names of those lost by death.

B. L. ROBINSON, Cambridge, Massachusetts, July, 1935.
A. N. CAUDELL, Washington, D. C., March 1, 1936.
W. H. WILMER, Washington, D. C., March 12, 1936.
A. F. FOERSTE, Washington, D. C., April 23, 1936.
J. A. NIEUWLAND, Notre Dame, Indiana, June 11, 1936.

On January 1, 1937, the membership consisted of 14 honorary members, 3 patrons and 524 active members, one of which was a life member. Of the active members, 387 were classed as resident and 137 as non-resident. Since the By-Laws limit the number of active members to 400 resident and 200 non-resident, there were, therefore, 13 vacancies in the resident and 67 non-resident vacancies.

The Board of Managers held four meetings with an average attendance of 17. The following amendment to the By-Laws was passed by the Board and ratified by the membership by an almost unanimous vote:

"Article 1, Section 2. Active members who have been in good standing for the previous ten years and who have been retired because of age or disability, shall be relieved of further payment of dues but shall have all the privileges of active membership."

Article 1, Section 1, to read, "The number of active members, *excepting those who have retired as provided for in Section 2*, shall not exceed six hundred, etc. . . ."

Since there are several active members who have been retired in the past few years, the amendment will create more vacancies than has usually been the case. This is especially true of resident members.

The Recording Secretary presented the following report:

The 39th year of the Academy began with the 269th meeting and ended with the 275th meeting. All seven meetings were held in the Assembly Hall of the Cosmos Club.

The 269th meeting was held jointly with the Chemical Society of Washington on January 30, 1936. About 175 persons were present. FREDERIC BARRY, Professor of the History of Science, Columbia University, delivered an address upon *The new Aristotle.*

The 270th meeting was held jointly with the Philosophical Society of Washington on February 20, 1936. Dr. W. J. HUMPHREYS discussed *Some episodes along the meteorological highway.*

The 271st meeting was held on March 19, 1936, with 212 persons present. The four reel Leeuwenhoek Tercentenary Film was presented by MORRIS C. LEIKIND of the Institute of the History of Medicine of The Johns Hopkins University, and the two reel film on The Mammalian Egg: Its Ovulation, Fertilization and Development, was presented by EVERETTE I. EVANS, Bureau of Dairy Industry, Department of Agriculture.

The 272nd meeting was held jointly with the Botanical Society of Washington on April 16, 1936, with about 200 persons present. Prof. E. D. MERRILL, Administrator of Botanical Collections of Harvard University, gave an illustrated address on *Plants and civilizations.*

The 273rd meeting was held jointly with the Geological Society of Washington on November 19, 1936, with about 95 persons present. Mr. GEORGE H. ASHLEY, State Geologist of Pennsylvania, gave an address on *The emergence of ideas as illustrated from geology.*

The 274th meeting was held on Thursday, December 17, 1936, with about 85 persons present. Dr. Henry B. Ward, Professor Emeritus of Zoology of the University of Illinois, gave an illustrated address on *Salmon psychology*.

The 275th meeting of the Academy was held January 21, 1937, with 75 persons present. Vice-President Silsbee introduced Retiring President O. E. Meinzer who addressed the Academy upon the subject, *Our water supply*.

The report of the Treasurer, H. G. Avers, was read by Howard S. Rappleye:

CASH RECEIPTS AND DISBURSEMENTS

Receipts				
From Back Dues		$ 135.00		
From Dues for 1936		2,385.00		
From Dues for 1937		35.00		
From Subscriptions for 1936		787.00		
From Subscriptions for 1937		264.70		
From Subscriptions for 1938		6.00		
From Sales of Journals		52.58		
From Payments for Reprints		293.82		
From Sales of 1935 Directory		5.40		
From Interest on Deposits		28.21		
From Interest on Investments		1,181.50		
From Sale of Bond of Va. Rys.		1,099.25		
Total receipts			$6,273.76	
Cash Balance January 1, 1936			2,368.77	
To be accounted for				$8,642.53
Disbursements				
For Secretary's Office, 1935		$ 7.00		
For Secretary's Office, 1936		272.80		
For Treasurer's Office, 1935		2.75		
For Treasurer's Office, 1936		187.80		
For Journal Office, 1935		35.73		
For Journal Office, 1936		43.34		
For Journal Printing, 1935		27.38		
For Journal Printing, 1936		2,281.62		
For Journal Reprints, 1935		95.57		
For Journal Reprints, 1936		437.17		
For Illustrations, 1936		267.36		
For Illustrations, 1937		20.98		
For Meetings Committee, 1935		20.00		
For Meetings Committee, 1936		303.87		
For Affiliated Societies Committee		2.60		
Bank Debit Memos, as follows:				
Dues	$0.35			
Subscriptions	.23			
Reprints	.35	.93		
Total Disbursements			$4,006.90	
Cash Balance December 31, 1936			4,635.63	
Total				$8,642.53

Note: Of the above expenditures, $188.43 was paid chargeable to 1935 and $20.98 was paid chargeable to 1937.

The Auditing Committee, Howard S. Rappleye and George Tunell, reported:

"The Treasurer's records of receipts and expenditures as shown in his account books and included in his report have been examined and found correct. All vouchers have been examined and found to be correct and properly approved. The balance sheets submitted by the bank and the securities listed in the Treasurer's report have been examined. The statement of the assets of the Academy was found correct. No coupons not yet due were missing from any of the securities bearing coupons. The records of the Treasurer's Office have been carefully and systematically kept, thus greatly facilitating the work of the auditing committee."

The Board of Editors, F. G. BRICKWEDDE, R.W. BROWN, and E.H. TOOLE, submitted the following report covering the publication of Volume 26 of the Journal for the year 1936:

"There were 76 original papers. Forty-four of them were by members of the Academy and 32 were communicated. Original papers were illustrated by 73 line cuts and 17 half-tones. Excess cuts illustrating several papers were paid for by the respective authors. Space in the volume was distributed among the different sciences, as follows:

	Pages
10 papers on Physics, including Astronomy, Geophysics and Crystallography	116.3
3 papers on Chemistry	17.5
2 papers on Medicine including Physiology	19.8
10 papers in Paleontology including Paleobotany	49.0
7 papers on Entomology	32.9
17 papers on Botany	84.0
26 papers on Zoology	152.7
1 paper on General Science	30.0

Proceedings of the Academy and affiliated societies occupied 34.5 pages, as follows:

The Academy	6.0
Botanical Society	1.4
Geological Society	12.0
Philosophical Society	15.1

Obituaries occupied 2.6 pages.

The Journal is relatively speaking up-to-date with manuscripts submitted to it."

The tellers, F. G. TRYON, K. S. MARKLEY and L. V. JUDSON, reported the election of the following officers: President, CHARLES THOM; Non-resident Vice Presidents, THOMAS BARBOUR, Cambridge, Massachusetts, and P. W. BRIDGMAN, Cambridge, Massachusetts; Corresponding Secretary, NATHAN R. SMITH; Recording Secretary, OSCAR S. ADAMS; Treasurer; H. G. AVERS; Board of Managers, F. G. BRICKWEDDE and J. F. COUCH.

The Corresponding Secretary read the list of nominations for vice-president submitted by the affiliated societies as follows:

Philosophical Society of Washington, FRANK WENNER
Anthropological Society of Washington, F. H. H. ROBERTS, JR.
Biological Society of Washington, H. C. FULLER
Washington Section, American Chemical Society, J. H. HIBBEN
Entomological Society of Washington, C. F. W. MUESEBECK
National Geographic Society, A. WETMORE
Geological Society of Washington, W. T. SCHALLER
Medical Society of the District of Columbia, H. C. MACATEE
Columbia Historical Society, ALLEN C. CLARK
Botanical Society of Washington, JOHN A. STEVENSON
Archaeological Society of Washington, ALES HRDLICKA

Washington Section, Society of American Foresters, S. B. DETWILER
Washington Society of Engineers, PAUL C. WHITNEY
Washington Section, American Institute of Electrical Engineers, H. L. CURTIS
Washington Section, American Society of Mechanical Engineers, H. L. WHITTEMORE
Helminthological Society of Washington, EMMETT W. PRICE
Washington Branch, Society of American Bacteriologists, H. W. SCHOENING
Washington Post, Society of American Military Engineers, C. H. BIRDSEYE
Washington Section, Institute of Radio Engineers, J. H. DELLINGER

By vote of the Academy, the Recording Secretary was instructed to cast one vote for the list as read and the vice-presidents were declared elected.

President MEINZER appointed Past Presidents McCOY and TUCKERMAN to escort President-elect THOM to the chair. President THOM took over the gavel and addressed the Academy briefly.

Adjournment followed at 10:15.

CHARLES THOM, *Recording Secretary*

CONTENTS

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VOL. 27 APRIL 15, 1937 No. 4

JOURNAL
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Journal of the Washington Academy of Sciences

This Journal, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The Journal is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

Manuscripts may be sent to any member of the Board of Editors. It is urgently requested that contributors consult the latest numbers of the Journal and conform their manuscripts to the usage found there as regards arrangement of title, subheads, synonymies, footnotes, tables, bibliography, legends for illustrations, and other matter. Manuscripts should be typewritten, double-spaced, on good paper. Footnotes should be numbered serially in pencil and submitted on a separate sheet. The editors do not assume responsibility for the ideas expressed by the author, nor can they undertake to correct other than obvious minor errors.

Illustrations in excess of one full-page halftone or two full-page line drawings may be paid for by the author. Line drawings are preferred.

Proof.—In order to facilitate prompt publication one proof will generally be sent to authors in or near Washington. It is urged that manuscript be submitted in final form; the editors will exercise due care in seeing that copy is followed.

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150	1.25	1.90	2.55	3.25	3.50
200	1.75	2.60	3.60	4.50	4.25
250	2.00	3.30	4.65	5.75	5.00

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Exchanges.—The Journal does not exchange with other publications.

Missing Numbers will be replaced without charge provided that claim is made to the Treasurer within thirty days after date of following issue.

Officers of the Academy

President: Charles Thom, Bureau of Plant Industry.
Corresponding Secretary: Nathan R. Smith, Bureau of Plant Industry.
Recording Secretary: Oscar S. Adams, Coast and Geodetic Survey.
Treasurer: Henry G. Avers, Coast and Geodetic Survey.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 27 APRIL 15, 1937 No. 4

GEOLOGY.—*Sun symbol markings.*[1] WALTER B. LANG, U. S. Geological Survey. (Communicated by Roland W. Brown.)

Situated high upon a mesa spur at the confluence of Fewkes and Cliff Canyons in Mesa Verde National Park, Colorado, is Sun Temple. This ceremonial house was left uncompleted by the Indians when, for an unknown reason, they abandoned Mesa Verde. In 1915, when this ruin was excavated from an accumulation of debris that had become overgrown with cedars, pinyons and brush there was discovered at the southwest corner a peculiarly marked stone (Fig. 1) which was described by Fewkes[2] as follows:

> This cornerstone (has) a central depressed zone with sharp radiating ridges. . . . A natural object with these characters would greatly affect a primitive mind, and no doubt was regarded with more or less reverence by the builders. . . . At all events, they have partially enclosed this emblem in walls in such a way as to enclose the figure on three sides. There can be no doubt that the walled enclosure was a shrine and the figure in it may be a key to the purpose of the building. The shape of the figure on the rock suggests a symbol of the sun, and if this suggestion is correct, there can hardly be a doubt that solar rites were performed about it long before Sun Temple was built.

Fewkes further notes that a person sitting in the shrine on September 21 observes the setting sun directly before him.

Various explanations have been given for this natural figure. It has been referred to as the impression of a palm leaf[3] and as a fossil Cretaceous spring.[4] Neither of these explanations seems to be an adequate interpretation of its origin. The writer's attention was focused upon these radial markings subsequent to a visit to Mesa Verde in 1931. Undoubtedly on many previous occasions he had casually seen similar marks on rock exposures for since then they have been observed on the weathered surfaces of many limestone and limy

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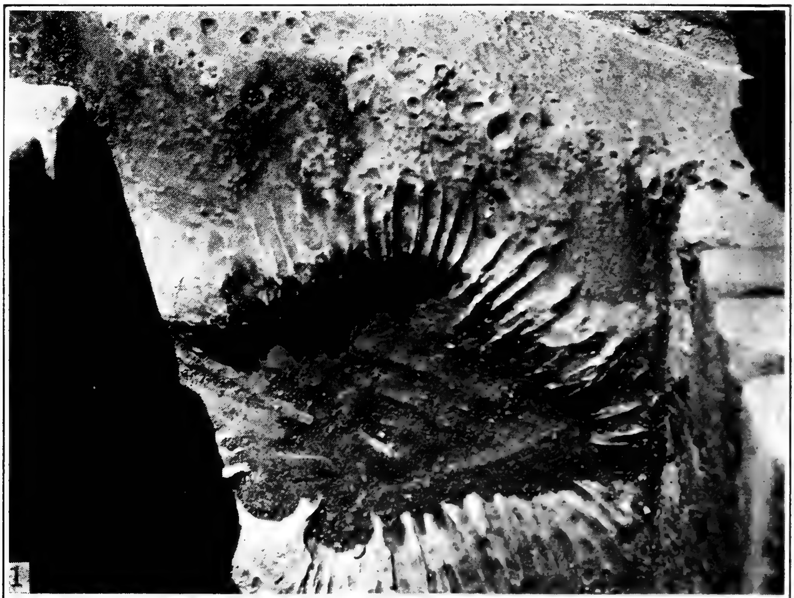
[1] Published by permission of the Director, U. S. Geological Survey. Received January 15, 1937.

[2] FEWKES, J. WALTER. *Excavation and repair of Sun Temple, Mesa Verde National Park.* Dept. of the Interior, Washington, pp. 20–21, 1916.

[3] Mesa Verde National Park guide book, Dept. of the Interior, Washington, p. 12, 1916.

[4] Mesa Verde National Park guide book, Dept. of the Interior, Washington, p. 35, 1927.



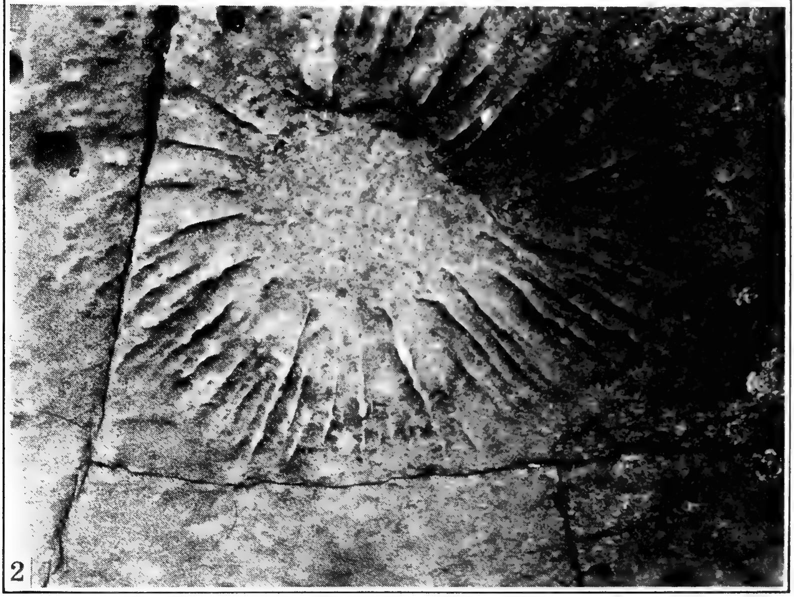


Fig. 1.—Sun Symbol, southwest corner of Sun Temple, Mesa Verde National Park, enshrined by protecting walls built by the Cliff Dwellers. Distance between buttresses approximately two feet. Fig. 2.—Sun Symbol mark taken from the rim rock of Mesa Verde National Park, near Balcony House. Diameter of bowl averages 7 inches, depth 2 inches. Radial ridges extend outward 8 inches. Lichen growth show whitish in the lower right hand corner. Jointing cracks of recent origin are younger than the Sun Symbol. Specimen now in the U. S. National Museum. Photograph by C. Marshall Finnan.

sandstone beds throughout the Southwest, more particularly on the San Andres limestone, the Carlsbad limestone in the Carlsbad Caverns National Park and sandstone beds of the Carlsbad limestone in upper Dark Canyon, New Mexico, the Comanche limestones of West Texas, and the Kaibab limestone at the Powell Memorial Monument, Grand Canyon. In consideration of the general distribution of these erosion figures as a common phenomenon on certain types of rocks and the preservation of one of them at Sun Temple it seems appropriate to designate them as Sun Symbol[5] markings.

Through the courtesy of the National Park Service a specimen of Sun Symbol marking was sent to the writer from Mesa Verde National Park in 1933 and Mr. C. Marshall Finnan, who made the selection from some twenty or more markings that are already known to exist there, thus describes their occurrence:

> As a general rule these "Sun Symbols" are found along the canyon rims at the southern end of the mesa among the pinyon and juniper forest. They are only found in one particular brown layer of the Mesa Verde sandstone. This layer, about 4 feet thick, lies just beneath the red top soil and is exposed along the rim of the canyons. It is at these exposed places only, that these peculiar erosive characters are evident.

The Sun Symbol markings at Mesa Verde (Fig. 2) usually range from 1 to 2 feet in diameter. They are composed of two parts—a central bowl or basin from 1 to 6 inches deep and a fringe of radial ridges and furrows surrounding the bowl. The figure is usually circular in form and the length of the furrows is about equal to the diameter of the central basin. At their outer ends these furrows blend into the irregularities of the rock surface but where they descend into the bowl they become more prominent by forming troughs which in some instances are as much as an inch in depth. Near the margin of the bowl the radial ridges and troughs plunge downward at an angle whose steepness usually depends upon the depth of the bowl. The Sun Symbol marking looks like a large sunflower impressed in rock.

A vertical section cut across the Mesa Verde specimen (Fig. 3) exposed a buff colored sandstone of even texture composed of angular quartz grains 0.15 mm in diameter, cemented by silica with considerable calcium carbonate and hydrous iron oxide. Though treatment of a sample of the rock with hot hydrochloric acid removed completely the iron oxide and calcium carbonate, an almost imperceptible amount of silica cement still held the grains in place. The rock is of

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[5] The insignia of the State of New Mexico, the Indian Zia sign or sun symbol, is very similar in form to these natural figures.

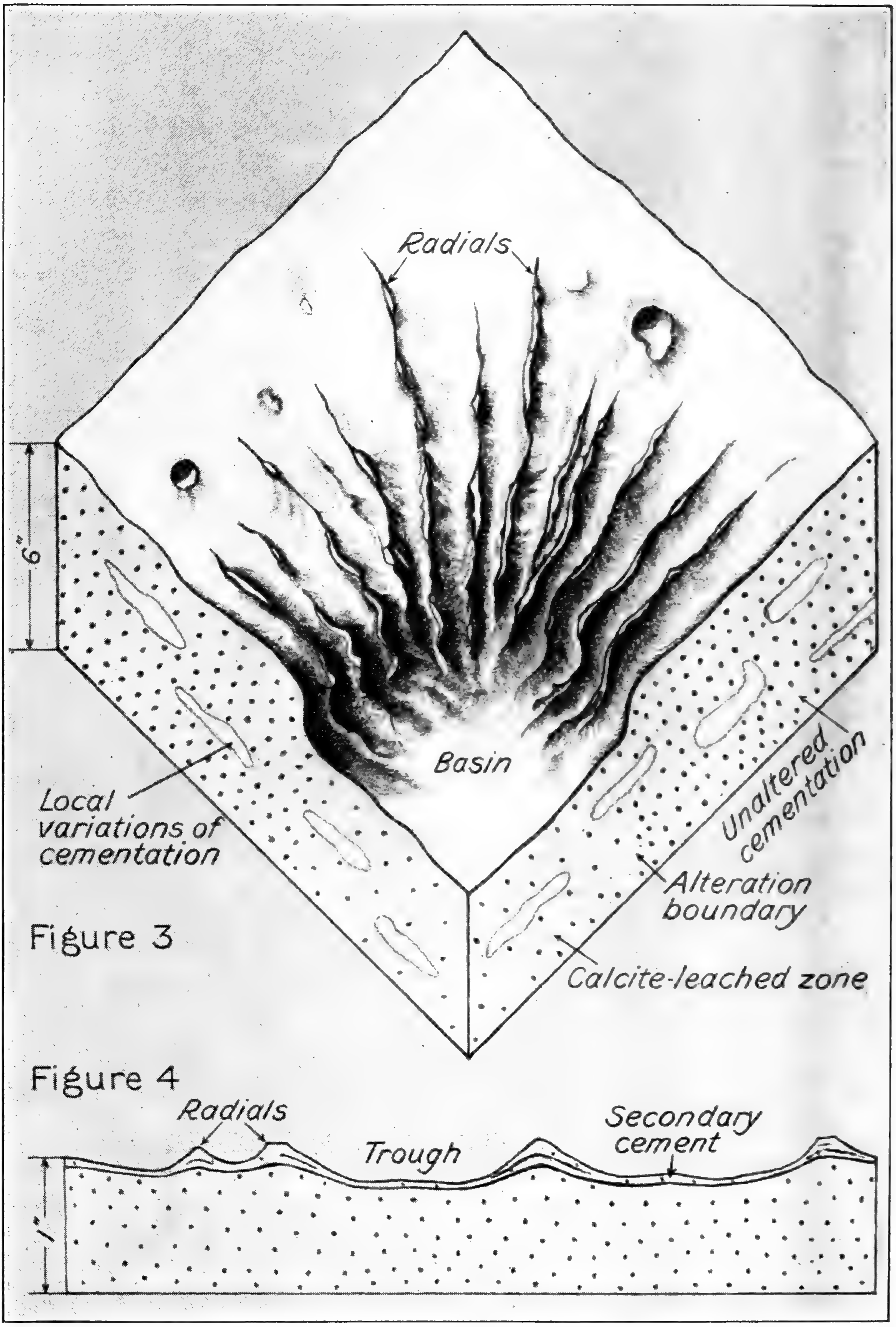

Fig. 3.—A sectional diagram of a Mesa Verde Sun Symbol. Fig. 4.—A section made across the area of the radial zone showing the thin band of secondary cement that is deposited at the surface by the evaporated rain water. Note that the band of cement is thickest beneath the radials.

very uniform texture, but horizontal stratification is suggested by the orientation of slight variations in the cementing materials. On the cut surface splotches one half to three quarters of an inch long are pale buff or whitish due to a greater concentration of calcite, whereas other patches are slightly darker brown from a concentration of iron oxide. Most of the coloration areas have gradational boundaries; a few are sharply defined. The major axes of these coloration areas lie parallel to the bedding plane.

On the weathered surface of the sandstone is a dark, thin, well-defined band 1 to 3 mm deep. This band or capping is thicker over the ridges than in the troughs or furrows. It contains a concentration of calcium carbonate and iron oxide, and effervesces actively when treated with hydrochloric acid. Beneath this thin layer lying within the bowl, the calcium carbonate cement is almost negligible whereas the iron oxide content appears relatively constant throughout the rock except for the small patches above mentioned. Much of the calcite cement has been leached from below the bowl, though the original amount of cementation here may have been less than in the surrounding portion of the rock.

When a rock of uniform texture is exposed to weathering, differences in degree and kind of cementation vary the rate of erosion and a smooth surface may soon become irregular and pitted. Rain water falling through the air and in its travels upon the surface of the ground soon acquires carbonic and organic acids and thus becomes a solvent of rock cements. In percolating downward into the sandstone the water dissolves the binding cement and frees the quartz grains, which, subsequently, are removed by wind, water, and other agencies of transportation. The more permeable areas of the rock are relatively more easily weathered and form initial hollows that catch surface water, thus forming pockets or basins (tinajita) that tend to deepen and expand with each ensuing shower. So long as the rocks remain moist and the climate relatively humid, downward percolation of rain water is the dominant process, but in the semi-arid Southwest another important agency comes into play. There the greatest amount of the annual precipitation falls during thunder showers in the summer months when the air is dry and warm. The porous surface rocks quickly become saturated during one of these downpours, but dry out rapidly after the storm has passed. Some of the absorbed moisture descends to the water table or an aquifer but most of it in the upper part of the rock is drawn to the surface by capillarity or by plants and evaporated. The water thus leaves the dissolved mineral matter at or near the surface. Where irregularities develop, protruding slightly above the general level, more rapid evaporation takes place and therefore more dissolved salts are deposited, thus serving to restrain erosion in those areas. The lower areas accumulate more water, suffer more solution, and acquire less salts. Therefore, a differential action is set up, bringing into greater relief the initial variations in surface expression.

As a depression forms, it becomes a center for accumulation of rain water. Rills[6] develop upon the rim, extending outward as they conduct more and more water to the central basin, and deepen to form radial troughs. If the depression deepens rapidly, the radial lines and troughs follow down into the basin as well as grow farther outward. The Sun Symbol mark is therefore a transient impression made upon the weathering surface of rock and persists only so long as the conditions favoring its development are operative. They must come and go as the rock surface is worn down. Thus the Sun Symbol mark is the product of erosion on sandstones so constituted as to initiate these surface effects.

So far only Sun Symbol marks in limy sandstones have been considered. Sun Symbol marks are probably far more numerous in limestones but apparently less conspicuous. They depend upon the same process for their formation. Hill and Vaughn noted the presence of rills (Karrenfelder) on the Edwards limestone.[7] Solution-faceted pebbles,[8] conspicuously developed in the Pecos Valley, are small examples of the process of solution. In western Texas the Permian limestones, but more especially the blocky exposures of Cretaceous limestone, present cupped weathered surfaces with hard upturned edges bounding the joint planes. As noted by Udden,[9] algae are present upon the rocks and in the bowls of these depressions but to what extent their products of metabolism contribute to the evolution of the pocked surfaces is not clearly understood. It is, however, evident that rills on rock surfaces do develop quite independently of organisms.

In his description of pebbles (later called solution-faceted pebbles by Bryan) he had seen in the river gravels of the Rio Grande near

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[6] Laudermilk, J. D., and Woodford, A. O. *Concerning Rillensteine.* Am. Jour. Sci. **23**: 135–154. 1932.

[7] Hill, R. T., and Vaughn, T. W. *Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas; with reference to the occurrence of groundwaters.* U. S. Geol. Survey 18th Annual Report, pt. 2, p. 229, 1896–97.

[8] Bryan, Kirk. *Solution-faceted limestone pebbles.* Am. Jour. Sci., 5th ser. 18, **105**: 193–208. 1929.

[9] Udden, J. A. *Etched potholes.* Texas Univ. Bull. **2509**: 5–9. 1925.

Eagle Pass, Texas, Udden referred thus to furrowings on their surfaces: "In very rare cases one may see etched grooves radiating from the elevated center of one of the flattened surfaces of these boulders."[10] This no doubt is but a reversal of the direction of flow of the dissolving water that produces the Sun Symbol mark. Again quoting Udden: "This radiated, furrowed sculpture is one of the most common sculpture forms seen on the bare limestone surfaces in situ in this part of America." This suggests that he had recognized radial patterns caused by an outward flow of water.[11]

So far no cuspated potholes or radial erosion marks have been reported from humid regions[12] where on similar rocks marginal erosion may exceed that taking place over the central portion and the surfaces tend to become convex. In arid or semi-arid climates the marginal areas may receive a protecting deposit of salts, concentrated there by the wick-like action of the rim during the process of solution by rain water and its subsequent evaporation, and so develop concave surfaces.

BOTANY.—*New species of* Paspalum *from Tropical America.*[1] Agnes Chase, Bureau of Plant Industry.

Three of the species here proposed belong to the Decumbentes, a group of *Paspalum* characterized by the development of the first glume in the lower of the pair of spikelets, sometimes in the upper also. The species, except *P. nutans* Lam. which is found also in Mauritius, are confined to the American tropics and warm temperate regions.

Paspalum Hintoni Chase, sp. nov.

Perenne; culmi ascendentes, 30–45 cm alti, compressi; vaginae carinatae; laminae planae, 3–6 cm longae, 2–5 mm latae, hirsutae; racemi solitarii, longe pedunculati, terminales et axillares, 4–7 cm longi; spiculae geminae, 2.2–2.3 mm longae, 1.2 mm latae, glabrae; gluma prima nulla aut minutissima, gluma secunda spiculam dimidiam subaequans; lemma sterile 3-nerve; fructus subtilissime papilloso-striatus.

Perennial, in small tufts; culms ascending, slender, compressed, 30–45 cm tall, the nodes appressed-pubescent; sheaths compressed-carinate, ciliate

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[10] Udden, J. A. *Flattening of limestone gravel boulders by solution.* Geol. Soc. America Bull. **25**: 66–68. 1914.

[11] Large steep-sided sandstone boulders in the Dog Canyon area of the Guadalupe Mountains show these centrifugal troughs. Also where the dolomitic anhydrites of the Rustler formation are exposed in the Pecos Valley a fine display of large well-developed vertical rills is to be seen.

[12] Hummel, K. *Lösungserscheinung auf Kalkstein an der dalmatinischen Küste.* Natur und Museum **62**: 381–382. 1932. A solution figure (sun symbol) developed in limestone on the Dalmatian coast under conditions simulating those of a semi-arid climate.

[1] Received January 28, 1937.

on the margin and hirsute at summit; ligule about 0.7 mm long; blades flat, spreading, 3 to 6 cm long, 2 to 5 mm wide (the uppermost reduced) papillose-hirsute on both surfaces; racemes solitary, terminal and axillary, on long slender peduncles, usually two from the uppermost sheath, 4 to 7 cm long, subarcuate, the rachis about 1 mm wide, pubescent at the very base, otherwise glabrous; spikelets in pairs, 2.2 to 2.3 mm long, about 1.2 mm wide, slightly purple tinged; first glume obsolete on both spikelets of the pair or developed as a very minute truncate scale on a few spikelets; second glume about half as long as the spikelet, 3-nerved; sterile lemma rather firm in texture, 3-nerved, its membranaceous palea well developed but empty; fruit about 2.1 mm long, pale, minutely papillose-striate.

Type in the U. S. National Herbarium no. 1611719, collected at 1,080 meters altitude at Vigas, Temascaltepec District, State of Mexico, Mexico, September 22, 1932, by George B. Hinton (no. 1807). This is part of a single specimen received for study from Kew Herbarium and returned to that institution.

The species is closely related to *Paspalum pilosum* Lam., and *P. Peckii* F. T. Hubb., differing from both chiefly in the smaller spikelets and short second glume. It differs also in that the first glume is alike in both spikelets of the pair, whereas in *P. pilosum* and *P. Peckii* the first glume is unequally developed in those of the pair.

Paspalum Altsoni Chase, sp. nov.

Perenne; culmi ramosi, decumbentes; laminae planae, 5–11 cm longae, 5–11 mm latae; pedunculi 2–4 e vagina suprema; racemi solitarii, 2–5 cm longi; spiculae geminae, 2.5–2.7 mm longae, circa 1.5 mm latae; gluma prima spiculae superioris parva, ea spiculae inferioris quam spicula 2–4-plo brevior; gluma secunda et lemma sterile 5-nervia, gluma quam lemma brevior; fructus subtilissime papilloso-striatus.

Perennial in small tufts; culms spreading or prostrate, freely branching, the branches somewhat divergent; sheaths loose, shorter than the internodes, or the lower overlapping, glabrous or the margin ciliate toward the summit; ligule about 2 mm long; blades flat, 5 to 11 cm long, 5 to 11 mm wide (the uppermost somewhat reduced), slightly narrowed to a rounded base, very sparsely pilose on the upper surface near the base or glabrous, the margin finely fluted below, the pale midnerve prominent beneath; peduncles 2 to 4 from the upper and middle sheaths, subfiliform, finally long-exserted, the later axillary ones concealed in the sheaths until the maturity of the primary racemes; racemes solitary, 2 to 5 cm long, straight or slightly arcuate, the rachis slender, slightly channeled; spikelets in pairs, the pairs somewhat distant, 2.5 to 2.7 mm long, about 1.5 mm wide, elliptic-obovate; first glume small and nerveless on the upper spikelet of the pair, 1-nerved, subacute and one-quarter to one-half as long as the spikelet on the lower spikelet, both glabrous or with a few weak hairs; second glume and sterile lemma 5-nerved, rather firm in texture, with a few scattered hairs or glabrous, the glume slightly shorter than the spikelet; fruit nearly the size of the spikelet, pale-stramineous, minutely papillose-striate.

Type in the U. S. National Herbarium no. 1539437, collected in moist sandy crevices on rocks in the open, at about 75 meters altitude, Macreba Falls, "Kurapung River," in the upper Mazaruni District, British Guiana, September 3, 1925, by R. A. Altson (no. 392).

In this species the habit and foliage resemble those of *Paspalum decumbens* Swartz and *P. nutans* Lam., but the spikelets are larger with the first glumes of the pair dissimilar as in *P. pilosum* Lam. and its close allies.

Paspalum petilum Chase, sp. nov.

Perenne; culmi graciles, ascendentes, 15–22 cm alti, foliosi; laminae planae, 3–10 cm longae, 3–4 mm latae, glabrae; pedunculi 2–3 ex vagina suprema; racemi solitarii, terminales et axillares, 1–2.5 cm longi, arcuati; spiculae geminae, 1.7–1.8 mm longae, circa 1.1 mm latae; gluma prima parva, obtusa, in margine pubescens; gluma secunda et lemma sterile pubescentia; fructus subtilissime papilloso-striatus.

Perennial in small tufts; culms slender, ascending or spreading, 15 to 22 cm tall, leafy throughout, the uppermost blade often equaling the inflorescence; nodes appressed-pubescent to glabrescent; sheaths mostly overlapping, densely pubescent along the margin and on the collar; ligule about 1 mm long; blades flat, 3 to 10 cm long, 3 to 4 mm wide, tapering to the often folded base, glabrous, the pale midnerve prominent beneath; peduncles 2 or 3 from the upper sheath, filiform; racemes solitary, 1 to 2.5 cm long, arcuate, the rachis slender, slightly channeled; spikelets in pairs, scarcely crowded, 1.7 to 1.8 mm long, about 1.1 mm wide, elliptic-obovate; first glumes similar on the spikelets of the pair, short, obtuse, nerveless, pubescent on the margin; second glume and sterile lemma 3-nerved or obscurely 5-nerved, sparsely pubescent, the glume two-thirds or three-fourths as long as the spikelet; fruit about 1.6 mm long, pale, very minutely-papillose-striate.

Type in the U. S. National Herbarium no. 1298462, collected on wet rocks, China Creek, Konawaruk River [County of Essequibo], British Guiana, September 1906, by A. W. Bartlett (Bot. Gard. Georgetown Herb. no. 8569).

In habit this species resembles *Paspalum dispar* Chase, of Hispaniola, but differs in having smaller pubescent spikelets and first glumes similar on the spikelets of the pair. In *P. dispar* the glume on the lower spikelet is about two-thirds as long as the spikelet.

Paspalum ionanthum Chase, sp. nov.

Perenne, caespitosum; culmi ascendentes, 15–40 cm alti, paucifolii; vaginae compressae; laminae planae aut subinvolutae, 0.5–8 cm longae; racemi 2, subconjugati, ascendentes, 3–5.5 cm longi; spiculae solitariae, 3.4–3.7 mm longae, circa 1.5 mm latae, ellipticae, glabrae, saepius purpurascentes; gluma et lemma sterile aequalia, 5-nervia, minute apiculata; fructus subtilissime papilloso-striatus.

Perennial in dense hard tufts with numerous short leafy sterile shoots at base; culms ascending, compressed, 15 to 40 cm tall, with a single node above the base; sheaths compressed, those of the sterile shoots short, overlapping, sparsely hirsute to glabrous, mostly stiffly ciliate, at least toward the summit, those of the culms longer, glabrous; ligule almost obsolete; blades firm, flat to subinvolute, those of the sterile shoots 5 to 8 cm long, 2 to 5 mm wide, those of the culms 0.5 to 4 cm long, all ciliate at the very base; racemes 2, subconjugate, ascending, 3 to 5.5 cm long, the rachis about 0.8 mm wide, with a few hairs at base, otherwise glabrous, one of the pair usually naked at the very base; spikelets solitary, 3.4 to 3.7 mm long, about

1.5 mm wide, elliptic, glabrous, mostly purple-tinged; glume and sterile lemma equal, rather firm in texture, 5-nerved, minutely apiculate at the subacute apex; fruit pale, about the size of the spikelet, minutely papillose-striate.

Type in the U. S. National Herbarium no. 1037280, collected in the region of Lake Ypacaray, in central Paraguay, in December 1913, by Dr. E. Hassler (no. 12383).

This species belongs in the Notata group and is most nearly related to *P. almum* Chase, of Texas, southern Brazil, and Paraguay. It differs from that in the numerous short sterile shoots, the shorter much firmer blades, in the shorter stiffer racemes, and in the larger spikelets. The type collection was named by Dr. Hassler as a variety of *Paspalum notatum* Flügge. The varietal name is unpublished and cannot be used as a specific name because it is preoccupied.

Paspalum almum was described[2] from Texas. At the time I hesitated to cite the South American specimens, but further study leaves no doubt that they belong to the same species as the Texas material. Three racemes are not infrequent in the South American specimens and in one specimen there are 5 and in another 6 racemes. A specimen of this species, No. 21 *Plantae Pilcomayenses,* collected in 1906 in the Gran Chaco by Theodore Rojas, custodian of the Hassler Herbarium, was described by Hackel as *Paspalum ovale* Nees var. *apiculatum* Hack.[3] An examination of Nees' type of *P. ovale,* in the Berlin Herbarium, shows that it is not the species to which Hackel applied the name. The name "apiculatum" could not be used because it is preoccupied by *P. apiculatum* Doell, 1877.

The following South American specimens are referred to *Paspalum almum:*

BRAZIL: Porto Esperança, on Rio Paraguay, Matto Grosso, *Chase* 11078, 11095, 11109.

PARAGUAY: Gran Chaco, *Rojas* 21. Puerto Santa Rita, *Rojas* 2675 (*Hort. Paraguayensis* 11071). Rio Verde, *Herter* 4831. San Bernardino, *Rojas* 1660. Lake Ypacaray, *Hassler* 12334.

URUGUAY: Santa Rosa Cuareim, *Herter* 336 i (*Herter Herb.* 82565).

ARGENTINA: Mercedes, Prov. Corrientes, *Parodi* 6370. Formosa, *Parodi* 2936 (collector unknown).

ZOOLOGY.—*North American monogenetic trematodes. I. The superfamily Gyrodactyloidea.*[1] EMMETT W. PRICE, U. S. Bureau of Animal Industry.

Genus DAITREOSOMA Johnston and Tiegs, 1922

Diagnosis.—Body with constriction about one-third of length from an-

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[2] This JOURNAL **23**: 137, fig. 1, 1933.

[3] Repert. Sp. Nov. Fedde **6**: 341. 1909.

[1] Continued from This JOURNAL, **27**: 114–130. 1937.

terior end; 3 pairs of head organs. Haptor not distinctly set off from body proper, with 2 pairs of large hooks—ventral pair larger than dorsal—articulating at their bases with a long, transverse, cuticular bar, and with 1 pair of marginal hooklets. Eyes present. Intestinal branches without diverticula, united posteriorly. Vitellaria not extending into posterior third of body. Vagina present.

Type species.—Daitreosoma constrictum Johnston and Tiegs, 1922.

Two species, *D. constrictum* from *Therapon carbo* Ogilby and McCulloch, and *D. bancrofti* from *T. hilli* Castelnau, have been described from Australia by Johnston and Tiegs (1922); neither of these species is known from North American hosts.

Genus Empleurosoma Johnston and Tiegs, 1922

Diagnosis.—Body with strongly developed lateral regions; 4 pairs of head organs. Haptor not distinctly set off from body proper, with 2 pairs of large hooks and 1 pair of marginal hooklets as in *Daitreosoma*. Vagina absent. Other characters as in *Daitreosoma*.

Type species.—Empleurosoma pyriforme Johnston and Tiegs, 1922.

This genus contains only the type species; it was described from the gills of an Australian fresh-water fish, *Therapon unicolor* Gunther.

Genus Anchylodiscus Johnston and Tiegs, 1922

Diagnosis.—Body without lateral constrictions and without strongly developed lateral regions. Haptor not distinctly set off from body proper, with 2 pairs of very large hooks supported by 2 cuticular bars, and with 14 marginal hooklets. Intestinal branches without diverticula and not uniting posteriorly. Eyes present. Vitellaria extending into posterior third of body. Vagina absent.

Type species.—Anchylodiscus tandani Johnston and Tiegs, 1922.

Two species have been described as belonging to this genus, namely, *A. tandani* Johnston and Tiegs from the gills of *Tandanus tandanus,* and *A. gadopsis* Hughes from the gills of *Gadopsis* sp.; both species are from Australian hosts.

Genus Murraytrema Price, 1937

Diagnosis.—Cephalic glands opening to exterior through 4 pairs of head organs. Haptor large, with 2 pairs of large hooks separated by 3 transversely placed non-articulate bars; 14 marginal hooklets. Intestinal branches not uniting posteriorly. Eyes present. Testis and ovary in equatorial zone. Cirrus with accessory piece. Vagina present, opening ventrally and medially.

Type species.—Murraytrema robusta (Murray, 1931) n. comb.

The type and only species of the genus was described as *Ancyrocephalus robusta* by Murray (1931) from specimens collected from the gills of *Sparus australis* Gunther in Australia. *Murraytrema* (Price, 1937) differs from *Ancyrocephalus* in having 3 haptoral bars instead of 2 as in the latter genus, and the vagina opens ventrally and medially in *Murraytrema* and laterally in *Ancyrocephalus*.

Genus CLEIDODISCUS Mueller, 1934

Diagnosis.—Cephalic glands opening to exterior through several (4 to 6) pairs of head organs. Haptor discoid, with 2 pairs of large hooks separated by 2 non-articulated bars, and with 14 marginal hooklets. Eyes present. Testis and ovary in equatorial zone. Cirrus simple, with movable accessory piece. Vitellaria extending into posterior third of body. Vagina present, opening on left body margin.

Type species.—Cleidodiscus robustus Mueller, 1934.

The genus *Cleidodiscus* contains the following species, all being from North American fresh-water fishes: *Cleidodiscus bedardi* Mizelle, 1926, from *Xenotis megalotis* (Rafinesque); *C. capax* Mizelle, 1926, from *Pomoxis sparoides* (Lacépède); *C. floridanus* Mueller, 1936, from *Ictalurus punctatus* (Rafinesque); *C. formosus* (Mueller, 1936), from *Pomoxis sparoides* (Lacépède); *C. incisor* Mizelle, 1936, from *Lepomis pallidus* (Mitchill); *C. longus* Mizelle 1936, from *Pomoxis sparoides* (Lacépède); *C. mirabilis* Mueller, 1937, from *Leptops olivaris* (Rafinesque); *C. pricei* Mueller, 1936, from *Ameiurus natalis* (Le Sueur) and *A. nebulosus* (Le Sueur); *C. nematocirrus* Mueller, 1937, from *Eupomotis gibbosus* (Linn.); *C. robustus* Mueller, 1934, from *E. gibbosus* (Linn.) and *Lepomis pallidus* (Mitchill); *C. stentor* Mueller, 1937, from *Amboplites rupestris* (Rafinesque); *C. uniformis* Mizelle, 1936, from *Pomoxis annularis* Rafinesque; and *C. vancleavei* Mizelle, 1936, from *P. annularis* Rafinesque.

Genus ACTINOCLEIDUS Mueller, 1937

Diagnosis. Haptor disc-like, flattened, with 2 pairs of large hooks, similar and about equal in length; haptoral bars with bases articulating; 14 marginal hooklets. Cirrus with movable accessory piece. Vagina present, opening on left body margin. Other characters as in *Cleidodiscus.*

Type species.—Actinocleidus oculatus (Mueller, 1934) Mueller, 1937.

Representatives of this genus are known only from North American freshwater fishes; the genus contains the following species: *Actinocleidus articularis* (Mizelle, 1936), from *Xenotis megalotis* (Rafinesque); *A. bursatus* (Mueller, 1936), from *Micropterus salmoides; A. fusiformis* (Mueller, 1934) (syn., *Ancyrocephalus cruciatus* of Cooper, 1915), from *Micropterus dolomieu* Lacépède; *A. gracilis* Mueller, 1937, from *Lepomis pallidus* (Mitchill); *A. maculatus* Mueller, 1937, from *Eupomotis gibbosus* (Linn.); and *A. oculatus* (Mueller, 1934), from *Eupomotis gibbosus* (Linn.).

Genus ARISTOCLEIDUS Mueller, 1936

Diagnosis.—Large hooks of haptor dissimilar, those of ventral pair with slender, angular blades and biramous roots, while those of dorsal pair have curved blades and only slightly biramous roots; haptoral bars non-articulating; 14 marginal hooklets present. Cirrus with immovable accessory piece. Vagina present, opening on right body margin. Other characters as in *Cleidodiscus.*

Type species.—Aristocleidus hastatus Mueller, 1936.

This genus contains only the type species which occurs on the gills of *Roccus lineatus* in Florida. Mueller (1936) in his description of this form was in error as regards the position of the large hooks and in the number of marginal hooklets. The large hooks which he termed the ventrals are actually the dorsals and *vice versa;* there are 14 marginal hooklets instead of 12 as originally given.

Genus TETRACLEIDUS Mueller, 1936

Diagnosis.—Haptor small, poorly set off from body. Large hooks about equal in size; bars non-articulating. Marginal hooklets probably 14 in number. Vagina present, opening on right body margin. Other characters similar to those of *Cleidodiscus.*

Type species.—*Tetracleidus banghami* Mueller, 1936.

This genus contains only the type species which occurs on the gills of *Micropterus dolomieu* Lacépède. It is questionable whether the genus *Tetracleidus* should be regarded as distinct from *Cleidodiscus,* since apparently the only important difference between the two genera is the position of the vaginal aperture.

Genus LEPTOCLEIDUS Mueller, 1936

Diagnosis.—Haptor small, poorly set off from body. Large hooks approximately equal; bars rudimentary, non-articulating; marginal hooklets probably 14 in number. Cirrus long, slender, lying in a large coil and passing to exterior through a grooved cuticularized vestibule or accessory piece. Vagina (?). Other characters as in *Cleidodiscus.*

Type species.—*Leptocleidus megalonchus* Mueller, 1936.

The type and only species of this genus occurs on the gills and in the throat of *Micropterus dolomieu* Lacépède. This species appears to be the form described by Cooper (1915) as *Ancyrocephalus paradoxus.*

Genus UROCLEIDUS Mueller, 1934

Diagnosis.—Haptor wedge shaped; large hooks of about equal size; bars non-articulating; marginal hooklets relatively small, 14 in number. Vagina absent. Other characters as in *Cleidodiscus.*

Type species.—*Urocleidus aculeatus* (Van Cleave and Mueller, 1932) Mueller, 1934.

The genus *Urocleidus* contains two valid North American species, *U. aculeatus* (Van Cleave and Mueller), from *Stizostedion vitreus* (Mitchill) and *U. adspectus* Mueller, 1936, from *Perca flavescens* (Mitchill).

Urocleidus angularis Mueller, 1934, from *Fundulus diaphanus menona* (Jordan and Copeland) was recently removed by Mueller (1936) from this genus to *Ancyrocephalus,* the latter being used in a general sense. The writer has studied the original specimens of *U. angularis* and is in agreement with Mueller that this species does not belong in *Urocleidus s. str.;* however, he sees no reason why it should be transferred to *Ancyrocephalus,* since it is more closely related to *Urocleidus* than to *Ancyrocephalus.*

Genus ONCHOCLEIDUS Mueller, 1936

Diagnosis.—Haptor wedge-shaped, with 2 pairs of large hooks and 2 non-articulating bars; 14 marginal hooklets present, these hooklets relatively large, 6 pairs being arranged around anterior edge of haptor and having their tips directed forward. Cirrus corkscrew-shaped, or simple with spiral fin, usually with immovable accessory piece. Vagina, when present, opening on right body margin. Other characters as in *Cleidodiscus.*

Type species.—Onchocleidus ferox (Mueller, 1934) Mueller, 1936.

This genus contains at present 11 species, all being from North America; these are: *Onchocleidus contortus* Mueller, 1937, from *Micropterus salmoides; O. distinctus* Mizelle, 1936, from *Xenotis megalotis* (Rafinesque); *O. ferox* (Mueller, 1934), from *Eupomotis gibbosus* (Linn.); *O. helicis* Mueller, 1936, from *Micropterus salmoides; O. interruptus* Mizelle, 1936, from *Morone interrupta* Gill; *O. mimus* Mueller, 1936, from *Lepibema chrysops* (Rafinesque) and (?) *Esox reticulatus* Le Sueur; *O. mucronatus* Mizelle, 1936, from *Helioperca incisor* (Cuv. and Valenc.), *Allotis humilis* (Giard), and *Eupomotis gibbosus* (Linn.); *O. perdix* Mueller, 1937, from *Lepomis pallidus* (Mitchill); *O. principalis* Mizelle, 1936, from *Micropterus pseudaplites* Hubbs; *O. similis* Mueller, 1936, from *Eupomotis gibbosus* (Linn.); and *O. spiralis* Mueller, 1937, from *Eupomotis gibbosus* (Linn.).

Genus PTEROCLEIDUS Mueller, 1937

Diagnosis.—Each large haptoral hook with wing-like blade arising near angle and passing parallel to point for about two-thirds its length. Vagina present, opening on right body margin. Other characters as in *Onchocleidus.*

Type species.—Pterocleidus acer (Mueller, 1936) Mueller, 1937.

In addition to the type species, which occurs on the gills of *Eupomotis gibbosus* (Linn.), this genus contains *P. acuminatus* (Mizelle, 1936) from *Xenotis megalotis* (Rafinesque); and *P. biramosus* Mueller, 1937, from *Lepomis pallidus* (Mitchill).

Genus HAPLOCLEIDUS Mueller, 1937

Diagnosis.—Large haptoral hooks similar but unequal, those of ventral pair about one-half as large as those of dorsal pair. Vagina present (?always), opening on left body margin. Other characters similar to those of *Onchocleidus.*

Type species.—Haplocleidus dispar (Mueller, 1936) Mueller, 1937.

This genus contains six species, namely, *Haplocleidus affinis* Mueller, 1937, and *H. dispar* (Mueller, 1936), from *Eupomotis gibbosus* (Linn.); *H. furcatus* Mueller, 1937, from *Micropterus salmoides; H. monticellii* (Cognetti de Martiis, 1925), from *Haustor catus* (Linn.); and *H. siluri* (Zandt, 1924), and *H. vistulensis* (Siwak, 1932), from *Silurus glanis* Linn.

The species described by Siwak (1932) as *Ancyrocephalus vistulensis* does not differ from *H. siluri* (Zandt), except in the number of marginal hooklets and in the character of the vagina. According to Zandt (1924) there are 16 marginal hooklets in *H. siluri*, whereas Siwak states that there are only 12 in *H. vistulensis;* apparently both figures are incorrect, the probable number in both cases being 14. Siwak states that the vagina is non-cuticularized in *H. siluri* and cuticularized in *H. vistulensis.* In spite of the differences mentioned above, the two species are identical in other respects, and both are from the same host and from the same region (Poland).

The species which Cognetti de Martiis (1925) described as *Ancyrocephalus monticellii* was collected in Italy from an American catfish. In this species the hooks of the dorsal pair were stated to be the largest; however, it seems probable from the description and figure of the bars and hooks that he was mistaken in the position of these structures, and it is on this assumption that the species is included in the genus *Haplocleidus.*

Genus AMPHIBDELLA Chatin, 1874

Diagnosis.—Body greatly elongated, fusiform; 3 pairs of head organs. Haptor lobed, distinctly set off from body proper, with 2 pairs of large similar hooks and 14 marginal hooklets; large hooks not supported by cuticular bars. Intestinal branches not united posteriorly. Eyes absent. Testis and ovary in anterior part of body, the latter elongated and curved, lying partly in extraintestinal field. Vitellaria confined to region posterior to ootype. Vagina present.

Type species.—*Amphibdella torpedinis* Chatin, 1874.

The genus *Amphibdella* contains only two species, *A. torpedinis* Chatin, 1874, and *A. flavolineata* MacCallum, 1916, the latter being a North American form.

Amphibdella flavolineata MacCallum, 1916 Figs. 1–4

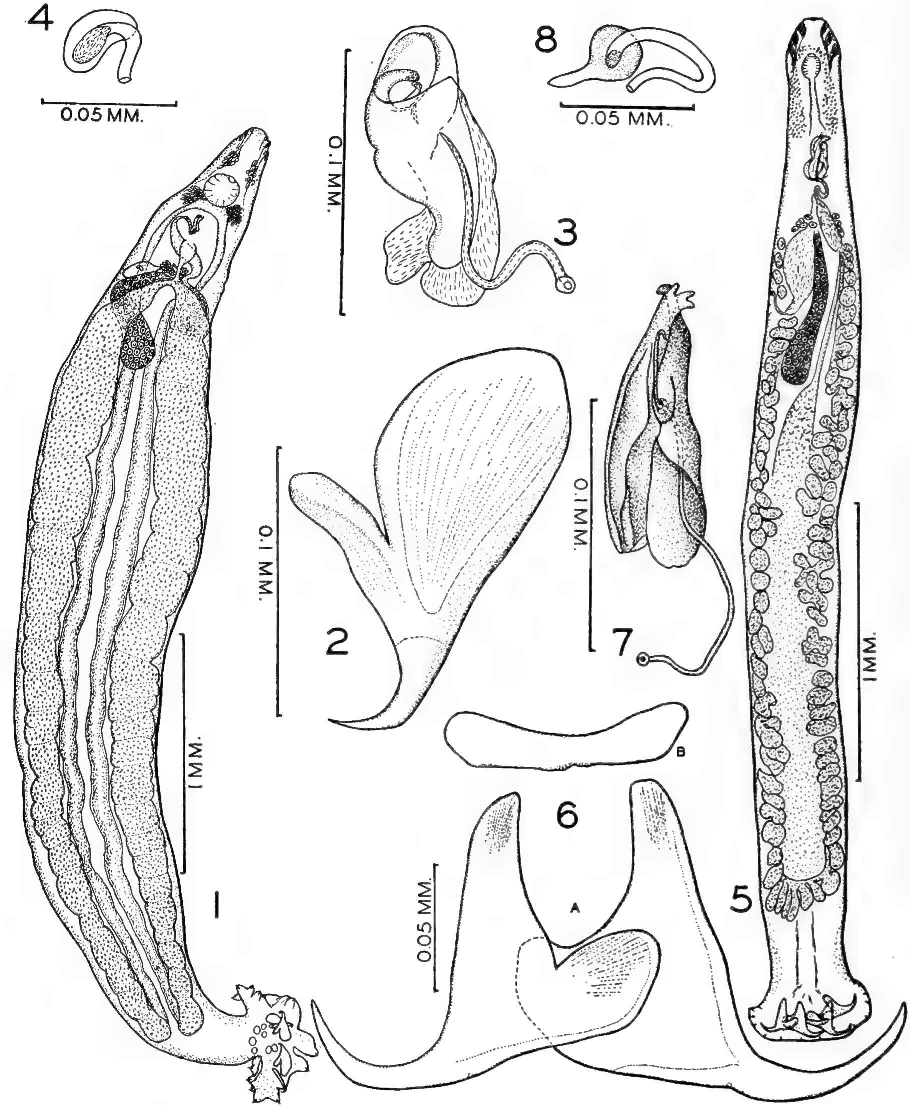
Description.—Body elongate, more or less fusiform, 3.8 to 4.3 mm long by 510 to 680μ wide. Cephalic glands lateral, prepharyngeal, opening through 3 pairs of head organs situated near anterior end. Haptor lobed, about 425 to 475μ wide, armed with 2 pairs of large similar hooks and 14 marginal hooklets; large hooks 150 to 160μ long, blade without shoulder-like process near base, otherwise similar to those of *A. torpedinis;* marginal hooklets about 10μ long, one on each lobe of haptor. Oral aperture ventral, median, about 190 to 230μ from anterior end of body; pharynx globular, 133 to 152μ in diameter; esophagus very short, with a group of unicellular glands on each side; intestinal branches simple, extending to distal limits of vitellaria, not united posteriorly. Nervous and excretory systems not observed; eyes absent. Genital aperture median, near intestinal bifurcation. Cirrus slender, tubular, about 100μ long, with very complicated accessory piece; seminal vesicle conspicuous, S-shaped. Testis single, sinistral, largely obscured by vitellaria. Ovary elongated, curved, opposite testis, lying partly in extraintestinal field. Vitellaria extracecal, consisting of large follicles arranged in linear series and extending from level of base of ootype to near posterior end of body proper. Vagina present, heavily cuticularized, near right margin of body immediately anterior to ovary, connected with a relatively large seminal receptacle. Ootype relatively slender, its base surrounded by unicellular glands. No eggs observed.

Host.—*Tetranarce occidentalis* (Storer) and "sting ray."

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. Nos. 35159 (cotypes), 35204 and 35699.



Figs. 1–4.—*Amphibdella flavolineata.* 1, Complete worm, ventral view; 2, large haptoral hook; 3, cirrus and accessory piece; 4, vagina. Original. Figs. 5–8.—*Amphibdelloides maccallumi.* 5, Complete worm, ventral view; 6, haptoral hooks and bar (A—large hooks, B—bar); 7, cirrus and accessory piece; 8, vagina. Original.

Specimens of this species were collected by Dr. G. A. MacCallum at Woods Hole, Mass., July 6, 1914, and on August 21, 1922, from a torpedo, *Tetranarce occidentalis* and later, July 20, 1923, a single specimen was collected by him from a "sting ray." This species is quite similar to *Amphibdella torpedinis* Chatin from which it differs principally in the morphology of the large hooks. In *A. torpedinis* the blade of the large hook is slender and widens more or less abruptly shortly before joining with the root or biramous portion, thus giving rise to a shoulder-like offset, while in *A. flavolineata* the blade of the hook is not so slender and tapers uniformly from the tip to the point of union with the root. This difference is, admittedly, slight, but constant so far as the writer has been able to ascertain. This shoulder-like offset is clearly shown in the figures of *A. torpedinis* as given by Chatin (1874) and by Ruszkowski (1931). In addition to the hooks, there appears to be considerable difference in the male copulatory organ.

Genus AMPHIBDELLOIDES Price, 1937

Synonym.—*Amphibdella* Chatin, 1874, in part.

Diagnosis.—Haptor not lobed; large hooks supported by a single cuticular bar. Other characters as in *Amphibdella.*

Type species.—*Amphibdelloides maccallumi* (Johnston and Tiegs, 1922).

Amphibdelloides maccallumi (Johnston and Tiegs, 1922), n. comb. Figs. 5–8

Synonyms.—*Amphibdella torpedinis* Perugia and Parona, 1889, not Chatin, 1874; *A. torpedinis* MacCallum, 1916, not Chatin, 1874; *A. maccallumi* Johnston and Tiegs, 1922.

Description.—Body slender, 1.1 to 3.5 mm long by 255 to 476μ wide. Cephalic glands abundant, forming a band across body anterior to pharynx and extending backward on each side to near level of genital aperture, opening to exterior through 3 pairs of head organs situated near anterior end of body. Haptor not lobed, 210 to 425μ wide, armed with 2 pairs of large hooks and 14 marginal hooklets, the large hooks supported by a single cuticular bar; large hooks 133 to 170μ long, shape similar to those of *Amphibdella flavolineata;* marginal hooklets about 10μ long; cuticular supporting bar slightly curved, 64 to 95μ by 19μ, concavity directed anteriorly. Oral aperture ventral, median, about 133 to 170μ from anterior end of body; pharynx globular, 76 to 95μ in diameter; esophagus relatively long. Nervous and excretory systems not observed; eyes absent. Genital aperture median, near intestinal bifurcation. Cirrus slender, tubular, about 175μ long; accessory pieces 2 in number, one with single curved tip and other tridigitate, about 130 to 160μ long. Testis elongate, median. Ovary elongate, slightly curved, median, pretesticular. Vitellaria lateral, consisting of large follicles uniting and forming a band across body at level of tips of intestinal ceca. Vagina slender, heavily cuticularized, opening near right margin of body at level of middle of ovary, and communicating with a large seminal receptacle lying along right margin of anterior part of ovary. Ootype and metraterm not discernable in available specimens. No eggs observed.

Hosts.—*Tetranarce occidentalis* (Storer) and *Squalus acanthias* Linnaeus.

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. Nos. 35700 (cotypes), 25701 and 35652.

This appears to be the species described as *Amphibdella torpedinis* by Perugia and Parona (1889) and later redescribed by Parona and Perugia (1890) from specimens obtained from *Torpedo marmorata* in the Mediterranean region. Perugia and Parona show that the large haptoral hooks are supported by a single transverse bar, but in the redescription they report the species as having 2 bars; this latter report appears in the light of the present study to be an error.

The specimens upon which the above description is based were collected by Dr. G. A. MacCallum at Woods Hole, Mass., and described by him in 1916 as *Amphibdella torpedinis* Chatin.

This species resembles *Amphibdella torpedinis* and *A. flavolineata* in a general way but differs from them in having an unlobed haptor and large hooks supported by a transverse cuticular bar.

Genus TETRANCISTRUM Goto and Kikuchi, 1917

Diagnosis.—Anterior end with 2 to 3 pairs of head organs. Haptor small, not distinctly set off from body proper, with 2 pairs of similar, and almost equal, large hooks supported by 2 cuticular bars, and sometimes, if not always, with (?) 14 marginal hooklets. Intestine united posteriorly. Eyes absent. Vagina present.

Type species.—*Tetrancistrum sigani* Goto and Kikuchi, 1917.

Tetrancistrum longiphallus (MacCallum, 1915), n. comb. Figs. 9–11

Synonyms.—*Diplectanum longiphallus* MacCallum, 1915; *Ancyrocephalus longiphallus* (MacCallum, 1915) Johnston and Tiegs, 1922.

Description.—Body more or less fusiform, 1.4 mm long by 255μ wide; cephalic glands opening through 2 pairs of head organs. Haptor 133μ wide, not distinctly set off from body proper, provided with 2 pairs of large hooks supported by 2 transverse bars, and with a number, possibly 14, marginal hooklets. Large hooks about equal in size, 57μ long, differing only slightly in morphology; ventral bar 53μ long, narrow, bifid at ends; dorsal bar 38μ by 15μ; marginal hooklets very delicate, about 10μ long. Oral aperture ventral, about 95μ from anterior end of body; pharynx 75μ long by 53μ wide; intestine not observed. Eyes absent. Cirrus simple, tubular, about 140μ long; seminal vesicle curved, to left of ootype. Testis elongate oval, somewhat lobed, about 300μ long by 95μ wide, postequatorial. Ovary oval, about 150μ long by 60μ wide, immediately pretesticular. Vitellaria extending from level of pharynx to about 250μ from posterior end of body, meeting in median field posterior to testis. Vagina present, opening near right margin of body near level of base of cirrus. Ootype elongated, its base surrounded by long-necked unicellular glands. Egg oval, about 75μ long by 50μ wide, with relatively long filament at one pole.

Host.—*Chaetodipterus faber* (Broussonet).

Location.—Gills.

Distribution.—United States (New York Aquarium).

Specimens.—U. S. N. M. Helm. Coll. No. 35702 (cotypes).

This species was described under the name *Diplectanum longiphallus* by MacCallum (1915) from specimens collected from the gills of a spade fish, January 23, 1915, at the New York Aquarium. The material consists of a few badly preserved and distorted specimens, only one specimen being in a suitable condition for description. A comparison of the available specimens with the description as given by MacCallum shows that the original description is inadequate in many respects. The measurements are not in agreement with those obtained by the present writer, the mouth is ventral instead of terminal, and no eyes are present; the cirrus is much shorter than MacCallum's measurements indicate, being about 140μ long instead of 250μ and the egg is about 75μ long instead of 20μ as stated by MacCallum.

A comparison of this species with descriptions of *Tetrancistrum sigani* Goto and Kikuchi (1917) from *Siganus fuscescens* Houttuyn from Japan, and of *T. lutiani* Tubangui (1931) from *Lutianus lioglossus* (Bleeker) from the Philippines, indicates that *Diplectanum longiphallus* MacCallum belongs in the genus *Tetrancistrum* rather than in *Diplectanum,* or in *Ancyrocephalus* where it was placed by Johnston and Tiegs (1922). The small size of the haptor, the similarity of the anterior and posterior hooks, the stalked Mehlis' glands, and the absence of eyes are characters which suggest affinities with *Tetrancistrum* rather than with *Ancyrocephalus;* the absence of squamodiscs alone excludes this species from *Diplectanum.*

Tetrancistrum longiphallus may be easily distinguished from the other two species of *Tetrancistrum* on the morphology of the large haptoral hooks and of the ventral bar. The hooks of *T. longiphallus* have blades more widely curved and longer than those of the other species, and the ventral bar is bifid at the extremities instead of rounded as in *T. sigani.*

Goto and Kikuchi (1917), as well as Tubangui (1931), state that the marginal hooklets of the haptor are absent in the genus *Tetrancistrum.* In *T. longiphallus* marginal hooks were found to be present although the exact number was not ascertainable; these hooklets are very small and transparent, and could be definitely detected only after careful study under an oil immersion objective. The fact that these hooklets are difficult to detect suggests that they were overlooked by the above mentioned authors.

GENUS INQUIRENDUM

DACTYLODISCUS Olsson, 1893

Diagnosis.—Cephalic glands and head organs (?); haptor pedunculated, lobed, with 2 pairs of hooks, the dorsal hooks being the largest, and having a peculiarly-shaped middle piece; marginal hooklets (?). Eyes present. Testis and ovary entire, equatorial. Cirrus simple. Vagina (?).

Type species.—Dactylodiscus borealis Olsson, 1893.

This inadequately characterized genus was proposed by Olsson (1893) for *D. borealis,* a species, found on the gills of *Thymallus vulgaris* and *Coregonus lavaretus.* Johnston and Tiegs regard *Dactylodiscus* as a subgenus of *Ancyrocephalus,* but owing to the inadequacy of the description of the type and only species, the writer prefers to retain it as a *genus inquirendum* until a more complete description is available.

Subfamily DIPLECTANINAE Monticelli, 1903

Synonym.—Lepidotreminae Johnston and Tiegs, 1922.

Diagnosis.—Body, especially posterior half, covered with anteriorly directed scale-like spines; cephalic glands present, opening to exterior through head organs. Posterior haptor with accessory structures (dorsal and ventral) or "squamodiscs," consisting of sessile or subsessile discs covered with concentric rows of scale-like spines, or of lamellae, with or without accessory hooks; haptor with 2 pairs of large hooks and basal supporting bars, and usually, if not always, with 14 marginal hooklets. Intestinal branches ending blindly, without diverticula. Eyes present, 2 pairs. Cirrus simple or complex. Testis and ovary without lobes. Vagina present.

Type genus.—*Diplectanum* Diesing, 1858.

KEY TO GENERA OF DIPLECTANINAE

1. Squamodiscs consisting of concentric rows of paired lamellae.......... ....*Lamellodiscus* Johnston and Tiegs
   Squamodiscs consisting of concentric rows of scale-like spines or spine-like hooks..2
2. Squamodiscs with backwardly projecting groups of spine-like hooks.... ....*Lepidotrema* Johnston and Tiegs
   Squamodiscs without spine-like hooks............*Diplectanum* Diesing

Genus DIPLECTANUM Diesing, 1858

Synonyms.—*Acleotrema* Johnston and Tiegs, 1922; *Lepidotes* Johnston and Tiegs, 1922; *Squamodiscus* Yamaguti, 1934.

Diagnosis.—Squamodiscs consisting of concentric rows of scale-like spines, without groups of accessory spine-like hooks. Large hooks of haptor supported by 3 transverse cuticular bars. Vagina present or (?) absent.

Type species.—*Diplectanum aequans* (Wagener, 1857) Diesing, 1858.

The genus *Diplectanum* has been considered as identical with *Ancyrocephalus* by most recent writers, including Johnston and Tiegs (1922), Fuhrmann (1928), Van Cleave and Mueller (1932) and Sprehn (1933). A review of the status of *Diplectanum*, however, indicates that it must be retained as a genus distinct from *Ancyrocephalus*.

Diplectanum was proposed as a genus (not as a subgenus as Maclaren (1903) stated) by Diesing (1858) to include *Dactylogyrus aequans* Wagener, 1857, and *D. pedatum* Wagener, 1857. The genus was defined by Diesing as follows: "*Plectana* duo sessilia vel pedicellata.—*Piscium* marinorum ectoparasitica.—Characteres reliqui ignoti."

The two species *D. aequans* and *D. pedatum*, which Diesing included in this genus, were named but not described by Wagener (1857a) who later in the same year (1857b) gave a brief characterization of these species; this description was barely generic but apparently enough to validate the species. Diesing did not designate a type for his genus *Diplectanum* and inasmuch as he listed *D. aequans* first, Stiles and Hassall (1908) have indicated that species as "probably type," therefore, for all intents and purposes *D. aequans* (Wagener) may be regarded as type by subsequent designation.

Apparently the reason that *Diplectanum* has not been more generally recognized as a valid genus was owing to the very meagre characterization of the species included in that genus, but if one regards Wagener's (1857b) description as sufficient to validate the species, as the present writer does, the genus must also be regarded as valid. Wagener's description is as follows:

"Dactylog. aequans (Branch. Labrax lupus) und pedatus (Julis spec. inc.) haben statt einer Schwanzscheibe deren zwei; die Innenfläche dieser Organe ist mit in konzentrische Kreise gelegten Stäbchen bekleidet."

"Die beiden Schwanzscheiben sind durch einen 3gliedrigen Apparat getrennt, dessen äussere Enden die scheerenartig gegeneinander beweglichen 2 grossen Hakenpaare tragen."

"Die grossen Haken haben stets häutige Scheiden, deren Oeffnung meist von einer festen Einfassung umgeben ist."

Van Beneden and Hesse (1863), Stossich (1896) and Maclaren (1903) have given descriptions of a species from *Labrax lupus*, which they regard as *D. aequans*. These descriptions are of a worm the characters of which conform to those given above for *Diplectanum*, and in view of the fact that the worm described by these different authors was from *Labrax lupus*, the same host as that reported for *D. aequans* by Wagener, and from the same general geographic region, the writer believes that the species they had before them was *D. aequans* (Wagener).

In view of the above, it appears that Johnston and Tiegs, as well as the other writers who have apparently followed their action, erred in considering *Diplectanum* as a synonym of *Ancyrocephalus*, since the type species *A. paradoxus*, of the latter genus lacks the two accessory structures (squamodiscs) which are characteristic of *D. aequans* and, accordingly, of the genus *Diplectanum*.

The genus *Diplectanum* contains the following species: *D. aculeatum* Parona and Perugia, 1889; *D. aequans* (Wagener, 1857); *D. americanum* n. sp.; *D. collinsi* (Mueller, 1936); *D. echeneis* (Wagener, 1857); *D. fluviatilis* (Johnston and Tiegs, 1922); *D. girellae* (Johnston and Tiegs, 1922); *D. longipenis* (Yamaguti, 1934); *D. pedatum* (Wagener, 1857); and *D. sciaenae* Beneden and Hesse, 1863. Of these species, *D. pedatum* from *Julis* sp.; *D. sciaenae* from *Sciaena aquilla; D. aculeatum* from *Corvina nigra;* and *D. echeneis* from *Chrysops aurata, Sargus rondeletii* and *Pagrus vulgaris* are inadequately described, although they probably are distinct species. Only two species, *D. collinsi* (Mueller) from *Roccus lineatus*, and *D. americanum* n. sp., are known to occur in North America.

Diplectanum americanum, n. sp. Figs. 12–15

Description.—Body elliptical, 765μ to 1.1 mm long by 210 to 390μ at level of ovary; posterior part of body armed with anteriorly directed scale-like spines extending forward almost to level of testis; anterior end of body rounded; cephalic glands present, opening to exterior through 4 pairs of head organs. Posterior haptor 170 to 190μ wide, with dorsal and ventral squamodiscs, and armed with 2 pairs of large hooks supported by 3 transverse cuticular bars, and with 14 marginal hooklets. Squamodiscs subsessile, about 120μ in diameter, each consisting of 20 concentric rows of scales; hooks of ventral pair 76μ long, those of dorsal pair 50μ long; lateral supporting bars 76μ long, middle bar 114μ long, marginal hooklets about 10μ long. Oral aperture ventral, about 117μ from anterior end of body; pharynx about 38μ in diameter; intestinal branches not observed. Brain immediately anterior to pharynx; eyes present, 2 pairs, those of anterior pair smaller than those of posterior pair. Genital aperture not observed; male copulatory organ conspicuous, consisting of a simple cuticular tube (cirrus) 38μ long and a reniform, apparently heavily cuticularized structure (?) ejaculatory bulb) 87μ long by 38μ wide, divided by septa into 4 compartments. Testis globular, about 45μ in diameter, slightly postequatorial. Ovary piriform, 38μ wide, partly overlapping testis. Vitellaria extending from level of posterior margin of pharynx to within short distance of anterior margins of squamodiscs. Vagina present; Mehlis' gland conspicuous, surrounding ootype. No eggs observed.

Host.—*Promicrops itaiara* (Lichtenstein).

Location.—Gills.

Distribution.—United States (New York Aquarium).

Specimens.—U. S. N. M. Helm. Coll. No. 35703 (type and paratypes).

The above description is based on 5 stained and mounted specimens, collected by Dr. G. A. MacCallum, September 3, 1914, from *Promicrops guttatus* (=*P. itaiara*) at the New York Aquarium. Owing to the rather poor condition of the specimens, some of the details could not be made out. This species is easily distinguished from all other species of the genus by the peculiar structure of the male copulatory organ.

Genus Lepidotrema Johnston and Tiegs, 1922

Synonyms.—*Flabellodiscus* Johnston and Tiegs, 1922; *Empleurodiscus* Johnston and Tiegs, 1922.

Diagnosis.—Dorsal and ventral squamodiscs composed of concentric rows of scale-like papillae, each with a number of backwardly projecting spine-like hooks arranged in a fan-like manner; large hooks of haptor supported by 4 cuticular bars articulating with a more or less complex central piece. Vagina present or absent.

Type species.—*Lepidotrema therapon* Johnston and Tiegs, 1922.

This genus and the subgenus *Flabellodiscus* (also used in the sense of a genus by Johnston and Tiegs), as well as *Empleurodiscus*, were proposed by Johnston and Tiegs (1922) for small monogenetic trematodes occurring on the gills of Australian fresh water fishes of the genus *Therapon*. These genera were regarded as distinct on the basis of characters such as the width of the haptor in comparison with body width, on the number of accessory spine-like hooks of the squamodiscs, and on the complexity of the male copulatory organs. In the writer's opinion these characters are of specific rather than generic value, and *Flabellodiscus* and *Empleurodiscus* are dropped as synonyms of *Lepidotrema*.

The genus as here constituted contains the species *Lepidotrema therapon*

Johnston and Tiegs, from *Therapon carbo* Ogliby and McCulloch; *L. tenue* Johnston and Tiegs, 1922, from *T. hilli* Castelnau; *L. fuliginosum* Johnston and Tiegs, 1922, from *T. fuliginosus* Macleay; *L. simplex* (Johnston and Tiegs, 1922), from *T. fuliginosus* Macleay; *L. angustus* (Johnston and Tiegs, 1922), from *T. unicolor* Gunther; and *L. bidyana* Murray, 1931, from *Therapon bidyana* (Mitchell).

Genus Lamellodiscus Johnston and Tiegs, 1922

Diagnosis.—Dorsal and ventral squamodiscs consisting of numerous concentric rows of paired lamellae; large hooks of haptor supported by 3 cuticular bars. Vagina present.

Type species.—Lamellodiscus typicus Johnston and Tiegs, 1922.

In addition to *Lamellodiscus typicus*, which occurs on the gills of *Sparus australis* Gunther, Murray (1931) has described two species, *L. pagrosomi*, from *Pagrosomus auratus*, and *L. major* from *Sparus australis*. All three of the species are known only from Australia.

Subfamily BOTHITREMATINAE Price, 1936

Diagnosis.—Cephalic glands scattered throughout the preoral part of body and not arranged in lateral groups as in other members of family, opening to exterior through 4 pairs of cup-like head organs. Haptor disc-like, with 1 pair of large hooks separated by 2 cuticular bars, and with 14 marginal hooklets; in addition to hooks and other cuticular structures, a row of radially arranged tube-like cuticular structures are present near the margin of the haptor. Intestine single, sac-like. Eyes present. Testis single, postovarial. Vagina (?).

Type genus.—Bothitrema Price, 1936.

Genus Bothitrema Price, 1936

Synonym.—Acanthocotyle Monticelli, 1888, in part.

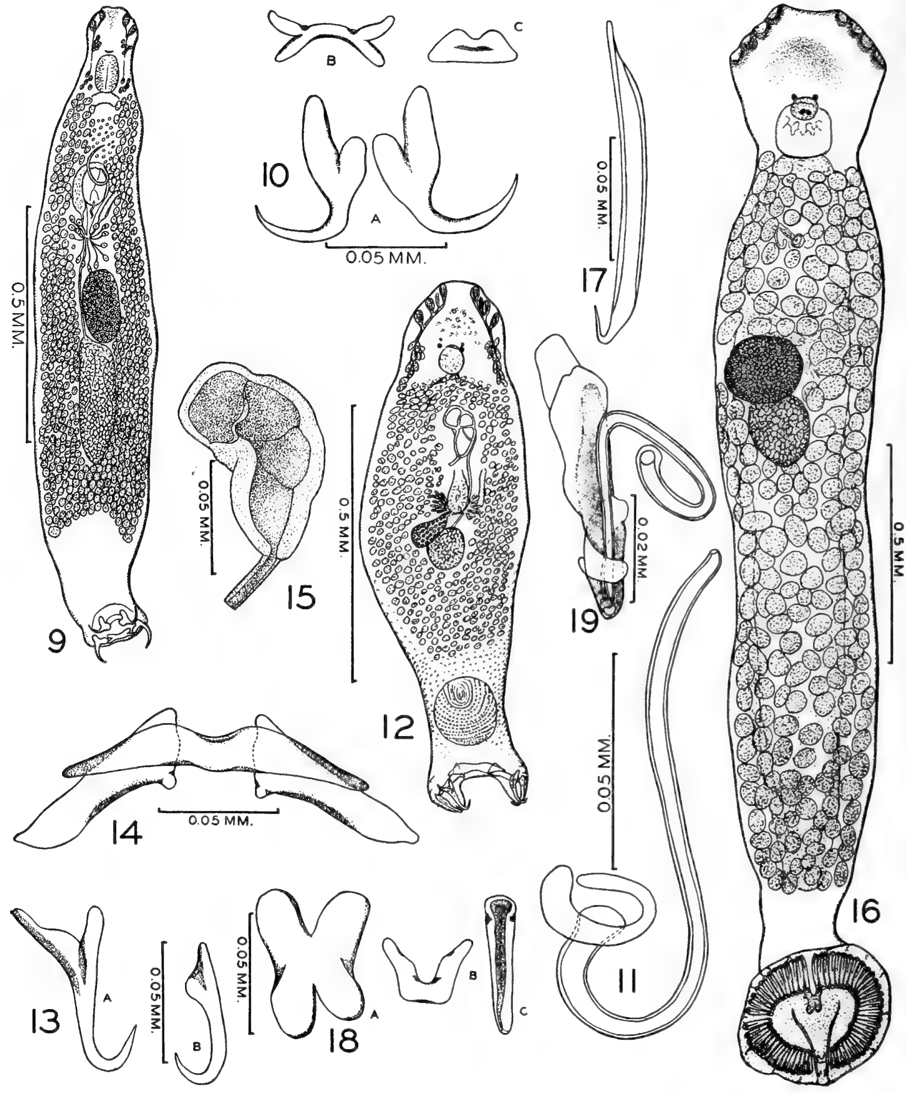
Diagnosis.—With characters of subfamily.

Type species.—Bothitrema bothi (MacCallum, 1913) Price (1936).

Bothitrema bothi (MacCallum, 1913) Price, 1936 Figs. 16–19

Synonym.—Acanthocotyle bothi MacCallum, 1913.

Description.—Body elongate, 1.4 to 2.5 mm long by 255 to 390μ wide, with distinct constriction in region of pharynx; anterior end angular, with 4 pairs of head organs apparently representing concentrations of ducts of numerous cephalic glands distributed throughout preoral portion of body. Haptor disc-like, 285 to 340μ in diameter, its ventral surface concave and bearing 1 pair of large hooks, 14 marginal hooklets, 2 cuticular bars—1 ventral and the other dorsal—and 52 to 60 radially arranged cuticular tube-like structures. Large hooks 120 to 133μ long, their distal ends sharply pointed and recurved, and separated near their tips by a U-shaped cuticular bar 20 to 25μ long by 22 to 30μ wide; ventral cuticular bar somewhat H-shaped, 57μ long by 40μ wide, located between bases of large hooks; radial cuticular structures 65 to 90μ long; marginal hooklets 15μ long. Oral aperture ventral, 114 to 200μ from anterior end of body; pharynx rectangular, 100 to 114μ long by 95 to 136μ wide, its anterior end with papilla-like projections; intestine single, median, sac-like, extending posteriorly as far as limits of vitellaria. Brain antero-dorsal of oral aperture; eyes present, 2 pairs, one pair close together and immediately dorsal of oral aperture and the other pair farther apart and at level of anterior margin of oral opening,



Figs. 9–11.—*Tetrancistrum longiphallus*. 9, Complete worm, dorsal view; 10, haptoral hooks and bars (A—large hooks, B—ventral bar, C—dorsal bar); 11, cirrus. Original. Figs. 12–15.—*Diplectanum americanum*. 12, Complete worm, ventral view; 13, large haptoral hooks (A—hook of ventral pair, B—hook of dorsal pair); 14, haptoral bars; 15, copulatory organ. Figs. 16–19.—*Bothitrema bothi*. 16, Complete worm, ventral view; 17, large haptoral hook; 18, supporting structures of haptor (A—ventral bar, B—dorsal bar, C—one of tube-like accessory structures); 19, cirrus and accessory piece. Original.

or slightly more anterior to that point. Genital aperture ventral, median, about midway between ovary and pharynx; cirrus simple, tubular, about 75μ long, with complicated accessory piece about 55μ long. Testis single, globular, 130 to 170μ in diameter, median, immediately postovarial. Ovary globular, 150 to 170μ in diameter, about one-third of body length from anterior end and to right of median line; Mehlis' gland voluminous, immediately preovarial. Vitelline follicles numerous, large, about 40 to 50μ in diameter, extending from level of base of pharynx to near posterior end of body. Vagina not observed. Egg triangular, 50μ wide, and with polar filament, according to MacCallum.

Host.—*Lophopsetta maculata* (Mitchill).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. No. 35186 (cotypes), 35704, 35705 and 35706.

This species was originally described by MacCallum (1913) as *Acanthocotyle bothi* from specimens collected in 1912 from *Bothus maculatus* (=*Lophopsetta maculata*). The description contained a number of errors of interpretation of the various structures, which he later (1916) attempted to correct. Unfortunately, however, he carried over into the redescription many of the errors originally made. The most outstanding of the misinterpretations not corrected in the latter description were in regard to the number of testes, the character of the intestine, and the nature of the radial structures on the posterior haptor. According to MacCallum (1913) "there are about thirty-seven testes,'' but actually there is only a single testis located immediately posterior to the ovary and this is the structure labeled "seminal reservoir" in his figure; the structures which MacCallum regarded as testes were the large vitelline follicles lying over the intestinal cecum and which, owing apparently to some error of technique, took the stain somewhat differently from the other follicles. The intestine consists of a single sac-like structure and not 2 ceca as indicated by MacCallum. The radial structures on the posterior haptor are not "really hooklets" as MacCallum stated, but are rather heavily cuticularized tube-like pieces imbedded in the haptor.

This species is apparently an aberrant member of the Dactylogyridae standing in a position intermediate between that family and the Monocotylidae. Its lack of laterally arranged cephalic glands suggests affinities with the Monocotylidae, but the presence of cuticular supporting bars between the large hooks excludes it from that family.

MacCallum's inclusion of this form in the genus *Acanthocotyle* was apparently due to a misconception, since he regarded the tube-like structures on the posterior haptor as structures comparable to the radially arranged spines on the pseudohaptor[2] of *Acanthocotyle*.

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[2] The large terminal disc of *Acanthocotyle* is probably not homologous with the haptor of the tristomes, monocotylids and gyrodactylids, but is an added structure, the true haptor being the minute hook bearing disc located at the margin of the large disc or pseudohaptor.

Family CALCEOSTOMATIDAE (Parona and Perugia, 1890) emend. Price, 1937

Synonym.—Calceostomidae Parona and Perugia, 1890.

Diagnosis.—Cephalic gland ducts not concentrated into head organs but remaining scattered over a considerable area on either side of anterior end of body, the anterior end being expanded and forming head lappets. Haptor sucker-like but not strongly muscular, with or without large hooks, with or (?) without marginal hooklets. Intestine with short diverticula. Eyes present or (?) absent. Testis single. Cirrus simple, cuticularized. Vagina present or absent.

Type genus.—*Calceostoma* Beneden, 1852.

KEY TO GENERA OF CALCEOSTOMATIDAE

Vagina absent	*Calceostoma* Beneden
Vagina present	*Fridericianella* Brandes

Genus Calceostoma Beneden, 1852

Diagnosis.—Anterior end of body expanded and forming large curled head lappets. Haptor cup-shaped, armed or (?) unarmed. Intestinal limbs with numerous short diverticula. Eyes present. Testis elongated. Ovary branched. Vagina absent.

Type species.—*Calceostoma calceostoma* (Wagener, 1857) Johnston and Tiegs, 1922.

This genus contains 3 species, *C. calceostoma* (Wagener, 1857) (syn., *C. elegans* Beneden, 1858), *C. inerme* Parona and Perugia, 1889; and *C. glandulosum* Johnston and Tiegs, 1922. No representative of the genus has been reported from North America.

Genus Fridericianella Brandes, 1894

Diagnosis.—Head lappets not as prominent as in *Calceostoma.* Haptor cup-like, with 1 pair of small centrally placed hooks; marginal hooklets (?) absent. Eyes absent. Intestinal branches with lateral diverticula, united by commisure posterior to testis. Testis single, rounded. Ovary tubular, median. Vagina present, opening laterally near equator of body.

Type species—Fridericianella ovicola Brandes, 1894.

This genus contains only the type species which was described by Brandes (1894) from specimens collected from the eggs of *Arius commersonii* Lac., a fresh- and brackish-water fish from South Brazil.

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ENTOMOLOGY.—*Some neotropical and oriental syrphid flies in the United States National Museum.*[1] Frank M. Hull, University of Mississippi. (Communicated by C. F. W. Muesebeck.)

Several years ago the late Dr. J. M. Aldrich, to whom the writer owed much encouragement in his early studies of diptera, submitted an accumulation of exotic syrphid flies to the writer for study and identification. This material is almost entirely Neotropical in origin, although a certain amount of it comes from the Orient. It was later supplemented by material from the same regions, kindly made available for study by Dr. E. A. Chapin, to whom the writer is greatly indebted for extending the fullest facilities of the Museum. Finally, I wish to thank Mr. C. T. Greene for his helpful suggestions. The present paper presents the undescribed species of syrphids, the types of which are in the U. S. National Museum.

Volucella nitidigaster n. sp.

Male.—Eyes densely long black pilose, touching for a distance of length of antennae, with a bare horizontal band about the middle of each eye. The vertex, the greatly swollen front, face and cheeks brilliantly vitreus black, a small whitish pubescent area beneath the antennae, narrowly prolonged to each eye and on the eye margin intensified and slightly enlarged. There is a narrow brown stripe dividing cheeks and face, beginning at eye but not reaching the oral margin. Antennae, dark brown; arista pale, darker at apex, twenty to twenty-one rayed above. Tubercle of the short obconical face large, evenly rounded.

Thorax, scutellum, pleurae and abdomen strongly shining black with a bluish opalescent tinge. The thorax with a narrow anterior band of fairly long upright brassy pile, the remainder of the dorsum with short brassy pile obscured by dense long erect black pile. The lateral and calli bristles appear to be exceptionally long, stiff, shining black. Pile of mesopleurae long and brassy. Scutellum rather higher than usual, the margin without a definite depression but barely flattened at the apex on a small area, where it is also punctate or roughened. Scutellum conspicuous for the thick mass of long black pile on its dorsum basally, in the middle. Squamae black, with brassy fringe. Halteres ivory white. Abdomen with faint suggestion of a brownish area on either side on second and third segments.

Legs vitreus shining black, the mid and hind tarsi except terminal two joints dark brown.

Wings tinged on anterior joints with yellow. Stigma dark brown. Stigma cell light brown.

Length 6 mm.

One male. Villa Nogues, Pov. Tug. (R. A.) (1–1921)

Type in the U. S. National Museum, No. 51352.

Volucella punctigena n. sp.

Female.—Front and vertex, except for a shining black trifurcate spot above antennae and face, except for an obscure spot on either side just below

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[1] Received January 16, 1937.

antennae, shining mahogany red and polished. The angle across from eyes at antennae, and the cheeks pale brownish yellow. The yellow of the cheeks is bordered behind and in front with a shining black stripe. Facial knob prominent and face descending to a distance below eyes equal to length of antennae from base to tip of arista. Antennae and arista light brownish yellow, the apical third of the latter blackish, with twenty-two to twenty-five rays dorsally. Eyes short pale pilose. Pile of head and face pale.

Thorax shining dark reddish brown, the whole middle anterior three-fourths shining jet black, its posterior margin produced as four vittae, their ends rounded, the outer pair the farthest, none reaching the scutellum. Pleurae blackish, the margins of some segments brownish. Scutellum light reddish brown shining, subtranslucent. Squamae and fringe pale brown. Halteres snow white. Scutellum with a deep depression, its base smooth, a few long black bristles on the margin.

Abdomen flattened, almost round, dark blackish in color, the disk of second, third and fourth segments purplish reddish, and the base of the second segment with two small pale yellow translucent triangles, their median and basal edges straight and forming a right angle. The pile of the abdomen short, very thick, whitish, quite erect.

Legs largely shining black, narrow apices of femora, basal half or third of tibiae and tarsi light brownish. Pile of legs black.

Wings strongly tinged with brown, especially on the veins and cross veins.

Length 9 mm.

One female. Siquinola, Guatemala.

Type in the U. S. National Museum, No. 51348.

Volucella albipilosa n. sp.

Male.—Eyes densely long white pilose, touching for the length of the antennae. Vertex, the swollen front, face, lower occiput and cheeks, except for a narrow shiny brown stripe from eye to oral margin, pale yellowish brown. Ocelli on a slightly raised blackish area. Pile of vertex and front thick, black, longer than that of the eyes. Face and cheeks with a few scattered black hairs on the upper middle of the former and upper posterior corners of the latter; elsewhere pale, appressed, brassy. Occiput from middle downward, long, white pilose, the whole densely punctate white pubescent. Antennae reddish brown, the third joint rounded, slightly concave above. Arista brown with twenty-five rays above. Face descending vertically below antennae to a faint tubercle, thence receding very slightly to the cone shaped tip of the epistoma.

Thorax largely and scutellum wholly shining light yellow brown, the anterior half of thorax with a large shining black spot, indented posterior-medially, and with a posteriorly directed continuation at each posterior corner. On the black area may be seen two short broad whitish pollinose vittae situated anteriorly. Pleurae shining black below, light brown above, its pile long and crinkly, pale, with a few tufts of black hairs. Pile of thorax long, anteriorly and narrowly at base of scutellum pale in color, elsewhere black. Lateral margins of thorax including humeri and post calli with several long black bristles, but none before the scutellum or on its margin. Scutellum without depression. Squamae and its fringe and stem of halteres dark brown; knob of the latter white.

Abdomen, its margin inrolled, almost entirely light reddish brown, the narrow posterior edge of the third segment, and apico median triangle, a very small basi median triangle on the second segment and the suggestion of a narrow connecting vita black or blackish. First segment blackish. Venter the same light brownish color. The whole abdomen subtranslucent. The pile consists of conspicuous long white appressed tufts in each anterior angle of the third and fourth segments, and the very long erect surface pile of the fourth segment. Abdomen everywhere covered with short appressed black bristles.

Legs dark brown to blackish, black pilose or bristly, except that the tibiae posteroventrally and the tarsi ventrally are appressed golden pilose. Extreme apices of femora paler in color.

Wings hyaline, except for stigma, with four quite small dark brown spots on the cross veins in the middle of the wing.

Length 15 mm.

One male. San Martin, Mexico, May 27, 1922 (E. G. Smyth).

Type in the U. S. National Museum, No. 51357.

Volucella lunulifera n. sp.

Male.—Eyes densely long blackish pilose, widely touching. The small vertex swollen, the front and face and cheeks brilliantly vitreus black, a little silver pubescence beneath the antennae, a small spot of yellowish brown, triangular in shape near the eye margin of either side just below the level of the antennae, and a similarly colored narrow stripe dividing face and cheeks, beginning at the eyes and running to oral margin. Pile of face, cheeks, occiputal and front pale whitish; of vertex black. The face does not descend very deeply. It is bluntly obconical and the tubercle is large, oval and evenly rounded. Antennae dark brown. Arista paler, fifteen rayed above.

Thorax shining black, in places purplish and bluish opalescent. The scutellum shining vitreus black with a brassy cast, the marginal depression deep and conspicuous. Pile of thorax abundant, rather long, upright, pale brassy, with a few longer slender black hairs intermixed especially before the scutellum. Scutellum basally and marginally pale, the long marginal bristles black. Pleurae black, golden pubescent above, pale pilose. Squamae dark with blackish fringe, halteres pale yellow.

Abdomen shining black with an opalescent cast, with sharply defined pale yellow basal spots on the second segment, narrowly medially, oval on its posterior edge, i.e., subtriangular, and prolonged laterally part of the way down the sides. Third segment with similarly colored very small spots on anterior corners; fourth with a narrow lateral marginal stripe. Abdominal pile entirely erect, pale.

Legs shining black, very narrow apices of femora and bases of tibiae and the tarsi brown.

Wings hyaline, brownish anteriorly and an apical half, cross veins clouded, the stigma brown and the stigmal cell yellow.

Length 7.5 mm.

One male. Iquitos, Peru, Mar.–Apr. 1931 (R. C. Shannon).

Type in the U. S. National Museum, No. 51355.

Volucella cubomaculata n. sp.

Female.—Eyes very short pale pubescent. Front and vertex shining black, vitreus. The face and cheeks light clay brown or yellow, in the middle of the face with a narrow dark brown stripe from oral margin to antennae; a similar stripe, lighter in color, separating cheeks and face from eye to oral margin, and another between cheeks and occiput. Face rather pointed, tubercle quite low, evenly rounded, not deeply excavated above. Antennae light reddish brown, arista darker, twenty-four rayed above.

Side of dorsum of thorax, pleurae, scutellum, except its margin darker, all light yellowish brown. The dorsum in the middle dark blue black, opalescent, with coppery lights. Bristles, including those of scutellum where the apical two are most prominent, and the prescutellar row, all black.

Pile of thorax exceptionally short, of quite appressed, brassy color; on the pleurae a little longer but similarly colored pile. A few short black hairs on scutellum. Squamae dark brown with brown fringe; halteres ivory knobbed.

Abdomen with first segment entirely and basal two-thirds of second pale subtranslucent yellowish brown. Third and fourth segment each with a pair of basal yellow spots not reaching the sides, widely separated medially, the last pair rather cubical in shape, the first pair more irregular in outline. Elsewhere the abdomen is shining blackish.

Legs dark brownish black, black pilose, all the femora a lighter shade of brown.

Wings with apical two-fifths grey or smoky, not diagonally marked, the basal part of the wing yellowish, the stigmal cell brownish grey.

Length 8 mm.

One female. Iquitos, Peru, Mar.–Apr. 1931 (R. C. Shannon).

Type in the U. S. National Museum, No. 51353.

Volucella lumina n. sp.

Female.—Eyes densely pale, short pilose. Front above antennae light brown, above and on vertex very dark brownish red, a median stripe black, everywhere shining. Face and anterior part of cheeks pale brownish yellow or clay yellow, vitreus, a narrow median stripe of reddish brown reaches from oral margin to antennal base, and a similar stripe separates cheeks and face and is followed by the same color on the posterior section of the cheeks. Occiput pale, very pale punctate-pollinose, and its pile pale. Short pile of front and vertex black and the whole top of the very large obtuse tubercle densely short black bristly. Face deeply excavated below antennae. Face short obconical. Antennae dark reddish orange infuscated apically. Arista pale, thirty-one to thirty-three rayed above.

Thoracic dorsum on the sides light brown, in the center widely black with a very strong bluish and coppery opalescence. Scutellum light brown, subtranslucent, opalescent. Pile of thorax short, brassy, subappressed, on the posterior half mixed with some black pile. Black lateral, scutellar and prescutellar bristles greatly strengthened and exceptionally long, at least as long as the scutellum in midline. Squamae pale brown with darker fringe. Halteres ivory white with brownish stalk. Pleurae brown, densely clothed in middle with long appressed brassy hairs.

Abdomen shining black with bluish opalescence on the base of the second segment with a pair of large, sharply graduate yellow, translucent spots, divided medially by a little less than their own thickness. Abdomen somewhat denuded but with both black and brassy hairs.

Legs everywhere very dark reddish brown appearing practically black, clothed with jet black bristles and pile. Wings much larger than abdomen, on outer diagonal half dark brownish; the brown widest posteriorly, the basal half of wing yellowish; all the veins brown.

Length 12 mm.

One female. Ramupasa, Bolivia, December (W. M. Mann) (Mullford Biological Expedition).

Type in the U. S. National Museum, No. 51349.

Microdon aurifacia n. sp.

Male.—Head shining black except on the sides of the face where it is dark mahogany brown. Face with abundant pale brassy pile directed downward, glittering. Occiput with similar but scanty pile. Vertex and front black pilose, a few pale hairs above the frontal depression. Antennae very long and slender, the first joint as long as second and third, the third five times as long as second. Arista concolorous, shorter than third joint. Eyes scanty, short pubescent below. There is a narrow bare vertical non pilose stripe on the face.

Thorax shining black, the anterior half covered with short appressed pale brassy pile, very dense and startlingly brilliant from in front. Posterior half with similarly appressed black pile. Pleurae dark mahogany colored, black pilose. Scutellum shining black with two very stout black spines, set fairly wide apart, at outer angles of scutellum, reddish in color, and cloaked with black pile. Scutellum deeply sulcate medially and about twice as wide as long in the sulcate midline.

Abdomen shining black, thick short, apically pointed, with flared basal margins on the second segment, its pile through the middle and on the lateral margins short appressed, pale, brassy; elsewhere black.

Legs, except the mahogany brown tarsi, entirely black; black bristly except on the ventral surface of all the tarsi, where it is golden brown, almost reddish. Posterior basitarsi flattened but not exceptionally large or thickened.

Wings smoky, especially on the apical half. A stump of a vein protrudes into the first posterior cell from the third longitudinal vein.

Length 15 mm.

Two males, one female. Itaquaquecetuba, Peru, Nov. 18 and Sept. 20. The female lacks the pale brassy pile, which is evidently a sexual character.

Type in the U. S. National Museum, No. 51370.

Allograpta flavomaculata n. sp.

Male.—Related to *Sphaerophoria micrura* O. S. The head bears a wider stripe of black on the face and front. The slant from oral margin medially to cheeks and occiput is greater, and the pile of the upper occiput is black in *flavomaculata* and white in *micrura.* Scutellum with a well marked hemicircle of black in the center. The scutellum of *micrura* is entirely pale. However, there are differences in the markings of the abdomen which are here described.

First segment with a very small yellow spot in the anterior basal corners of the segment. Second with a narrowly interrupted band in the middle of the segment, the band reaching the side margins, the median interruption short, that is, the inner ends of each spot, drawn out and tapering to an abrupt point. Third segment with a similar band, not interrupted, widest just back of lateral margin, the median area pointed sharply above and below, as if the band had been interrupted and bridged by a small oval longitudinal spot. Fourth segment with a still wider band practically as thick in the middle as near the sides. The outer third of this and the preceding band is directed posteriorward at an angle of forty-five degrees. Last segment with four small yellow spots, the inner pair sub-triangular, the right angle basal and medial.

Length 9 mm.

One male. Bogota, Colombia (B. Guevara, coll.)

Type in the U. S. National Museum, No. 51375.

Meromacrus vittata n. sp.

Female.—Vertex, middle stripe of front, shining black, the sides of the front long, yellow tomentose, the shining black face and cheeks obscured by pale whitish pollen, and long white pile. Occiput silvery pollinose, pale pilose. A few black hairs on vertex. Eyes bare. Antennae reddish brown, the dorsal edge of third joint blackish. The arista pale yellow with brownish tip.

Thorax obscurely shining black, with three very sharp continuous greyish yellow vittae, confluent just before the scutellum, and another on either side on the posterior half which does not reach beyond the suture. On the outer edge of the suture, and on the humeri, a conspicuous tuft of bright yellow tomentum. Pile of thorax and scutellum long, dense and yellow, the ground color of the latter pale brownish yellow subtranslucent. Squamae and halteres pale brownish yellow, the latter with a dark annulus on the stalk.

Abdomen shining black, metallic, the first segment grey dusted in the middle. The second third, fourth and fifth segments with narrow opaque yellow posterior margins, and the fourth post marginally with a reddish brown border or spot, not reaching the sides. Pile of abdomen extraordinarily appressed, except on the side margins, all pale in color. Legs entirely light reddish orange, pale pilose, the only black vestiture being the basi-spinules on the hind femora.

Wings hyaline; anterior margin pale brownish, the extreme base strongly orange brown.

Length 10.5 mm.

One female. Villa Nouges, Tug., Jan. 1929 (R. A.).

Type in the U. S. National Museum, No. 51953.

Meromacrus lineascripta n. sp.

Male.—Eyes bare, narrowly touching. Vertex raised and swollen. Ground color of head, except beneath facial stripe, shining black, the lower vertex, very narrow sides of front, and the face broadly, except for the wide bare middle stripe, and the cheeks narrowly along the posterior eye margins, all pale whitish pubescent or pollinose. The pile of the vertex is black. Elsewhere on the face it is snow white. Antennae dark greyish brown, the third joint but little longer than wide, the arista wholly pale yellow.

Thorax black, obscurely shining, a very narrow midline pale yellow pubescent, and a very narrow transverse band widely separated medially and not reaching either side, a continuous, slightly wider prescutellar band, covering calli and scarcely wider in the midline. A diagonal stripe runs from base of suture along inner edge of humerus, to extreme anterior thoracic margin, all pale yellow tomentose, almost white. Humeri bare. Scutellum blackish basally and on the sides, otherwise reddish, everywhere like the thoracic dorsum, thick, appressed short black bristly. Pleurae black, heavily whitish dusted. Squamae pale with darker fringe. Halteres cream colored.

Abdomen largely pale orange, the first segment, the base of the second

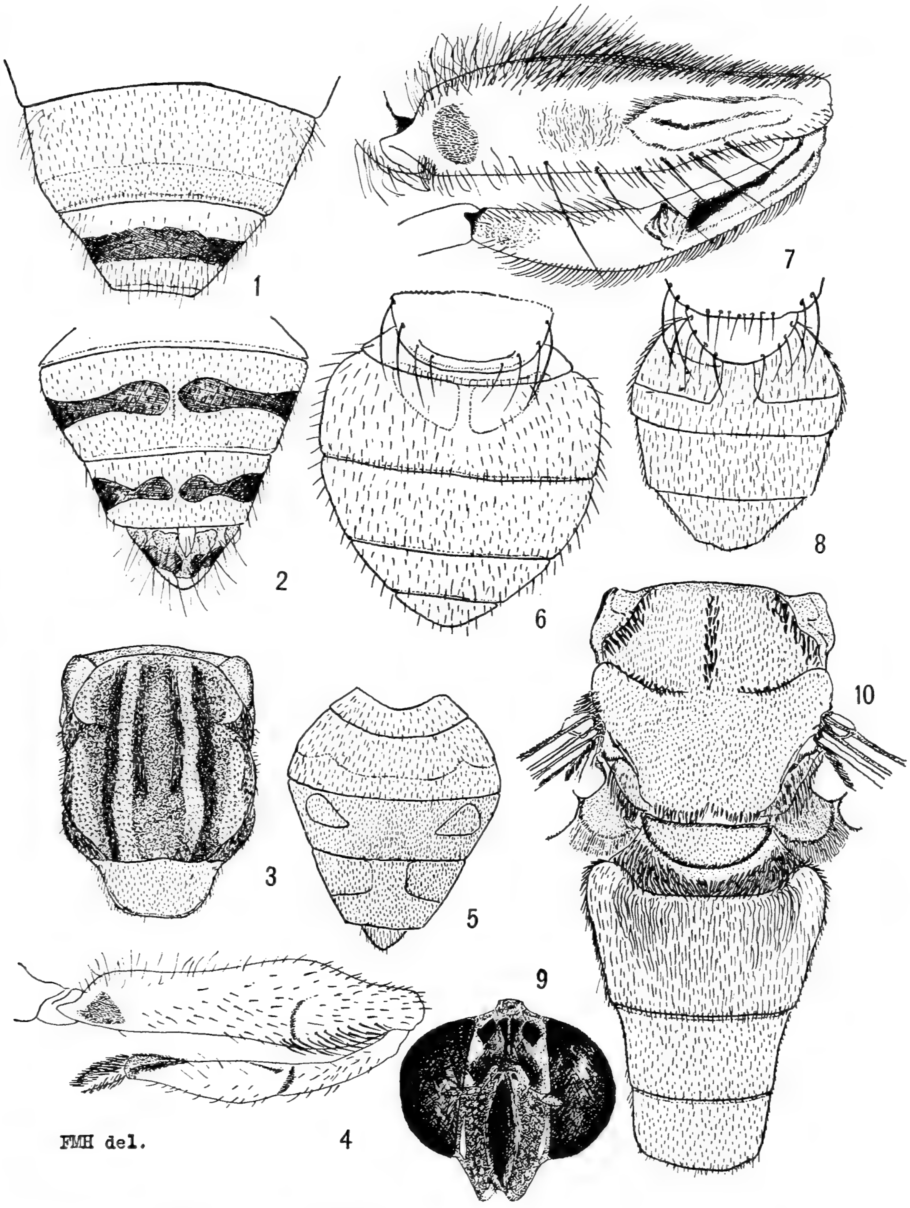

Fig. 1.—*Eristalis flavoscutellata* n. sp. (termination of abdomen). Fig. 2.—*Eristalis brevillosa* n. sp. (termination of abdomen). Fig. 3.—*Nausigaster nausicaa* n. sp. (thorax). Fig. 4.—*Eristalis brevillosa* n. sp. (hind femora). Fig. 5.—*Volucella cubomaculata* n. sp. (abdomen). Fig. 6.—*Volucella punctigena* n. sp. (abdomen and scutellum). Fig. 7.—*Eristalis flavoscutellata* n. sp. (hind femora). Fig. 8.—*Volucella lumina* n. sp. (abdomen and scutellum). Fig. 9.—*Braziliana vittithorax* n. sp. (front view of face). Fig. 10—*Meromacrus lineascripta* n. sp. (dorsum of thorax and abdomen).

narrowly blackish. Hypogium reddish, pale dusted. The narrow posterior margins of the second, third, and fourth segments faintly shining cream color, bare. The apex of the first segment bordered conspicuously with the pale cream colored tomentum, but not reaching the sides. Outer third of second segment basally with long black hair extraordinarily appressed directed posteriorward. Remainder with many appressed short golden spinules. Pollen of hypopygium ripple-like.

All the femora thick, the hind ones extraordinarily so, the thickening of all largely basal, on the third pair flattened ventrally. Legs light brownish red, the femora darker basally, all the femora basiventrally and the last sternite with remarkably curious tufts of thick, very long, crinkly whitish pile.

Wings with anterior border brown, the costal cell yellowish.

Length 12 mm.

One male. Ivon Beni, Bolivia (W. M. Mann) (Mullford Biol. Expedition, 1921–1922).

Type in U. S. National Museum, No. 51371.

Nausigaster nausicaa n. sp.

Female.—Eyes bare. The raised and swollen front, the square area about the base of the antennae, a very narrow median line bisecting the golden pollinose area between the square spot and the vertex, the wide median facial vitta, and a narrow one on the cheeks from eye to oral margin, all shining steel blue. The remainder of cheeks and face, including a band below antennae, the entire occiput except just behind vertex, densely yellow pubescent (pilose) and short pale pilose. The blue area above antennae with a few pale hairs, the remainder bare. Antennae quite large, the third joint twice as wide and twice as long as the second, all bright brownish orange. Arista bare, brownish.

Thorax brilliant steel blue, slightly purplish, with four conspicuous wide stripes or vittae of pale pollen, the outer one not interrupted at the suture, all running the full length of the thorax, the angles before the suture on either side with a yellow pollinose area and the stripe enclosed by the outer and inner pollinose vittae on either side is a rich brassy color with just a suggestion of bronze. Clothing of thorax ultra microscopic, black on the dark areas, light on the vittae. Pleurae and scutellum entirely bright steel blue. Squamae pale; halteres yellow.

Abdomen largely dark steel blue, obscurely shining. The first segment and base of second dusted with whitish. The narrow posterior borders of second, and third each continuing narrowly along the side margins, the posterior margin of the fourth more widely, triangularly produced medially as a large spot, all bright golden pubescent. Abdomen everywhere microscopically short black bristly.

Legs largely very dark reddish brown, the femora apically, the tibiae basally, more blackish, all covered with pale short appressed pile, except where it becomes golden on the posterior tarsi ventrically.

Wings clear hyaline. Stigma brown.

Length 7.5 mm.

One female. Montevideo, Uruguay (Tremoleras) Dec. 20, 1930. (Penarol). A remarkable and beautiful species.

Type in the U. S. National Museum, No. 51369.

Eristalis flavoscutellata n. sp.

Female.—Very close to *E. obscurus.* Front and vertex with black and yellow pile mixed, the former predominating. Face shining black, its pile pale. Facial knob prominent and bare. Antennae light brownish orange, dorsally blackish on the third joint. Arista reddish throughout, quite long and bare. Eyes very short whitish pilose.

Thorax and pleurae black, dully shining with long reddish yellow pile. Scutellum light brownish orange, with thick but rather short golden pile.

Abdomen large, swollen, shining black, the second segment on either side with obscure reddish, shining spots and suggestions of similar ones, but smaller, similarly placed on the third segment. Narrow posterior margins of second, third and fourth segments opaque pale yellow. Pile of second segments short, black and yellow intermixed; on third segment black; on fourth segment, except on the narrow base, entirely pale and erect. Only the black pile subappressed.

Legs with black femora, apices narrowly pale, the mid tibiae reddish, all the tarsi bright orange, orange pilose. Hind femora quite thick, shining black, with a few long pale bristles beneath and shorter thick erect black ones above. The hind tibiae black, with a dense dorsal (ventral when tibiae is adjacent to femora) fringe of black cilia.

Wings hyaline with a conspicuous quadrate brown spot in the middle.

Length 10.5 mm.

One female. Hiquito, San Mateo, Costa Rico (Pablo Schild).

Type in the U. S. National Museum, No. 51363.

Eristalis brevivillosa n. sp.

Female.—Vertex and front considerably swollen. The ground color is obscurely shining, dark brown above, becoming quite pale brownish yellow below on face. Front, vertex, face almost entirely covered with pale brownish yellow pollen, slightly darker on vertex, almost golden on the face, and obscurely punctate on the front. The antennae are small, set below the middle of the profile, and from base to vertex the front is thickly short black pilose. The eyes are very short yellow pubescent above, and there is some brassy pile on the upper part of the face. Tubercle medium sized, slightly more shining. Occiput from just past cheeks nearly to vertex is blackish, white dusted. The upper occiput exhibits a creased margin running to the corners of the eyes. Antennae pale brownish orange, the third joint oval. One and one-half times as long as wide. Arista pale, long, slender, bare.

Thorax black, dully shining, densely brown pollinose, two or three short median vittae are suggested but obscure on the anterior half; pile thick, short, nearly erect, brassy in color, becoming reddish on the lateral margins of the dorsum where the ground color is reddish brown. Pleurae black, whitish dusted, with tufts of long golden hairs on the upper mesopleurae. Scutellum large, broad, evenly rounded. Opaque rust red or rust yellow, its dorsum thickly beset with stubby black bristly hairs, a few golden ones laterally and ventrally on the margin. Squamae very large, reddish brown, its fringe yellow; halteres light yellow.

Abdomen very dark brown almost, but not quite black; mostly opaque, but with a shining jet black band interrupted medially on the middle of the third segment; a similar maculation on the fourth, both reaching the lateral margin, and both shaped somewhat on their inner ends as exclamation marks, the lateral tips of which are also dilated. Second segment with a pair of small obscure reddish spots. First segment basally, on either side, pale yellowish white. Fifth segment shining black in posterior half, basally with a pair of small quadrate golden pilose spots, and similar ones more irregular in outline, similarly placed on the fourth segment.

Legs largely dark vitreus reddish, mahogany colored on posterior femora, the narrow apices of the face and mid femora, the bases of all the tibiae the first four more widely, pale yellowish. The tarsi are a lighter shade of dull yellowish brown. Hind femora not greatly thickened, but widest for a short distance before apex and sharply enlarged from this end. Hind tibiae flattened, slightly arcuated, but not ciliary fringed and not spurred apically.

Wings almost hyaline, yellowish tinged. Stigma sharply dark brown in color.

Length 10.5 mm.

One female. Lima, Peru, 2000+ ft. (Piches and Perene) Soc. Geogade.

Type in the U. S. National Museum, No. 51364.

Eristalis flavovillosa n. sp.

Male.—Eyes touching. The swollen vertex, front, face and cheeks black, the latter shining, the facial knob slightly shining, the remainder densely whitish grey pubescent. Facial tubercle rounded, low, inconspicuous. Antennae dark brown, the narrow base of the third segment light brown. Arista very long, thickened on basal third, brown in color, pale apically, and bare. Vertex, upper occiput, front and upper face covered with thick long shaggy, bright yellow pile. Eyes densely short whitish pilose.

Thorax black, obscurely shining, densely brown pollinose and very densely long shaggy yellow pilose, the pile erect, plush-like, bright in color, but nowhere golden. Scutellum similarly pilose, in color pale brownish yellow, obscurely shining. Squamae and fringe and halteres light brown.

Abdomen black, obscurely shining. On the second segment with a bluish coat, the sides of that segment in the middle with a light yellow spot or triangle, its posterior border horizontal, its inner angle acute. Posterior margins of first, second, third and fourth segment narrowly opaque yellow, the bases of the third and fourth and the yellow posterior margin of the fourth with a yellowish grey opaque band, equally narrow, all of them uninterrupted. With the exception of half a dozen long black bristles on either side of posterior margin of fourth segment, the pile is everywhere erect, very long, very dense, bright yellow. The pile of the venter is still longer, and paler.

Femora, except the narrow yellowish brown apices, shining black, about the middle brown pollinose. The hinder pair moderately thickened. Fore tibiae on apical half, mid tibiae on apical sixth, hind tibiae on apical three-fifths, blackish, remainder light brownish yellow, everywhere yellow pilose, except on the apical half of the hinder pair, which is black ciliated below. Hinder tibiae somewhat arcuated and flattened. All the tarsi brown, the hind tarsi lighter, the other dark. Pile of femora yellow. Hind femora apico-ventrally with long black bristles.

Wings largely hyaline, faintly brownish, especially about the center.

Length 14 mm.

Two males. Suifu, Szechuan, China (D. C. Graham, coll.).

Type in the U. S. National Museum, No. 51952.

Spheginobaccha melancholia n. sp.

Female.—Head shining black, the sides of the face, the cheeks, the narrow lateral eye margins of the front up to where a transverse band is formed in the depression, all shining silver pubescent. The vertex and front especially the former, remarkably swollen and tumid, evenly rounded, the eyes at the posterior angles widely excavated so that the occiput is here quite thick. Antennae situated at upper two-thirds, without prominence, the third joint dark brown, a little longer than the first two evenly rounded and bearing a black bare, basally thickened arista. Pile of head scanty, short, everywhere pale except on the vertex. Ocelli placed far forward.

Thorax black, obscurely shining, with short dense reddish brown pubescence, and suggestions of two quite narrow vittae, and an equally narrow trace of a horizontal band across the suture and not interrupted in the middle. Scutellum and pleurae similarly colored and pubescent, the latter on the lower pleurae whitish. Squamae pale yellow; halteres light brown.

Abdomen black, shining, shorter than wings, with a pale obscure yellow spot of some size on either side of the second segment near the base. Pile of the abdomen largely pale. Some appressed black bristles on posterior borders of the segments.

Legs, black, the femora very narrowly at the apices, the basal halves of all the tibiae pale yellow. Hind femora slender.

Wings uniformly dark blackish or fumose, slightly paler posteriorly. Wings everywhere black pubescent.

Length about 15 mm.

Two females. Prang Bon, 30 mi. N. W. of Saigon, Cochin China, July 19, 1932, (M. Piolane, coll.).

Type in the U. S. National Museum, No. 51372; paratype in the author's collection.

Korinchia nova n. sp.

Female.—Vertex and front, except just above antennae, black, shining the upper portion of the latter pollinose (greasy in the specimen) and the extreme lower front shining brown. Face and cheeks light yellowish brown, interrupted by a shining dark brown stripe on the anterior portion of the cheeks from eye margin to oral margin. Antennae dark brown. Third joint oval, one and a half times as long as wide, unusually large. Arista very long, bare, basally yellowish, apically white. Eyes bare. The ocelli are situated on a raised area and the width of the vertex is less than the width of the third antennal joint.

Thorax black, obscurely shining, a band across from the humeri, jutting a little way posteriorly in the middle, another band on the sutures, interrupted widely in the middle, and a prescutellar band, pale yellowish grey pollinose. Scutellum tricolored, the narrow impressed rim pale greyish yellow, the middle light brown, the base black, all except the rim shining. Pile of thorax and scutellum short, rather thick, brassy in color, slightly longer before the scutellum, and still longer on the margin of the scutellum and with curious tufts of long flattened golden pile on the sides of posterior thoracic disk and calli, directed backward. Pleurae dark brown, largely bare, with a vertical stripe of pale pollen, pale pilose up the middle. Squamae whitish with yellow border. Halteres brownish yellow.

Abdomen black, obscurely shining, the lateral margins everywhere narrowly reddish and a triangular spot on the basal angles of the second segment narrowly meeting medially. The short dense bristles of the abdomen appressed, black on the black areas except that the basal borders of each segment are narrowly golden bristly. All segments including the first, with a narrow posterior, opaque yellow pollinose border, golden appressed bristly. Side margin of abdomen with short brassy pile.

Legs largely pale yellow, waxy in appearance, except fore tarsi and tibiae blackish, the latter with postero-lateral hemicircle of pale yellow in the middle. Pile of legs short, largely pale. The hind femora apically, particularly beneath, black bristly, a few black bristles on the posterior tarsi, the anterior pair entirely so. Hind femora slightly infuscated postero-medially, quite slender, without tooth or spicules.

Wings nearly hyaline slightly yellowish basally. Stigma pale yellow.

Length 12 mm.

One female. Ningyuenfu, China (D. C. Graham, coll.).

Type in the U. S. National Museum, No. 51360.

Braziliana vittithorax n. sp.

Female.—Vertex quite swollen, brilliant shining metallic steel blue. Ocelli bright red. Eyes widely apart, bare. Whole face, where not pollinose, shining steel blue, glittering. The pollinose band of the face is ripple-like with large bare punctate spots, the outer margin of the metallic stripe coppery. Front across the middle black pollinose, trimaculate, leaving along each eye margin above and below the antennae, three whitish semi-oval pollinose spots. A conspicuous depression or trough transversely before scutellum. Facial pile pale. Vertical and upper frontal pile black, everywhere scanty. Antennae light brownish, blackish apically. First joint as long or longer than second and third; third pointed. Arista a little longer than third joint, basally pale.

Thorax opaque black trivittate, the outer vittae as broad wedges directed acutely backward, not proceeding past the suture anteriorly; the median one narrow, running full length; all three vittae confluent before the scutellum. Ground color on mid-dorsum steel blue, shining, whitish dusted anteriorly and around the shining anterior thoracic tubercle. Pleurae silver dusted except on the totally bare and brilliant pteropleurae (anterior part only). Scutellum shining metallic blackish. Squamae white with blackish border. Halteres brownish yellow.

Abdomen brownish black, a pair of oval, yellowish spots, pointed at either end, diagonally placed on the third segment, touching only the basal margin and widely separated. Suggestions of similar spots on the fourth and fifth segments which cannot be made out very definitely. Abdominal pile very short, scanty, pale.

Legs pale brownish yellow, the mid-femora, except narrow apex, the apical two-thirds of slightly thickened hind femora, and distal posterior tarsi blackish.

Wings hyaline, stigma brown.

Length 8 mm.

One female. Antigua, Guatemala, June 17, 1923 (E. G. Smyth).

Type in the U. S. N. M. No. 51376.

Obituary

William Major Beaman, Chief of Inspection and Editing of the Topographic Branch of the U. S. Geological Survey, died at his home in Washington, March 2, 1937. He was born February 20, 1867, at which time his father, the late Rear Admiral George Beaman, was stationed at Annapolis. After making a special study of Civil Engineering and Topographic Engineering at the Massachusetts Institute of Technology, he joined the U. S. Geological Survey in 1889 and was in charge of topographic field parties until he became inspector of field work, in 1907. With the exception of a furlough in 1922 for duty with the War Department, in Brazil, this position was held until the World War during which he served as major in the Corps of Engineers. In 1918 he was appointed to the position he held at the time of his death.

Major Beaman was the inventor of the Beaman arc used on telescopic alidades and transits and was author of the chapter of the Topographic Instructions of the Survey on topographic mapping used widely in colleges. He was a member of the Board of Surveys and Maps of the Federal Government, the American Society of Civil Engineers, the Society of American Military Engineers, the Washington Society of Engineers and the Washington Academy of Sciences.

Clarence Bloomfield Moore, noted American archeologist, died March 24, 1936, at his home in Philadelphia, Pa.

He was born in Philadelphia, January 14, 1852. After graduating from Harvard University in 1873, he traveled extensively in Eurasia, Africa and South America. His earliest published article described the ruined temple of Boro-Budur, in Java, then little known. An accident, while hunting big game, injured his eyesight and he turned to exploration of the mound cultures of the Southern States. His first work, on the shell heaps of the St. Johns River, Florida, appeared in the *American Naturalist*, 1892–1894. From then on two expeditions were made each year, with the summers devoted to preparation of the "Reports," which were published at Mr. Moore's expense in the *Journal of The Academy of Natural Sciences of Philadelphia* and freely distributed to the scientific world. One volume, privately printed, has been republished in *Indian Notes and Monographs* by the Heye Foundation.

In 1915, Mr. Moore graciously surrendered to the Heye Foundation all surveys and prospect data, prepared for his own further exploration of Red River, the gift thus making possible the work of M. R. Harrington on Caddoan Sites in Arkansas. Generous gifts of archeological objects, from time to time, enriched the collections of Peabody Museum at Harvard University, Phillips Academy, and other institutions, but the great C. B. Moore Collection was given to The Academy of Natural Sciences of Philadelphia, for the benefit of his native city. In 1929, with the reluctant consent of the donor, the Academy sold the collection to the Museum of the American Indian, Heye Foundation. The great body of material amassed in Mr. Moore's collection and accurately recorded in the twenty-two volumes of the "Reports" is an indispensable source of information and an inspiration to all archeologists working in the southeastern United States.

Mr. Moore was a member of the American Association for the Advancement of Science, the Anthropological Association, and many other American and foreign societies.

Reverend JULIUS ARTHUR NIEUWLAND, of the Congregation of the Holy Cross, died suddenly of a heart attack in the chemical laboratory of the Catholic University, Washington, D. C., on June 11, 1936.

Father Nieuwland was born on February 14, 1878, at Hansbeke, Belgium. While still a child, he was brought by his parents to this country, the family settling in South Bend, Ind. He received his A.B. in 1899 at the University of Notre Dame.

Father Nieuwland won distinction in two fields of science—biology and chemistry. In the latter his work was more recent and was perhaps more widely known, but, as Professor of Botany at the University of Notre Dame from 1904–1918, as the founder and first editor of the *American Midland Naturalist,* and as the author of about a hundred papers on the taxonomy of flowering plants and ferns his reputation as a botanist was well established. In 1918, Doctor Nieuwland became Professor of Organic Chemistry at the University of Notre Dame and was serving in that capacity at the time of his death. He was Dean of the College of Science, 1918–1922. Doctor Nieuwland's chemical studies were devoted largely to an extension of the work involved in the Doctor's dissertation entitled *Some reactions of acetylene,* which he had submitted in 1904 to the Faculty of the Catholic University of America. During eighteen years of chemical research he worked indefatigably and became an outstanding authority on the reactions of acetylene, the preparation of organic derivatives of acetylene and of other related compounds. These studies included the fundamental researches underlying the synthesis of duprene, one of the so-called synthetic rubbers; and the preliminary steps leading to the preparation of lewisite. As already noted, Father Nieuwland received the degree of Doctor of Philosophy from the Catholic University in 1904. The degree, Doctor of Science, was conferred upon him by the University of Notre Dame in 1911. In 1933 he was awarded the Morehead medal by the International Acetylene Association for outstanding work in acetylenes, and in 1935 was awarded the Nichols medal, the highest honor awarded by the American Chemical Society. At the presentation of the latter medal, Dr. J. M. Weiss, chairman of the jury of award, pointed out that Father Nieuwland at the risk of his own life had experimented with acetylene reactions—research shunned by most investigators because of the danger of explosion—until he so controlled these reactions that they could be studied in general laboratory work with comparative safety. In recognition of his achievements in the advancement of science he was awarded the Gregor Mendel medal by Villanova College a short time before his death.

On January 10, 1937, the University of Notre Dame held special memorial services in honor of her distinguished son and scientist.

ELIHU THOMSON, noted electrical engineer and director of the Thomson Research Laboratory at Lynn, Mass., died March 13, 1937.

Doctor Thomson was born at Manchester, England, March 29, 1853. He graduated from Central High School, Philadelphia, Pa., in 1870. In 1890 he received an honorary A.M. from Yale; an honorary Ph.D., Tufts College, 1896; an honorary Sc.D., Harvard, 1909, Manchester, 1924; and a LL.D. from the University of Pennsylvania, 1924.

From 1870 to 1880 he was professor of chemistry at Central High School, Philadelphia, and from 1880 he was electrician for the Thomson-Houston and General Electric Companies. At the Massachusetts Institute of Technology he lectured on applied electricity, and from 1920 to 1922 was acting president of that institution. His researches and publications deal with the phenomena of alternating current induction, high potentials and high frequency apparatus, production of fused quartz, electric welding, and many other phases of applied electricity. For his great accomplishments he was honored with the Grand Prix, Paris, 1889–1900, and in succeeding years he was the recipient of the Scott, Rumford, Edison, Cresson, Fritz, Hughes, Kelvin, Franklin, and Faraday medals.

Doctor Thomson was a member of the National Academy, Franklin Institute, Philosophical Society, American Academy, and of numerous other American and foreign societies. He was a Chevalier and Officer, Legion d'honneur.

DR. WILLIAM ALANSON WHITE, for the past thirty-four years Superintendent of St. Elizabeth's Hospital and for many years a member of the Washington Academy of Sciences, died of influenza and pneumonia on Sunday, March 7, 1937, in his home at the institution of which he was the distinguished head.

Dr. White was born in Brooklyn, N. Y., January 24, 1870, the son of Alanson and Harriet Augusta White. He was graduated from Cornell University in 1889 and two years later received his M.D. degree from Long Island Medical College. While a student at Cornell, Dr. White's interest in psychology was aroused and fostered by his friendship with Dr. Bert G. Wilder, an eminent authority on the nervous system. This special interest in the human mind and its disorders led logically to the first professional work at the New York State Hospital at Binghamton, where he labored from 1892, the year after his graduation in medicine, until 1903. In that year, having become Second Assistant Superintendent of the Binghamton institution, he was called to assume full charge of St. Elizabeth's Hospital at Washington, D. C.

Nothing could more strikingly portray the exalted stature of Dr. White, both as administrator and as scientist, than the transformation of St. Elizabeth's Hospital during his life there. Coming as a young man of thirty-three years to assume charge of an institution long a football of politics and needing to rely exclusively upon politically controlled resources and personnel, he effected the necessary change of regime, rehabilitated and enormously extended its physical equipment, and made it a place of beauty and comfort. He sustained opposition and criticism, weathered the storms of transition, and survived accusations leading to numerous congressional investigations. Himself a leading factor in the renaissance of psychiatry, he was a pioneer in the practical application of the developing resources in that field until the old Government Hospital for the Insane, a mere custodial asylum for the hopeless, became one of the greatest institutions for the care and cure of the mentally ill, a training ground for many brilliant recruits to the psychiatric profession, and a research center of rich fruitfulness.

Dr. White's contributions to the literature of psychology and psychiatry were numerous and came in a steady stream throughout his professional life. Much of his earlier writing was in collaboration with Dr. Smith Ely Jelliffe, the volume on *Diseases of the nervous system* bearing both names. They were also associated in editing journals of psychology and psychiatry. One of the most important of Dr. White's books is *An outline of psychology*, written in 1909, and now in its fourteenth edition. His latest volume, *Twentieth century psychology*, was based on the material for the series of Salmon lectures he delivered before the New York Academy of Medicine.

Dr. White became Professor of Psychiatry at George Washington University in 1904 and taught the same subject to the students of the Army and Navy Medical Schools. He was a teacher wherever he appeared and his frequent contributions to the program of medical societies constituted a continuous post-graduate school for his professional associates. These activities led to recognition in the educational field by honorary degrees conferred upon him by Boston University, Washington University (St. Louis), Georgetown University, and George Washington University, the last at the convocation held February 22 of this year.

Dr. White was a Fellow of the American Medical Association and of the American College of Physicians; a member and former president of the American Psychiatric Association, the American Psychopathological Association, the American Psychoanalytical Association; also president (1930) of the International Congress on Mental Hygiene; sometime president of the Washington Institute of Mental Hygiene and of the Washington Academy of Medicine. His membership in the Washington Academy of Sciences resulted in several notable addresses before that body.

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JOURNAL
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VOL. 27 MAY 15, 1937 No. 5

GEOPHYSICS.—*Structure of continents and ocean basins.*[1] RICHARD M. FIELD, Princeton University. (Communicated by JOHN A. FLEMING.)

While I consider it an honor, as well as a pleasure, to be asked to address the Philosophical Society of Washington on this most comprehensive subject, I hasten to assure you that I am fully aware of the difficulties of the task, not the least of which are my own inabilities to do full justice to so fundamental and important a problem. Perhaps my principal excuse is that I have had an excellent opportunity to observe the work of my colleagues in geological-geophysical synthesis during the past decade at fairly close range; by that I mean particularly the advantage of taking part in the inception, planning, and execution of several cooperative research programs and expeditions which are directly related to the topic assigned to me for this evening. On the other hand, I do not propose to stress any particular hypothesis as to the origin of continents and ocean basins, but rather to submit to you a historical review of the data and, more particularly, the lack of data which have led geophysicists and geologists to propose certain working hypotheses; for it seems to me that such a review is highly essential at a time when there appears to be a sudden and rapidly increasing cooperation between geophysicists and structural geologists in the attempt to discover the major structures of the lithosphere. There is still, however, some danger that full cooperation may be delayed by misapprehensions as to the proper relative functions of the geophysicist and the geologist in their specific fields.

With the recent development of theoretical geophysics, certain questions have been posed which, although of some theoretical interest, are not highly methodological. Granted that the theoretical geophysicist has the realm of the sublithic portion of the earth practically to himself, the same does not hold true for the so-called "crust," or outer lithosphere. Too often the theoretical geophysicist implies that rocks are merely physical-chemical types of matter,

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[1] Address before the Philosophical Society of Washington, January 30, 1937. Received February 13, 1937.

without paying any particular attention to the essential, natural structural controls of their origins. For a seismologist to state that a certain layer or zone of the earth "behaves like a granite" does not necessarily lead to the conclusion that it is granite. Or, to put it in another way, if the surface of the suboceanic lithosphere should be proved to have large areas of granite, the geologist would know that these areas represented the roots of profoundly eroded mountain ranges; possibly an ancient pre-Cambrian erosion surface. To the geologist, therefore, a granite "outcrop" suggests a long and complicated structural-erosional (geomorphological), as well as petrological-chemical, history.

The function of the geophysicist is to adapt the principles and techniques of physics and physical chemistry to the solution of geodetic and geological problems. The function of the geologist is to demonstrate what the major structural geological problems are which, in his estimation, particularly require the aid of the geophysicist; and to help the geophysicist interpret the data which he provides. In making this statement I do not wish to imply that geophysics should be merely the handmaiden of geology, and I certainly *do not* wish to imply that geophysics should be the mistress of any pet geological hypothesis. An exceedingly close and sympathetic union is, however, absolutely essential if we are to realize the full potentialities in earth science. The geophysicist, as this title implies, is deeply concerned with the developments of his techniques, including those "border line problems" which require the help of the theoretical and experimental physicist. In a sense, he bridges the gap between the physicist and the geologist. He also has the advantage over the geologist, in that the application of his techniques to the study of materials is subject to relatively accurate and rigid analysis; and he comes nearer to what we might term the mathematical type of scientist. On the other hand, the geologist, by means of his techniques, is able to produce certain fundamental observable data regarding a relatively small quantity of the lithosphere. In almost every case, the broad areal, as well as the downward continuity, of his major structures can not be directly observed, and, therefore, must be inferred from their traces and trends as exposed in the elevated and dissected areas of the continents. Progress in the study of the lithosphere is seriously retarded when the geologist fails to take full advantage of the techniques and data provided by the geophysicist; or, when the geophysicist, in his more deep-seated studies and speculations, fails to appreciate the important surficial data which have already been provided by the geologist. Further, many geologists do not yet seem to fully realize the essential aid which the geophysicists can render in greatly extending the area, as well as the depth, of geological surveys. This statement applies particularly to approximately five-sevenths of the surface of the globe, which, at the present geological "instant," is covered by water and ice. Naturally, until the last decade, the geologist has had to confine his studies to the continental lithosphere, and in these studies he has relatively recently been greatly aided by the geophysicist. In no branch of earth science has this union of geophysics and structural geology been more effective from the scientific, as well as the economic, point of view than in the locations of ore deposits and oil wells. Those really responsible for the development of the mineral resources of our country have clearly demonstrated the importance of including geophysics as an essential technique in geological surveys.

But what I wish to emphasize particularly this evening is: (1) The outstanding influence which that great *terra incognita*, the suboceanic lithosphere, has had on geologic speculation as a whole; (2) upon what meager data this influence depends; and (3) the future rôle of the geophysicist in helping to provide the data. Since such great responsibility rests upon the geologists, it would indeed be unfortunate if archaic or unnecessary geological hypotheses were to hinder or delude the geophysicist in the application of his talents and methods. As we all know, the principal values of a hypothesis, as well as a theory, are the trends which it suggests for further research; the major difference between a crank and a scientist is that the latter insists upon a "working hypothesis"—one that still further stimulates the critical application of old and the development of new techniques. But we must remember that even geologists are human, and, once having originated or espoused a hypothesis, they are apt to defend it beyond the point where it helps to promote fundamental research.

One hundred years ago, Ehrenberg noted that the calcareous and siliceous tests of microscopic organisms found in deep sea deposits also played an important rôle in the formation of continental deposits. By 1870 most geologists were firmly convinced that the British Cretaceous chalks, limestones, and also the glauconitic and radiolarian deposits, such as those of eastern North America and the San Franciscan area, were originally deposited in oceanic depths. It is important to note that C. E. Dutton gave his important paper on *The causes of regional elevation and subsidence* before the American

Philosophical Society in the spring of 1871. In the spring of 1889, I believe in this very room, Dutton first proposed the theory of isostasy to account for the gradually reversed reliefs of relatively contiguous areas of the face of the earth. It is also important to note that Dutton was primarily a geologist, with only scanty geodetic data at his command, and it was not until Hayford, Pratt, Airy, Bowie, and others had continued the investigation of Dutton's "working hypothesis" by means of the available, gradually increasing, number of geodetic and gravity data that the theory of isostasy may be said to have become a major geophysical-geological hypothesis. The father of the hypothesis was, however, a geologist, not a geophysicist. It is rather surprising how little attention structural geologists paid to the idea of isostasy, with the exception of a few such as Barrell and Lawson, until about twenty-five years ago, when, first in Europe, and then gradually in the United States, the concept of low angle overthrusts, nappes, and relatively great horizontal translocations of the lithosphere, as exemplified in the Scottish Highlands and the Alps, appeared to be in sharp contrast to isostatic principles. During the past twenty years, it has been this battle between the present champion of isostasy, Dr. Bowie, and many of the leading structural geologists of Europe and America, which has served to illustrate the growing importance of the application of pendulum gravity to the solution of major problems in structural geology, as particularly exemplified by the recent studies of Meinesz, Thom, Bucher, Chamberlin, and Longwell.

But, to return to the purely sedimentary, or stratigraphic, aspect of the problem. Gradually, within the last fifty years, paleontologists and stratigraphers have acquired the data which proves that the bulk, if not practically all, of the continental sedimentary formations, including limestones, were laid down in relatively shallow water—certainly not in oceanic depths; and thus quite independent of, and, to a certain extent, in spite of other data, arose the concept of the relative permanency of oceanic basins and continental platforms throughout geologic time. This statement is particularly true in relation to the Atlantic oceanic basin and its continental margins. A growing appreciation of the major relief pattern of the face of the earth, together with relatively meager geological and geophysical data concerning ocean basins, seemed to indicate, according to J. W. Gregory, that the said major relief pattern had "been shaped and distributed in accordance with some ancient, deep-based plan." In 1887 W. L. Green proposed his Tetrahedral Hypothesis, under the title of *Ves-*

tiges of the molten globe, in order to explain the origin and persistency of continental platforms and oceanic basins. This essentially contractional hypothesis, founded on the apparent similarity between the relief pattern of the globe and the geometric principles involved in the gradual evolution of a spherical tetrahedron from an original spheroid, was accepted by many of the leading geologists of his time, and is still included in Hobbs' 1931 edition of *Earth features and their meaning.* I shall not attempt to summarize the many and serious difficulties which the structural geologists discovered in attempting to harmonize a purely contractional hypothesis with their growing data on the structure of the observable portion of the lithosphere, but shall pass on to the epitome, or ultimate goal, of all students of the history of the Earth—paleogeography.

The fundamentals of modern stratigraphical and paleogeographic techniques have been supplied by workers from many lands, but the profound influence of E. O. Ulrich's splendid researches in North American Paleozoic stratigraphy, resulting in 1908 in the production of an excellent series of paleogeographic maps by Charles Schuchert, can not be overestimated. These two outstanding Paleozoic paleogeographers, together with their British and European colleagues, tacitly, and almost unconsciously, accepted the dictum of the permanency of oceanic basins, in spite of the fact that they found considerable difficulty in providing suitable physical means for the essential intercontinental migrations of both marine and terrestrial organisms. May I again remind the audience that the theory of the permanence of oceanic basins was originally proposed by geologists, not by geophysicists. The necessity for the intercontinental migrations of organisms led to the postulates of either "land bridges" or of "rafting," the bulk of the paleogeographers preferring "land bridges." Thus, while diastrophism and the periodic flooding of the continents by shallow seas are accepted by all geologists as the basis for the delimitation of geologic periods, relatively permanent oceanic depressions seem to be required, in order to accommodate the surplus of water which must exist even during the maximum inundations of the continents.

For geologists, the outstanding events of the second decade of the 20th Century were the World War and the Wegener Hypothesis of Drifting Continents. I well remember how a well-known geologist delivered a stirring and satirical denunciation of this hypothesis in 1916 before a relatively small anti-German group at the Harvard Club in Boston. Only a few months later, this same geologist had become the chief exponent of the Wegener Hypothesis in this country. This is a single example of the irritating and stimulating effect which the Wegener Hypothesis has had on the rank and file of geologists.

Among the many discussions of the Wegener Hypothesis, perhaps the best is that given by Gregory in his presidential address before the Geological Society of London in 1929. Under the title, *The theory of permanent oceans and continents,* he gave an excellent summary of all the physiographic, structural, paleontological, stratigraphical, and paleogeographical evidence both for and against all existing hypotheses on the origin of continents and ocean basins. He clearly recognized the need for the exploration of the sub-Atlantic lithosphere, and concluded his address with the following interesting statement:

> The combined evidence of stratigraphical geology, paleontology, and the distribution of the existing animals and plants proves that there was no ocean entitled to rank as the Atlantic during the Paleozoic and Mesozoic eras, and that its formation began at the end of the Cretaceous, *and was effected mainly after the widespread mountain-forming movements of the Oligocene.*

In 1936, under the title of *Recent developments in the geophysical study of oceanic basins,* I had the temerity to suggest, "that the sub-Atlantic lithosphere constitutes a vast area of *downwarped* Pre-Cambrian and Paleozoic geology, fully comparable in the complexity of its subsidiary stratigraphic, structural, and paleogeographic features to the *upwarped* Pre-Cambrian and Paleozoic geology of the surrounding continental areas . . . In the late Tertiary (and early Quaternary) there may still have been some subaerial remnants whose land areas were temporarily enlarged by the climatic events of the Pleistocene." Since making this statement, I still further suggest that there may have been profound, local, Quaternary movements in the basin itself; and that these movements may have affected ocean level, especially if there were coincident movements in the floor of the Pacific.

In a sense, geologists today may be classified as pro- or anti-Wegenerians. Most of the pro-Wegenerians are European, although we have a number in the United States and Canada. It is hardly necessary to remind you that the Wegener Hypothesis suggests that the Pacific was the one and original oceanic basin, and that the present pattern of the continents is like a picture puzzle, North and South

America having broken away from Europe and Africa at the close of the Paleozoic. Thus the Atlantic is supposed to have been growing bigger and bigger throughout the Mesozoic and Cenozoic eras, at the expense of the Pacific, while the great American continental rafts slowly but surely plowed their way southward and westward. During the last twenty years, the geophysical debate on this hypothesis has centered around such questions as: (1) The possible mechanism for continental drift. (2) The possibilities for determining the rate of the drift. Or, in other words, if the continents are drifting they may have drifted the distance required by the hypothesis. Up until ten years ago little or no positive data, other than a few soundings, existed on the condition of the suboceanic lithosphere. Thus the principal arguments put forward by the geologists in support of the Wegener Hypothesis were confined to: (1) The marginal patterns of the continents as exemplified in the outlines of the submerged continental margins. (2) The supposed lithological, structural, and stratigraphical similarities of the torn continental margins. When one doubting American geologist was asked why he proposed to restudy the Old Red Sandstone of the Scottish Highlands, he humorously replied: "To see if I can discover the tail of a new species of Devonian fish whose head I have recently collected from the coastal cliff of the Gaspé Peninsula." Even the fish is assumed to be moving westward at the time of its demise. With the possible exception of isostasy, and the postulate of the geosyncline, no hypothesis has so served to stimulate further and more varied geological and geophysical investigation, both applied and theoretical, as has Alfred Wegener's suggestion of drifting continents. In my own case, at least, I can affirm that the hypothesis has strongly influenced my motives in attempting to obtain, through geophysical means, original data on the structure of the submerged continental margins of the sub-Atlantic lithosphere. To sum up present opinion regarding the Wegener Hypothesis:

1. A number of structural geologists, especially those who are thoroughly familiar with Alpine tectonics, are in favor of continental drift.

2. An increasing number of geophysicists and astronomers find it an attractive working hypothesis, without perhaps sufficient interest in its origin or the reasons why it was formulated.

3. Nearly all paleogeographers, and most American structural geologists, are against the hypothesis, and this, in spite of the fact that it was originally proposed to mitigate, if not entirely overcome,

most of the serious difficulties imposed on the student of Paleozoic paleogeography by the earlier dictum of the permanency of relatively large oceanic areas.

4. The hypothesis, at least, attempts to solve an important dilemma; namely, it does away with the necessity of Paleozoic land bridges and yet allows for sufficient oceanic area at all times during the structural evolution of the earth.

This problem of the quantitative constancy of the hydrosphere has become of increasing importance in major geological problems during the past few years. It has not yet been definitely determined whether or not the hydrosphere has materially decreased or increased throughout geologic time. Undoubtedly a large amount of water has been temporarily removed from the hydrosphere as connate water and permanently as water of crystallization; on the other hand, an appreciable amount of juvenile water must have been added to the hydrosphere by volcanoes, both continental and submarine. During the past five years, the study of the submarine canyons which dissect the drowned margin of the continental shelves has led to the suggestion that the general ocean level may have been temporarily reduced, over a mile, during the Pleistocene. These submarine canyons were first called to the attention of geologists by J. W. Spencer in 1903. The recent revival of interest in submarine canyons is principally due to new data produced by the skillful geophysical methods of the U. S. Coast and Geodetic Survey, and the mapping and discussion of the data by F. P. Shepard. Shepard suggests that the canyons are entirely of subaerial origin, cut during the Pleistocene, when the ocean level was reduced approximately 3,000 to 6,000 feet by the temporary accumulation of ice on the continents. R. A. Daly, the exponent of a similar hypothesis in relation to the origin of coral reefs, will agree to the reduction of ocean level some 250 feet, but cites what he considers to be insurmountable geophysical difficulties in such a reduction of ocean level as demanded by Shepard. Daly and others have also attempted to explain the origin of the canyons by other means,[2] but no geologist believes that the canyons could be

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[2] Daly suggests that the canyons have been eroded by the submarine scour of exceedingly muddy and super-saline waters, which he postulates occurred at the margins of the Pleistocene ocean. In a recent letter, E. B. Bailey suggests that submarine earthquakes might "help" Daly's hypothesis. H. H. Hess and Paul MacClintock agree with Shepard that the submarine canyons must be of subaerial origin, the result of the requisite reduction of sea level. They, however, in order to overcome what they consider to be the difficulties of a 20,000 to 50,000 foot ice sheet on the continents, suggest what is, apparently, a still more comprehensive astronomical, geodetic, and geophysical difficulty, namely, a relatively rapid and recent change in the ellipticity of the surface

explained by recent pronounced differential movements of the continental margin and ocean floor. Yet it is particularly interesting that the mouths of these submarine canyons dissect the boundary of one of the most pronounced topographic features of the submarine lithosphere, with the possible exception of the foredeep associated with island arcs.

The rise of the application of geophysical methods to the study of the suboceanic lithosphere really began some ten years ago, when F. A. Vening Meinesz first discovered the strip of highly negative gravity anomalies paralleling the East Indian arc and associated foredeep. On the U. S. Navy-Carnegie Expedition of 1928, and the U. S. Navy-Princeton Expedition of 1932, Meinesz discovered the western end of another negative strip. On the recent U. S. Navy-

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of the oceans, due to a sudden decrease in the rate of the rotation of the Earth, and the consequent drawing of the oceanic waters into the polar latitudes. From a letter on the very important question of submarine surveying and physiography, which Dr. D. W. Johnson allowed me to read to the Committee on Continental and Oceanic Structure at the Edinburgh meeting of the International Union of Geodesy and Geophysics, I quote as follows:

"The student of submarine topography, like the unhappy children of Israel, is forced to make bricks without straw. This is clearly apparent in current discussions of the long-debated problem of submarine canyons, where the investigator must formulate hypotheses without that adequate basis of facts which detailed maps of the ocean floor alone can give. The hypothesis that submarine canyons are normal river valleys, carved when the lands stood thousands of feet higher than now, involves consequences for the adjacent land areas which do not appear to be realized. The hypotheses which depend upon the subsurface flow of reaction currents of the type described by Ekman, of heavy currents of colder water, or of heavy currents of silty water, seem of doubtful validity because the potency of the cause appears insignificant when compared with the magnitude of the results accomplished. It is equally difficult to see how submarine landslides could effect the headward development of canyon-like depressions which appear to be long, narrow, and deep. As Professor Davis remarked a few years ago, the origin of submarine canyons remains an open question.

"Recently while studying the supposed meteorite scars of the Carolina coast I have had occasion to consider the effects of underground waters welling up in the form of so-called 'fountain springs,' and producing elongated depressions by a sort of headward migration up the coastal plain slope. It is known that the coastal plain deposits carry water under heavy pressure out under the sea, and that such water rises in artesian wells drilled on islands or sandbars several miles off the coast. I have wondered whether it could be possible that some pervious bed or beds of the coastal plain, at least in occasional places, carry water under pressure to the edge of the continental shelf. If deep submarine springs should develop there, would not such springs perforce migrate backward into the shelf deposits, leaving canyons the depth of which would depend upon the depth at which the upwelling waters escaped on the face of the continental scarp? It will be recalled that such impressive features as the deep and long "alcoves" eroded in the scarps of lava plateaus in the northwestern United States have been ascribed to just such headward migrating spring action. Submarine canyons cut in continental shelves at present submerged off rocky coasts may have been carved when parts of the shelf were above sea level and served to take in water which then migrated down the dip to the scarp face; or aquifers in the older rocks may connect under ground with overlying pervious formations of the blanketing shelf deposits.

"I mention this hypothesis of submarine canyon origin, not because it is now entitled to serious consideration (it occurred to me recently in the midst of other work, and I have not had time to test it adequately, or even to discover whether it has already appeared in the literature), but because it illustrates the difficulty of working without adequate facts."

Geophysical Union Expedition, which returned this January 15, Maurice Ewing, A. J. Hoskinson, and Harry Hess have proved that the negative strip parallels the West Indian Island Arc to its southern termination. Thus we can now say that a pronounced lineal concentration of the greatest known negative gravity anomalies appears to be a common and exceedingly important characteristic of what is suspected as the most profound type of deformation of the lithosphere, from the point of view of both relief and structure. It is also interesting to note that this statement is equally true for both the Atlantic and the Pacific, in spite of the fact that recent seismic evidence strongly suggests important widespread and deep-seated petrological and structural differences between these two great suboceanic areas of the lithosphere.[3]

The geophysical study of island arcs also appears to throw new light on the origin of geosynclines, or those great continental lineal troughs which are characterized by excessive thicknesses of folded and faulted shallow water sediments. It now appears that these great troughs, or furrows, such as the foredeeps, are formed quite independently of sedimentary load. In the case of island arcs, the parallel geanticline is of such small area that it contributes little or no sediment to the trough while it is being formed. On the other hand, where such furrows are developed marginal to, or within, continental areas, they may be filled with sediments as rapidly as they are depressed, any excess sediment being carried beyond the lineal loci of the depressed basement rocks. This evidence that major diastrophic movements of the lithosphere may be entirely independent of the shifting

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[3] During the meeting of the Committee on Continental and Oceanic Structures at Edinburgh, this fall, Dr. Meinesz referred to the distribution of positive anomalies as follows: "Besides the narrow strip of negative anomalies in the East Indies, another systematic deviation of isostasy has been found: The deeper basins of the archipelago all show rather strong positive anomalies over the whole fields of the basins. These fields of positive anomalies are also found in other parts of the world in (possible) geosynclinal areas; they have been found over the basins of the West Indies (Gulf of Mexico, Sea between Cuba and Mexico, and in a few stations in the Caribbean), in the deeper basins of the Mediterranean (e.g., Tyrrhenian Sea and the northwestern part of the Mediterranean). Most of these basins are considered by the leading geologists to have sunk away in recent times; viz., since the Tertiary or in the last half of the Tertiary. A tentative explanation may perhaps here be suggested. It is difficult to explain these fields of positive anomalies by an increase of density of the crust and a sinking because of a subsequent readjustment of isostasy for in that case it cannot be understood that these basins are still so far out of isostatic equilibrium. The hypothesis of convection-currents in the substratum seems to promise more." [It is possible that magnetic studies in these regions of positive anomalies might give additional data on the convection-currents hypothesis.—R.M.F.] Dr. Meinesz closed his discussion with the following statement: "As many of the features of the gravity anomalies are clearly related to the surface features of the crust, topographical and geological, it seems advisable to study them in close collaboration with the geologists and geomorphologists, who have an intimate knowledge of these subjects."

load of sediments is still further being confirmed by the greatly increased number of soundings which have been obtained by geophysical methods in both the Atlantic and the Pacific. Whereas, only a few years ago, the bottom of the Pacific was supposed to be relatively flat, we now know, thanks to the excellent work of the U. S. Navy, that it has high relief, probably of much the same type as that of mountainous continental regions. In his recent interpretation of the bathymetric data obtained on the Snellius Expedition, 1935, P. H. Keunen calls attention to the probable existence of submarine troughs, block-faulted mountains, and fault scarps on an even greater order of magnitude, and more sharply defined both topographically and structurally, than exist on the continents. To quote:

> The theoretical importance of these scarps appears to be considerable. As erosion is practically non-existent on the sea-bottom, and as sedimentation is comparatively slow, it is in itself not surprising to find that a fault scarp, once it is produced, remains standing as a bold cliff, in some cases as much as 3,000 feet high, a feature far more striking than the most pronounced subaerial fault scarps known. The chief interest of these scarps is that they prove the rigidity of the bottom where they occur and that they demonstrate the ability of a fault to reach gigantic proportions without the aid of erosional obliteration of the load of the thrown-up limb.

It must be further appreciated that these submarine structures are formed under 5,000 to 6,000 meters of sea water, the resulting hydrostatic pressure corresponding to a depth beneath the surface of the continental lithosphere of approximately 5,000 to 6,000 feet of solid rock. Thus the suboceanic lithosphere must be quite rigid, not only at the surface but also at considerable depth beneath the surface. Finally, perhaps most important of all, the varied types of evidence just cited necessarily intimate profound diastrophism in the suboceanic lithosphere, over great areas, entirely independent of the transference of load through erosion and deposition; in other words, that the fundamental causes of diastrophism may be deep-seated and largely independent of surface processes.

In closing this greatly condensed history of the geophysical-geological exploration of oceanic basins, I feel it is necessary to emphasize two particularly important submarine geophysical-geological techniques which were started several years ago, and which, within the past few months, have not only produced very important data, but have clearly demonstrated their great potential value. Not only students of sedimentation, but all students of earth science are deeply indebted to C. S. Piggot for the remarkable instrument which he has developed for procuring 10–14 foot cores of oceanic sediments. Time does not permit, nor should I wish to attempt to anticipate the important data which will result from the study of these and future cores, but it is important to note that Piggot has been the first man to improve fundamentally the method of sampling deep sea sediments since the historic voyage of the *Challenger*. This is no mean accomplishment in a pioneer field. To supplement the data derived from the samples of the upper few feet of suboceanic sediments, the American Geophysical Union, through its special Committee, promoted a project for the seismic study of the submerged portion of the continental shelf. Under the able leadership of Maurice Ewing and N. H. Heck, and with the indispensable cooperation of the U. S. Coast and Geodetic Survey, the Woods Hole Oceanographic Institution, and the Geological Society of America, by means of this important new technique, a submarine seismic profile was run from the wedge-point of the Cretaceous-Tertiary overlap to the edge of the continental shelf. According to this single profile, the wedge of Cretaceous-Cenozoic sediments thickens rapidly until, at the continental margin, it is approximately two miles thick.[4] Thus the pre-Cretaceous erosion surface exposed to view in the Piedmont region is at least a mile below the bottom of the bathyal slope at the continental margin. Every effort will be made within the next year or two to discover if this important structural feature continues beyond the edge of the continental platform and eastward under the Atlantic basin. Present indications are that the topographic limit of the Atlantic continental margin may be of no particular structural significance. This prophesy is apparently still further strengthened by the work of Gutenberg and Richter who, after making a careful study of the Atlantic seismic reflections, produced by earthquakes, have come to the conclusion that the Atlantic basin is everywhere underlain by sial, instead of sima; or, in other words, that from 15 to 20 kilometers of continental rocks form the basement of the entire sub-Atlantic lithosphere. Thus the new data suggest not only that there may have been no Atlantic basin in existence during an appreciable portion of the earlier history of the earth, but, more interesting still, that the present Atlantic basin may be due to the downwarp, in post-Paleozoic time, of a vast and now vanished continental area. Such a lost continent could not be a "lost Atlantis" according to the popular conception of the term, but, if true, it might be called a "lost Atlantica" in the structural and

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[4] As the wedge thickens oceanwards it may include lower Mesozoic marine sediments.

paleogeographic sense. At any rate, I believe that, by geophysical methods, we shall be able, before long, to procure sufficient data concerning the basement rocks of the Atlantic to be able to prove, among other things, whether North and South America ever were connected with the present trans-Atlantic continents. While discussing this possibility with Harold Jeffreys last fall at Edinburgh, he said: "I hope that the present sub-Atlantic area was not a continent during the Paleozoic because if it was, I certainly would not know where to put the Atlantic Ocean during the Paleozoic Era." I agreed that would be a tremendous amount of water on anybody's mind, even after making due allowances for essential geosynclinal, epeiric, and epicontinental seas. But, as I have previously mentioned, we may already be faced with considerable difficulty in accounting for the origin of the submarine canyons in the continental shelves. In 1909 Daly demanded a reduction of ocean level of some 300 feet to account for the origin of atolls. Today Shepard demands the reduction of ocean level over a mile to account for the subaerial erosion of the now submarine canyons. A short time hence, we may be wrestling with the problem of where to put the Atlantic Ocean during the Paleozoic. I, therefore, suggest that, until we have more data on the topography and structure of the suboceanic lithosphere, we are not in a particularly strong position to check any major hypothesis which attempts to explain the pattern of the face of the earth. On the other hand, we already have sufficient data which strongly suggest theories other than those already proposed; I refer particularly to the data on the pronounced relief of relatively large areas of the bottoms of the oceans. In the first place, this pronounced relief is not particularly synonymous with the phrase, "ocean basin." We are still apt to think of a basin as a relatively circular depression with a relatively concave, smooth surface. I do not wish to emphasize this conception further than to point out that, in terms of smooth surfaces, a wide shallow basin will accommodate the same amount of water as a smaller but deeper basin. Also, provided the basin remains the same size, its liquid capacity may be increased or decreased by the deformation of its relatively smooth surface. Thus depressions such as the foredeeps of island arcs and fault valleys or grabens, such as the Bartlett Deep, which are developed below the mean basin level, tend to reduce ocean level; while, on the other hand, great positive areas, such as the somewhat misnamed Atlantic Ridge, tend to raise the ocean level. Thus, without necessarily changing the general shape of the basin, the development of many but minor inequalities in its surface will alter the liquid capacity; and the chances will always be strongly against the possibility that the elevations and depressions will cancel each other, especially if they are not subject to isostatic compensation. At the present time, we do not have sufficient topographic data to compute the relation of relief of basin surface to basin capacity. Also, we have not sufficient data concerning the structure of the suboceanic lithosphere to determine the space-time relationships of the depressions and elevations. We do, however, have seismic evidence as to areas in which deformation is active at the present time. For several reasons, it seems wise to plan our geophysical-geological surveys from the continental margins into the oceanic basins for, in this manner, we shall be able to determine the continuity or discontinuity of structures whose space and time relationships *are* known. If, for the present, the theory of drifting continents may be considered as a valuable working hypothesis, it is primarily because it serves to stimulate the exploration of oceanic basins, and thus helps to produce new and badly needed data on that great "terra incognita" of a major portion of the crust of the earth, let that data lead us where it may. Finally, until these data are available, we can not even be sure that the continents are fair geological samples of the entire lithosphere.

SUMMARY

1. The attempt has been made to review the growth of ideas, theories, and hypotheses on continental and oceanic structure, especially in relation to their effect on future trends in geophysical-geological research.

2. From the geological point of view, the epitome of the problem is paleogeography, especially the paleogeography of the pre-Mesozoic history of the earth.

3. Emphasis has been placed on the lack of physiographic and structural data on the suboceanic lithosphere, and the importance of acquiring these data.

4. It has been suggested that further data on the topography and structure of the suboceanic lithosphere will throw important light on such major questions as isostasy, geosynclines, and continental drift.

5. Available data on the suboceanic lithosphere suggest that diastrophism, or the major deformation processes, is relatively independent of transference of surficial load, such as takes place under the conditions of erosion and deposition.

6. Fortunately, geophysical techniques are already, or soon will

be, available for making a geophysical survey of ocean basins. These techniques, to date, include exact positions and sounding, and determination of gravity and seismic methods, all equivalent in accuracy to those now used on the continents. Further, the techniques are sufficiently varied so that they can be used to support or check each other.

7. Since the oceans are international territory, they are not the particular business of any nation, and, though the freedom of the seas may be open to debate, the ocean bottom is unclaimed territory. Last fall, the International Union of Geodesy and Geophysics, at its Edinburgh meeting, created a Commission on Continental and Oceanic Structure. This Commission is approved and supported by twenty-four nations, and it is hoped and planned that it will help serve to promote effective international cooperation in the exploration of the suboceanic lithosphere.

8. The ultimate progress of submarine geophysical-geological surveying depends, however, first, on the methods to be employed or plan of attack, and, second, on the increasing use of important contributing agencies. While a certain amount of money is, of course, a necessary part of each project, such grants can be greatly reduced by the use of existing agencies. Further, in most cases, the grants will be useless without such important material contributions as submarines, cable ships, the specially equipped vessels of marine biological laboratories, and last, but not least, the trained personnel to operate these various types of vessels. So far, we have not found that geophysicists or geologists are particularly good sailors!

In conclusion, I wish to express the thanks of the American Committee of the International Geodetic and Geophysical Union to the United States Navy, the United States Coast and Geodetic Survey, the Woods Hole Oceanographic Institution, the American Bell Telephone Laboratories, the American Philosophical Society, the British Admiralty, the Geophysical Institutes of Norway and Holland, and the Geological Society of America for their most generous and indispensable aid in the exploration of "no man's land." But, as Dr. Bowie has so frankly put it, present thanks carry the intimation of a desire for future favors. Fortunately, even geophysicists and geologists are human, and particularly the new amphibious variety, who have braved the ocean deep, and who, in fear of being wrecked upon a storm of hypotheses, are crying out for more and more help in their factual surveys.

BOTANY.—Phacelia mustelina, *a new plant from Death Valley, California.*[1] FREDERICK V. COVILLE, Bureau of Plant Industry.

Eleven species of the genus *Phacelia,* family Hydrophyllaceae, are known from Death Valley. One of them, *Phacelia perityloides,* is a round-leaved, white-flowered perennial. All the others are annuals that have blue, violet, purple, or lavender flowers. In years of good rainfall several of these species are abundant and characteristic plants of the desert landscape, and a few of them are conspicuous for their beauty. Their blossoms occur in a one-sided cluster known as a scorpioid raceme, or scorpioid cyme, which unrolls, as the flowers open, from a tight, flat spiral. From this characteristic of their inflorescence, the species of *Phacelia* are known as curlybloom.

The present paper deals with an apparently new species of this genus, discovered in Death Valley by M. French Gilman.

Phacelia mustelina Coville, sp. nov.

Planta annua, *Phaceliae rotundifoliae* affinis, sed foliis ovatis vel oblongis et corolla violacea, quam calyce fere duplo longiore, corollae tubo calycem a circiter duplo longitudine loborum corollae superante; *Phaceliae pulchellae* etiam affinis, sed caulibus glanduloso-pilosis, corollae latitudine circiter 4–5 mm. *Phaceliae rotundifoliae* folia orbicularia vel reniformia sunt, et corolla alba, tubo calycem vix superante; *Phaceliae pulchellae* caules glanduloso-puberulenti sunt, et corollae latitudo 8–10 mm.

Plant annual, 3 to 10 cm high, branching; stems, as well as the petioles, leaf blades, peduncles, pedicels, and calyx lobes, pilose with weak hairs, many of them gland-tipped; leaf blades up to 2.5 cm long, ovate to oblong, mostly cordate at the base, coarsely and shallowly dentate with as many as 5 large teeth on each side and often with much smaller teeth in the sinuses between the large teeth, the lower leaves with petioles longer than the blades, sometimes twice as long; inflorescence consisting of terminal several-flowered scorpioid bractless cymes, on peduncles 1.5 cm or less in length, the lowest pedicels 5 mm long or less; calyx lobes 3.5 to 5.5 mm long, narrowly oblanceolate to narrowly oblanceolate-spatulate, obtuse; corolla about 4 to 5 mm across when expanded, 6 to 9 mm long, violet, nearly twice as long as the calyx, the corolla tube usually exceeding the calyx by about twice the length of the corolla lobes, and about 2 to 3.5 mm in diameter at the base of the lobes, pilose above with long weak hairs, an occasional hair gland-tipped, the lower part of the corolla tube glabrous, the lobes rounded, broader than long, about 2 mm wide and 1.5 mm in length, the corolla appendages attached by one margin to the corolla tube, linear, narrowed above and without a free apex; stamens 5, shorter than the corolla tube, the filaments unequal, very sparingly hairy toward base but usually appearing hairless even under a lens; ovary and immature capsule sparingly hairy, ovules 40 in the ovary examined, the style longer than the calyx, sparingly hairy below, bifid at the apex to the depth of about 1 mm; seeds immature 0.5 to 0.8 mm long, pitted.

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[1] Received January 29, 1937. This is the last paper written by Dr. Coville.

Type specimen in the United States National Herbarium, no. 1,630,905, collected June 23, 1935, by M. French Gilman, no. 1810, in Death Valley, California, at the head of Titus Canyon, Grapevine Mountains, tightly wedged in the crevices of a ledge of rhyolite rock, at an elevation above 6,000 feet.

Collected also on rock ledges at similar elevations in a branch of Wildrose Canyon, June 13, 1935 (Gilman 1706), and in Wood Canyon, June 18, 1935 (Gilman 1750), both on the west slope of the Panamint Mountains, which border Death Valley on the west.

Probably the nearest relative of *Phacelia mustelina* is *P. gooddingii* Brand, 1913, a species which appears to be the same as *P. pulchella* A. Gray, 1875. Brand, in his account of the genus *Phacelia* in the Pflanzenreich (Heft 59, 1913), distinguishes *gooddingii* from *pulchella* by its glabrous filaments and its approximately 25 ovules on each placenta. He describes *pulchella* as having sparsely pilose filaments and 7 to 10 ovules to each placenta.[2] A careful examination of the original collection on which *Phacelia pulchella* was based, C. C. Parry no. 182,[3] and of the original collection from which *P. gooddingii* was described, Goodding no. 2307, shows that in both specimens the filaments are sparingly pilose toward the base, and the ovules are about 50 to 60 per capsule. Both type specimens are branched from the base, the branches ascending and glandular-puberulent. In both specimens the calyx, at flowering time, is about 5 mm long, and the corolla twice as long or sometimes more. I can find no reason for separating *gooddingii* from *pulchella*. The type specimen of *pulchella* came from the vicinity of St. George, southwestern Utah, where it grew on "gypseous clay knolls." The type of *gooddingii* came from Las Vegas, southeastern Nevada, little more than a hundred miles from St. George and in the same climatic zone, and was recorded by its collector, Leslie N. Goodding, as growing on "gumbo flats."

Phacelia mustelina differs from *P. pulchella* in its glandular-pilose stems, the hairs weak and the longer ones half a millimeter or even a millimeter in length; its non-glandular hairs (mixed with gland-tipped hairs) on the leaf blades weak and often reaching a length of 0.7 mm or more; and its corolla about 4 to 5 mm across, when the lobes are expanded. In *pulchella* the stems are glandular-puberulent, the gland-tipped hairs stout, and probably not more than a tenth of a millimeter in length; the non-glandular hairs (mixed with gland-tipped hairs) on the leaf blades are stout and less than half a millimeter in length; and the corolla is about 8 to 10 mm across when the lobes are expanded. In all our specimens of *mustelina* the larger leaves are cordate at the base, a characteristic seldom found in *pulchella*. Mature seeds of *P. mustelina* are not available for comparison with those of *pulchella*.

Among the phacelias of Death Valley itself the species most closely related

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[2] Pflanzenreich **59**: 105, 116, 120. 1913.

[3] See A. GRAY, Proc. Amer. Acad. Sci. **10**: 326. 1875. Also C. C. PARRY, Amer. Nat. **9**: 16. 1875.

to *mustelina* is *Phacelia rotundifolia* Torr. Our specimens of *rotundifolia* from the Death Valley region were collected at elevations below 5,000 feet, the lowest at 900 feet. Besides this differences in altitudinal range and the differences between *mustelina* and *rotundifolia* cited in the Latin diagnosis, Mr. Gilman writes that the odor of the herbage of the new species is different from that of *rotundifolia* and is the "odor of an angry or scared weasel," a characteristic indicated in the name *mustelina*.

BOTANY.—*New species and nomenclatorial changes in eastern Asiatic Myrsinaceae.*[1] EGBERT H. WALKER, U. S. National Museum. (Communicated by ROLAND W. BROWN.)

This is the fourth paper[2] the writer has published on the Myrsinaceae of China and Japan preliminary to a critical revision of this group. The new species and nomenclatorial changes are here published because of unavoidable delay in the appearance of the revision.

Ardisia (Subg. **Akosmos** Mez) **brunnescens** Walker, sp. nov. Fig. 1

Frutex 3 m altus undique glaber; folia subtus brunnescentia glandulis marginalibus non donata, nervis lateralibus 10–15-jugis, subtus elevatis, venulis elevatis reticulatis, nervo marginali non prominulo vel nullo; inflorescentiae in ramulis glabris lateralibus specialibus subterminales, paniculato-cymosae vel duplicato-umbellatae, ramulis gracilibus, pedicellis gracilibus nonnihil clavatis; flores 4 mm longae; sepala ovata, obtusa, per anthesim non valde dextrorse imbricata, non-numquam obscure fusco-lepidota; fructus atro-rubescens, nonnihil obscure punctatus.

Type in the herbarium of the New York Botanical Garden, collected by H. B. Morse at Lungchow, Kwangsi, no. 708, distributed by A. Henry. An additional specimen is Wang no. 485, collected in Yun Fou District, West River region, Kwangtung, distributed by Sun Yatsen University.

This species seems to resemble most closely *A. viburnifolia* Pitard in Lecomte's Fl. Gen. Indo-Chine **3**: 821. 1930. In the original description of that species no collector's number is cited, but a specimen in the New York Botanical Garden, Poilane no. 11914 from the same locality, apparently belongs to Pitard's species. It differs in having fewer prominent lateral nerves and flowers about half as large as those of *A. brunnescens*.

Ardisia (Subg. **Crispardisia** Mez) **filiformis** Walker, sp. nov. Fig. 2

Frutex 1 m altus, ramulis pergracilibus glabris; folia membranacea, 12–19

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 27, 1937.

[2] *Four new species of Myrsinaceae from China.* This JOURNAL. **21**: 477–480, figs. 1–4. 1931.

Embella scandens (Lour.) Mez and its eastern Asiatic allies. Lingnan Sci. Jour. **10**: 475–480. 1931.

Maesa hirsuta (Myrsinaceae), a new shrub from Kweichow, China. Papers Michigan Acad. Sci. **20**: 231–232, pl. 50. 1935.

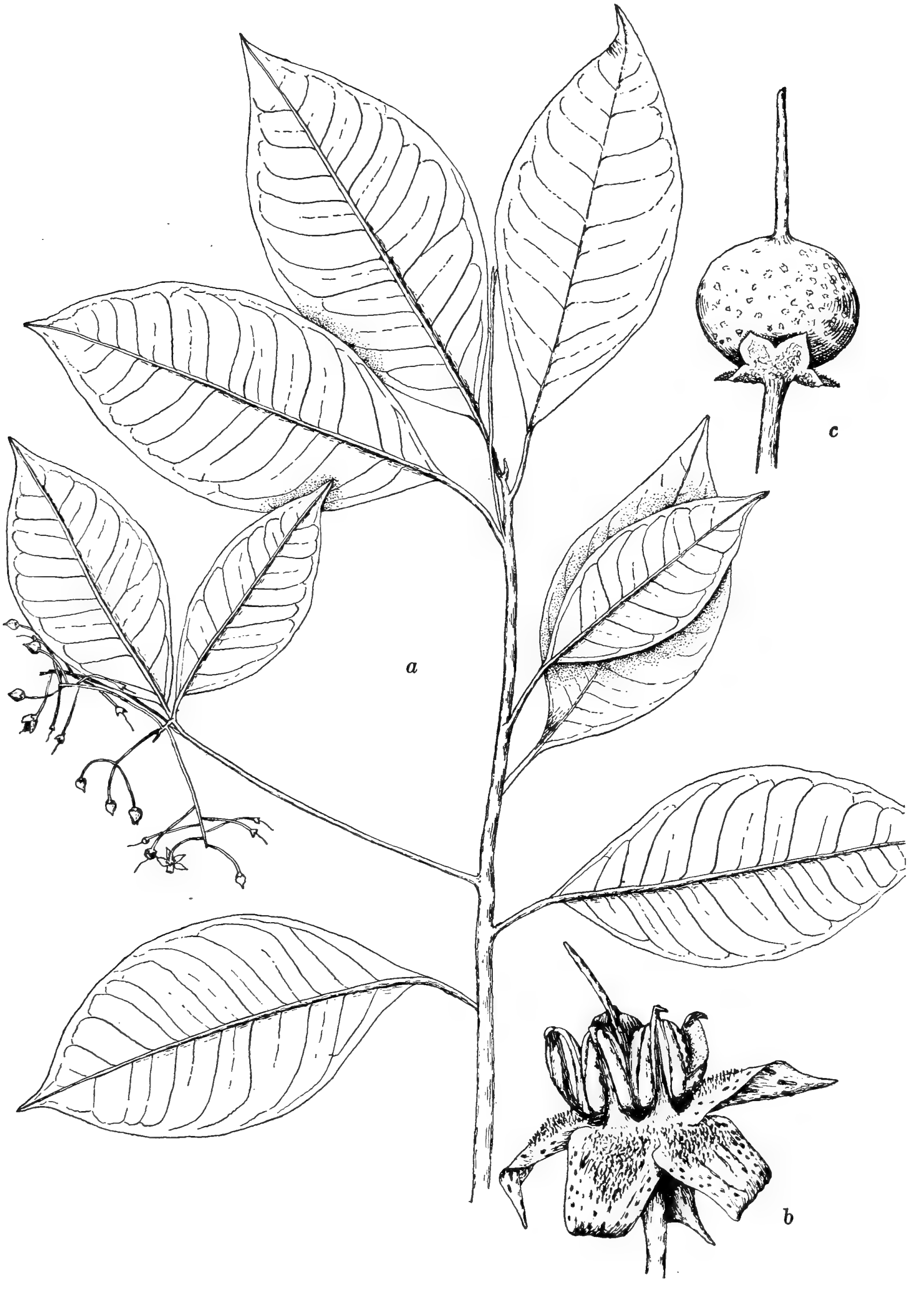

Fig. 1.—*Ardisia brunnescens* Walker, sp. nov. *a*, Branchlet with inflorescence, ½ nat. size; *b*, flower, ×5; *c*, fruit, ×5. Drawn from type specimen *Morse* no. 708.

cm longa, 1–2.5 cm lata, glabra, subtus paulum lepidota, nervis marginalibus distinctis, nervulis ramosis in glandulas marginales desinentibus; inflorescentiae glabrae, paniculatae, ramulis valde gracilibus; sepala non valde imbricata, minute punctata; antherae dorso non punctatae; fructus circa 6 mm longus, rubescens, distincte punctatus.

Type in the United States National Herbarium, no. 1,273,493, collected under forest at Seh-feng Dar Shan, S. Nanning, Kwangsi, Oct. 19, 1928, by R. C. Ching, no. 8000. Additional specimens seen are *W. T. Tsang*, no. 22393, collected May 27, 1933, near Iu Shan village, southeast of Shang-sze, Shang-sze district, Kwangsi near the Kwangtung border, deposited in the Arnold Arboretum; and *W. T. Tsang* no. 22567, collected in the same locality June 26, 1933, deposited in Arnold Arboretum and in the United States National Herbarium.

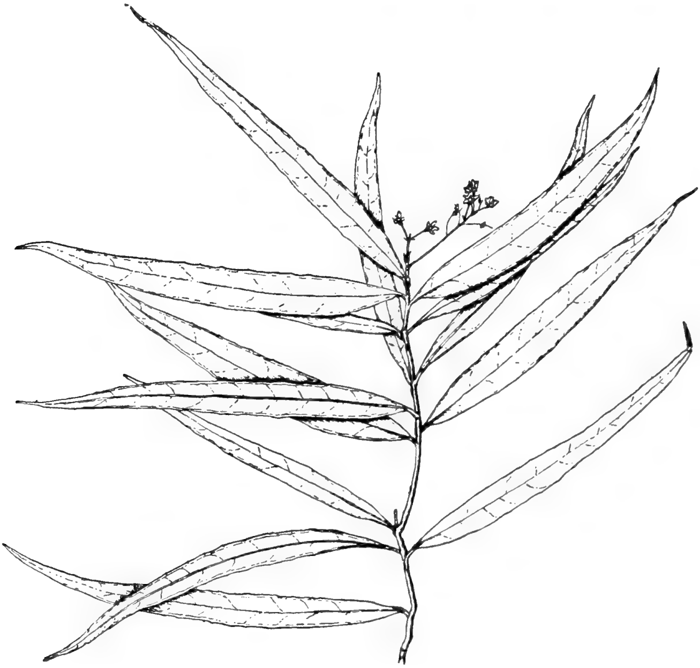

Fig. 2.—*Ardisia filiformis* Walker, sp. nov. Branchlet with inflorescence ×⅓. Drawn from *W. T. Tsang* no. 22393.

This species is distinct in its very slender branchlets, its paniculate inflorescences with almost filamentous peduncles and pedicels, and its slenderly lanceolate, long-acuminate membranous leaves. The marginal glands subtending the veinlets which branch from the distinct marginal nerve are very small and sometimes almost wanting. Its position in the subgenus *Crispardisia* is thus uncertain.

Embelia henryi Walker, sp. nov. Fig. 3

Frutex scandens, ramulis novellis puberulis glabratis; folia coriacea, 20–30 mm longa, 8–10 mm lata, serrulata, subtus nigro-punctata, nervis lateralibus numerosis, obscuris, subtilibus; flores 5–7, 5-meri, subcorymbosi, pedunculo 4 mm longo, e basi subsquamosa vel subnuda oriundo, pedicellis 3–4 mm longis; fructus globosus, 4 mm longus, atro-ruber, nigor-punctatus.

Type in the herbarium of the Arnold Arboretum, collected at Mengtze, Yunnan, by A. Henry, no. 10913; duplicate in the Herbarium of the New York Botanical Garden.

Fig. 3.—*Embelia henryi* Walker, sp. nov. *a*, Branchlet with inflorescences, natural size; *b*, portion of corolla of ♀ flower showing attached stamens, ×8; *c*, pistil, ×8.

Maesa insignis Chun, Sunyatsenia **2**: 81, pl. 20. 1934

Maesa hirsuta Walker, Papers Michigan Acad. Sci. **20**: 232, pl. 50. 1935.

The description of Chun's species appeared in print while that of *M. hirsuta* Walker was in process of publication and the manuscript could not be recalled. Subsequently a type collection of Chun's species was examined and found to differ significantly only in length of petioles. However, such a difference is not a valid character for separating these two species.

(For explanation of Fig. 4, see bottom of opposite page.)

Maesa permollis Kurz, Jour. Asiat. Soc. Bengal. **40^2**: 66. 1871

Stout climbing shrub, 2 to 3 m high, the branches rather few somewhat thickened or the ultimate rather slender, densely pubescent with rufous setose hairs almost throughout; leaves petiolate (3–25 mm), the blade thick-membranous, about 25 cm long, 12 cm wide, ranging from 12 to 30 cm long, 4 to 18 cm wide, elliptic or oblong to broadly obovate, rounded or obtuse at base, obtuse to acute or acuminate at apex, distinctly sinuate or serrate-dentate with callose teeth, green and glabrous or nearly so above, brownish and densely rufous pilose or hirsute beneath especially on the nerves, the midrib prominent, the lateral veins terminating in the teeth; inflorescence short, subglomerate or racemose or subpaniculate, shorter than petiole or up to 4 cm long, rather many-flowered, densely hirsute; flowers about 3 mm long, on short pedicels scarcely 1 mm long, white, the bracts minute, about equaling the pedicels; sepals equaling the pedicels, united into a tube almost as long as the limb, ovate, acute, densely hirsute or pilose, the margin narrowly scarious; corolla tubular campanulate, glabrous, the tube about 2 mm long, lightly lined or smooth, the lobes ovate, narrowly rounded, more or less spreading; stamens included, attached within the tube, the filaments short, the anthers about equal to the filaments, broadly elliptical; pistil with short thick style and indistinctly lobed stigma; fruit about 4 mm long, ovoid, acute or apiculate at apex, reddish, densely hirsute.

Distribution.—Southern Asia from Burna to Yunnan and Kweichow.

Specimens examined in various American and British herbaria:—Kweichow: *Y. Tsiang* 4622, 4768. Yunnan: *Forrest* 29394; *Henry* 9649, 9649A, 9649B, 11707, 11707A, 11707B, 11707C, 11707D; *Rock* 2580.

Maesa permollis var. **effusa** Walker, var. nov. Fig. 4

Frutex 3–8 m altus, e forma typica inflorescentibus valde paniculatis ad 9 cm longis differens.

Type in the herbarium of the Royal Botanic Gardens, Kew, England, collected by G. Forrest, No. 12143, in Yunnan; duplicate in the herbarium of the Royal Botanic Garden, Edinburgh. An additional collection is *Forrest* 13637, collected in the "open Jungle in the Taping valley, Upper Burma, . . . alt. 2000 ft, April 1917."

ZOOLOGY.—*A note on the members of the nematode genus* Trichostrongylus *occurring in rodents and lagomorphs, with descriptions of two new species.*[1] GERARD DIKMANS, U. S. Bureau of Animal Industry. (Communicated by EMMETT W. PRICE.)

The genus *Trichostrongylus* was established by Looss (1905) with *Trichostrongylus retortaeformis* (Zeder, 1800) Looss, 1905, as type species. At the present time the genus contains a large number of species of which the following have been reported from rodents and lagomorphs:

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[1] Received March 2, 1937.

Fig. 4.—*Maesa permollis* var. *effusa* Walker, var. nov. Type specimen, slightly less than half natural size.

1. *Trichostrongylus fiberius* Barker, 1915, from the American muskrat, *Ondatra zibethica* (=*Fiber zibethicus*), (?) Nebraska.
2. *Trichostrongylus calcaratus* Ransom, 1911, from cottontail rabbit, *Sylvilagus floridanus mallurus*, Bowie, Maryland.
3. *Trichostrongylus retortaeformis* (Zeder, 1800) Looss, 1905, from the domestic rabbit, *Oryctolagus cuniculi*, and European hare, *Lepus europeaus*, Europe.
4. *Trichostrongylus pigmentatus* (von Linstow, 1904) Hall, 1916, from *Lepus nigricollis*, Ceylon.
5. *Trichostrongylus affinis* Graybill, 1924, from wild rabbits, Princeton, New Jersey.
6. *Trichostrongylus delicatus* Hall, 1916, from the squirrel, *Sciurus aberti mimus*, Colorado.
7. *Trichostrongylus colubriformis* (Giles, 1892) Ransom, 1911, from hares and rabbits in U.S.S.R. and from *Sylvilagus nuttallii pinetis* and *Lepus* sp. in the United States.

As noted by Hall (1916), Barker's description of *Trichostrongylus fiberius* is very unsatisfactory. Neither the nature of the bursal rays nor that of the spicules can be determined from his figures and descriptions. During the course of the present investigation, trichostrongyles collected from muskrats originating in New Jersey and Iowa have been identified as *Trichostrongylus calcaratus* Ransom, 1911.

Trichostrongylus retortaeformis (Zeder, 1800) Looss, 1905, has been reported as a parasite of rabbits and hares from Europe, but to date there is no record of its occurrence in these animals in the United States. The one specimen labeled *Trichostrongylus retortaeformis* found in the Helminthological Collection of the U. S. National Museum proved on examination to be *Trichostrongylus calcaratus*.

An examination of rabbit parasites which had been entered in the Helminthological Collection of the Bureau of Animal Industry showed that a bottle labeled *Nematodirus* sp. from *Sylvilagus nuttallii pinetis* collected at Howbert, Colorado, contained two kinds of nematodes, one of which on examination proved to be *Trichostrongylus colubriformis;* this nematode was found to have been collected also from *Lepus* sp. in Nebraska. The determination of these latter specimens was made by Dr. E. W. Price of the Zoological Division. They are listed in the collection under Nos. 28165 and 28181. We have, therefore, three records of the occurrence of *T. colubriformis* as a parasite of the Leporidae in the United States. These records are from Colorado and Nebraska.

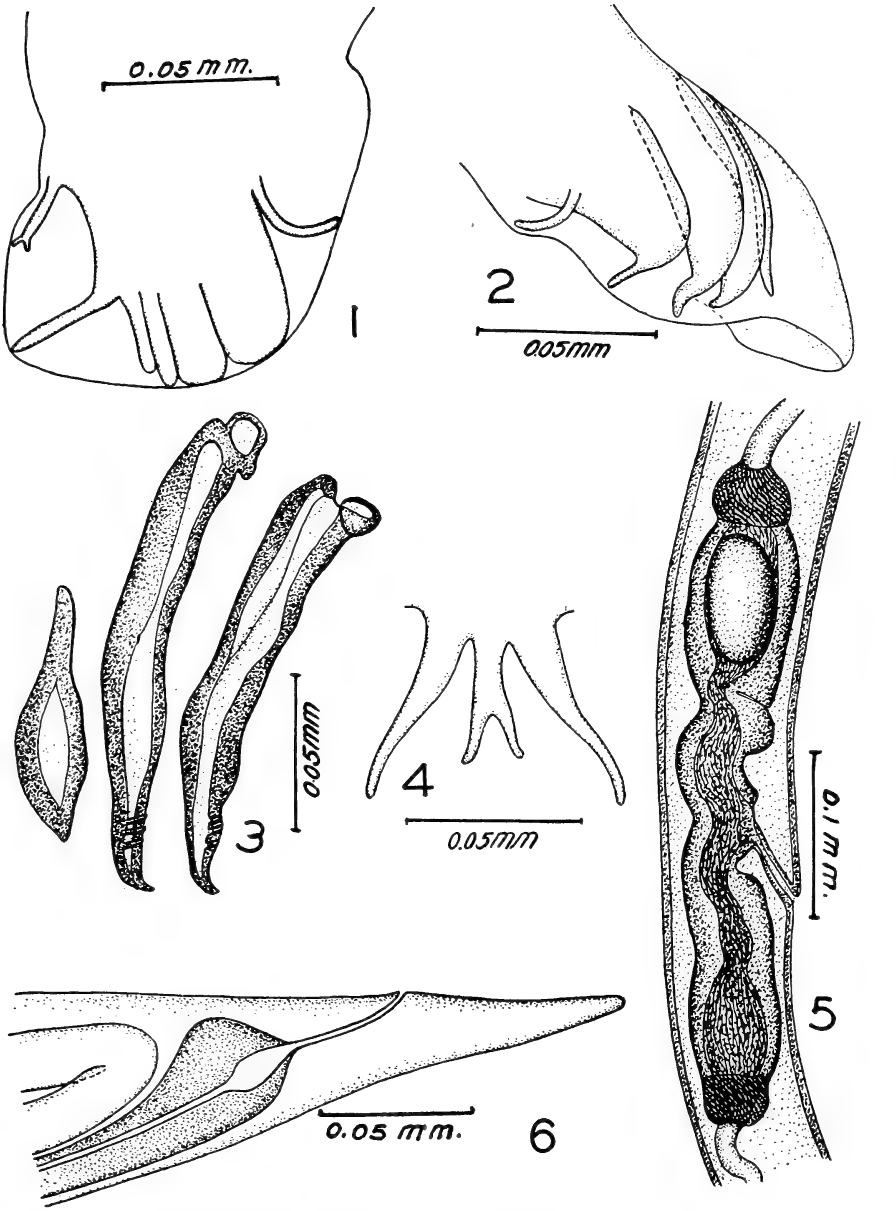

Fig. 1.—*Trichostrongylus ransomi*, n. sp. 1, bursa, right lateral view; 2, bursa, left lateral view; 3, spicules and gubernaculum; 4, dorsal rays of bursa; 5, muscular portion of ovejectors; 6, terminal portion of female.

Trichostrongylus calcaratus was reported by Ransom from *Sylvilagus mallurus* from Bowie, Maryland. During the present investigation these nematodes have been found also in the muskrat, *Ondatra* *zibethica*, and the ground hog, *Marmota monax monax*. This nematode is also a common parasite of wild rabbits in Louisiana.

Trichostrongylus delicatus Hall, 1916, has been reexamined by H. F. Nagaty of the Liverpool School of Tropical Medicine and in a letter dated February 28, 1931, addressed to Dr. M. C. Hall, he states that in his opinion *T. delicatus* is identical with *T. colubriformis* (Giles, 1892) Ransom, 1911. (= *T. instabilis* (Railliet, 1893) Looss, 1905, and *subtilis* Looss, 1905.)

In addition to the species listed above, two new species, one from a rabbit and the other from a prairie dog, have been found and are described below.

Trichostrongylus ransomi n. sp. Fig. 1

Specific diagnosis.—Trichostrongylus:

Male 2.25 to 3 mm long by 100μ wide just anterior to bursa; head about 8μ wide. Esophagus 500 to 600μ long. Spicules equal and similar 130 to 140μ long; distal part of each recurved rather sharply and ending in a sharp point; there are three short projections on the inner side of the spicule a short distance in front of the termination of the spicule, which give it the appearance of being serrated. The bursa is tightly rolled in such a manner that it is almost impossible to determine the disposition and course of the rays. As in *T. calcaratus* and *T. affinis*, the ventro-lateral and the externo-lateral rays are the heaviest; externo-dorsals with slender tips but widening considerably at their juncture with the postero-lateral and dorsal rays; dorsal ray lying midway between the two externo-dorsals bifurcating once and terminating in two straight processes.

Female from 3 to 3.5 mm long. Combined length of muscular portions of ovejectors 375 to 440μ. Distance from vulva to anus about 450μ; that from anus to tip of tail 50 to 60μ. Eggs 60 to 70μ long by 30 to 36μ wide.

Host.—Rabbit (probably *Sylvilagus floridanus alacer*).

Location.—Small intestine.

Locality.—Jeanerette, Louisiana, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection no. 30462.

Trichostrongylus texianus n. sp. Fig. 2

Specific diagnosis.—Trichostrongylus:

Male 2.8 to 3 mm long and 65 to 70μ wide in region of proximal ends of spicules. Esophagus 800 to 825μ long and about 30μ wide near its termination. Spicules unequal in length; right spicule about 85μ long and left spicule about 100μ long. Right spicule 25μ wide at a distance of about 65μ from proximal end, narrowing abruptly from that point and ending in a sharp point; left spicule also ending in a sharp point; when viewed from the side both spicules present frontal projections, the one on right spicule located about 20 to 22μ from distal end, the one on left spicule about 30μ from distal end, both spicules presenting bluntly pointed branches originating near

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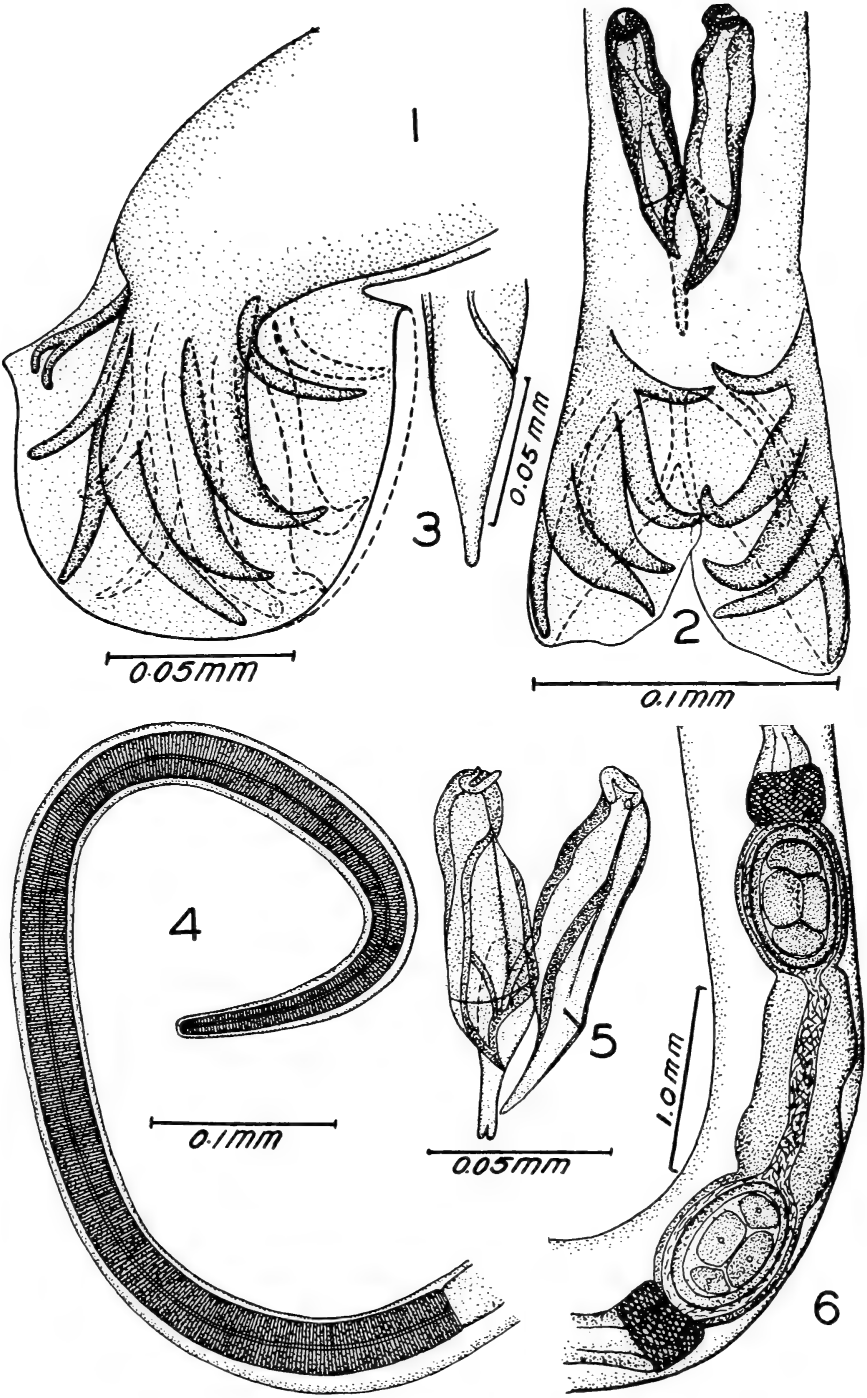
Fig. 2.—*Trichostrongylus texanus*, n. sp. 1, bursa, lateral view; 2, terminal portion of male, ventral view; 3, tail of female; 4, anterior portion of body; 5, spicules and gubernaculum; 6, muscular portion of ovejectors.



(For explanation of Fig. 2, see bottom of opposite page.)

dorsal border. Gubernaculum paddle-shaped, 55μ long and 15μ to 17μ wide, with a slight indentation in the end of the handle of the paddle; handle of paddle about 20μ long and indentation about 5μ long. Bursa symmetrical; ventro-ventral ray small and widely separated from ventro-lateral ray as in other members of genus; ventro-lateral, externo-lateral and medio-lateral rays running parallel toward edge of bursa; postero-lateral diverging from medio-lateral in the dorsal direction; externo-dorsal rays originating at base of dorsal ray; dorsal ray bifurcating about 12 to 15μ from distal end, the unbranched tips of bifurcation bending ventrally.

Female 4.8 to 5.2 mm long and 85 to 90μ wide in region of vulva; head 7 to 10μ wide. Esophagus 850μ long by 25 to 30μ wide at its distal portion. Combined length of muscular portions of ovejectors, including sphincters, 350μ. Vulva 850μ from end of tail; distance from anus to tip of tail 60 to 65μ. Eggs 70 to 80μ by 45 to 50μ.

Host.—Prairie dog, *Cynomys ludovicianus arizonensis.*

Location.—Small intestine.

Localities.—Nolan and Runnels Counties, Texas, U.S.A.

Type specimens.—U. S. National Museum Helminthological Collection no. 30463.

The two species described above may be differentiated from other species occurring in rodents and lagomorphs by the following key:

KEY TO THE SPECIES OF TRICHOSTRONGYLUS IN RODENTS AND LAGOMORPHS[2]

1. Spicules more than 550μ long; viscera pigmented black. . *T. pigmentatus*
   Spicules less than 500μ long; viscera not pigmented black 2
2. Spicules more than 175μ long, asymmetrical; distal end of right spicule smooth, of left spicule serrated. . . . . *T. calcaratus*
   Spicules less than 175μ long 3
3. Spicules 130 to 155μ long, distal ends provided with two blunt recurved hooks; distance from anus to tip of female tail 140 to 165μ *T. affinis*
   Distal ends of spicules not provided with blunt, recurved hooks; distance from anus to tip of female tail less than 140μ. 4
4. Spicules 130 to 140μ long, distal ends recurved, ending in sharp points and with three projections on inner side of each spicule. . . . *T. ransomi*
   Distal end of spicules not provided with projections as above 5
5. Spicules equal, 135 to 145μ long, terminal hook of spicules long and sharply defined but not high; distance from anus to tip of female tail 55–70μ. . . . . *T. colubriformis*
   Spicules unequal 6
6. Spicules similar in conformation to those of *T. colubriformis*, shorter spicule 145μ long, longer spicule 157–172μ long; median side of each spicule provided with two long, thin appendages; female tail long and narrow. . . . . *T. retortaeformis*
   Right spicule about 85μ and left about 100μ long; right spicule narrowing abruptly about 65μ from proximal end; both spicules terminate in sharp points . . . . *T. texianus*

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[2] *T. fiberius* has not been included in this key because it is impossible to determine its identity from the original description and figures.

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ENTOMOLOGY.—*Records of* Argynnis diana *and of some other butterflies from Virginia.*[1]

AUSTIN H. CLARK, U. S. National Museum, and CARROLL M. WILLIAMS, University of Richmond.

The great diversity of geographic conditions in Virginia is reflected in widely varying faunal conditions in different portions of the State. The low-lying eastern portion is a northeasterly extension of the Lower Austral life zone. The mountains in the west are characterized by a southwesterly extension of the Transition zone, with their highest summits, in the southwest, capped by Canadian "islands." Between the Lower Austral and Transition zones is a narrower strip of Upper Austral not very clearly differentiated—so far as the butterflies are concerned—from the Lower Austral.

The Lower Austral zone in Virginia presents some curious anomalies. Perhaps the most interesting of these anomalies is the occurrence in localized areas of species of butterflies characteristic of the Transition zone. Such species are *Argynnis diana, Satyrodes eurydice,* and the typical form of *Atrytone dion,* which seem quite out of place on the hot coastal plain. *Argynnis cybele,* common in the Upper Austral and Transition zones, also occurs here.

In these same areas *Enodia creola* is widespread and locally common, and *Amblyscirtes carolina* is almost everywhere present, though apparently never very numerous. *Enodia portlandia* and *Amblyscirtes textor* also are common here, but both of these range eastward to the sea.

Atrytone dion dion occurs in the cool boggy hollows between the sand dunes west of Cape Henry; the southern form, *A. d. alabamae,* occurs further to the northward, in the Dahl swamp in Accomac County. The other species are found, in more or less widely separated localities, along the western border of the Dismal Swamp and in and

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[1] Received March 2, 1937.

near the swamps bordering the Blackwater and the Meherrin rivers.

We have thought it advisable at this time to call attention to this curious feature in the distribution of butterflies in Virginia in the hope that others may be stimulated to undertake investigations in this region. A very large number of records will be necessary before this and other anomalies in the distribution of the butterflies in the Virginian coastal plain can be properly interpreted.

Through the courtesy of a number of our colleagues we are privileged to include their records with our own. We are under special obligations to Prof. Ellison A. Smyth, Jr., of Salem (formerly of Blacksburg), Va.; to Prof. Lorande Loss Woodruff of Yale University, New Haven, Conn.; to Dr. G. W. Rawson, of Detroit, Mich.; to Mr. Herman J. Erb, of Ozone Park, N. Y.; to Mr. C. C. Walton of Richmond, Va.; and to Mr. W. Herbert Wagner, of Washington, D. C.

Argynnis diana.—The male of *Argynnis diana* was described and figured by Pieter Cramer in 1779. The locality he gave for his specimen was "Virginia."

The species was not again recorded from Virginia until 1895 when Prof. Ellison A. Smyth, Jr., wrote that it occurred in Montgomery County and "along the Blue Ridge," and in 1896 when Dr. Henry Skinner said that "the females found in eastern Tennessee, western North Carolina and southern Illinois are larger than those found in the mountains of Virginia."

In 1899 Sherman Denton mentioned its occurrence in "Western Virginia." In 1916 William C. Wood recorded it from Camp Craig, near Blacksburg, and Professor Smyth recorded it from Blacksburg and said that he had found it in Montgomery, Washington, and Giles Counties.

In 1934 and 1935 the senior author recorded it from Apple Orchard mountain in Bedford County.

The locality from which came Cramer's specimen still remained a mystery, for all the later records are from the mountains—territory but little explored in Cramer's time.

This butterfly has a much wider range in Virginia than one would be led to suppose from the few published records. It even occurs on the coastal plain. During the past summer the junior author took it south of Zuni and southeast of New Bohemia in the vicinity of the Blackwater river, and presumably it occurs elsewhere in this region.

Its occurrence here in the long settled portion of Virginia would explain satisfactorily how it happened that Cramer was able to secure a specimen, and we believe that eastern Virginia should be regarded as the type locality of the species.

The localities from which *Argynnis diana* is known in Virginia are:

Bath County: Warm Springs (G. W. Rawson); Hot Springs (Col. Wirt Robinson). Alleghany County: Clifton Forge, July 5, 1936 (C. C. Walton). Giles County: (E. A. Smyth, Jr., 1916); Mountain Lake, July 1936 (L. L. Woodruff). Bland County: Effna, July 19, 1936 (A. H. and L. F. Clark). Dickenson County: Fremont, July 18, 1936 (A. H. and L. F. Clark). Washington County: (E. A. Smyth, Jr., 1916); Damascus, July 13, 1936 (A. H. and L. F. Clark); Konnarock, July 13, 1936 (A. H. and L. F. Clark). Smyth County: Iron Mountain, July 10, 1936 (A. H. and L. F. Clark); Elk Gardens (Miss Umbarger); below Elk Gardens, July 11–13, 1936 (A. H. and L. F. Clark). Patrick County: Blue Ridge Mountain, near Lovers' Leap, September 1, 1936 (A. H. and L. F. Clark). Montgomery County: (E. A. Smyth, Jr., 1895, 1916); Blacksburg (E. A. Smyth, Jr., 1916); Camp Craig, near Blacksburg, taken by C. Harvey Crabill in August, 1914 (Wood, 1916); Poverty Hollow, near Blacksburg, 1933 (H. J. Erb). Roanoke County: Salem (E. A. Smyth, Jr.). Bedford County: Apple Orchard Mountain (A. H. Clark, 1934, 1935). Chesterfield County: (C. M. Williams). Prince George County: Southeast of New Bohemia, July 28, 1936 (C. M. Williams). Isle of Wight County: South of Zuni, August 22, 1936 (C. M. Williams). *Indefinite records:* Along the Blue Ridge (E. A. Smyth, Jr., 1895); Mountains of Virginia (Skinner, 1896); Western Virginia (=? West Virginia) (Denton, 1899); Virginia (Cramer, 1779).

Although this butterfly is widely distributed over the state it is very local, and in the places where it is found it occurs as a rule only in small numbers. Its favorite haunts are steep damp slopes and ravines where it keeps largely in the woods unless lured to the roadsides or into the open by the flowers of milkweed or ironweed.

Argynnis cybele.—This species, common in the piedmont region and in the mountains, was found south of Zuni, Isle of Wight County, on September 6, 1936 (A. H. and L. F. Clark).

Enodia creola.—This butterfly proves to have a fairly extensive range in eastern Virginia, flying usually, though not always, with *E. portlandia.* Unpublished records are: Near New Bohemia, Prince George County, June 22, 1936 (G. W. Rawson and W. H. Wagner); near Petersburg, Dinwiddie County, June 25, 1936 (C. M. Williams); near Zuni, Isle of Wight County, September 6, 1936 (A. H. and L. F. Clark); Emporia, Greensville County, August 19, 1936 (C. M. Williams). We have noticed, independently, that both this species and *E. portlandia* are invariably associated with the cane (*Arundinaria gigantea*) which we therefore believe is their food plant in eastern Virginia. Both species are curious in being normally more or less active in the evening until it becomes too dark to see them.

Satyrodes eurydice.—Unpublished records for this species are: Langley, Fairfax County, July 5, 1936 (A. H. and L. F. Clark); Difficult Run, Fairfax County, September 19, 1936 (W. H. Wagner); Richmond, Henrico

County, July 1, 1936 (C. M. Williams); Quinton, New Kent County, August 30, 1936 (C. M. Williams); Burks Garden, Tazewell County, July 19, 1936 (A. H. and L. F. Clark); and near New Bohemia, Prince George County, June 22, 1936 (G. W. Rawson and W. H. Wagner); Emporia, Greensville County, September 3, 1936 (A. H. and L. F. Clark).

Neonympha areolatus var. *septentrionalis.*—Apparently widely distributed, though very local, in the coastal plain and lower piedmont; new records are: Lunenburg, Lunenburg County, September 2, 1936 (A. H. and L. F. Clark); north and south of Emporia, Greensville County, August 19, 1936 (C. M. Williams); Courtland, Southampton County, August 25, 1936 (C. M. Williams); north of Factory Hill, August 26, 1936 (C. M. Williams); south of Petersburg, Dinwiddie County, August 25, 1936 (C. M. Williams).

Cercyonis alope ?pegala.—Dark males from 45 to 49 mm in expanse lacking the posterior eye spot in the yellow band on the fore wing, agreeing with those from New Jersey that are regarded by some as representing a dwarf form of *pegala,* have been taken south of Petersburg, Dinwiddie County, July 18, 1936; North of Cypress Bridge, July 23, 1936; and northeast of Homeville, Sussex County, July 29, 1936. These were compared with several specimens from New Jersey and with one (recorded as *pegala*) from the District of Columbia.

Strymon liparops form *strigosa.*—This butterfly has been taken by Mr. Herman J. Erb near Blacksburg in July.

Pyrgus centaureae wyandot.—Unpublished records for the State are: Hayfield, Frederick County, April 28, 1935, frequent (A. H. and L. F. Clark); Sexton Shelter, Skyline Drive, May 26 and June 2, 1935, frequent (W. H. Wagner); Blacksburg, Montgomery County (E. A. Smyth, Jr.).

Pholisora hayhurstii.—Found along the western border of the Dismal Swamp near Suffolk, September 4, 1936 (A. H. and L. F. Clark).

Hesperia metea.—Taken at Richmond, April 26, 1936 (C. M. Williams).

Hesperia leonardus.—New records are: Meadows of Dan, Patrick County, September 1, 1936 (A. H. and L. F. Clark); Big Meadows, Skyline Drive, August 27, 1933 (A. H. and L. F. Clark); Blacksburg, Montgomery County (E. A. Smyth, Jr.).

Hesperia sessacus.—Unpublished records are: Hayfield, Frederick County, May 17, 1936, common (A. H. and L. F. Clark); summit of Stony Man mountain, Page County, May 24, 1936 (A. H. and L. F. Clark); Blacksburg, Montgomery County, variable in abundance (E. A. Smyth, Jr.).

Atrytonopsis hianna.—New records for the State are: Clifton Forge, Alleghany County, May 12, 1936 (C. C. Walton); Warrenton, Fauquier County, May 24, 1936, frequent (A. H. and L. F. Clark); Richmond, Henrico County, May 12, 1936 (C. M. Williams); Glebe, Westmoreland County, May 31, 1936 (W. H. Wagner).

Atrytone logan.—New records are: South of Zuni, Isle of Wight County, August 20, 24, 1936 (C. M. Williams); north of Walters, Isle of Wight

County, August 22, 1936 (C. M. Williams); Clifton Forge, Alleghany County, July 26, 1936 (C. C. Walton).

Poanes viator.—Found in great abundance near Port Richmond, King William County, on June 7, 1936 (A. H. and L. F. Clark).

Amblyscirtes carolina.—This little skipper has approximately the same range within the State as *Enodia creola.* Unpublished records are: New Bohemia, Prince George County, June 22, 1936 (W. H. Wagner); Emporia, Greensville County, September 3, 1936 (A. H. and L. F. Clark); Cypress Bridge, July 23, 1936 (C. M. Williams).

Panoquina panoquin.—New records for this salt marsh skipper are: New Point, Mathews County, August 23, 1936 (A. H. and L. F. Clark); Lynnhaven, Princess Anne County, September 5, 1936, abundant (A. H. and L. F. Clark).

ANTHROPOLOGY.—*The finding of two ossuaries on the site of the Indian village of Nacotchtanke (Anacostia).*[1] T. D. Stewart and W. R. Wedel, U. S. National Museum.

When Capt. John Smith ascended the Potomac river in 1608 he described an Indian village extending some distance along the eastern bank of a large tributary entering from the east near the head of navigation. To this village, "with 80 able men," Smith gave the name "Nacotchtanke" (Arber). Later the missionaries, who arrived on the Potomac in 1634, latinized this name to Anacostan (Tooker), whence is derived the present name of the river and city—Anacostia. Except for references to trade relations and skirmishes, both with the English and neighboring tribes, this village figures very little more in written history. The date of its abandonment is not certain, but it was probably during the middle or latter part of the seventeenth century. The Potomac region in general was abandoned by the Indians about 1700, according to Mooney.

There is some question as to the tribal affiliation of the inhabitants of Nacotchtanke. Mooney (map, pl. VII) considers them Algonkins and includes them in the Powhatan Confederacy, but notes that they received Smith peacefully, thus disobeying Powhatan's orders. According to the Handbook of American Indians, Shea considers this group Iroquoian.

In substantiation of the historical record regarding the location of Nacotchtanke are the reports of local collectors. In 1889 Proudfit stated (pp. 242–243):

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[1] Approved for publication by the Secretary of the Smithsonian Institution. Received February 19, 1937.

> These fields [from Giesboro Point on the south to within a short distance of Bladensburg on the north] have been under cultivation for many years, and are regularly visited by local collectors, yet they are today, in places, fairly strewn with the wreck of the old village life.
>
> In addition to the stone relics . . . , it should be observed that an abundance of pottery, in fragments, is to be found—one of the unfailing evidences of permanent aboriginal occupation.

This statement seems to have been accepted by the investigators who have published subsequently, including Holmes and Ulke.

Since the above covers almost everything that is known regarding Nacotchtanke, it is of interest and importance to record the finding of two ossuaries at Giesboro Point during the past year. As is often the case, the burials were discovered accidentally. In the course of grading operations directed toward the extension of Bolling Field, the army flying field, a power-shovel exposed some human bones on September 11, 1936. The District coroner, Dr. A. Magruder MacDonald, was notified by those in charge of the work. He pronounced the bones to be those of Indians and ordered them saved; also, he notified the Smithsonian Institution.

On the morning of September 12 the senior author visited the site in company with F. M. Setzler, Acting Head Curator of Anthropology, U. S. National Museum. At this time a skull and a few bones, still remaining *in situ*, were removed. In the afternoon Dr. Wedel accompanied the senior author to the site. We were soon rewarded by the exposure of a second ossuary which we were permitted to excavate by our own methods. This operation, in which we were assisted by Robert Ladd of Washington, required the next two whole days. The details follow.

THE SITE

At the confluence of the Potomac and Anacostia the eastern shore (Fig. 1) is comparatively low-lying, forming an almost level plain between the rivers on the west and the hills to the east. At the time of our visit the grading operations were far advanced. Since some 7–8 feet of earth was being removed at the point where the ossuaries were located, it appeared that here a natural ridge of sandy soil extended in an east-west direction from the shoreline toward the hills. This agrees with the location of the ten-foot contour line on the Geological Survey map (Fig. 1).

Pit no. 1.—This was located some 150 yards from the river bank and about a quarter of a mile south from the line of the Portland

Street entrance to Bolling Field. Most of the bones had been removed by workmen and the power-shovel prior to our arrival and had been placed in barrels. From descriptions given by the laborers, as well as from the few bones left *in situ*, it appears that less than twelve inches of sandy soil covered the bones. The layer within which the latter were scattered was of about the same thickness. Owing to the uniformly sandy character of the surrounding soil and to its disturbance by machinery, efforts to define the original edge of the pit were unsuccessful. It was evident, however, that the area within which the remains occurred was not more than ten or twelve feet in diameter. No record was obtained of any cultural material having been seen.

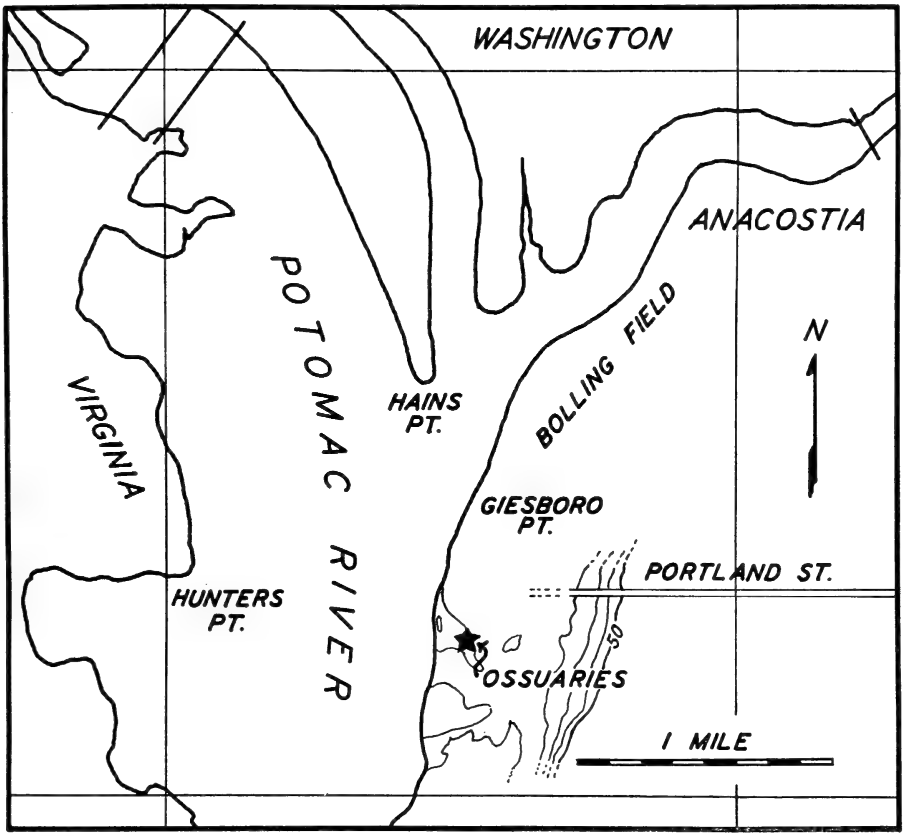

Fig. 1.—Map showing the location of the ossuaries and the topography in their immediate vicinity. (Based on the Geological Survey map of the District of Columbia, edition of 1929.)

Pit no. 2.—The second pit was encountered by the shovel at the time of our work and was completely excavated by hand. It lay some

50 or 60 yards due east of the first. The soil covering it was but a few inches deep, and there was some evidence that the uppermost bones had been broken and otherwise disturbed by plowing. No pit outline could be traced, but the bones occurred over an irregular area roughly fifteen feet in diameter and at a depth of six to eighteen inches. The "matrix" in which the bones occurred was of the same light colored sand as that constituting the ridge.

Burial was clearly secondary but some articulated bones were found. The skulls, most of which were crushed, were scattered throughout the pit, with a somewhat greater number in the lower level. In some instances two or more skulls lay together, but there appeared to be no consistent disposition in "nests." Generally the long-bones were grouped in bundles, those of several individuals sometimes being found together. Pockets of calcined human bone were noted, but it was not clear whether this represented cremation or was due to some accidental factor. Mingled with the human bones at one point were a number of deer bones.

Cultural material was obtained from the second ossuary, but in very limited amount. There were recovered three small grit-tempered potsherds, bearing impressions of a cord-wrapped paddle. Also, a small crudely made serpentine ornament, perforated and carelessly scored, was found in the dirt thrown out of the pit. Since they were not seen *in situ*, it is possible that both the sherds and ornament entered from the surface. Directly associated with and partly contained in one skull were fourteen tubular shell beads, 6 mm in diameter and from 10 to 20 mm long. No metal, glass or other material of European origin was found.

THE BONES

Since the first pit had been almost completely excavated before our arrival, we could not hope to recover many whole bones for the Museum collections. Alternatively, we limited our collection to those parts of more particular interest, namely, the temporal bone, jaws and teeth, distal end of the humerus, proximal end of the femur, pathological and anomalous bones. The same policy was adopted in selecting bones from the second pit, but here fortunately the method of excavation permitted the recovery of more whole bones. A count of the temporal bones, humeri, and femora from the two pits (Table 1) gives some reason for believing that approximately the same number of individuals was buried in each. This number is above 63 but is not likely to have been more than 70. The smaller number of temporal bones recovered from the first pit may be explained by the fact that the workmen and others removed the skulls for souvenirs before our arrival. The excess of temporal bones in the second pit may possibly mean that more skulls than extremities were interred. However, it should be remembered that, when broken, the parts of the long-bones are more difficult to identify than the parts of the skull. It is quite possible, therefore, that we may have overlooked some humeri and femora.

TABLE 1.—NUMBER OF BONES RECOVERED FROM OSSUARIES

Bone	Pit No. 1		Pit No. 2	
	Right	Left	Right	Left
Temporal	39	38	63	63
Humerus (distal)	56	36	49	39
Femur (proximal)	50	47	48	40

It is certain from an examination of the bones that both sexes are represented, but not disproportionately. According to the stages of dentition shown in the lower jaws, adults predominate. Four immature lower jaws, the youngest 2–6 years old, were found among the bones from the first pit. Of twelve such jaws from the second pit, the youngest was 1–2 years old.

Measurements of two skulls from the first pit give cranial indices of 68.3 and 71.9. Nine skulls from the second pit, all reconstructed and mostly female, have cranial indices ranging from low dolichocrany to high brachycrany (72.6, 72.7, 75.1, 75.6, 75.7, 77.3, 79.4, 84.0 and 86.0). Except for the most extreme brachycranic skull, the range is characteristic of the Algonkins (Hrdlička, 1927).

Two other features of the bones indicate that the inhabitants of this site were typical eastern Indians. Ear exostoses are present in 10 per cent of the ears (169), which is only slightly higher than the figure (8.5) reported by Hrdlička (1935) for the Indians north of Virginia. Septal apertures of the humerus are present in 43.2 per cent of the cases (134), and this too agrees well with the figure (40.4) reported by Hrdlička (1932) for the eastern Indians. These similarities become more impressive when it is realized how different are the figures for other Indian tribes. For example, among the Sioux the incidence of ear exostoses rises to 22 per cent, whereas that of septal aperture falls to 21.5 per cent (Hrdlička, 1932, 1935).

Among the pathological bones recovered were a number, mostly tibiae, bearing lesions generally regarded as having been produced by syphilis. It is noteworthy that more of these bones occurred in the first pit, in which also the bones were somewhat better preserved. Another, but minor, pathological condition to which these Indians were extremely susceptible was dental caries.

DISCUSSION

The finding of two ossuaries at Giesboro Point is further evidence of a habitation site in the vicinity. According to historical record this was Nacotchtanke. Although nothing is known of the limits of this village at the time the burials were made, it is reasonable to believe that it was not very far away—perhaps to the north. It is probable also that originally the burials were deeper, and it is possible even that a low mound was raised over them. The ultimate shallow position of the bones may be accounted for through the farming operations to which this area was subjected later. The number of individuals buried in these pits probably has some relationship to the population of the village, but the time interval involved is not known.

The chief reason for reporting these ossuaries is that they indicate some of the burial customs prevailing in this region. When Bushnell, in 1920, reviewed these customs for the Powhatan Confederacy, he knew of only one site at which ossuaries had been found. Since then, in 1935, Judge Graham has reported a group of four ossuaries found at Potapaco (now Port Tobacco), another site marked on Smith's map.

The senior author had the pleasure of assisting Judge Graham in excavating the pits at Port Tobacco, so he was in a position to make comparisons between the two sites. Briefly, it may be said that in appearance the burials were very similar, making due allowance for differences in soil. The scarcity of cultural material in the Anacostia pits is in contrast to those at Port Tobacco. Nevertheless, the type of cultural material encountered—beads, ornaments—is still consistent with Smith's statement (quoted from Bushnell, p. 28) that,

> For their ordinary burial they digge a deep hole in the earth with sharpe stakes; and the corpses being lapped in skins and mats with their jewels, they lay them upon sticks in the ground and so cover them with earth.

While it is not clear what Smith meant by the term "corpses," it is possible that he is referring to bodies that have been allowed to decompose in a charnel house. At Port Tobacco remnants of skins and mats which had been preserved by copper were found associated with the bones in the fourth pit. The finding of calcined bone in the second pit at Anacostia is something new for this area and cannot be clearly explained.

The occurrence of pathological bones in the pits, both at Anacostia and at Port Tobacco, with lesions resembling syphilis may be interpreted in different ways depending on whether or not syphilis is proved to be a pre- or post-Columbian disease. If pre-Columbian, this finding is of little significance historically. However, if post-Columbian, then these burials would date from the historic period and the different incidence of diseased bones in the two pits would take on more meaning. The absence of associated European objects is not contrary to the possibility that syphilis is a post-Columbian disease; it could have preceded Smith to this region.

Skeletal remains are rapidly being accumulated from Maryland and Virginia. Already it is recognized that a rather uniform physical type existed among the eastern Indians. Detailed study of this material eventually should indicate the closer physical affiliations of the various bands.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

540TH MEETING

The 540th meeting was held in the Assembly Hall of the Cosmos Club, April 8, 1936, Vice-President R. C. **Wells** presiding.

Informal communications.—T. A. **Hendricks** discussed obtuse-angled cone-in-cone structures from the Missouri Mountain slate of Arkansas.

Program.—A. J. **Eardley**: *Silts of the lower Yukon valley.*

T. S. **Lovering**: *Origin of the telluride ores of Boulder County, Colorado.*

541ST MEETING

The 541st meeting was held in the Assembly Hall of the Cosmos Club, April 22, 1936, Vice-President H. D. **Miser** presiding.

Informal communications.—L. W. **Stephenson**: *Flat-bottomed stream erosion by wetting and drying.* Little Walnut Creek is a small, intermittent tributary of Walnut Creek which joins Colorado River a few miles east of Austin, in Travis County, Texas. Little Walnut Creek heads in the belt of outcrop of the Austin chalk about 8 miles north of Austin, and flows within that belt in the upper 5 miles of its course. In a stretch a thousand feet or so long, above the iron bridge at the old Sprinkle road crossing (abandoned), 5 miles northeast of Austin, the stream has cut its channel some 15 or 20 feet deep and 70 to 75 feet wide in a rather hard, massive, uniform facies of the chalk. About 300 feet upstream from the bridge a normal fault drops stratigraphically higher and softer beds of the chalk down against the harder facies. The gradient steepens sharply just above the fault as the stream passes from the harder to the softer beds.

In its course through the harder facies of the chalk, including the descent from this facies to the softer facies below, a transverse profile of the stream bed is so nearly level that water when present is distributed with almost perfect uniformity across its entire width. When I visited the locality on November 20, 1935, the water was low and was so evenly spread that I waded the stream, scarcely wetting more than the soles of my boots.

In the case of a stream cutting its channel by abrasion it is to be expected that the part of the bed carrying the swiftest current will be most deeply eroded. In Little Walnut Creek abrasion is an insignificant factor in the process of erosion, as the stream is carrying little or no sand to serve as a cutting tool; solution may play a part in the process, but is probably a minor factor; fragmentation of the brittle chalk, caused by successive wetting by rainwater and drying, is believed to be the effective agent of erosion; the products of this process are easily swept away by occasional flood waters.

When water is present in the channel the chalk is protected from the wetting and drying process and is not eroded; the banks on either side are subjected to the process and are gradually eaten back down to water level; any part of the stream bed that may for any reason rise above water level is subjected to wetting and drying and is quickly reduced to the level in which wetting will protect it. When there is no water in the creek fragmentation due to wetting by occasional local showers and subsequent drying, will take place uniformly across the channel, thus maintaining its level profile.

Fragmentation of chalk by wetting and drying is an important erosion process in the channels of many of the streams crossing the chalk formations of the Gulf Coastal Plain. (*Author's abstract.*)

CLYDE P. ROSS described etched limestones in the Brazier limestone, Borah Peak Quadrangle, Idaho.

Program.—J. P. MARBLE: *Age of monazite from Mars Hill, North Carolina.* Analyses of a specimen of monazite from Mars Hill, N. C., for lead, thorium, and uranium, indicate an approximate age of 584 million years, or uppermost pre-Cambrian. Radiographs showed the mineral, a portion of the extremely large crystal collected by Schaller, to be relatively fresh and unaltered. The age found is in reasonable agreement with the field evidence. As the mineral is extremely low in uranium, further studies are projected.

G. A. COOPER: *Devonian correlations in Michigan and Ontario.*

SPECIAL MEETING

A special meeting was held in the Assembly Hall of the Cosmos Club, April 29, 1936, Vice-President H. D. MISER presiding.

Informal communiations.—JOSIAH BRIDGE remarked on the productive and illustrious life of Dr. A. F. Foerste, recently deceased.

D. F. HEWETT remarked on the life and work of H. D. McCaskey, recently deceased.

Program.—C. H. BEHRE, JR., Northwestern University: *Geologic History of South Park, Colorado.*

FRANCIS P. SHEPARD, University of Illinois: *Evidence of a greatly lowered sea-level.*

542ND MEETING

The 542nd meeting was held in the Assembly Hall of the Cosmos Club, October 28, 1936, President M. I. GOLDMAN, presiding.

Program.—ROBERT F. GRIGGS, George Washington University: *Timberlines as indicators of climatic trends.*

GEORGE TUNELL and C. J. KSANDA: *Some general conclusions from investigations of the calaverite group.* The peculiar face development of calaverite crystals, which has been known since 1895, was discussed in relation to the crystal structure of calaverite (determined by the authors). Certain adventive (non-structural) diffraction planes were correlated with the complex faces. Although a complete explanation of the complex faces and adventive diffraction planes has not yet been found, sufficient progress has been made to indicate that these peculiarities of calaverite will not lead to an alteration in the theory of space-groups or the law of simple rational indices, but are rather to be conceived as due to some type of subidiary phenomenon in the crystals. (*Author's abstract*).

WENDELL P. WOODRING: *Depositional environment of Lower Pliocene oil-bearing formations of the Los Angeles Basin, California.*

543RD MEETING

The 543rd meeting was held in the Assembly Hall of the Cosmos Club, November 11, 1936, President M. I. GOLDMAN, presiding.

Informal communications.—J. B. REESIDE, JR., reviewed criticisms of Lauge Koch by eleven of his contemporaries.

M. I. GOLDMAN reported on a statement by de Margerie regarding the criticism by a group of Danish geologists of the work of Lauge Koch (from C. R. somm., no. 6, p. 97, 1936) as follows: The manifesto carrying the signatures of a dozen geologists, Scandinavian and German, criticizing the work of Lauge Koch in Greenland, has in effect no less an object than to discredit the methods of the eminent explorer. Overlooking the invaluable services which Koch has rendered to the study of the Artic regions, these gentlemen pick out trivial errors such as can be found in every human product and overlook the outstanding discoveries by which he has enriched and transformed in such large measure the picture of the geology of Greenland that one of the signers, Böggild, drew 20 years ago. They even go so far as to reproach the Danish scientist for having had recourse to the airplane for completing his reconnaissance. There is here a lack of perspective which is positively shocking and one which a purely objective comparison of the texts cannot fail to bring out. It is hard to see what science gains by attacks so evidently biased.

C. B. HUNT described a method for obtaining data on total precipitation over an extended period of time.

Program.—J. B. MERTIE, JR., *Glacial features of the Nushagak district, Alaska.* The Nushagak district lies in a remote and little-visited part of southwestern Alaska. The Tikchik Mountains of this district are of particular interest because they are the site of a Pleistocene ice cap which covered an area of 6,000 square miles or more but was not a part of the great ice fields of the Alaska Range and contiguous territory.

The central part of the Tikchik Mountains is a rugged fretted upland, composed of comb ridges, pinnacle-like peaks, and high alpine valleys that show all the marks of severe and long-continued glaciation. Along the eastern side of these mountains is a system of twelve nearly parallel lakes from 7 to 35 miles in length, of which ten are connected together into two systems of interlake drainages that discharge eastward and southward. The present Nushagak Valley, which lies east of these lakes, is a great desolate, swampy lowland, composed of glaciofluviatile and outwash deposits which issued from the glaciated mountainous area.

The border lakes, though originally barrier lakes, now occupy essentially bedrock basins, and are classified as alpine glint lakes. They have depths ranging from 340 to 930 feet and in their deepest places reach from 300 to 600 feet below sea level. A number of these lakes have narrow fiord-like headwater bays which are separated from the main lakes by bedrock constrictions or barriers but are as deep as, or deeper than, the main lakes. Both the headwater bays, and the main lakes below these bedrock constrictions, increase rapidly in depth to the maximum, then gradually become shallower toward their lower ends, terminating in bedrock shoals, islands or barriers. It is possible that the headwater bays indicate either a pause in the retreat of the ice sheet, or a very late rejuvenation of glaciation.

All the usual physiographic features that are associated with severe glaciation are found in the country surrounding these lakes. These features include glacial scouring and plucking, steep-walled U-shaped cross sections, and well-developed cirques in hanging valleys, in the upper parts of the lakes; and morainal deposits at the lower ends of the lakes. Postglacial erosion is relatively slight close to the higher mountains but is perceptibly greater in the lower hills to the east. Another significant physiographic feature is a system of rather well-developed postglacial lake terraces, ranging in elevation from 5 to 65 feet above present lake levels.

The ancient valleys, now partially filled by these lakes, were occupied in preglacial time by alpine streams, but in their lower reaches had higher gradients than at present. This deduction is based upon drill-hole records at tidewater, where the outwash fill is known to have a thickness of 200 feet or more. The present interlake drainage was caused by the alluviation of these ancient valleys by morainal and outwash deposits that were laid down as the ice tongues retreated. This alluviation finally raised local base levels of erosion sufficiently to cause the lakes to spill over into one another, thus establishing the present abnormal system of interlake drainages. The various lake terraces record not only the maximum magnitude of this alluviation, but also the subsequent sequence of lowering of the lake levels. (*Author's abstract.*)

J. C. REED: *Significance of amygdales in Columbia River lava.* Periodic tilting of a fault block in north-central Idaho is reflected by the convergence of bands of silica that fill large gas cavities in lava. The fault block, the Whitebird block, is about 15 miles long and 12 to 15 miles wide. It is bounded on its east and west sides by normal faults. The lava series of about 35 flows with some interbedded unconsolidated sediments that constitute the upper 2,600 feet or more of the block is tilted to the northwest at 17 degrees.

The bands of silica in the filled cavities, or amygdales, consist of alternating layers of quartz and mixed opal and quartz. The bands were apparently deposited horizontally under the influence of gravity. The convergence of the bands indicates tilting of the block between times of deposition of the bands. The amygdales that were examined show a maximum convergence of bands of 14 degrees or reflect almost the complete tilting history of the block.

Between the rock around the amygdales and the banded interiors is a zone of concentric layers that ranges from less than a millimeter to more than 10 millimeters thick. The sequence of these concentric layers in all the amygdales examined in order from the outside toward the interior is nontronite, greenalite, melanophlogite, erionite, chalcedony, and mixed chalcedony and opal. The minerals were determined by their optical properties, which should be checked by other methods. The concentric layers probably were deposited by deuteric emanations long before the banded interiors were laid down from supergene solutions. (*Author's abstract.*)

JOINT MEETING

A joint meeting with the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, November 19, 1936, President O. E. MEINZER, of the Washington Academy of Sciences, presiding.

Program.—GEORGE H. ASHLEY, State Geologist of Pennsylvania: *The emergence of ideas as illustrated from Geology.*

544TH MEETING

The 544th meeting was held in the Assembly Hall of the Cosmos Club, November 25, 1936, Vice-President H. D. MISER presiding.

Program.—Testimonials for the late Dr. David White of the United States Geological Survey, by H. D. MISER, W. C. MENDENHALL, CHARLES BUTTS, F. E. WRIGHT, K. C. HEALD, and E. W. BERRY.

545TH MEETING

The 545th meeting was held in the Assembly Hall of the Cosmos Club, December 9, 1936, President M. I. GOLDMAN, presiding.

GEORGE TUNELL, chairman of the committee to select the first and second best papers delivered before the Society during the year, announced that W. P. WOODRING was awarded first prize and E. T. ALLEN second prize.

Vice-President R. C. WELLS took the chair during the presentation of Mr. Goldman's presidential address: *Petrographic features of salt dome cap rock.*

44th Annual Meeting

The 44th Annual Meeting was held in the Assembly Hall of the Cosmos Club after the adjournment of the 545th regular meeting, President M. I. Goldman presiding. The annual report of the secretaries was read. The treasurer then presented his annual report showing an excess of assets over liabilities of $1,319.48 on December 9, 1936. The auditing committee reported that the books of the treasurer were correct.

The results of the balloting for officers for the ensuing year were as follows: President, R. C. Wells; Vice-Presidents, F. C. Calkins, H. D. Miser; Treasurer, A. H. Koschmann; Secretaries, G. A. Cooper, M. N. Bramlette; Members-at-large-of-the-Council, R. W. Brown, W. S. Burbank, C. H. Dane, Earl Ingerson, J. C. Reed; Nominee for Vice-President of the Washington Academy of Sciences representing the Geological Society, W. T. Schaller.

G. A. Cooper, *Secretary.*

Obituary

Benjamin Lincoln Robinson, who a few years ago retired from the Asa Gray Professorship of Systematic Botany, which he had held since 1900, died July 27, 1935. He was born in Bloomington, Illinois, November 8, 1864, and received his A.B. degree from Harvard College in 1887. After taking his Ph.D. degree at Strasburg in 1889 he returned to Harvard University as assistant in the Gray Herbarium and became its curator in 1892, which position he held until he retired. With others he was an editor of *Synoptical flora of North America* from 1892 to 1897. He was editor of *Rhodora*, the journal of the Northeast Botanical Club, from 1899 to 1928, and also editor of the seventh edition of Gray's *New manual of botany*. He was the author of many published papers upon the classification and distribution of the spermatophytes of the United States, Mexico, northern South America and the Galapagos Islands. He was awarded a bronze medal at the Louisiana Purchase Exposition held in St. Louis, 1904, and the Centennial Gold Medal of the Massachusetts Horticultural Society in 1929 "for eminent service to botany." Besides being a member of the Washington Academy of Sciences and the National Academy of Sciences, Professor Robinson was a member of seventeen other American and foreign scientific societies. He was president of the Botanical Society of America in 1900, president of the Northeast Botanical Club from 1906 to 1908, and honorary member of the Chilean Society of Natural History.

Charles Henry Smyth, Jr., emeritus professor of geology at Princeton University, died at the Princeton Hospital, April 4, 1937, from pneumonia and complications resulting from a fractured hip received in a fall two weeks previously.

Doctor Smyth was born at Oswego, N. Y., March 31, 1866. He received the Ph.B. degree in 1888 and the Ph.D. degree in 1890 from Columbia University. He studied at Heidelberg, Germany, 1890-1891. From 1891 to 1905 he was professor of geology and mineralogy at Hamilton College, and from 1905 until his retirement in 1934 he was professor of geology at Princeton University. His chief scientific contributions related to the Clinton type of iron ore, the regional geology and mineral deposits of the northwest Adirondacks, the origin of alkali-rich igneous rocks, and problems of chemical geology.

Doctor Smyth held membership in the American Association for the Advancement of Science, Geological Society of America, Philosophical Society, New York Academy, and Washington Academy of Sciences.

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 27 JUNE 15, 1937 No. 6

PHYSICS.—*Explorations in the superconducting state.*[1] FRANCIS B. SILSBEE, National Bureau of Standards.

In the early days of this Society, its leaders were in a large measure pioneer workers, blazing new trails into hitherto unknown territory. I need only list Henry in Electromagnetics, Langley in Aerodynamics, Dutton and Hayford in Isostasy, and in literal geographic exploration Powell, to remind you of their achievements. Today most of us spend our lives mapping with meticulous precision the rich provinces which they first opened up, and can only rarely venture as they did into unbroken fields, where the general nature of the phenomena is still unknown, where the basic concepts are still to be conceived, and where even a suitable language for an adequate description of events is yet to be invented. Nevertheless the call of the unknown still has a glamour for all scientists and it is, therefore, without apology that I propose this evening to give a further report of recent progress in one of the few remaining unexplored regions of physics.

When in 1908 Kamerlingh Onnes first liquefied helium, he opened the way into a large and most fruitful province. I say "large" advisedly for though the newly available temperature range, namely 2°K to 10°K, seems small when expressed in degrees, it is more properly regarded as extending over more than two octaves in absolute temperature. An equal journey by a factor of 5 from our room temperature of 300°K, if taken upward, will bring us to 1500° when all but the most refractory materials are melted, or if taken downward, will lead well below liquid air temperatures.

During the past few years Giauque, Debye, and other explorers have passed the boundaries set by the helium province to start operations in a still more remote region, but we shall limit our wanderings this evening to the nearer but still strange and mystic territory known as the liquid helium range.

This helium region contains many features which to the eye of the

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[1] Address of the retiring president, delivered before the Philosophical Society of Washington, January 16, 1937. Publication approved by the Director of the National Bureau of Standards of the Department of Commerce. Received January 18, 1937.

physicist seem as bizarre and fantastic as the monsters with which geographical explorers used to ornament their maps. For one thing there is no fluid but helium and all profit must be based on its use. All other substances can here exist only in the solid state. Any leakage of air into the apparatus is dreaded not because of its oxidizing action but merely because the piping will be clogged by a plug of solid air. In this topsy-turvy land platinum and copper lose their utility as resistance thermometers and show a resistance which is almost independent of temperature, while on the other hand manganin and constantan are quite suitable for resistance thermometry. Another paradox shows up even in one of the very methods used for arriving at this wonderland. A strong vessel is filled with helium gas at a fairly high pressure and cooled to liquid hydrogen temperatures. The valve is then opened and after *half* of the helium has been allowed to escape, the vessel is found to be *two-thirds* full of liquid.

Just as the wanderer in the fairy story came upon a baffling mountain of glass in which mechanical friction was non-existent, so did Kamerlingh Onnes in 1911 find himself confronted by a wire of quicksilver in which electrical friction (i.e. resistance) was non-existent. It is of the more recent explorations in this range of glass mountains, or as Kamerlingh Onnes called it, the superconducting state, that I wish to talk this evening.

In the time available any attempt at a complete summary of the subject is out of the question, and I shall merely touch upon the more outstanding features of the pioneer findings and here and there venture some rather rash speculations of my own as to what may lie beyond the horizon. In opening a conference on the subject in 1935, McLennan (4)[2] characterized one phase of the situation by saying that "the experiments agree only in that the result is never quite what might be expected." If, therefore, my surmises turn out to be quite far from the truth, the present delightfully paradoxical atmosphere of the subject will not have been disturbed.

First, to refresh your memories, let me outline the earlier work in this field. Until 1923 all experimental work was confined to the Cryogenic Laboratory of the University of Leiden, but now explorers recruited from the far corners of the earth are working in laboratories at Berlin, Toronto, Oxford, Cambridge, Kharkov, and Washington.

The early work served to establish that the resistivity of a material in the superconducting state was exceedingly low. Recent experi-

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[2] Numbers in parentheses refer to the bibliography at the end of the paper.

Francis B. Silsbee
President, Philosophical Society of Washington
1936

ments (9) on Pb have shown it to be certainly less than 10^{-15} times its value at 0°C. If a wire having a resistivity equal to this upper limit were drawn down to a diameter of 1 micron, then to secure a resistance of 1 ohm it would require a length sufficient to encircle the earth 100 times. Many metals such as Hg, Pb, Sn, Tl, Ta show this property, though others, such as Au, Cu, Ag, Bi have not shown it at the lowest temperature at which they have thus far been tested. It is therefore still an open question whether or not superconduction is a common property of all metals. Many alloys which have at least one superconducting component are also superconducting, and even Au_2Bi becomes superconducting at 1.84°K, although neither of its constituents shows the phenomenon even at much lower temperatures. Still stranger is the fact that a number of compounds such as CuS, TiC, VN, ZrC, ZrB, etc., which are relatively very poor conductors of electricity at ordinary temperatures, become superconducting at helium temperatures. The list of superconducting materials grows almost daily and I will not attempt to give it in full here.

The early workers also discovered that if a sufficiently intense magnetic field was applied to a superconductor its resistance was restored. The requisite intensity of field is a function of temperature and is roughly proportional to the difference between the temperature of the specimen and the critical temperature at which it becomes resisting in the absence of a magnetic field. A similar limiting intensity was found for the current which the specimen could carry and still remain superconducting, and it was a very obvious suggestion on my part that these two limits should be connected by the relation that the critical current was of such a value that the magnetic field which it produced at the surface of the material was equal to the critical magnetic field. The truth of this relation has been confirmed experimentally (33) for Sn and Pb, and for 19 years the hypothesis was assumed to be generally applicable until it was found to be most certainly *not* true for Ta and several alloys by laboratory groups of one of which strangely enough I was a member.

It would be expected that such a tremendous change in one property of a material would be accompanied by corresponding changes in other properties. For a long time, however, no trace of any other changes could be found. More recently de Haas and Bremmer (5, 6, 7 and earlier papers) found that the thermal conductivity at temperatures well below the normal transition temperature is somewhat abnormal unless a sufficient magnetic field is applied to prevent the appearance of superconduction. In the case of Pb, In and Sn the onset of the superconducting state, by the removal of an inhibiting magnetic field, decreases the thermal conductivity in direct contradiction to the Wiedemann-Franz relation, while with the alloy $PbTl_2$ the effect is strangely enough of the opposite sign.

A second property which has been found to be different in the superconducting state is the specific heat. Keesom and van den Ende have shown that for Sn and Tl the specific heat is about 50 percent greater when the material is in the superconducting state, and that in the absence of a magnetic field there is no latent heat of transition.

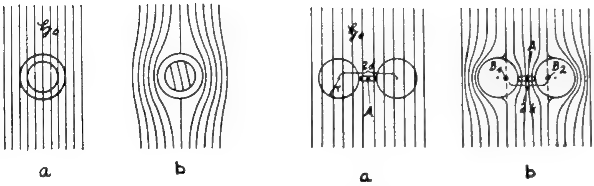

Fig. 1.—Expulsion of magnetic flux produced by cooling a lead tube (left) and a pair of tin cylinders (right) in the presence of a transverse external magnetic field which had been applied while the specimens were above their transition temperature; *a* before, *b* after, cooling.

A new era was begun by the publication by Meissner and Ochsenfeld in 1933 of the results of experiments (20) in which the magnetic field in the neighborhood of their specimens was measured, by a "flip coil," while the specimens were cooled through the transition temperature while in the presence of a magnetic field. Under these conditions it would be expected that the magnetic lines of induction which passed through the specimens at the initial temperature would still link the specimen and in fact would now be even more firmly "frozen in," since any tendency for them to decrease would induce currents tending to preserve the status quo. Strangely enough, however, the experiment showed that in some mysterious way the lines of induction were automatically crowded out of the specimen and their presence in the surrounding space was made evident by the increased deflection of the ballistic galvanometer connected to the exploring coil. Fig. 1 shows the two forms of specimen used in the original experiment,[3] and the distortion of the initially uniform magnetic field which was found to exist when the specimens had been cooled well below the transition temperature. The most startling feature of this experiment is the fact that here apparently the mere

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[3] Fig. 1 is reproduced from the paper by Meissner, Ochsenfeld and Heidenreich (20).

abstraction of degraded heat energy from the specimen enables it to do work against the magnetic field. Presumably the potential ability to do this work developed when the magnetic field was applied to the hot specimen and the cooling has merely removed an inhibiting effect. Nevertheless, the mere existence of the *Meissner effect,* as it has come to be called, indicates that the primary phenomena involved in the superconducting transition are inherently reversible in the thermodynamic sense.

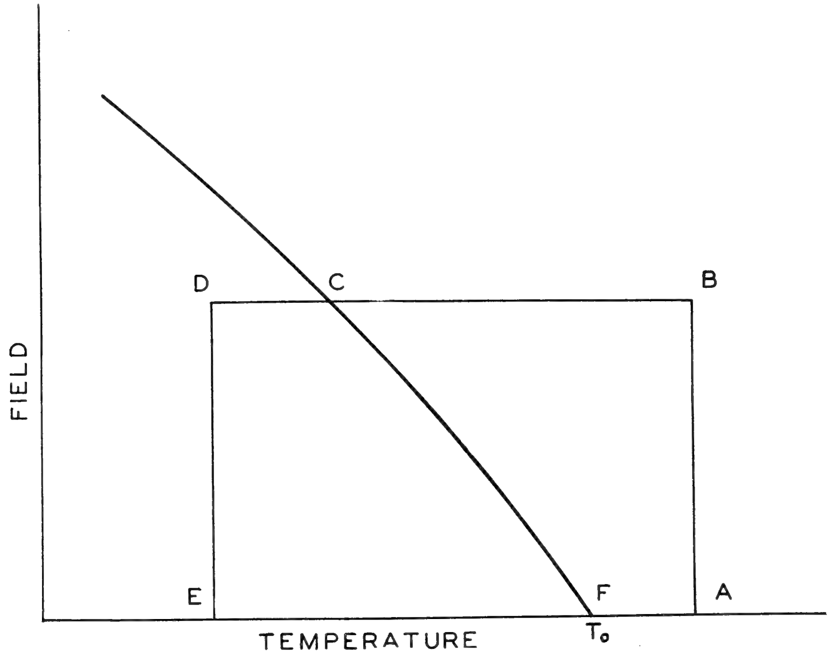

Fig. 2.—Curve FC is a graph of critical magnetic field H_k vs. temperature for a typical superconductor. Points to the left of this curve correspond to superconducting and points to the right, to normal resisting conditions.

The theorists have been prompt to recognize the implications of the Meissner effect and the older definition of a superconductor as a material in which inherently the resistivity equals zero has almost come to be replaced by the newer definition that the magnetic induction equals zero. Notable among the theorists are F. & H. London (15, 16, 17, 18, 19) who have developed a set of differential equations to describe a material in the superconducting state. The electrodynamic equation describing an ordinary conductor can be written

$$\rho J - E = 0$$

where ρ is resistivity, J is current density, and E electric force. In a superconductor $\rho=0$ and $E=0$, leaving J indeterminate. The Londons suggest as a fundamental equation

$$c \text{ curl } \Lambda J = -H$$

where c is the velocity of light, H the magnetic field and Λ a positive constant, characteristic of the material. Combining this equation with the usual equation $c \text{ curl } E = -\dot{H}$ yields

$$c \text{ curl } (\Lambda \dot{J} - E) = 0$$

which indicates that any electric force will produce an acceleration of the flow of the system of superconducting electrons, the inertia of the system being characterized by the coefficient Λ. If this inertia is simply the mass of a cloud of otherwise free electrons, one per atom as in the calculations of Becker, Heller, and Sauter, it works out that the resulting flow of current is appreciable only in a surface layer about 10^{-5} cm thick.

The suggestion of reversibility has been followed up theoretically by Gorter and Casimir and experimentally by Keesom, Kok and van Laer (12, 14) at Leiden. Considering a diagram, Fig. 2, in which the applied magnetic field is plotted as ordinate and temperature as abscissa so that any point represents a possible condition of the specimen, you will note that by reason of the Meissner effect a specimen at D is in the same magnetic condition if it arrived there by the path AFED as if it had traversed the path ABCD. The complete rectangle represents a thermodynamic cycle. If it is traversed in the counterclockwise direction the material will function like the working fluid of a heat engine and deliver (magnetic) work at the expense of a flow of heat from a higher to a lower temperature. Conversely, clockwise cycles produce a refrigerating effect. Unfortunately this cooling is not well adapted to the actual production of low temperatures. The method of adiabatic demagnetization which has proved so very useful in the low temperature field in the last few years, while theoretically slightly analogous, is in detail totally different. A related consequence of this thermodynamic reasoning is that there must be a latent heat of transformation when by reason of the presence of a magnetic field the transition takes place at a temperature lower than normal. For Tl this latent heat at 1.91°K (0.45° below its normal transition) is 0.000346 cal/mol; and for Sn at 2.66°K (1.07° below its normal transition) is 0.0012 cal/mol. This theory would predict a magneto-caloric cooling when a thermally insulated specimen is carried from the superconducting to the normal state by an increase in magnetic field. Such a cooling was found experimentally at Oxford by Mendelssohn and Moore.

A much more complete confirmation of the thermodynamic relations results from the calorimetric work at Leiden in which blocks of thallium and of tin were in effect carried around the cycle clockwise while the energy transfers were carefully measured. On calculating the various entropy changes and making due allowance for the magnetic work involved, the net failure to close the cycle, which could result from irreversibility, did not exceed 2 per cent of the gross change in entropy in the experiment with Tl and was even less in the case of Sn. In view of the exceedingly minute energies involved in these experiments, only 0.0004 cal/mol for thallium at 1.9°K, this agreement is a triumph of experimentation as well as of theory.

The transition may be regarded as at least analogous to what Ehrenfest has called a "change of phase of the second order" and on this basis Rutgers has deduced (27) the relation

$$\Delta C_p = (T_0/4\pi\delta)\ (\mathrm{d}H_k/\mathrm{d}T)^2$$

between ΔC_p, the discontinuity in the specific heat, and the slope $\mathrm{d}H_k/\mathrm{d}T$ of the transition curve. (δ is here the density and T_0 the transition temperature in the absence of a field.) This relation has also been verified experimentally for tin and thallium as shown in Table I.

TABLE I.—EXPERIMENTAL VERIFICATION OF RUTGERS' EQUATION

Element	T_0 (°K)	$\mathrm{d}H_k/\mathrm{d}T$ (oersteds/°K)	Δc(cal/°K/mol)	
			calc.	obs.
Tin	3.71	151	0.00229	0.0024
Thallium	2.36	137	0.00144	0.00148

The successes just enumerated may give the impression that the subject has now been fully explored, but when the Russian workers Schubnikow and Chotkewitsch, applying Rutgers formula to a PbBi alloy, which happens to have the very large value of 5000 oersteds/°K for $\mathrm{d}H_k/\mathrm{d}T$, they found no trace of any discontinuity in the specific heat although they could have detected as little as 1 percent of the predicted value. A similar negative result is reported by Mendelssohn and Moore for $PbTl_2$. Moreover, of the many repetitions and variations of the Meissner experiment which were promptly performed in other laboratories, only a few, such as those with very pure mercury, showed 100 percent Meissner effect, while others showed partial effects and some alloy samples showed no Meissner effect whatever, but a complete "freezing in" of the induction. It is evident that there is more in the field of superconduction than is dreamed of in our present philosophy.

Next to the tremendous factor by which the conductivity changes, the most outstanding peculiarity of the superconducting transition is the abruptness of the change. One of the first questions which arises is therefore "How abrupt is the transition?" or in slightly different form "Does each volume element change abruptly or continuously through the transition?" In the usual polycrystalline wire specimens, the transition curve, in which the resistance is plotted against temperature or external magnetic field, has a finite slope and is rounded more or less at both ends, the range from 0.1 to 0.9 of the normal resistance being about 0.02°K. Curves obtained with monocrystalline specimens are notably steeper, sometimes having a range of only 0.0001°K, while those with alloys are often flatter. In certain mercury specimens subjected to a decreasing magnetic field the decrease in resistance has occurred in a relative few definite steps each presumably corresponding to the transition of an individual crystal. The increase of resistance was however continuous. This of course strongly suggests that in the ideal case the change is discontinuous. Most of the theoretical workers with due regard for Occam's warning against superfluous hypotheses, have assumed the discontinuous "all or nothing" basis, and have tried to account for the observed phenomena by suitable combinations within the test specimen of regions, each consisting of only one of the two fundamental states, superconducting or normal. Notable among these treatments are those of Gorter and Casimir and of the Londons. Recently Peierls (26) has abandoned this effort as impossible and postulates the existence of a third "transition state." In this state the resultant magnetic field H is required to have the constant value H_k but the magnetic induction B may have any value between 0 and H_k. For the (magnetic) cases which he treats, he is not concerned directly with the resistivity and so does not commit himself as to whether or not its variation is also continuous in the transition state. Experiments by Schoenberg (28) have been interpreted as suggesting that there is a finite resistivity in this intermediate state.

If the "all or nothing" hypothesis is to be retained (at least as regards the change in resistivity) we have as the next question, the cause of the finite range usually observed. The easiest answer in the case of polycrystalline wire would be that the individual crystallites having different orientation with respect to the direction of current flow exhibited slightly different transition temperatures. Very careful work by de Haas, Voogd and Jonker on three monocrystals of tin having radically different orientation have shown only such exceedingly small differences in threshold temperature as to practically eliminate this explanation of the range. Mechanical strain is known to affect the transition temperature slightly and may well be the cause of at least part of the observed range, the rest is still unexplained.

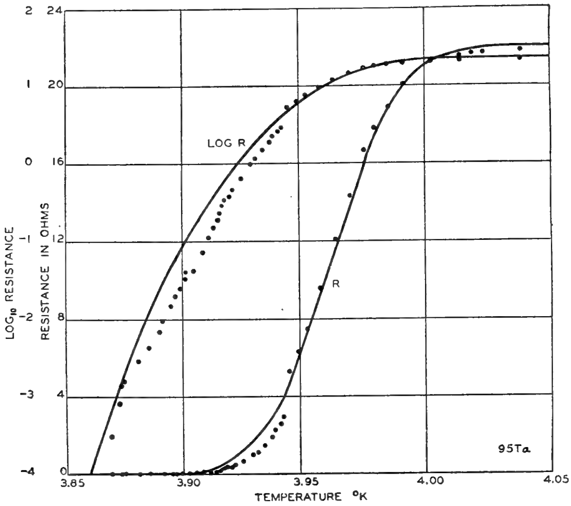

Fig. 3.—Transition curve of a tantalum specimen. Points show experimental values of resistance and of the logarithm of the resistance plotted against temperature. The curve R has the equation

$$R = \frac{R_n}{2}\left(1 + \frac{2}{\sqrt{\pi}}\int_0^x e^{-x^2}dx\right)$$

where $x = 3.09\ (T - 3.963)$ and T is the temperature and R_n the normal resistance.

A supplementary question is "How far does the toe of the transition curve extend?" The importance of this lower end of the curve lies in the fact that the rate of decay of any induced currents is fixed by the residual resistance, and true superconducting behavior is to be expected only when the resistance is so low that the relaxation time of the currents is long compared with the duration of the experiment.

One example of a transition curve obtained at the National Bureau of Standards by Brickwedde, Scott and the author is shown in Fig. 3. This is for a specimen of hard-drawn tantalum wire, 0.075 mm in diameter, 210 cm long, as measured at decreasing temperature with a measuring current of 1 ma. The S-shaped distribution of the observed points rather suggested that the influences tending to shift the transition temperatures of the various parts of the specimen away from the mean might have a random distribution. To test this, the solid curves were calculated from the assumed Gaussian distribution passing through the mid-point *R* and having a parameter *h* fitted to the slope of the curve at that point. The good fit of the resistance curve *R* to the observed points is perhaps to be expected but the fact that the left-hand extremity of the log *R* curve fits so closely the observations at values of resistance only one ten-thousandth of that for which the curves were fitted is striking and perhaps significant.

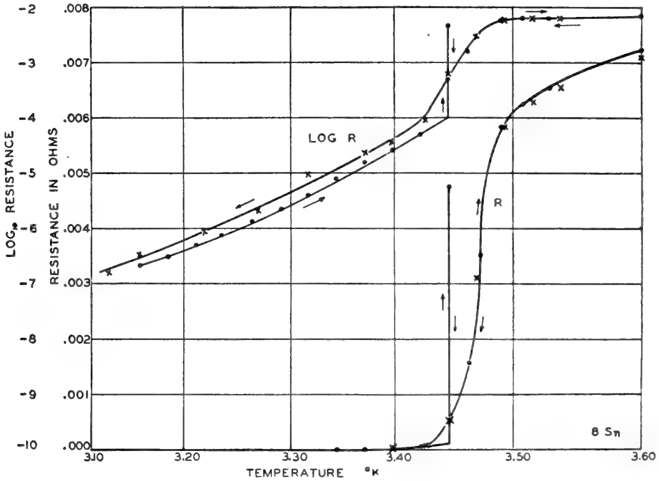

Fig. 4.—Transition curve of a tin specimen. Experimental values of resistance plotted against temperature.

Another transition is shown in Fig. 4. This is for a sample of extruded tin wire 0.22 mm in diameter measured with a relatively large current, viz. 1.8 amperes. The bulk of the transition is similar in trend to the preceding, though it cannot be so closely fitted by a simple Gaussian curve. The "toe" of the curve is however totally different and shows a prolonged almost exponential variation with temperature which is suggestive of a Boltzmann distribution.

The preceding examples have shown transitions as the temperature was varied at a constant (zero) magnetic field. With polycrystalline specimens, the curves obtained on varying the magnetic field at constant temperature are much the same in shape and are nearly the same whether the field is parallel or transverse to the direction of current flow.

De Haas, Voogd and Jonker have found that if a cylindrical single crystal is subjected to a transverse magnetic field a markedly different type of transition is obtained. The field required for full resistance is about double that at which a measurable resistance is first noted, the resistance rising almost linearly with the field provided the current is fairly large. With smaller currents the resistance at intermediate fields is materially less than with larger currents. The wide range of field over which the transition extends obviously calls for a different type of explanation and some recent work on the details of the process of the penetration of a magnetic field into a superconducting body may perhaps furnish the clue to the origin of curves of this type.

The work in question, by de Haas and Guinau (10, 11) at Leiden on a monocrystalline tin sphere, parallels and amplifies work by Mendelssohn and Babbitt (21, 22, 23) at Oxford and by Schoenberg (28) at Cambridge on polycrystalline specimens. Starting with the sphere at a low temperature, these workers applied an external magnetic field which in the absence of the sphere would have been uniform, and measured the intensity of the resulting field at various points near the equator of the sphere and in holes bored through it. The intensity was measured by noting the change in resistance of small bismuth wires suitably placed. If H_k is the critical value of magnetic field for the particular temperature at which the sphere was held, then for external fields less than $2/3\ H_k$ the sphere behaved as if it had zero permeability and all the lines of force were forced to detour around it. It follows from the equations of the electromagnetic field that under these conditions the field intensity at the equator is $3/2\ H_0$ when H_0 is the intensity of the external field at a great distance (or the intensity which would exist at the center if the specimen were absent). Measurements confined to external points cannot determine whether such a field distribution is the result of a true diamagnetism existing throughout the body of the sphere (its volume susceptibility being $\kappa = -1/4\pi$), perhaps as a result of microscopic Amperian currents, or whether there is a macroscopic system of currents circulating around the surface of the sphere in planes normal to the axis of the field. The measurements at Leiden using bismuth detectors located in a hole along the polar axis, and in a thin equatorial crevasse could make the necessary distinction. The detectors showed zero magnetic field under these conditions, and thus proved that the second hypothesis (viz. macroscopic currents circulating in the surface of the sphere) was the correct one.

The next question is "What will happen when the field is increased so that 3/2 H_0 exceeds H_k?" It might well be supposed that the material in an equatorial zone would become resisting so that the macroscopic currents there would die out, but that a new system would develop within the material so that the central portion in the form of a prolate ellipsoid would still remain superconducting, and that currents on the surface of this inner region would separate it from the outer resisting zone. It is to be noted that if such a distribution existed the field would drop off rather rapidly outside it so that the outer equatorial zone would again be in a field less than H_k. There is a little evidence in the Leiden data that this condition may exist over a narrow range, but when H_0 has increased by 10 percent above 2/3 H_k, the entire system of macroscopic currents on the spherical surface seems to break down. The data yielded by the internal detectors then become consistent with a truly diamagnetic body. The system of persistent currents must therefore have become subdivided into eddies smaller in diameter than the detector. Perhaps these enclose "columns" or "needles" of superconducting material, the axes of which lie parallel to the field, but they may of course degenerate in both dimensions into small spherical volumes of perhaps molecular dimensions. The total flux of induction threading the equator of the sphere increases linearly with further increases in the external field until, when this has reached the value H_k, the specimen behaves like a normal material in which $\mu = 1$ or $\kappa = 0$. For values of H_0 intermediate between 2/3 H_k and H_k the field distribution inside and outside is that corresponding to a material having a mean permeability given by the relation: $\mu = (3H_0/H_k - 2)$. The detailed nature of these current eddies which must persist and enclose certain superconducting and fluxless regions embedded in a matrix of normally resisting material, still remains to be studied.

The picture suggested by these experiments on spheres can now be carried over to the cylindrical wires previously discussed. For a circular superconducting cylinder placed transversely in the field, the factor by which the initially uniform external transverse field H_0 must be multiplied to get the maximum intensity is 2, instead of 1.5 as in the spherical case. Von Laue pointed out that the first signs of disturbance noted by de Haas and Voogd and Jonker occurred at about 1/2 of the field which was found to be critical in the longitudinal case, and offered this distortion of the field by a factor of 2 as an explanation. If the penetration had occurred by the gradual process first suggested above, so that the superconducting region became an elliptical cylinder of gradually increasing eccentricity, the long axis of the ellipse forming the diameter of the wire parallel to the field, von Laue's explanation would fail, because the superconduction along this axial "blade" would be ample to prevent the appearance of resistance. However, since the penetration of the sphere is not continuous but proceeds by an abrupt degeneration of the system of persistent currents into small regions having their axes parallel to the field, the surrounding matrix of normally resisting material may well form a continuous "phase" and introduce a measurable resistance even when most of the total volume is still in the superconducting state. If the total induction increases linearly in the cylindrical as well as in the spherical case, as seems very reasonable, the fraction of the total volume which is normally resisting will also increase linearly (assuming $B=0$ in the superconducting portions) and the resistance offered to the measuring current which flows in a direction transverse to this columnar distribution would also be expected to vary linearly. To explain the other features of the results of de Haas, Voogd and Jonker we need only make the further assumption that imperfections in the crystal or some other causes have produced a few slender superconducting paths running more or less axially from one main superconducting column to the next. In the intermediate stage a very small measuring current can meander mainly by such paths from one end of the wire to the other with but little resistance. A larger current, however, attempting a slender path, will produce such an intense local magnetic field around itself as to destroy the superconductivity of the path and will consequently experience the normal resistance except when flowing athwart the larger superconducting columns.[4]

The fact that a measurable resistance just appears at a field somewhat greater (by about 15 percent) than that predicted by von Laue can be explained by assuming that the initial stages of penetration proceed some distance by the gradual process just suggested before the degeneration of the persistent current system sets in.

A phenomenon which is apparently distinct but which may perhaps be merely another manifestation of this same degeneration of the current system when a magnetic field penetrates a superconductor was discovered by Brickwedde, Scott and myself at the National Bureau of Standards in 1934. It can best be described by following

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[4] It would appear that the curious result, deduced by Peierls for material in his "transition state," that the boundaries of the superconducting regions must be (generalized) cylinders parallel to the external field will also apply in this case and thus insures the needed parallelism of the superconducting columns.

the course of an experiment in which the apparent resistance of a specimen of wire carrying a relatively large current is watched as the temperature is raised gradually from a low value through the transition range. Fig. 4 shows a typical example of this phenomenon in a tin wire. At a particular temperature, in this case 3.44°K, the resistance increases spontaneously in the course of a few seconds to 0.0048 ohm, a very considerable fraction of its full value, and then decreases again at a somewhat slower rate to a fairly low value 0.0006 ohm. Further increase in temperature causes the resistance to rise again along a curve which approximates the normal transition. No corresponding phenomenon is found on cooling. For lack of a better term we have called each of these spontaneous increases of resistance followed by a decrease an *overshoot.*

I have described this overshoot as occurring as the temperature is raised with a constant current in the wire and a constant external magnetic field. Similar overshoots occur when the current is increased at constant temperature and field and when the field is increased at constant temperature and current. They are much less marked when they occur at small currents, as is the case when temperature or field is high, than when they occur with a larger current at a lower temperature.

After an overshoot has proceeded to completion, a prompt repetition of the stimulus which produced it, as by opening the circuit and reclosing it with the same large current, will *not* produce a second overshoot. Hence, although its resistance is again very low, the specimen just after the overshoot must be in a condition different from that just before the overshoot. The original condition in which the possibility of an overshoot is again latent can be attained by cooling the specimen a few tenths of a degree for a few minutes.

To relapse again to speculation, may it not be that the resistance during the overshoot exists while the regime of current flow is changing from a simple macroscopic distribution, stable at low temperatures and induced perhaps by the Meissner effect, to a new regime characterized by a subdivision of the volume into regions some of which are resisting while others are superconducting? This second regime may utilize more effectively than the first those portions of the interior of the specimen which happen to be particularly favorably situated to be superconducting.

The classic experiment of Meissner and Ochsenfeld, itself, demonstrates that, on cooling their tin cylinders while they were carrying a current, there occurred a spontaneous change in regime of current flow which was the converse of the change which we are now postulating to explain the overshoot.

One peculiar feature of this overshoot phenomenon is the fact that it involves a process which requires a certain time for its completion. The time rate of progress of a process often gives a valuable clue to the nature of the process. It was with this in mind that the workers at Toronto undertook a study of the behavior of superconductors at high (radio) frequencies. At first McLennan thought he had found a real effect but later it was concluded that the observed effects had resulted from changes in the magnitude of the currents used and that there is no appreciable change in the transition point up to frequencies of 3×10^7 cycles per second.

Two years ago I had the honor of presenting to this Society a report of somewhat similar experiments by Brickwedde, Scott and myself which however went one step further and showed that a tin wire could change from the superconducting to the normal state and back again fast enough to keep in step with the pulsations of an impressed magnetic field which had a frequency of 3×10^6 cycles per second.

More recently Keesom and van Laer (13) have announced that when an ellipsoidal tin specimen passes from the superconducting to the normal state as a result of increasing temperature, in the presence of a constant magnetic field, there is a time lag of the order of 30 seconds. This lag in the transition is made manifest by the corresponding lag in the evolution of the latent heat. No such lag is observed when the transition is stimulated by an increase in magnetic field at substantially constant temperature. If a superconducting tin cylinder of the diameter (3.5 cm) used by Keesom and van Laer had suddenly been endowed with the full normal resistance appropriate to 4°K, the lag in penetration of the magnetic field which would be expected from the induced eddy currents comes out at only about 1.5 seconds, and any smaller eddy circuits in normally resisting material would respond still more quickly. If the lag is the result of the time required for eddy currents to die out, it is evident that the average resistivity of the circuits must be much less than normal and that at least 95 percent of the circuit must be superconducting. The time required for an *overshoot* is of the same order of magnitude as the thermal lags reported from Leiden, but the stepwise changes noted during the decrease in resistance imply that the phenomenon may be more complex than a mere eddy current decay. Both Mendelssohn and Pontius (24), and the Russian workers have also reported similar changes in magnetic induction with time, the former noting step-like changes. Keesom and van Laer suggest that this lag is an indication of a weak coupling between the atomic lattice and the system of superconducting electrons, while the prompt response to changes in magnetic field indicates in contrast to this, a strong coupling between this field and the superconducting electrons.

The Russian workers Rjabinin and Schubnikow (29, 30) have attacked the subject from the point of view of the magnetician and using as a specimen a fairly long cylinder (or prolate ellipsoid) have obtained *B–H* curves both for Pb and for $PbTl_2$. With a specimen of this shape the distortion of the external field by the specimen is much less than with a sphere, and the corrections for the "demagnetizing effect" of the ends is much less. Of course in this topsy-turvy subject, the "demagnetizing" action of these apparently diamagnetic specimens really aids the external field. The measurements on the Pb specimen showed that as the applied field is increased from zero the flux varies as would be expected theoretically, being zero up to the critical field and then rising abruptly to the value corresponding to $\mu=1$. When the field is reduced below the critical value a partial Meissner effect is observed, the flux decreasing abruptly but not to zero. Further decrease in the applied field causes a further decrease in flux (i.e. some flux was neither "frozen in" nor expelled by Meissner action). There is a positive remanent flux when $H=0$, and as H is increased in the opposite direction this flux continues to decrease linearly until it has reached zero just as H reaches the value $-H_k$. The remainder of a cycle yields a symmetrical and reproducible hysteresis loop.

When the Russian workers performed a similar experiment with an alloy $PbTl_2$ the dictum of McLennan was again exemplified. They found to their surprise that the magnetic field began to penetrate the specimen at a field H_{k1} much less than that value H_{k2} which previous experiments had shown to be critical as regards the restoration of resistance. The penetration was however not quite complete and the flux within the specimen slowly proceeded to approach more and more closely that corresponding to $\mu=1$, finally reaching that value at the field H_{k2} some 17 times that at which penetration began.

On reducing the field a slight hysteresis was observed and at zero applied field there was a small but definite remanent induction. Qualitatively similar results were obtained on a PbBi alloy and have been confirmed by other workers. Moreover it is found that with alloys the critical value of current which destroys the superconduction is less even than that which would produce the penetrating field

H_{k1} and hence much less than H_{k2}. I have already mentioned that these alloys violate Rutgers' relation for the specific heat. It therefore seems that we must subdivide the general class of superconductors into two sub-classes for which the provisional names of *normal* and *anomalous* have been proposed by the workers at Toronto. A superconductor may be classed as normal if

1) it shows no penetration by magnetic fields less than that required to restore resistance to even small currents;
2) the Meissner expulsion of flux on cooling is manifested to at least some extent under favorable conditions;
3) the restoration of resistance by heavy currents coincides with the attainment of the critical field at the surface in accordance with Silsbee's hypothesis;
4) the change in specific heat at the transition is related to the critical magnetic field by Rutgers' equation.

While all of these properties have not been checked in all cases it seems probable that tin, lead, thallium, and mercury are normal in all these respects. On the other hand, a substance which disobeys one of these rules is classed in the anomalous group. In this anomalous group are now listed the element Ta and the metallic compounds $PbTl_2$, Bi_5Tl_3, Pb_2Bi, and PbSn. All of them have not been tested for all of the properties listed but none has been found to be exceptional in one respect and normal in another, so that it seems probable that they will be found to be anomalous in all respects.

It is perhaps therefore not too wild a speculation to suggest that it is the critical field H_{k1} for penetration which is to be taken as the basis not only for property (1) but also for use in Rutgers' equation and in estimating the critical currents. The primary distinction of the anomalous group would then become merely the single property of being able to carry without resistance a small test current in a longitudinal direction in a field up to H_{k2} much larger than H_{k1}. Unfortunately the jumps in specific heat calculated from the H_{k1} values are so low as not to be measurable. It should however be possible to detect experimentally a correlation between the Meissner expulsion and the penetrating field if one exists.

The correlation between the critical current and the penetrating field for anomalous materials is definitely not as close as in the case of the normal materials. Yet even here when the critical currents for wires of different diameter are compared it is found that it is the tangential magnetic fields produced by the critical currents which are equal and not the currents themselves nor the current density. The observed difference in the penetrating powers of magnetic fields produced by internal and by external currents remains a challenge to the future.

The workers at Toronto (25) have made a very extensive study of the behavior of thin films (0.5μ to 30μ thick) of Pb and particularly of Sn. For convenience these films are supported on wires or tubes of constantan or of German-silver on which they are deposited either by dipping in the molten metal or electrolytically. They find that films less than 1μ thick do not become superconducting at any temperature down to 2°K and that if an outer layer of copper or nickel is deposited over the tin no superconduction appears unless the film is at least 4μ thick.

The films of tin behave very much like alloys of the anomalous class, and have abnormally high critical fields and abnormally low penetrating fields and critical currents. The abnormality increases as the film becomes thinner. The curves showing the progressive penetration of magnetic field in these tin films are strikingly like the corresponding curve for $PbTl_2$ observed by the Russian workers.

This connection between superconduction and a physical dimension (i.e. thickness) should prove a valuable clue to some scientific detective. In fact certain theoretical calculations of Becker, Heller and Sauter have been applied by Grayson-Smith to indicate that a necessary thickness of the same order of magnitude as that of the films used might be expected purely from the effect of the mass of the electrons in retarding their otherwise "free" response to an electric field.

You will have noted that throughout this discussion it is the magnetic field which has been considered the limiting variable which could not be exceeded without causing a breakdown of the superconducting mechanism. Yet even here we have a paradox, for while the material is superconducting, the field cannot penetrate it, and if the field cannot exist in the material how can it interfere with its ability to conduct electricity? Of course the answer is that the field is kept out by a flow of current and hence that the permissible linear density of current expressible in amperes per centimeter width along the surface is really the limiting feature. It would seem much more reasonable to expect that a surface density of current expressible in amperes per square centimeter of cross-section would constitute the more fundamental limit. Perhaps this work on films may complete the picture by showing an independent reason why the superconduction current is limited in its possible thickness.

I have reported tonight the current tidings from the many expeditions in this field, both from the amateur dashes of the Washington group up the most readily accessible peaks and points of vantage as well as from the larger and more completely equipped expeditions guided by the years of experience of Leiden. The expeditions have sent back pictures which show beautiful agreements between thermal and magnetic measurements and between theory and experiment and yet other pictures of yawning chasms between quantities which would be expected to agree, and of precipitous discontinuities in what would be expected to be a continuous declivity. Let us hope that ultimately the surveys will close, and that from some of the higher peaks in this region we may secure more penetrating vision than ever before into the innermost nature of electricity and of matter.

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BOTANY.—*A basis for mycogeography* [1] W. W. Diehl, Bureau of Plant Industry. (Communicated by John A. Stevenson.)

Where ships unload strange cargoes from distant ports even the loiterer has a quickened feeling of romantic curiosity about those cargoes. Perhaps the herbarium botanist may be excused for a quickened pulse when he examines specimens from foreign lands or even from distant sections of his own land. Frequently the specimens are novelties that cannot be matched in our collections; again, however, the specimens from the antipodes are identifiable as species to be found also in our own dooryards. That is not true of most seed plants. One can readily detect an ordered arrangement, a seeming causal relation between geography and the distribution of vascular plants. But all too often our sense of order is outraged by the apparent contradictions afforded by our incomplete knowledge of mycogeography. As Bisby (1) has pointed out, "Mycologists have been able to map

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[1] Address of the retiring President of the Botanical Society of Washington, presented December 3, 1935. Received February 20, 1937.

with accuracy the geographic distribution of comparatively few fungi." On the other hand, phanerogamic botanists have been able not only to map with approximate accuracy the distribution of seed plants, but to formulate principles governing their distribution. In spite of a paucity of such attempts to generalize regarding the geographic distribution of fungi, some phases of this many sided subject will be discussed, avoiding in so far as possible questions concerning their dissemination.

EDAPHIC FACTORS

In the experience of those who have attempted to cultivate a fungus the most immediate problem is to determine its nutrient requirements or what the plant geographer and the ecologist would term the "edaphic factors." As nutrients all fungi require the elaborated organic materials of plant or animal origin. Certain fungi if not especially *choosy* in this regard may have a wide distribution over the earth and are said to be cosmopolitan in range. This is true of the Myxomycetes, most species of this taxonomically questionable group being found indiscriminately in the Arctic as well as in the tropics. Lichens do show obvious relations to climate, but they present problems of their own and are not discussed here.

Aquatic fungi.—The sea is of much greater area than the land, but, unfortunately, even less is known about the fungi in the sea than about those in fresh water, and much less of fresh water fungi than of those to be found on the land. Even so, in the case of the true water molds we have the conformity of a taxonomic group to aquatic habitats, although within the water itself the fungi may have highly restricted sources of nutrition, that is to say, the tissues of particular species of plants or animals. Despite all the effort that has gone into the study of water fungi very little is on record about those growing upon algae, in fact, more is known about the fungus parasites of fungi than about those of algae, both terrestrial and marine. To a certain extent water molds appear to be cosmopolitan and European species, or species closely related, are frequent on this continent. Of late years studies of water molds upon protozoa and lower invertebrates have revived an interest in such fungi, but thus far little is known of their geographic relations. More perhaps has been known about those few described species, chiefly cosmopolitan, which grow upon fishes.

We would expect marine fungi to be cosmopolitan. A striking recent instance was that of an apparently unknown ascomycete growing upon eelgrass (*Zostera*), along the eastern coast of Canada. It was described as new in 1934 (5), and within the same year it was reported by Tutin (11) from England, and by Petersen (6) from Denmark. A similar cosmopolitanism has been observed for *Tetramyxa parasitica* which grows in both hemispheres upon *Ruppia maritima,* another salt-water seed plant. We know of these instances because they have been conspicuous upon particular seed plants, and because economic interest has focused considerable attention upon them. Doubtless numerous analogous cases exist, but have not been studied and recorded.

Terrestrial fungi.—During the last 150 years there has accumulated a vast literature concerning fungi that have been found in the earth or growing upon plants and animals or their remains upon the earth. There are numerous fungus floras of various nations, states or other areas, usually mere lists with new species added where the author was unable readily to identify certain specimens. One can peruse such lists *ad nauseam*, but unless the specimens on which they are based can be examined for verification the particular names in these lists are too often of doubtful meaning. For the most part these floras and the many related records of specific occurrences do not present any easy road to an understanding of the geographic distribution of fungi. When, however, these seemingly unrelated accounts are carefully sifted, verified and pieced together into a new pattern they may present a picture with some significance for the plant geographer.

Regional lists of the more common sort include, of course, many of the conspicuous mushroom fungi, which grow to a large extent from the earth or from partly buried materials. These records are of greater meaning, however, when supplemented by the more technical studies of the type undertaken by the soil microbiologist. Although such studies are not directly concerned with geography they have afforded means of explaining significant differences between soil floras.

Since most soils are surcharged seasonally with water, the soil is itself a harbor for some aquatic fungi; and certain studies of water molds in soils have been illuminating, but they are insufficient to indicate broad geographic relations. Water molds in soils must suffer periodic drouth and during dry seasons only those can survive which are capable through resistant spores or other means of enduring the drouth conditions.

Many fungi thought of as soil fungi in reality grow from roots or other remains of organic life underground. When restricted to particular host species the fungus involved cannot be cosmopolitan, but is limited to the region where that host exists. Perhaps such a fungus is not properly a soil organism anyway. In general it is not improbable that soil fungus floras are as much determined by the peculiarities of the decomposition products of certain plant and animal remains as by the character of the inorganic substances present.

That the chemical nature of a soil, or for that matter of any natural medium, is a significant factor in determining the success of a fungus is attested by the results of a multitude of studies of the growth of various species *in vitro* correlated with studies of them in their natural habitats. One of the most readily observed chemical effects upon a fungus is that produced by the reaction of the medium. Such effects were recognized and measured even before the present conception of hydrogen-ion concentration was given publicity. As an instance may be cited the writer's attempt in 1915 to isolate on artificial media the purple *Rhizoctonia* from alfalfa roots. Other fungi and bacteria grew as well or better than the *Rhizoctonia.* Slight acidification prevented growth of bacteria and most contaminating fungi, but there was a contaminating *Fusarium* which was almost as stubbornly tolerant of acid as the *Rhizoctonia.* It was found, however, that with the continued addition of acid a point was reached where the *Rhizoctonia* could tolerate the acid and grow while the *Fusarium* could not. The reaction of the medium here was plainly a factor in regulating the fungus flora. Many comparable studies could be cited wherein the reaction determined the ability of a fungus spore to germinate and of the mycellium to grow or to produce reproductive bodies. The common cultivated mushroom is an excellent example. According to some unpublished data furnished by Dr. E. B. Lambert, *Agaricus campestris* has a considerable latitude in regard to acid tolerance for vegetative growth, but it will produce fruiting bodies only if the casing soil is above pH5. Those who have gathered mushrooms of this species by the bushel in such neutral or limestone soils as occur in the Ohio Valley have always remarked upon the contrast afforded by the poor harvests to be encountered in the acid soils along the Atlantic seaboard. The same is true with respect to the relative abundance of morels in their season in limestone areas as contrasted with their scarcity here. Morels have been noted by various observers as especially abundant following fires in forest and field. W. H. Long (4) in a discussion of fungi about Austin, Texas, called attention to their size and abundance in alkaline cedar-brake soils. Other effects of certain soil constituents have been observed. It is known that some minerals when in sufficient quantity are toxic to certain fungi and others are stimulating, but our knowledge of a consistent relation between soil minerals and mycogeography is sadly insufficient for any generalization.

That complex biological relations other than saprophytism and parasitism exist between fungi is apparent from studies in the laboratory. It is a common observation attested by numerous records that certain fungi in mixed culture thrive together while others are antagonistic to each other. Studies of successions such as those on dung long ago suggested the production by some species of substances toxic or deleterious to certain others, or to themselves, yet not deleterious at all to certain species. Such ecological relations are detected in artificial cultures and have been noted for localized natural areas in studies of fairy-rings, but we have no knowledge of their effect over any extensive range.

The physical condition of a soil, whether sandy or clayey, is an obvious determinant of some species. Certain species are rarely met except in sandy soils, but here again the question of distribution is locally ecological rather than geographic. If the nomenclature of fungi were a clue to specialization in sand, such specialization is rare for few fungi bear the specific names *arenarius*, *arenicola*, etc., which appear rather frequently for seed plants.

It is true that many fungi in soils are more or less specialized in their saprophytism or parasitism. But published accounts with respect to substrata have at least a shadow of accuracy when the record gives the name of the plant, living or dead, as the natural medium for the fungus. The degree of accuracy becomes greater for those substrata not buried in the soil. A glance at any of the regional lists, or better into Saccardo's *Sylloge Fungorum*, reveals an overwhelming number of fungi recorded as growing upon the tissues of particular host plants, chiefly the aerial parts of such plants. It is evident that for ages past there has been a specialization of certain species either as saprophytes limited to specific organic substrata or as parasites varying in behavior through specialized facultative parasitism to obligate parasitism.

Fungi specialized to grow on animals.—There are indications that some fungi may be versatile enough to grow upon non-living tissues of both plants and animals. But there is a large number of species of fungi specialized to grow only upon or in certain animals. Too little is known, unfortunately, about the nature of their structure or activities. That the field is unexplored is indicated by the fact that Seymour's Host index of fungi of North America (8), considered practically complete up to 1923, devotes but 20 out of a total of 718 pages to names of fungi known upon animals, the rest (679 pages) listing the names of fungi recorded upon plants. Of the 20 pages listing fungi on animals less than one page includes all those fungi then known to grow upon the lower invertebrates in America. Less than one page is devoted to fungi on vertebrates. The lion's share of the 19 pages of zoöphilous fungi consists of those on Arthropods, and here but one fungus is recorded for the Crustacea. The 19 pages of fungi on Arthropods is practically an index of the species of Entomophthorales and Laboulbeniales on insects described by the late Roland Thaxter. Although he revealed a new world of fungi we are still without an adequate knowledge of their geographic distribution. That this small total of fungi on animals is not a true picture of the condition in nature is attested by such an increased interest in the subject since 1923 that there have been more American records of such fungi since 1923 than before. Not only in America but in Europe also there is an increased activity in studies of fungi upon animals, although we are still without knowledge of their distribution over the earth except in so far as they are obviously related to disease in man. The geography of certain fungous parasites of man is better known because there is a wealth of clinical record of thrush, of ringworm, and of certain even more repulsive skin diseases caused by fungi. Many of these are almost exclusively tropical while others are known only in temperate climates. Whether the prevalence in the tropics of certain of these fungi is due to the climate or to the less sanitary habits of many tropical peoples is an open question. Certain it is that there is here a distribution according to geography. There is a preponderance of Italian records of fungi pathogenic to man, but this disproportion is doubtless merely the result of the mycological training and traditional interest in mycology in Italy.

CLIMATIC FACTORS

This distribution of fungi in man suggests a response to climate because *Homo sapiens* of various races tends to be susceptible to the fungi of a given region. Many fungi both saprophytes and parasites of plants are limited to the tropical or neo-tropical zone, although certain species of the *Xylariaceae,* and certain Phalloids show notable extensions northward. These latter saprophytes occur sparingly along our seaboard, but their main range is from the West Indies to Brazil. Species of *Balansia,* obligate parasites of grasses, have this same range. When plants infected by some species of *Balansia* are cultivated under cool conditions, the fungus grows more slowly or dies while the host, continuing to grow, becomes normal, i.e. without the fungus. This temperature effect on the host and parasite is related to a climatic effect upon their geographic distribution. Where substrata or hosts are limited to the tropics it is easy to suggest that the ecology of the host is the chief factor in limiting the fungus to the tropics. Such is doubtless true of the unique genus *Camillea* with remarkable species that stand out from the woody substratum, resembling nothing so much as nails partly driven into the wood. Species of *Camillea* are always tropical and it is thought that their substrata are woods limited to the tropics. Many species of autoecious rusts are limited to particular portions of their normal host ranges. In this region we have a species of *Pucciniastrum*, *P. americanum*, growing on red raspberries. This species is found northward into the Canadian zone, but in that life zone it meets a close relative, *P. arcticum* which is found through the Hudsonian and Arctic-alpine zones into Asia. The remarkable rust genus *Ravenelia*, largely tropical, ranges into the United States, and the species are generally more southern than most of the hosts. The powdery mildews are much more in evidence in the drier western United States than eastward, but when we have arid conditions eastward they become more prevalent here. This is really not so much plant geography as it is epidemiology; but it does illustrate a climatic effect upon normal occurrence. *Puccinia glumarum* causing stripe rust of wheat is practically restricted to the western highlands and the Pacific Coast from Mexico into Canada. This distribution is in marked contrast to that of most common parasites of wheat; and the role of temperature and prevailing winds as pointed out by Sanford and Broadfoot (7) is here a factor in the general climatic complex affecting varying annual dissemination.

Although rusts and many other types of fungi are able to thrive in comparatively arid as well as moist regions because they utilize moist conditions when they appear, most of the Phycomycetes are not so versatile. Tucker (10) has noted that species of *Phytophthora* are favored by high humidity and are rare in arid regions. He notes that certain species are primarily tropical in distribution while others are limited to temperate regions. In contrast to the Phycomycetes there are doubtless many fungi, which like the Texas root rot fungus, *Phymatotrichum omnivorum*, are found only in the arid Southwest. The most comprehensive and significant regional lists of fungi have been compiled for arctic areas. These lists, chiefly of parasitic fungi, contain a great number of species well known to the European and North American mycoflora. But a considerable number of species in the Arctic (common to alpine areas also) do not otherwise occur in Europe. This has been ably discussed by Lind (3) who concluded that compared with the condition in temperate regions Pyrenomycetes were numerous, Discomycetes few, powdery mildews rare (some developing no conidia, others only conidia), that the Uredinales were largely those having a perennial mycelium without a full complement of spore forms, and as expected certain Peronosporales were abundant. Lind noted also that there were few saprophytic molds and bacteria to compete with other saprophytic fungi in plant tissues. The well-known parasite of the rusts, *Darluca filum* (Biv.) Cast., was common in the arctic as well as in temperate and tropical areas. The arctic mycoflora thus includes temperate-zone and cosmopolitan species as well as numerous endemics.

Most instances of altitudinal distribution of fungi appear to be merely responses to the requirements of temperature and humidity which delimit the so-called 'life zones.' An instance of a different sort is that of an old claim recently reiterated by Costantin (2) that rust on coffee, disastrous at low altitudes, becomes rare at certain higher elevations at which the coffee can still thrive. Here in the eastern United States, the apple-scab fungus is more abundant at higher elevations, but it is primarily northern and the apple bitter-rot fungus southern. The former is chiefly restricted to the Canadian and Alleghanian life zones and the bitter rot organism chiefly Carolinian and Austro-riparian. But there is an annual fluctuation of range depending upon seasonal conditions. The rapid adaptation of some fungi enables them to surmount the barriers which for seed plants permit more easy delineation of life zones.

BARRIERS AND ENDEMISM

These seasonal fluctuations in apparent range for fungi restricted by temperature demonstrate the effectiveness of unfavorable temperatures as barriers. A temperature barrier is as effective as an ocean. With the unintentional aid of modern man those obvious barriers of temperature and of ocean tend to be circumvented. All are familiar with the remarkable adaptation of the Andean potato to the climate of Ireland with its fulfillment of the need in Ireland for a cheap and suitable source of food, and with the fact that the first Irish potato famine came on shortly after the early steamboats with more rapid transportation could have carried the potato blight fungus alive to Ireland. Here the shorter journey enabled the fungus to survive the tropical voyage, an impossibility in the slower sailing vessels. In like manner, the chestnut-blight fungus, endemic in Asia, by the aid of man was enabled to surmount the ocean barrier.

The penetrating and almost nauseating odor of the Phalloids or stink-horns is familiar to all. In New Zealand, Australia and South Asia there are certain remarkable species of these found nowhere else. One of these known as *Lysurus mokusin* is endemic in south China, but on a steaming hot midsummer day it can be found emerging from the ground in the court back of the Smithsonian Building and at several other points in Washington. Washington, D. C., and Chico, California, are the only places known for it other than South China. Our eastern American Phalloid, *Dictyophora duplicata*, is now established in Germany and Austria as has been reported by Ulbrich (12). It is possible, indeed likely, that the common mushroom, *Agaricus campestris*, which grows primarily on horse manure, came to America with the horse.

Other barriers, of course, are mountains and deserts and the absence of favorable substrata and hosts. It is obvious that those fungi requiring special hosts may be found wherever those hosts exist. An excellent example is afforded by that remarkable ascomycetous genus *Cyttaria* parasitic only upon species of *Nothofagus*, the antarctic beech, with the coincident discontinuous geographic distribution in Chile, New Zealand, and Tasmania. It is conceivable, however, that where a plant occurs sparingly its obligate parasite may not be able to reach all of its outlying stations, especially if the fungus spores are not windborne. Such a case was reported in 1917 by N. E. Stevens (9) for the natural distribution of *Endothia gyrosa* on oaks. He found that in the northern United States where oaks became infrequent the fungus, although apparently able to survive and reproduce itself under existing conditions, was much less frequent than the host. In other words there was here insufficient opportunity for infection, an actual barrier of non-oak trees existing between infected trees and uninfected trees over which barrier the fungus could not spread.

In the same manner the absence of a requisite alternate host from a given area would preclude the reproduction within that area of any fungus requiring two different host species for the annual cycle. Such is the condition in the genus *Gymnosporangium* (our common species in this area forming galls on red cedar and the alternate stage on the apple and its close relatives). Changes in the natural range of species have been much influenced, firstly by the introduction through cultivation of different hosts and substrata and secondly by the local eradication of certain hosts and substrata. That the directions of unfavorable winds complicated, of course, by bird migration, can prove barriers, was shown by the slow westward spread of the chestnut-blight contrasted with its rapid spread southward.

The presence of deleterious organisms, parasitic, predaceous or merely chemically antagonistic to the growth of a particular fungus, ought to constitute a barrier, but consistent evidence is lacking.

Many endemics still persist in their localized habitats never having been gathered elsewhere. Endemics may present practical problems, as, for example, where some such fungus has surmounted its natural barriers to assume economic importance in the newly invaded region. Thus it will be seen that the natural distribution of a fungus species is significant in interpreting its possibilities in a new range. Through the agency of transported plants and animals as direct vectors man has been the agent in notable changes from endemism to cosmopolitanism.

In eastern America we have many species extending from South America up the eastern coast of the United States. Certain species of *Xylaria*, *Hypoxylon*, *Simblum*, *Clathrus*, as saprophytes, and of *Balansia* and *Dothichloe* as parasites show this range. They are not found west of the Cordilleran backbone. No species of *Balansia* and *Dothichloe* occur on the Pacific Coast of America, although their susceptible hosts are present. Cases of this sort, actually numerous, doubtless represent relics of ranges that are matters of geological history where by some remarkable accident the fungi in question have not yet surmounted the barriers of climate, ocean, mountains, or other restricting factors. When fungus provinces or zones are charted as has been done so well for higher plants and animals one such zone in America will be found to extend from Argentina to New England. Other ranges will be recognizable for fungi which do not conform to the usual life zone pattern and often present startling contrasts to them.

COSMOPOLITANISM

The fact that many species of fungi are practically world-wide has been mentioned earlier. In fact, cosmopolitanism is so commonplace that the taxonomist of fungi does not use a local flora to identify his plants, but must have recourse to the whole of the world's mycological literature if he would be even approximately correct. Hence it is that students of fungi have so little respect for the lists of new species that have often been proposed for each new region.

CONCLUSION

Compared with the available information regarding the geography of seed plants evidences of a reasonable mycogeography appear inadequate. From the mass of detailed records, however, some of the problems that arise in mapping the fungus vegetation of the world can be recognized and some conclusions arrived at if only tentatively:

Life zones bounded by climatic lines, although significant for part of the mycoflora, are chiefly recognizable for those species which require particular substrata which in themselves are dependent upon climate, although climatic limits for many non-obligate saprophytes are also in evidence.

Endemic species make up provinces not in accord with the life zones noted for higher plants and animals perhaps as a result of the geological history of those species complicated by the question of barriers. Delimitation of all areas of distribution is obscured by the general presence of cosmopolitan species.

These two types of provinces, life zone and endemic, are both bounded by barriers of climate, ocean, mountains, deserts, wind direction, lack of bridging hosts or vectors and possibly affected by parasites and other deleterious organisms. But through the influence of man with his mechanized civilization these barriers are now being crossed by many fungi with resultant new practical problems for the mycologist whether he is concerned with industry or with animal or plant pathology.

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ENTOMOLOGY.—*The North and Central American spider parasites of the genus* Pseudogaurax (*Diptera: Chloropidae*).[1]

DAVID G. HALL, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

Black widow spiders (*Latrodectus mactans* F.) have received much attention in the daily press of the United States during the past several years, and parasites of these spiders have become of general interest. Reproductions of photographs showing biological phases in the life history of one of these parasites of the black widow spider have received wide circulation in two popular monthly magazines, under an erroneous name.

The life history of no species of *Pseudogaurax* has been studied fully. The egg, larva, pupa, and adult of *Pseudogaurax anchora* Loew were figured by Howard.[2]

Eggs of some species belonging to this genus are known to be deposited upon the silken strands of egg sacs of spiders, on the cocoons of lepidopterous insects, or on egg masses of mantids. The larvae penetrate the coverings and destroy the contents. When full grown the larvae pupate within the cocoon or egg mass, or on the silk of the egg sac.

The late F. W. Stickney of the Bureau of Entomology and Plant Quarantine, during his investigations in southern California found cocoons of the black widow spider to be highly parasitized by *Pseudogaurax signatus* Loew. This species has been reared many times from egg sacs of the black widow spider in numerous localities in the southern part of the United States.

A key to separate the known North American and Central American species of *Pseudogaurax*, descriptions of four previously undescribed species, and illustrations of the dorsal thoracic color markings of seven species are presented herewith. The material upon which this paper is based is all in the U. S. National Museum.

PSEUDOGAURAX Malloch

Pseudogaurax Malloch, 1915, Proc. Ent. Soc. Wash. **17**: 159 (not Duda, 1930). (Genotype, *Gaurax anchora* Loew, by original designation.)

As pointed out by Malloch[3] in his key, the genus *Gaurax* previously included two distinct groups, one with the scutellum rounded and convex and the other with the scutellum elongate and dorsally flattened. For the group

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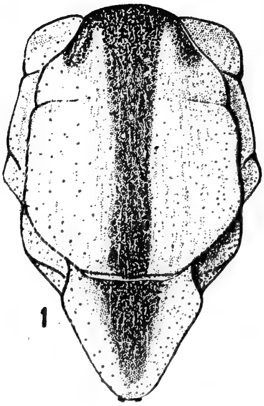
[1] Received March 13, 1937.

[2] HOWARD, L. O. *The insect book*, p. 184, fig. 106, 1902.

[3] MALLOCH, J. R. Can. Ent. **46**: 116. 1914.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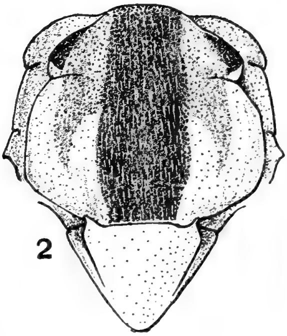
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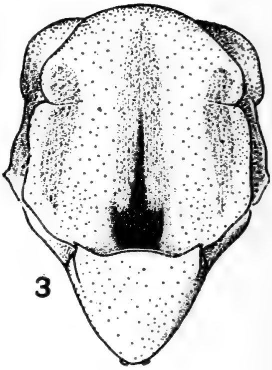
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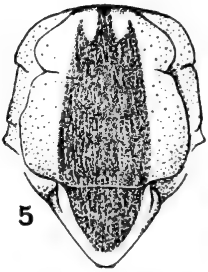
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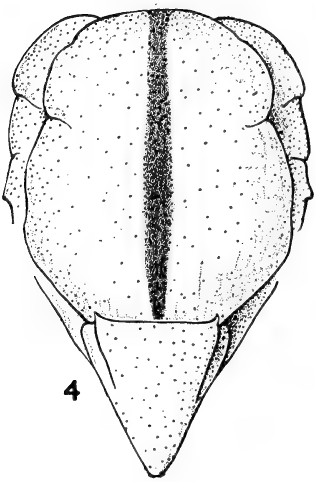
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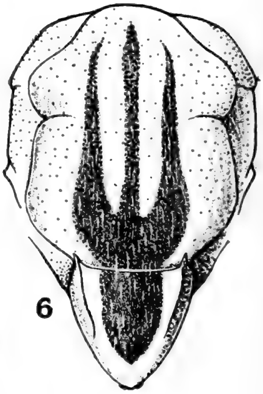
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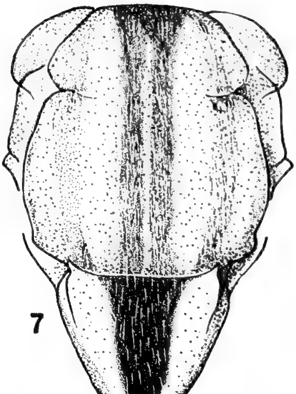
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Fig. 1.—*Pseudogaurax anchora* (Loew). Dorsum of thorax. Fig. 2.—*Pseudogaurax misceomaculata*, n. sp. Dorsum of thorax. Fig. 3.—*Pseudogaurax lancifer* (Coq.) Dorsum of thorax. Fig. 4.—*Pseudogaurax unilineata*, n. sp. Dorsum of thorax. Fig. 5.—*Pseudogaurax latimaculata*, n. sp. Dorsum of thorax. Fig. 6.—*Pseudogaurax lyrica*, n. sp. Dorsum of thorax. Fig. 7.—*Pseudogaurax signata* (Loew) Dorsum of thorax.

of species with the convex scutellum he erected the genus *Neogaurax*, with *Gaurax montana* Coq. as genotype. Discovering later (1915) that he had renamed the typical *Gaurax*, he named the group with the elongate scutellum *Pseudogaurax*, with *G. anchora* Loew as genotype, synonymizing *Neogaurax* with *Gaurax*.

Generic characters.—Head. Eyes with long pile, higher than long, emarginate posteriorly; frontal triangle with a single marginal row of setae; front irregularly setose; parafrontals each with a row of setae near eye, these descending nearly to the antennal insertion; bucca short and with a row of rather long setae along edge; epistoma slightly protuberant; clypeus slightly depressed; antenna with first segment short, second segment about 4 times as long as first and with long hair, especially along the inner edges, and a single longer seta dorsally; third segment ovate, higher than long, covered with abundant, short, curling hair; arista short plumose throughout its length, the rays from 2 to 4 times as long as the greatest diameter of the style; inner vertical bristles 1; outer vertical bristles 1, long and distinct; ocellar bristles reclinate. *Thorax* thickly covered with long, scattered, light-colored hair; posthumeral bristles arranged 1:2; postalar bristle 1. Scutellum flattened above, elongate, and ending in an obtuse point, with long apical setae arising from protuberant bases near the apex. *Wing* with costa extended to tip of fourth vein, fifth vein with a distinct flexure. *Legs* rather densely hairy, the hind tibia with an oval, smooth, velvety (sensitory?) area on the inner side.

As stated above, the genus *Pseudogaurax* differs from *Gaurax* in that the scutellum is elongate and flattened above, ending in a more or less obtuse point and with elongate apical bristles situated on approximated tubercles. In additon to these differentiating characters, the scutellum lacks elongate marginal setae. The genus differs most obviously from *Eugaurax* Malloch, in that *Eugaurax* has the posthumeral bristles arranged 2:3 or more, never 1:2 as in *Pseudogaurax*.

The species of *Pseudogaurax* that fall here are exceedingly similar in many respects and differ mainly in thoracic maculation and in thoracic proportions. These characters are so obvious that I have figured the dorsum of the thorax of each species.

Pseudogaurax Duda is distinct from and preoccupied by *Pseudogaurax* Malloch. The following disposition of it is made:

MIMOGAURAX, new name

Pseudogaurax Duda, 1930, Folia Zool. Hydrobiol., **2** (3): 86. (Preoccupied by *Pseudogaurax* Malloch, 1915.) Genotype, *Gaurax interruptus* Beck.

KEY TO SPECIES OF PSEUDOGAURAX FROM NORTH AMERICA AND CENTRAL AMERICA

1. Scutellum dorsally clear yellow 2
   Scutellum with black markings dorsally 4
2. Dorsum of thorax with wide, blackish brown, longitudinal maculations, small lateral presutural spots, the latter more or less connected to the broad central stripe by infuscated areas. Thoracic length, scutellar

length, and thoracic width in the proportion of 23:7.5:20. Puerto Rico . . . . *misceomaculata,* n. sp.

Dorsum of thorax with a single mid-dorsal longitudinal stripe 3

3. Mid-dorsal longitudinal stripe of thorax not extending full length of thorax and broadening more or less before scutellum. Thoracic length, scutellar length, and thoracic width in the proportion of 25:8:19. Puerto Rico, West Indies . . . . *lancifer* Coq.

Mid-dorsal longitudinal stripe of thorax extending full length of thorax and narrow throughout. Thoracic length, scutellar length, and thoracic width in the proportion of 33:11:22. Panama . . . . *unilineata,* n. sp.

4. Mid-dorsal longitudinal stripe of thorax relatively narrow, broadening anteriorly and extending into two shorter lateral stripes which do not reach posteriorly to the suture. Thoracic length, scutellar length, and thoracic width in the proportion of 28:8:18. Mass., Md., Va., Fla., O., Ind. . . . . *anchora* Loew

Color pattern of thorax not as above 5

5. Dorsum of thorax with a single, wide, longitudinal stripe. Thoracic length, scutellar length, and thoracic width in the proportion of 15.3: 4.5:11.25. Panama . . . . *latimaculata,* n. sp.

Dorsum of thorax with more than one longitudinal stripe 6

6. Dorsum of thorax with three longitudinal stripes in the shape of an inverted fork or the frame of a lyre. Thoracic length, scutellar length, and thoracic width in the proportion of 27:8:18. Costa Rica . . . . *lyrica,* n. sp.

Dorsum of thorax variable, usually with several indistinct, reddish orange to brown, longitudinal stripes, the scutellum always with a well-defined, dark-brown to black, dorsal spot. Thoracic length, scutellar length, and thoracic width, in the proportion of 30:11:20. Calif., Tex., Tenn., N.C., Va., Md., Mexico . . . . *signata* Loew

Pseudogaurax anchora (Loew)

Gaurax anchora Loew, 1866, Cent. **7** (94): 51; Williston, in Forbush and Fernald, 1896, Report on Gypsy Moth, p. 387; Coquillett, 1898, Bull. **10:** 71, n. ser., Div. Ent., U. S. Dept. Agri.; Howard, 1902, Insect Book, p. 184, fig. 106; Williston, 1908, Manual of North American Diptera, p. 311; Becker, 1912, Mon. Chlor. **4:** 75; Johnson, 1913, Dipt. Fla., p. 87; Psyche **20:** 35.

Pseudogaurax anchor [Loew], Malloch, 1915, Proc. Ent. Soc. Wash., **17:** 159; Johnson, 1925, Proc. Bost. Soc. Nat. Hist., p. 99; Auten, 1925, Ann. Ent. Soc. Amer. **18:** p. 244; West, 1928, N. Y. State List Ins., p. 861.

Male and female.—*Head* yellow; eyes reddish brown; arista and ocellar spot black. *Thorax* yellow, dorsum of thorax with brownish-black maculations as in Fig. 1; postscutellum black. *Abdomen* dorsally with first segment yellow, posterolaterally dark brown; second segment laterally dark brown to black, third and fourth segments dark brown to blackish laterally, sometimes lighter; venter yellow. *Wing* hyaline, veins yellow; haltere lemon yellow. *Legs* whitish yellow.

Type.—In the Museum of Comparative Zoology, Cambridge, Mass.

Remarks.—The National Museum collection contains 1 female, Weston, Mass., July 23, 1911; 1 female, Beverly, Mass., Aug. 27, 1909; 2 females, Rock Ledge, Fla., Feb. 6 (C. V. Riley); 2 females, Riggs Mill, Ind., May 15, 1914, "ex cocoon *promethea*" (G. W. Barber); 1 female, Hagerstown, Md., Aug. 2, 1918, "in cocoon of *Heterocampa leucostigma*" (Pennington); 1 female, Falls Church, Va., May 15 (Banks); 2 males and 4 females, Falls Church, Va., Jan. 26, 1930, "from cocoons of *promethea*" (Cushman).

This species has been reared upon numerous occasions from lepidopterous cocoons but whether it is a parasite or a scavenger has not been ascertained. All of the reared specimens in the National Museum collection were reared from cocoons of Lepidoptera. The notes upon such specimens indicate that the collectors believed the species to be parasitic.

Pseudogaurax misceomaculata, n. sp.

Male.—Like *anchora* except as noted in the key and in thoracic maculations as illustrated in Fig. 2. The species also differs from *anchora* in having a brownish black anterior and a smaller posterior mesopleural spot, in having the postscutellum decidedly glossy black with a smaller darkened area laterally, and in having the abdomen almost black.

Type locality.—Bayamon, Puerto Rico.

Type.—United States National Museum no. 51942.

Remarks.—One male labelled "on leaves of *Flamboyan*," Jan. 28, 1934 (San Juan accession no. 5135B), collected by C. G. Anderson.

Pseudogaurax lancifer (Coq.), n. comb.

Gaurax lancifer Coquillett, 1900, Proc. U. S. Nat. Mus. **22**: 265; Becker, 1912, Mon. Chlor. **4**: 76; Wolcott, 1923, Ins. P. R., p. 232; 1927, Ent. D'Haiti, p. 329; Duda, 1930, Folia Zool. Hydobiol. **2** (1): 87.

Male and female.—As in *signatus* except as noted in key and in maculations of the thorax as illustrated in Fig. 3. It also differs from *signata* in having the arista black, in possessing an additional brown spot on the posterior part of the mesopleura, in having the postscutellum but slightly darkened, and in having the legs clear light lemon yellow.

Type.—U. S. National Museum no. 4384.

Remarks.—The National Museum collection contains the type-series of 8 specimens "from spider's eggs," Puerto Rico, Feb. 9, 1899 (Busck), and 5 specimens "from spider's eggs," Montserrat, West Indies, March 16 (Hubbard); also 5 specimens, "spider parasites," Port Cangrejos, Puerto Rico, June 1, 1920 (Wolcott), and 1 specimen "on guava leaf," Barceloneta, Puerto Rico, Apr. 25, 1933 (Mills and Anderson).

This species appears to have much the same type of biology in the West Indies as *signata* has in the United States. It was reared in Puerto Rico in considerable numbers from the egg clusters of the spider *Gasteracanthia cancriformis* by G. N. Wolcott and forwarded to the National Museum under his accession number 333–21.

Pseudogaurax unilineata n. sp.

Male and female.—Like *signata* except as noted in the key and in thoracic maculations as illustrated in Fig. 4. It further differs from *signata* in having the aristal style yellowish, the anterior mesopleural spot more diffused and extended over a wider area, the tibiae more decidedly brownish, and also in the maculations of the yellow abdomen which are as follows: First segment yellow except for posterolateral darkened spots; second segment with larger posterolateral areas; third segment dark brown to black; fourth segment anterolaterally yellow, posterior margin yellow; venter entirely yellow.

Type locality.—Canal Zone, Panama.

Type.—Female, United States National Museum no. 51943.

Remarks.—Described from a holotype female and 13 paratype male and female specimens reared "from spider's nest," Ancon, Canal Zone, Panama, Oct. 20, 1923 (Zetek), and 1 paratype specimen, Alhajuelo, Canal Zone, Panama, March 18, 1912 (Busck).

Pseudogaurax latimaculata n. sp.

Male and female.—Like *anchora* except as noted in the key and in thoracic maculations as illustrated in Fig. 5. The species also differs from *anchora* in having the ocellar spot more extensive, in the postscutellum, which is yellow, and in the second, third and fourth abdominal segments of the abdomen, which are dark brown to black.

Type locality.—Alhajuelo, Panama.

Type.—Female, United States National Museum no. 51945.

Remarks.—Described from the holotype female and 1 paratype male collected March 12, 1912, Alhajuelo, Panama (Busck).

Pseudogaurax lyrica, n. sp.

Male and female.—Like *signata* except as noted in the key and in the light and dark pattern on the dorsum of the thorax as illustrated in Fig. 6. Also, the postscutellum is yellow, not brown or black, the wing veins are dark, not yellow, the legs are clear lemon yellow, and the abdomen is distinctly blackened.

Type locality.—Higuito, San Mateo, Costa Rica.

Type.—Female, United States National Museum no. 51944.

Remarks.—Described from the holotype female, and 4 paratype male and female specimens collected in Costa Rica by Pablo Schild.

Pseudogaurax signata (Loew), n. comb.

Gaurax signatus Loew, 1876, Zeitsch. Ges. Naturwiss., p. 338; Becker, 1912, Monogr. Chlor. **4**: 75; Duda, 1930, Folia Zool. Hydobiol. **2**: 87.

Gaurax araneae Coquillett, 1896, Ent. News, **7**: 320; 1896, Bull. **10**: **72**, n. ser. Div. Ent., U. S. Dept. Agr.

Gaurax signatus var. *mallochi* Duda, 1930, Folia Zool. Hydobiol., **2** (1): 87.

Male and female.—*Head* yellow, eyes reddish brown; ocellar spot black; arista dark brown. *Thorax* yellow; reddish brown to brownish black dorsal maculations usually as illustrated in Fig. 7, but sometimes also with a small dark posthumeral spot; mesopleura with a single brownish black spot anteriorly; postscutellum usually darkened centrally, sometimes light brown, but rarely blackened. *Abdomen* with first segment medianly yellow, laterally dark brown; second segment dark brown, sometimes lighter anteromedianly; third segment dark brown with yellow posterior margin; fourth segment dark brown with yellow posterior margin, sometimes lighter laterally; venter yellow. *Wings* clear, veins yellowish. *Legs* yellow, tibiae sometimes and tarsi usually darker yellow to brown dorsally.

Type.—In the Museum of Comparative Zoology, Cambridge, Mass.

Remarks.—In the United States National Museum there are nearly 60 specimens of both sexes of this species. Most of these have been reared from the egg sacs of *Argiope riparia*, or from *Latrodectus mactans*, although many records read only "from spider's nest." This species has been reared several times from mantid egg masses (Brownsville, Tex., by Vickery and St. Lucrecia, La Oaxaquena, Mexico, Sept. 1911, by Ulrich).

The species is evidently distributed throughout North America wherever *Latrodectus mactans* occurs.

ARCHEOLOGY.—*Burial area in Moyaone.*[1] ALICE L. L. FERGUSON. (Communicated by W. W. RUBEY.)

For the past two years the writer has been excavating the site of a large Algonkin village on the Potomac River, about eighteen miles below Washington and just below the mouth of Piscataway Creek, in Prince George's County, Maryland, and diagonally across from Mount Vernon. This is believed to have been the town of Moyaone shown on Captain John Smith's map.[2] Bozman[3] says that Moyaone "must have been somewhere about Broad Creek," and the *Handbook of the American Indians*[4] following Bozman, states that the location of Moyaone "was about Broad Creek." Bozman made his identification on the basis of the Smith map and apparently confused Broad Creek, which is further up stream, with Piscataway Creek. Broad Creek is little more than a bay on the river, while Piscataway Creek is wide for a considerable distance, has many little bays and tributaries and enters the Potomac at the bend just as the Smith map indicates. Mooney,[5] on the other hand says, "Moyaones appears, on the same map, to have been directly opposite (Tauxenent or Mount Vernon), on the Maryland side, just below the mouth of the Piscataway Creek." On Smith's map, Moyaone is diagonally across from Tauxenent. Thomas Jefferson,[6] in his table giving the situations of the Virginia villages, places Tauxenent in Fairfax County "about General Washington's." The Broad Creek site is not opposite Mount Vernon or Tauxenent.

Nacotchtank, shown on the Smith map, was latinized by the Jesuits into Anacostia which it is still called although now a part of the city of Washington. This makes a convenient tie point. It is futile to at-

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[1] Received March 10, 1937.

[2] A copy of this map may be seen in Edward Arber's edition of Captain John Smith's works, 1608–1631. The English Scholar's Library, Birmingham, 1884.

[3] BOZMAN, JOHN LEEDS. *History of Maryland.* **1**: 119. Baltimore, 1837.

[4] *The Handbook of the American Indians.* Bur. Amer. Ethn. Bull. **30** (pt. 1): 953. 1907.

[5] MOONEY, JAMES. *Indian tribes of the District of Columbia.* Amer. Anthropologist **2** (3): 259. 1889.

[6] JEFFERSON, THOMAS. Notes on the State of Virginia, p. 152. London, 1787.

Figure 1

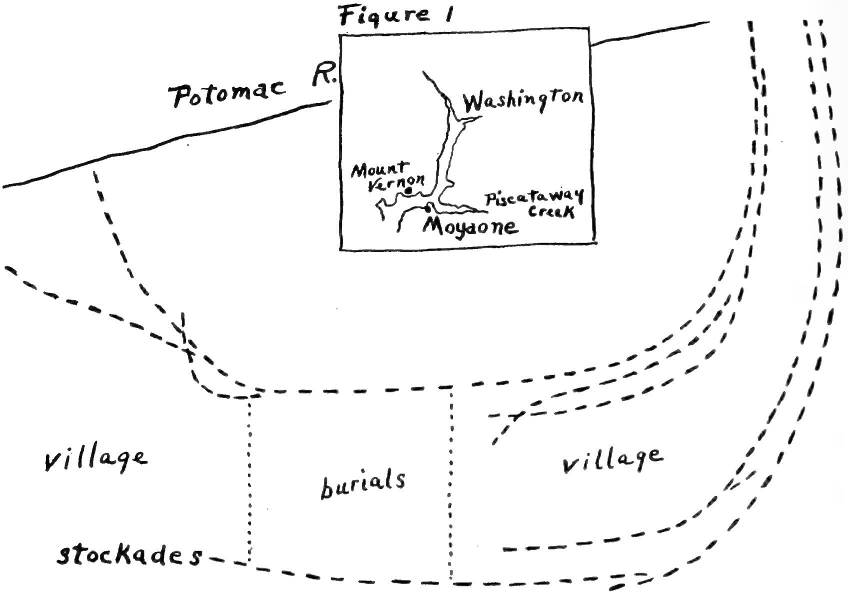

Figure 2

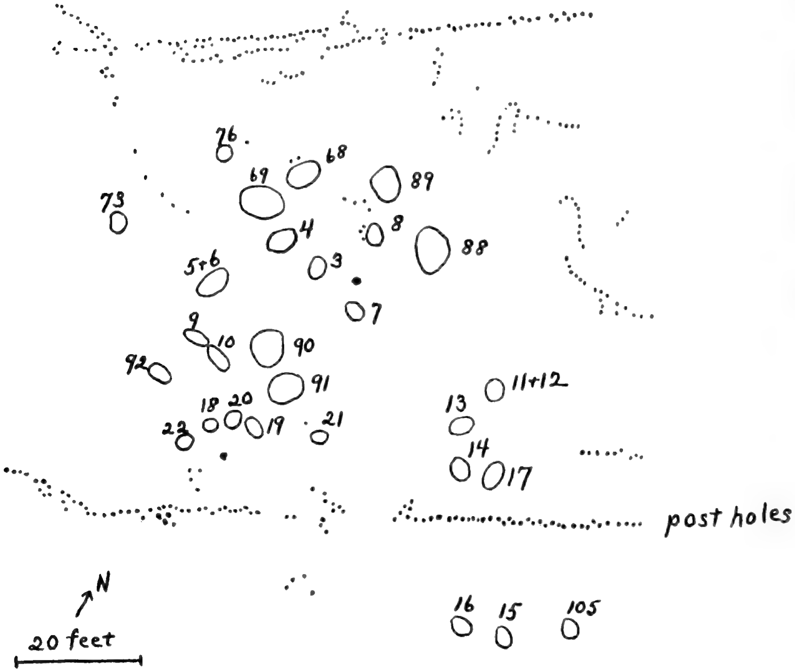

Fig. 1.—Sketch map of Moyaone showing the stockade lines and inset giving the location. Fig. 2.—Burial area in Moyaone.

tempt to make accurate measurements on a 17th century map but it is of interest that the measurement on the Smith map from the point in Virginia where the Eastern Branch flows into the Potomac opposite Nacotchtank, to Moyaone, is $3\frac{3}{4}$ marine leagues. The modern value of a marine league is 3.45 statute miles which makes the distance about 12.9 miles and the measurement on the modern map from the same point to the site is 11.7 miles while the Broad Creek site is only $8\frac{1}{2}$ miles. This placing of Moyaone near and below Piscataway Creek is further verified by four other early maps, "A Chart of Virginia" 1608, the "Simancas Map" 1610, "Belgii Novi, Angliae Novae et Partis Virginiae Novissimi" published about 1650 and the map of Johannes Vingboons published about 1665. Other historical evidence tending to identify this site as Moyaone is given in a manuscript on the history of the tribe now ready for publication. Moyaone was probably burned by the Virginians in 1623.

The site is a large one and was occupied for a long period. There is a great deal more work to be done and a final report must await the completion of the excavations. Work so far done indicates two periods of occupation. The site was first occupied by a large settlement of people about whom very little is known. They made the Popes Creek type of pottery—probably the earliest in this region—described by William H. Holmes[7] in his report on the pottery of the Eastern United States. This pottery is very common in the Potomac valley and is also found along the coast from the Carolinas through New England. In the current terminology this culture is called the Coastal Focus. Though the later occupants of Moyaone made pottery of another type, the Popes Creek ware and associated artifacts occurred in isolation over a considerable area beginning a hundred feet or more from the edge of the later site.

After the makers of the Popes Creek ware came a group of people whose pottery, according to William A. Ritchie[8] of the Rochester Museum of Arts and Sciences, corresponds to that of the third Algonkin period of culture in New York. Dr. Ritchie very kindly made a visit to the site and verified what is here called third Algonkin. The Popes Creek pottery is frequently yellow but usually red, and it is always very coarse with a grit or sand temper (Fig. 4). The third Algonkin pottery is all shades of gray and black, rarely red and yellow and it is tempered with ground up potsherds, clam shells, quartz,

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[7] Holmes, William H. *Aboriginal pottery of the eastern United States.* Bur. Amer. Ethn. Ann. Rept. **20**: 153. 1903.

[8] Ritchie, William A. *Algonkin sequence in New York.* Amer. Anthropologist **34** (3): 406–414. 1932.

Figure 3

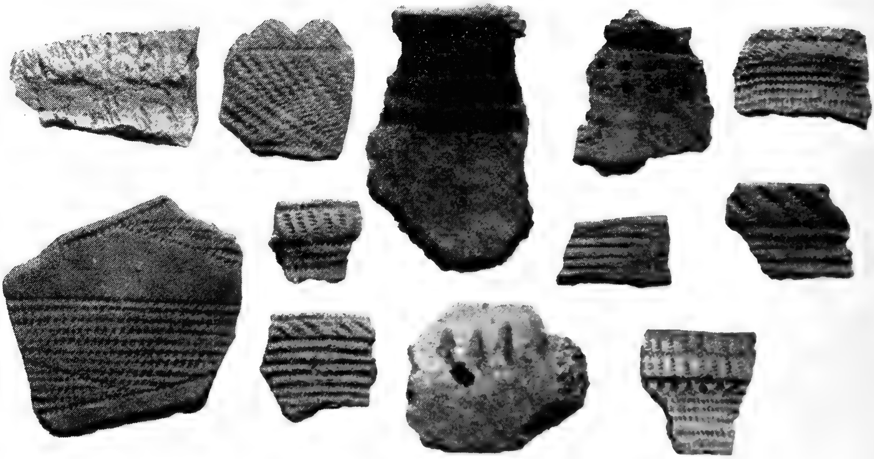

Figure 4

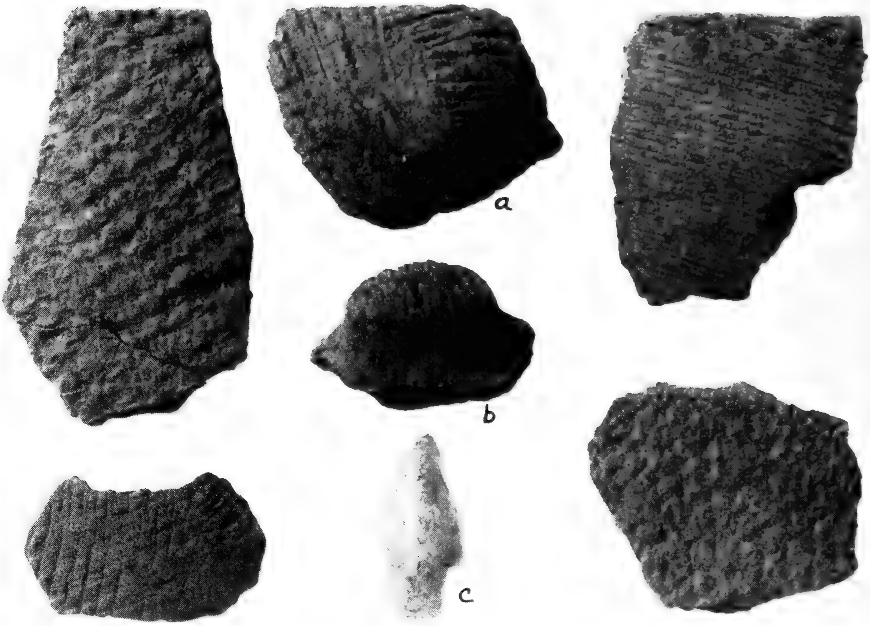

Fig. 3.—Third Algonkin pottery. Fig. 4.—Popes Creek pottery. a, a conical base; b, a lug, one of two found at the site; c, arrow point found in skull of No. 16.

sand and mica (Fig. 3). Occasionally the paste is so smooth that no temper is evident. This later pottery carries somewhat more ornamental designs than the earlier, especially around the rims of the pots, a few of which display real beauty, though many were badly made. Inside the stockades of the village, almost all the pits had a mixture of both types but a few pits were found that had only the third Algonkin.

Moyaone was in the shape of a huge crescent, the points of which, nearly four hundred feet apart, touched the Potomac River. Inside the stockades the ground was peppered with post holes. In the center of the crescent, at its broadest part, there were no post holes and no signs of village activity. The refuse pits and the pottery fragments, broken pipes and stone artifacts that had been scattered in every direction up to that point stopped, and instead of them twenty burials were found. The burials belonged to the earlier people, yet the later inhabitants of Moyaone, with a large population crowded into a restricted area, knew of the burials and respected them.

The only pottery found associated with the burial pits was of the Popes Creek type. All the bones were so far decayed that only thirteen of the twenty skeletons were in any way identifiable. Out of these thirteen, all were females except one, No. 3, which was that of a middle aged male with a large scar on the skull. Of the twelve females, six were middle aged, two were old, and four were young adults. It is unfortunate that even these thirteen were for the most part too poorly preserved to make it possible to obtain measurements. Dr. T. D. Stewart of the U. S. National Museum very kindly made the measurements given here and the writer would like to express her thanks to him:

No. 3, male, skull length 19.4 cm. No. 5, cephalic index 80.22; orbital index 92.5; nasal index 48.08. No. 6, skull length 18.2 cm. No. 7, jaw measurements; height of symphysis 3.1? cm; length of lower jaw 9.4 cm; breadth minimum of the ascending ramus 3.8 cm. No. 11, skull length about 18.8 cm, probably dolichocephalic. No. 12, probably brachycephalic. No. 13, skull length 17.4 cm; skull height 13.3 cm, meso- to dolichocephalic. No. 14, cephalic index 73.2; facial index 51.6; nasal index 54.3; orbital index 86.1; alveolar index 116. No. 20, very dolichocephalic. No. 21, head index below 70; head height measurable 13.6 cm.

Of these, four are dolichocephalic, one meso- to dolichocephalic, and two brachycephalic.

Three of the burials were grouped. No. 5, an aged female, lay directly over No. 6, a middle aged female. No. 9 seemed to be a secondary burial, it consisted of the fragmentary bones of two individuals, a child of between six and eight years of age and an adult.

Nos. 11 and 12, an old and a middle aged female, were buried side by side and so close together that it was impossible to determine which bones belonged to which skeleton.

A total of 44 random potsherds and 4 arrow points were found in the grave pits exclusive of an arrow point found at the base of the skull of No. 16 and fragments of a very large pottery jar found directly under the knee of No. 14. No other fragments of this jar were found in the pit although several small pieces of it were found fifty feet away. In the far corner of the pit of No. 16 was found a group of sherds that fitted together and were very like the fragment found with No. 14. Aside from the charcoal which was always present, and a small stone 3½ inches long smeared with red iron oxide paint, these were the only artifacts found in the burial pits.

Most of the burials, especially Nos. 4, 8, 10, 15, 16, 17 and 19 were in such poor condition that there was almost nothing left. Nos. 15, 16, 17, and 19 consisted only of jaw fragments and teeth, all so poorly preserved that they powdered at a touch. In this group of burials were seven pits, Nos. 68, 69, 88, 90, 91 and 92, which were completely empty. The pits were sharply defined and they contained the same charcoal flakes and the same brown discolored soil that marked the burial pits. They had scattered in them a total of 14 potsherds of the Popes Creek ware. It seems probable that these pits were also burial pits in which the bones had completely disintegrated.

The burials were all of about the same depth. Most of them were about 1.9 feet from the surface to the highest point of the burial. The shallowest burial, No. 9, was just under the plow line, a little less than a foot below the surface, and the deepest, No. 13, began at 2.35 feet.

All the pits had small flakes of charcoal scattered through them. Nos. 73, 76 and 105 were shallow fire pits. Nos. 73 and 76 contained a few deer bones and potsherds. On one side of fire pit No. 105 was the charred remnant of a small post about two inches in diameter, extending to a depth of 3.4 feet below the surface. These fire pits near the graves, containing the same type of pottery, suggest feasts and fires connected with the burial ceremonies. In the entire burial area, in addition to the sherds already mentioned which were more intimately associated with the burials, there were 170 sherds of the Popes Creek type scattered around generally and only 16 rather small sherds of the third Algonkin period.

Attention should be called to the large post hole, a foot in diameter, in the center of the burial area. No. 3, the only male burial found, was near the pole and the other burial pits tend to encircle it.

Only a few general customs appear from a study of this group of burials. The bodies were buried individually and they were flexed. There was no effort towards orientation. About half of the skeletons rested on the right side, and half on the left. With the exception of the pottery fragment found in burial No. 14 and possibly the fragment in No. 16, there were no mortuary offerings. The objects found in the other pits could easily have slipped in when the pits were being dug and filled.

The surprising thing about this burial area in the center of a crowded village, was that in it were found only sixteen sherds belonging to the later period of occupancy. It is remarkable that any taboo could have been sufficiently strong to hold an area as large as this unprofaned in the midst of all the village activities of a later settlement.

Obituary

Ozni Porter Hood, retired, Chief Mechanical Engineer of the Bureau of Mines, Washington, D. C. and former Chief of its Technologic Branch, died at his home in Washington April 22, 1937. The son of an inventor, born in Lowell, Massachusetts, on June 14, 1865, he was educated in mechanical engineering at Worcester and Rose Polytechnic Institutes, receiving the degrees of B.S., M.S., and M.E. He began his career as a pattern maker but shortly became a member of the faculty at Kansas Agricultural College and then at the Michigan College of Mines.

Dr. Hood joined the Bureau of Mines at its Pittsburgh Experiment Station in 1911. He assumed charge of the fuel investigations which had started in 1904 at the World's Fair in St. Louis and continued by the U. S. Geological Survey prior to the formation of the Bureau of Mines on July 1, 1910. He coordinated this work and developed mechanical and electrical engineering research pertaining to safety in mines. From small beginnings he organized a system for testing and approving, with respect to safety and efficiency, electrical equipment for use in gassy coal mines. The Davis multiple-unit calorimeter, the Burrell gas detector, and the Gibbs oxygen breathing apparatus are early examples of his mechanical genius. He made a pioneering study of gasoline mine locomotives in relation to safety and health.

With his co-workers he conducted fundamental research on the mechanism of combustion in fuel beds and participated in the practical development of the combustion of powdered coal and initiated timely studies on the gasification of coal. The publications on lignite and peat in which he participated still remain the outstanding documents on these subjects, although written many years ago. In the conduct of these investigations he designed and built a simple unit for carbonizing lignite. He directed smoke abatement investigations in various cities; carried out nation-wide sampling of coal and its analysis in connection with Government purchases of coal on specification; and made very substantial savings of heat and power in Government plants.

Dr. Hood was made a life member of the American Society of Mechanical Engineers in 1935, and in 1932 his Alma Mater, Rose Polytechnic Institute, conferred on him the honorary degree of Doctor of Engineering. In addition to membership in Tau Beta Pi, he belonged to the Cosmos Club, Washington, D.C., The Washington Society of Engineers, the Washington Academy of Sciences, the American Society of Mining and Metallurgical Engineers, the International Railway Fuel Association, and he became an honorary member of the American Society of Heating and Ventilating Engineers.

William Morton Wheeler, emeritus professor of entomology, Harvard University, died at Cambridge, Mass., April 19, 1937.

Professor Wheeler was born at Milwaukee, Wis., March 19, 1865. He attended Engelmann's German Academy in Milwaukee, and graduated from the German-American Normal School of that city. He received the degree of Doctor of Philosophy from Clark University in 1892, then studied for a year at Würzburg, Liege and the Naples Zoological Station. From 1894 to 1899 he was instructor and assistant professor of embryology at the University of Chicago, and from 1899 to 1903, professor of zoology at the University of Texas. During the next five years he was curator of invertebrate zoology at the American Museum of Natural History, but in 1908 accepted the appointment of professor of economic entomology at Harvard University. From 1915 until 1929 he was dean of the Bussey Institution, a graduate school of the University for research in applied biology; in the year 1924–1925 he was exchange professor to the University of Paris; and from 1926 he was professor of entomology at Harvard University and associate curator of insects at the Museum of Comparative Zoology.

Professor Wheeler's chief interest was the classification and behavior of ants, but his bibliography, which contains 467 titles, includes also such subjects as embryology, evolution, parasitism, and animal sociology in general. His studies in sociology led him into psychology and philosophy, on which he published numerous papers. Several of his works appeared in book form, such as *Ants*, *The social insects*, *Foibles of insects and men*, and *Demons of the dust.* Professor Wheeler wrote with clarity, pungency and humor, as is well illustrated by two of his shorter essays: *The dry-rot of our academic biology* and *The termitodoxa, or biology and society.*

In recognition of his scholarship and contributions to science, many honors were conferred upon him. He received an honorary Sc.D. from the University of Chicago in 1916, Harvard University in 1930, Columbia University in 1933; and an honorary LL.D. from the University of California in 1928. He was awarded the Elliot Medal, and the Leidy Medal from the Philadelphia Academy of Natural Sciences in 1931. In 1934 he was elected an Officer, Legion d'honneur. He was associated with many scientific organizations, including the National Academy, the American Academy, the Washington Academy, the Philosophical Society, the Royal Entomological Society of London, the Société Entomologique de France, and Société Entomologique de Belgique.

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JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 27 JULY 15, 1937 No. 7

CHEMISTRY.—*The chemical application of the Raman effect.*[1]

JAMES H. HIBBEN, Geophysical Laboratory, Carnegie Institution of Washington.

The Raman effect is too recent a discovery to have what is generally termed a history. It was early in 1928 that Sir C. V. Raman announced his observation of a new type of secondary radiation which was considered as "an optical analogue of the Compton effect." This secondary re-radiation has since been known as the Raman effect.

This subject has been investigated by most of the leading laboratories of the world with the result that within less than a decade there have been considerably more than a thousand publications concerning it. This widespread interest cannot be attributed solely to the novelty of the new discovery, but is primarily due to its fundamental nature from the point of view both of physics and chemistry.

The Raman effect is essentially another parameter by which the behavior of molecules may be measured, independently of their state of aggregation. Other direct methods, such as x-ray and electron diffraction, have indicated the position of the heavier atoms. These methods, like the Raman effect itself, have certain limitations. Fortunately, as compared with the Raman effect, they are complementary in the sense that what one system lacks the other provides. The information obtainable from the standpoint of the Raman method concerns the forces between atoms in a molecule in its normal state, to a certain degree the arrangement in space of the atoms, and their amplitudes and frequencies of vibration. In the simpler molecules this leads to a determination of some of the energy levels the molecules possess. These levels are the warp upon which the pattern of the molecule is woven. Finally this procedure yields in many cases the specific type of chemical linkage which exists in a molecule. This information in turn may lead to the calculation of specific heats and other information of interest to the physicist and to the chemist.

Perhaps the best approach to the problem of what is the Raman effect is to draw an analogy between this and x-ray analysis, which is

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[1] Address of retiring President of the Chemical Society of Washington, January 14, 1937. Received February 19, 1937.

known to some extent by everyone. In the latter case the atoms in the given molecule are bombarded with radiation of very short wave length compared to the size of the molecule. The refraction of this radiation may be recorded on the photographic plate as definite spots which are a function of the interatomic distances. In Raman spectra the molecules are bombarded with radiation of longer wave length in equivalent fashion. The type or wave length of light used, however, is in general immaterial. It may be long wave lengths as represented by the red light or it may be short wave lengths as represented by the far ultra violet. In the case of x-rays one deals essentially with a static situation. In the Raman effect it is not static but dynamic. Here it is a question of the motion of the atoms and the molecule and only indirectly their position in space. Nevertheless, as will be seen shortly, the geometric distribution of atoms does influence the result.

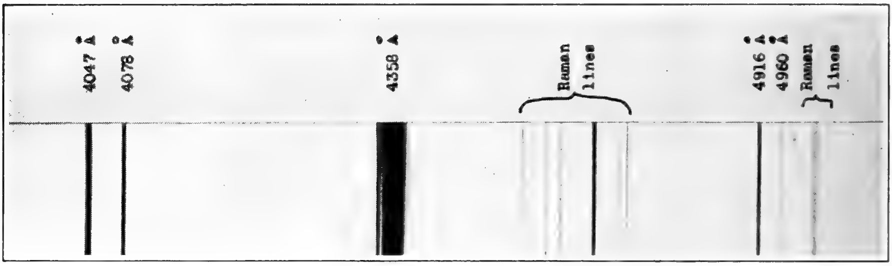


Fig. 1.—Partial Raman spectrum of nitrobenzene showing the 4358Å exciting line.

In effect, therefore, molecules, regardless of the state of aggregation, whether they are in the liquid, solid, amorphous or gaseous state, are bombarded with definite light quanta, that is, light preferably of a given single wave length, or what is generally termed monochromatic radiation. When these quanta of energy or photons collide or interact with the molecule, the energy they represent is distributed throughout the molecule in all its vibrational and rotational degrees of freedom. From a spectrographic point of view the results of this interaction are represented, after being transmitted through a spectrograph and photographed on a plate, as definite spectral lines. If real monochromatic radiation is employed (which is very difficult to realize experimentally), then this results in a single line on the photographic plate corresponding to this incident radiation, plus other lines if definite parts of this energy have been subtracted from the original quantum. These lines correspond to different type of vibration and rotation which the atoms in the molecule may possess. The result is the re-creation or re-radiation of light of longer wave lengths which did not exist in the original light but which is re-emitted by the molecules themselves.

This will be made clearer by means of a diagrammatic illustration of the apparatus used and a picture of these Raman lines as they appear on the photographic plate. These are shown in Figs. 1 and 2.

The source of light illustrated in the first figure is generally a mercury arc. This type of arc has four lines, among many others, which are sufficiently intense and reasonably well separated from other lines to be useful for this purpose. These lines, which do not all appear in the figure, are at 2537, 4047, 4358, and 5461 Å units. After the selection, therefore, of a given wave length to be employed to excite the Raman lines, the experimental set-up is so arranged that this radiation or light will pass at right angles to the end of the spectrograph through the liquid, gas, or other material to be studied. This is to diminish as much as possible any light, direct from the lamp, which might fall on the opening of the spectrograph, the only desired light being that which comes from the molecules to be investigated. Unfortunately, a spectrograph not only can "see" the light which is reflected, or what is generally termed scattered from the molecules after the interaction, but it can also "see" the light which is scattered from these same molecules in the form of Rayleigh scattering. Neglecting polarization, this is identical with the original exciting radiation. The net result of these two scattering phenomena is therefore a series of lines corresponding to the Raman lines not present in the original light and the more intense line corresponding to the original source of radiation.

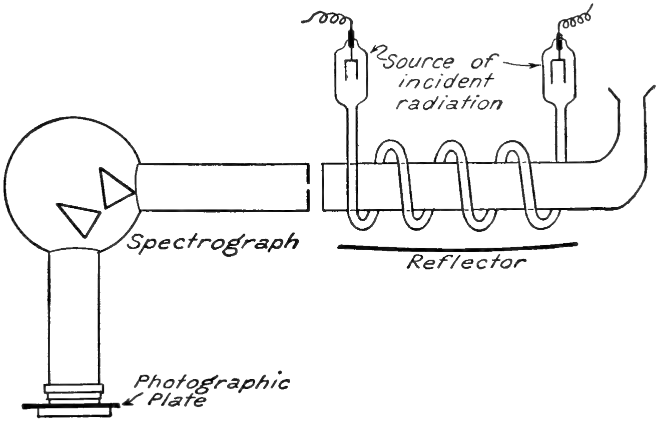


Fig. 2.—Experimental arrangement for recording Raman spectra.

The processes thus far described are the essential means used, together with the result obtained. As each of these Raman lines represents a given wave length its position is described on the color scale from the ultra violet to the infra red by this wave length. However, for the sake of convenience in comparing the work of different observers, it is necessary to adopt an additional system to describe these lines. The thing which is of importance is not the wave length per se of the Raman lines, but how much energy has been lost by each photon in giving rise to them. This is the energy which each type of vibration takes up, and consequently the results should be given in terms of the difference between the wave length causing these lines and the lines themselves.

However, as an additional matter of convenience, it is more useful to employ frequencies or wave numbers rather than wave lengths. These frequencies are related to wave lengths by the simple equation, $\lambda\nu = c$, where c is the velocity of light. Each mercury line and each Raman line therefore corresponds to a different value of ν which is the number of vibrations per second, or in terms of the number of waves per centimeter, $\nu = c\bar{\nu}$. As has just been mentioned, it is the difference between the value of $\bar{\nu}$ for the exciting line and the various Raman lines that is of interest, so that by common agreement the results are always given in terms of $\Delta\bar{\nu}$ per centimeter, which represents these differences. The line which is closest to the exciting line in Figure 1, therefore, has the lowest value for $\Delta\bar{\nu}$. These may vary from as low as 60 to possibly as high as 4500.

The simplest type of oscillator is a diatomic molecule. To give rise to a Raman line at all this molecule must have at least one type of atomic motion. The one most frequently encountered for this simple molecule is the linear oscillation of the two atoms in the direction of the valence forces which hold them together. If there is no definite chemical bond of homopolar nature, as in the case of completely ionized molecules, then no Raman line will appear. In the dumb-bell type of molecule, however, where the atoms are held together by a force which may be likened to a spring, the two oscillating components will vibrate with a characteristic frequency. This is true of any mechanical system. In this system the frequency vibration may be calculated from the equation for a harmonic oscillator:

$$\nu = \frac{1}{2\pi}\sqrt{F/m}$$

In an atomic system reducing this to spectrographic terms, $\Delta\bar{\nu} = 4.125 \times \sqrt{F/\bar{\mu}}$, where F is the valence force in dynes per cm. and $\bar{\mu}$ is the reduced mass as determined by the relative atomic weights. From this it follows that the greatest amplitude of vibration in centimeters of the atoms is given by the following equation:

$$\bar{a} = 8.2 \times 10^{-8}\sqrt{\frac{1}{\bar{\mu}\Delta\bar{\nu}}}$$

This amplitude varies between 0.06 and 0.09 Å.

For a triatomic molecule there are two possibilities: the molecule may be linear or nonlinear. For the linear molecule there are three possible types of oscillations, the symmetrical, asymmetrical, and deformation oscillation, known as ν_π, ν_σ, and δ_π respectively. These give rise to three Raman lines whose frequencies may be calculated. The nonlinear model possesses the types of vibration indicated in Figure 3.

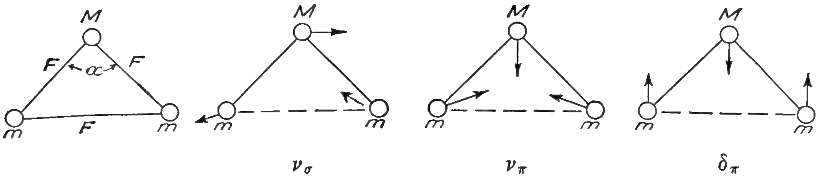


Fig. 3.—The motions of the nonlinear triatomic atom.

In general, in polyatomic molecules composed of several atoms, each atom has three degrees of freedom, so that the total represents 3n degrees of freedom. Of these, three are accounted for by the translational motion and three are described by the rotation of the molecule as a whole about its center of gravity. Consequently there are 3n–6 fundamental modes of vibration and therefore theoretically one Raman line for each mode. This represents a maximum and, as will be seen, is modified considerably by the particular conditions concerning each molecular species. The molecules of the type YX_3 and YX_4, for example, each have four frequencies, and the less symmetrical molecule XY_2Z six frequencies. The symmetry of the molecule occasionally results in one or more frequencies having the same value, the multiple coincidence of frequencies occurring whenever the motions of the atoms performing the vibration are isotropic in several dimensions. When these are isotropic in two or three dimensions respectively they are doubly or triply degenerate.

Each fundamental vibrational frequency in which all the atoms of the molecule participate may correspond to a vibrational Raman line. The relative motions of the atoms in respect to each other, together with the forces exerted between them and their masses, determine the frequency of this vibration or the magnitude of the resulting $\Delta\bar{\nu}$ shift. Except in the case of a diatomic molecule, it is not entirely accurate to state, therefore, that a particular Raman line corresponds to a single type of linkage such as C–H. However, in any given molecule there is usually some frequency originating in the essential vibration which consists chiefly of the linear or deformation oscillations of atoms of particular groups vibrating in unison. In ethylene, for example, there is one frequency which corresponds to the movement of the two CH_2 groups toward and away from each other. In this case the hydrogen atoms are moving in roughly the same direction as the carbon atoms. As their masses affect but little the C=C vibration, particularly since their motion is in phase with this oscillation, the net result is a characteristic frequency for the ethylenic linkage. In a similar fashion there is possible a motion of the hydrogen atoms toward and away from each carbon atom along the direction of the valence bonds, which gives rise to a frequency termed characteristic of this type of C–H linkage. Consequently, the characteristic frequencies and the force constants for various types of oscillation and bending may be determined. This is particularly valuable, first, because the presence or absence of a type of linkage may thus be possibly established, and second, because these frequencies are slightly altered by the proximity of other groups whose masses or effect on the valence force result in an alteration of the characteristic frequency. This is helpful in the delineation of the molecular structure of the molecule.

Unfortunately, the number of Raman lines which can be elicited from a molecule is not confined to fundamental vibrations, that is, vibrations corresponding to a particular type of motion. Other lines may appear due to overtones (harmonics) of a given frequency or due to combinations. These latter may appear as the sum or difference of other frequencies, the result being in some cases nearly ten times as many lines as are represented by the fundamental vibrations. As a rule, these overtones and combinations have much less intensity than the fundamentals. From this and their numerical values it is sometimes possible, even in a complicated molecule, where a profusion of lines appear in the same neighborhood, to make proper assignments. Otherwise it would be very difficult, except in general terms, to state that a given line is due to any particular mode of oscillation. Typical examples of characteristic frequencies and force constants for specific linkage are given in Table 1.

TABLE 1.—VALENCE FORCES (F) FOR DIFFERENT TYPES OF LINKAGE

Linkage	Frequency	$F \times 10^{-5}$ dynes cm^{-1}
C−H*	3050	5.02
C−C	993	4.64
C−O	1030	5.00
C−N	1033	4.85
N−H	3370	6.20
O−H	3650	6.80
H−H	4158	5.05
Cl−H	2880	4.75
Br−H	2558	3.80
S−H	2572	3.78
C−S	650	2.14
C=C	1620	10.60
C=O	1700	11.6
O=O	1556	11.4
C=N	1650	10.40
N=O	1640	11.80
C≡C	2120	15.82
C≡N	2150	17.5
C≡O	2146	18.50
N≡O	2224	20.9

* Aromatic

THE RAMAN EFFECT IN ORGANIC CHEMISTRY

SATURATED ALIPHATIC COMPOUNDS

In general the entire spectrum of the hydrocarbons may be divided into four groups, the first consisting of those frequencies below $\Delta\bar{\nu}$ 700. These correspond to the deformation or bending motion of the carbon atoms in the chain. From $\Delta\bar{\nu}$ 700 to approximately 1100 the lines represent the linear or symmetrical vibrations (ν_π) of the carbon atoms and their combination frequencies. From $\Delta\bar{\nu}$ 1100 to 1470 are deformation (δ_π) oscillations corresponding to the C−H linkage and finally from $\Delta\bar{\nu}$ 2600 to 3100 the linear (ν_π) oscillations for C−H. The actual magnitude may be illustrated by $\Delta\bar{\nu}$ 2918 for C−H in methane, 1450 for C−H (δ_π) in the higher homologues and 993 for C−C (ν_π) in ethane. For this region in butane there are no longer single frequencies. The frequencies in the region corresponding to C−H likewise become much more complicated. This is illustrated in Figure 4.

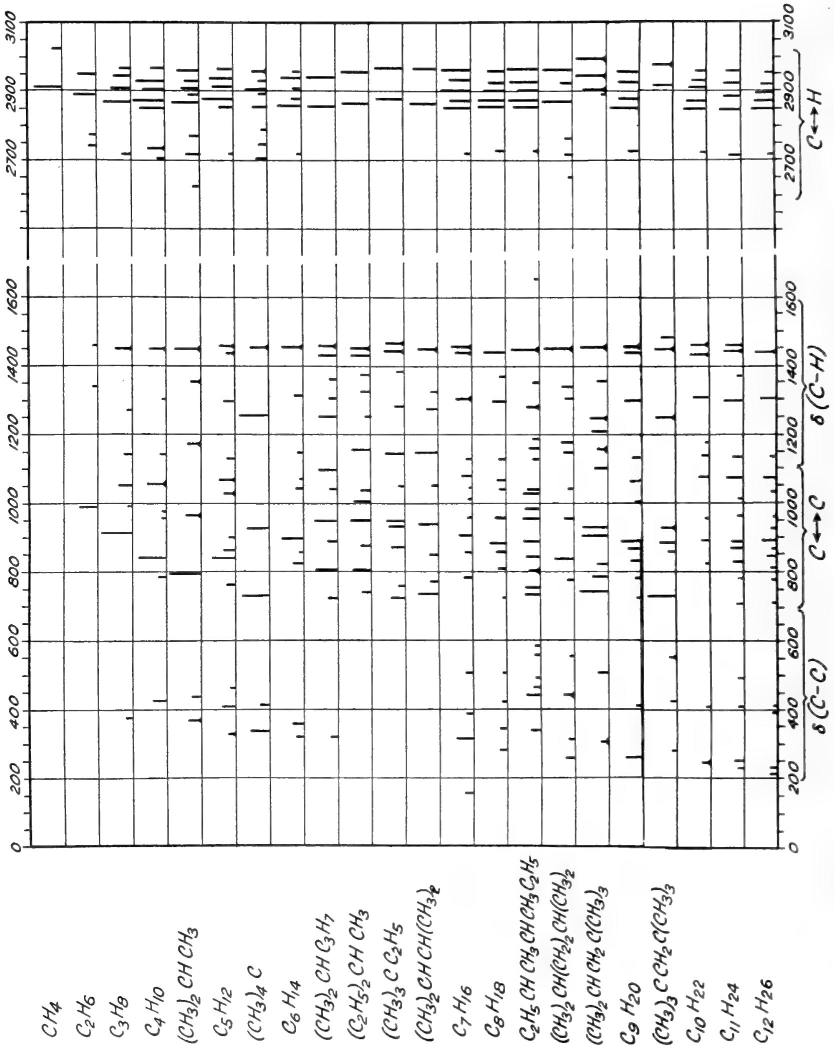


Fig. 4.—Comparison spectra of saturated aliphatic hydrocarbons.

The alcohols show spectra which are quite similar to the spectra of the hydrocarbons with the exception of the frequency occurring near $\Delta\bar{\nu}$ 3400 which corresponds to the H—O vibration. In no case, however, do any of these compounds give identical spectra.

The ethylene oxides or epoxy compounds are particularly characterized by one or two lines near $\Delta\bar{\nu}$ 1256 and 1277. In addition there appears a hydrogen frequency greater than $\Delta\bar{\nu}$ 3000, which occurs only in compounds having a triangular ring structure or in compounds attached to a carbon which is multiply bonded.

The halogen derivatives of the hydrocarbons exhibit characteristic frequencies which are lower than usual, partially owing to the increased mass of the halogen. The ν_π vibrations are $\Delta\bar{\nu}$ 710, 600 and 530, in methyl chloride, bromide, and iodide respectively. These are not proportional to the square root of the mass and consequently there is likewise progressively a change in the force constant. The effect of halogen substitution on the C—H vibration is to increase its frequency provided the substitution is made on the carbon atom to which is also bound the hydrogen.

Branching of the chains is reflected in altered spectra for all these hydrocarbons.

UNSATURATED ALIPHATIC COMPOUNDS

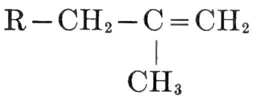
With very few exceptions the presence or absence of the functional group C=C may be determined by its characteristic frequency shift which occurs between $\Delta\bar{\nu}$ 1600 and 1680. This is sensitive to groups immediately adjacent, and as it occurs in that portion of the spectrum which is more or less free from other lines, this becomes exceedingly useful in the determination of molecular structure. Ethylene yields $\Delta\bar{\nu}$ 1620 but propene $\Delta\bar{\nu}$ 1647. This increase remains constant for all hydrocarbon substituent groups. However, if this group is an aldehyde the frequency becomes $\Delta\bar{\nu}$ 1618, and if it is a chloride it is reduced still further to 1608. There is likewise an effect on the characteristic C—H frequencies which are two in number, namely, $\Delta\bar{\nu}$ 3002, and 3080. In vinyl chloride these are augmented to $\Delta\bar{\nu}$ 3036 and 3134. Two other frequencies appear which remain relatively constant, namely, $\Delta\bar{\nu}$ 1290 and 1416.

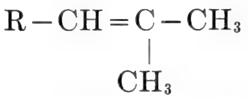
In compounds of the type $CH_3-CH=CHR$ there is introduced another possibility, *cis-* and *trans-*isomerism. As the effect of introducing one radical in place of a hydrogen in proceeding from ethylene to propene was to augment the C=C frequency by twenty wave numbers, the effect of introducing two radicals on each side of the double bond is to augment the frequency by roughly 40 wave numbers, which gives $\Delta\bar{\nu}$ 1658 for the hydrocarbon substituents in the *cis*-isomeric form. The *trans*- compounds yield a shift or line 15 wave numbers still higher or $\Delta\bar{\nu}$ 1674. This again is reduced on the substitution of aldehydes, esters, or acid groups. The results are indicated in Table 2. The trisubstituted ethylenes yield a frequency corresponding in behavior to that of the *trans*- compounds.

TABLE 2.—THE EFFECT OF DISUBSTITUTION ON THE C=C SHIFTS

Radical R	$CH_2=CH-R$	$CH_3-CH=CH-R$		Radical R	$CH_2=CH-R$	$CH_3-CH=CH-R$	
		cis	*trans*			*cis*	*trans*
CH_3	1647			$CH_2C\equiv CC_6H_5$	1642		
$CH_2O(COCH_3)$	1649	1665	1679	$CHClCH_3$	1640		
CH_2OH	1646	1658	1677	$CH_2C_6H_5$	1640		
$CHOHCH_3$	1646			CH_2Cl	1640		1671
$CHOHC\equiv CH$	1646		1676	$CHCl_2$			1666 (Kirrmann)
$CHOHCH=CH_2$	1646		1674	$CHBrCH_3$	1635	1651	1666
C_2H_5	1642	1658	1674	COOH	1638	1645	1652 (Kohlrausch)
C_3H_7	1642	1658	1674	COOR		1644	1655
C_4H_9	1642	1658	1674	C_6H_5	1631	1642	1665
C_5H_{11}	1642	1658	1674	H	1620	1647	
C_6H_{13}	1642	1658	1674	CN		1628	1645 (Kohlrausch)
C_7H_{15}	1642			CHO	1618	1625	1642
				Cl	1608		
$CH(CH_3)_2$		1659	1673	Br	1598		
$CH_2C_5H_9$	1642	1658	1674				
$(CH_2)_3C_6H_{11}$		1657					

A brief example of the use of these shifts to determine the presence of compounds may be cited in mixtures of rhodinol and citronellol which are identical except for the terminal groups. These are respectively:


$$R-CH_2-\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2$$


$$R-CH=\underset{\displaystyle CH_3}{\underset{|}{C}}-CH_3$$

The rhodinol, or α-form, yields $\Delta\bar{\nu}$ 1650 and the β-form 1678.

The effect of conjugation as shown in the diolefins is to reduce the ethylenic frequency very slightly. However, if the conjugation is of the nature found in the allenes, C=C=C, no typical ethylenic shift is observed but instead appear one or two lines occurring at $\Delta\bar{\nu}$ 1070 and 1130. Allene, like CO_2, is a linear molecule. The nature of this vibration is such as to allow a coupling between the vibrating components in such a way that the usual ethylenic shift is split into two components, one of which occurs at a lower frequency, corresponding to the symmetrical vibration, and one appears at a higher frequency, corresponding to the asymmetrical vibration. As the latter only appears very weakly in the Raman effect it does not register, the natural result being that the characteristic frequency in this case appears at a much lower value than ordinarily.

CARBONYL COMPOUNDS

Carbonyl compounds, like the ethylenes, yield a double bond shift quite characteristic of the constitution of the molecules. These shifts vary from $\Delta\bar{\nu}$ 1666 to 1800, depending upon whether the compound is an acid, ketone, aldehyde, ester, or acid chloride, and increase in the order named. The frequency varies slightly on the substitution of different aliphatic radicals in the α-position to the carbon of the carbonyl group; but, as has been indicated, the effect is more pronounced if the substitution takes place directly on the carbonyl carbon. This is likewise shown in a series of esters wherein the frequency remains constant regardless of the ester, but varies widely with the character of substitution on the carbonyl carbon. These effects are indicated in Tables 3 and 4.

Table 3.—Influence of Substitution on the Carbonyl Frequencies

Substance	$\Delta\bar{\nu}$				
	H_3CCOX	RH_2CCOX	R_2HCCOX	R_3CCOX	C_6H_5COX
Acid, $X = OH$	1666	1652	1648	1644	1647
Methyl ester, $X = OCH_3$	1736	1735	1732	1728	1720
Ethyl ester, $X = OC_2H_5$	1736	1732	1728	1724	1721
Ketone, $X = CH_3$	1710	1709	1709	1702	1677
Acid chloride, $X = Cl$	1798	1793	1788	1790	
Aldehyde, $X = H$	1715	1719	1719	1723	1689

Table 4.—Carboynl Frequency in Esters of the Type XCOOR

Ester (XCOOR)	$\Delta\bar{\nu}$						
	$X=H$	$X=Cl$	$X=CH_3$	$X=CH_2Br$	$X=CH_2Cl$	$X=CHCl_2$	$X=CCl_3$
1. $R=CH_3$	1717	1780	1738	1740	1748	1755	1768
2. $R=C_2H_5$	1715	1772	1736	1738	1747	1750	1763
3. $R=C_3H_7$	1719	1775	1739	1736	1742	1749	1764
4. $R=C_4H_9$	1718	1773	1737	1732	1739	1751	1765
5. $R=C_5H_{11}$	1718	1774	1738		1744	1756	1769

The remarkable constancy of the carbonyl shift in a series of aldehydes is illustrated in Figure 5, which shows only those shifts below $\Delta\bar{\nu}$ 1750.

The use of the Raman effect in demonstrating keto-enol tautomerism is illustrated in Figure 6. Here the normal carbonyl frequencies are slightly augmented owing to the effect of conjugation.

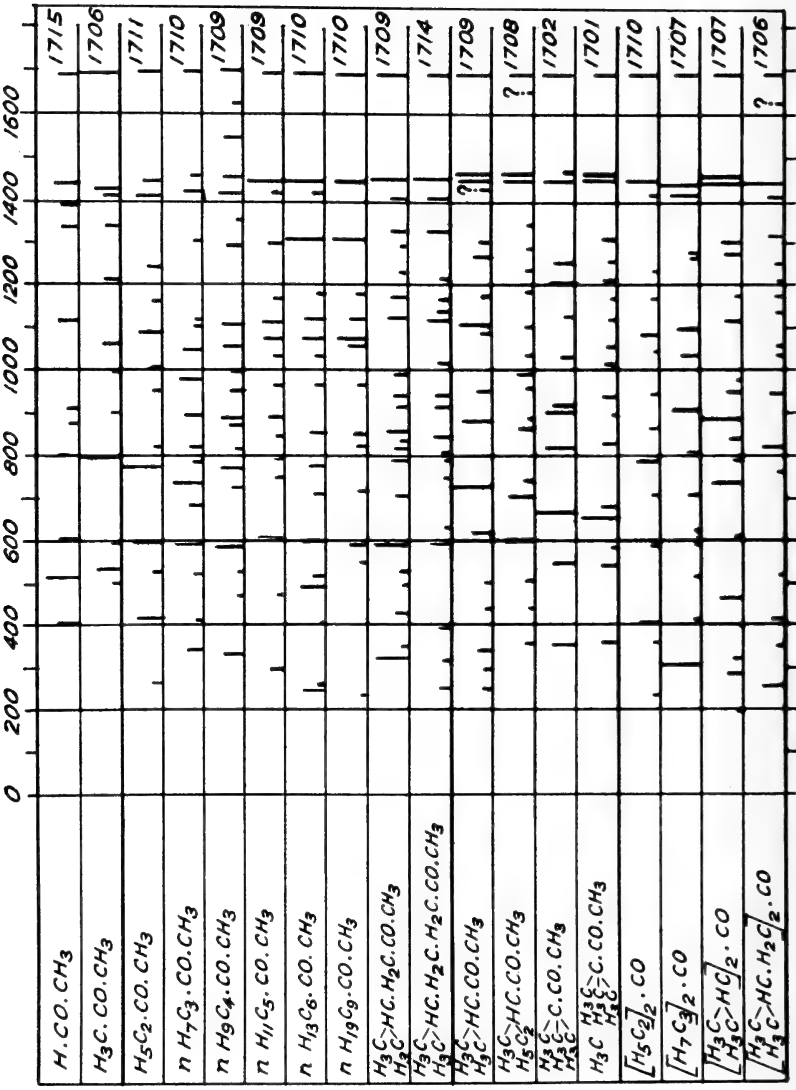


Fig. 5.—The low frequency Raman spectra of aliphatic ketones (after Kohlrausch and Köppl).

From the observations on Raman spectra it has been postulated that diacetyl, acetylacetone, acetonyl, and aldol exist in tautomeric forms.

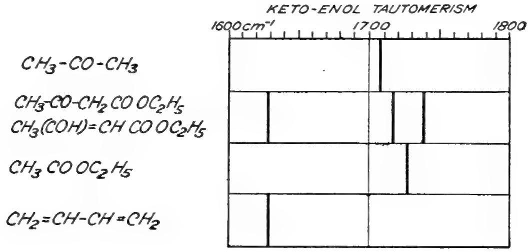


Fig. 6.—The Raman shifts of the keto and enol forms of ethyl acetoacetate as compared with similar compounds (after Andrews).

ACETYLENIC LINKAGE

As is observed in Table I, the force constant for $C \equiv C$ is approximately three times that obtained for the singly-bonded carbon. The effect of substitution is more pronounced than in the case of the ethylenes but shows the same general behavior. Acetylene yields $\Delta\bar{\nu}$ 1960. If one hydrogen is substituted by a hydrocarbon radical this increases to $\Delta\bar{\nu}$ 2120 and remains constant. Disubstitution causes both a marked augmentation of the acetylenic frequency and splitting generally into two components which appear at $\Delta\bar{\nu}$ 2238 and 2303. The alcohol and ether derivatives sometimes yield three frequencies depending upon the nature of the compound, while on the other hand, halogen derivatives yield but a single line. In addition to this characteristic shift for the acetylenic linkage, there appear in these compounds two others almost equally constant. These are $\Delta\bar{\nu}$ 340 and 3300. The first of these is probably attributable to the ν_π vibration of the chain and the second to the ν_π vibration of the $\equiv C-H$. These effects are illustrated in Table 5.

SATURATED CYCLIC COMPOUNDS

The cyclopropanes are characterized by strong constant frequencies $\Delta\bar{\nu}$ 860, 1170–1214, and 3065. The last is clearly connected with the hydrogen vibrations, but appears in no other saturated cyclic compound except cyclopropane and its derivatives. The cyclic compounds from cyclopentane to cycloctane show a progressively decreasing frequency in the $\Delta\bar{\nu}$ 860 region. Otherwise they exhibit remarkable similarity. Nevertheless, it is possible to distinguish the *cis*- and *trans*-isomers in compounds of such types as the cyclohexanes.

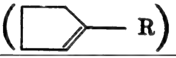
TABLE 5.—THE EFFECT OF SUBSTITUTION ON ACETYLENIC FREQUENCIES

$\Delta\bar{\nu}$

Hydrocarbons								
I		II				III		
$CH\equiv CH$	1960(5)[1]	$CH_3C\equiv CCH_3$	2234(10)		2312(5)	$C_5H_{11}C\equiv CCH_3$	2233(10)	2301(5)
$CH_3C\equiv CH$	2123(7)	$C_2H_5C\equiv CCH_3$	2238(10)		2304(5)	$C_5H_{11}C\equiv CC_2H_5$	2232(8)	2293(5)
$CH_2=CHC\equiv CH$	2098(7)	$C_3H_7C\equiv CCH_3$	2238(10)		2304(5)	$C_5H_{11}C\equiv CC_3H_7$	2234(7)	2293(5)
$C_4H_9C\equiv CH$	2121(7)	$C_4H_9C\equiv CCH_3$	2235(10)		2303(5)	$C_5H_{11}C\equiv CC_4H_9$	2231(7)	2293(5)
$(CH_3)_2CHCH_2C\equiv CH$	2118(7)	$C_5H_{11}C\equiv CCH_3$	2233(10)		2301(5)	$C_6H_5C\equiv CCH_3$	2214(10)	2253(10)
$C_5H_{11}C\equiv CH$	2118(7)	$C_6H_{13}C\equiv CCH_3$	2233(10)		2303(5)	$C_6H_5C\equiv CC_2H_5$	2210(5)	2238(7)
$C_6H_{13}C\equiv CH$	2119(7)	$C_5H_9C\equiv CCH_3$	2239(10)	2280(1)	2320(1)	$C_6H_5C\equiv CC_3H_7$	2210(2)	2238(7)
$HC\equiv C(CH_2)_5C\equiv CH$	2118(7)	$C_5H_9CH_2C\equiv CCH_3$	2234(10)		2302(5)	$C_6H_{13}C\equiv CCH_3$	2233(10)	2305(5)
$C_5H_9C\equiv CH$	2116(10)	$C_6H_5C\equiv CCH_3$	2214(10)	2253(10)		$C_6H_{13}C\equiv CC_2H_5$	2232(70)	2294(5)
$C_5H_9CH_2C\equiv CH$	2119(10)	$C_6H_{11}C\equiv CCH_3$	2239(10)	2259(2)	2316(2)	$C_6H_{13}C\equiv CC_3H_7$	2233(7)	2294(2)
$C_6H_5C\equiv CH$	2111(10)	$C_6H_{11}CH_2C\equiv CCH_3$	2235(7)		2303(5)	$C_6H_{13}C\equiv CC_4H_9$	2233(7)	2294(2)
$C_6H_5CH_2C\equiv CH$	2120(8)							
$C_6H_{11}C\equiv CH$	2118(7)							
$C_6H_{11}CH_2C\equiv CH$	2118(7)							

[1] The number in parenthesis following the Raman shift in this and other tables represents the intensity on a scale of 10.

TABLE 6.—CHARACTERISTIC FREQUENCIES OF SUBSTITUTED Δ^1-CYCLOPENTENE (



)

R	$\Delta\bar{\nu}$							
H	899(4)	1025(3)	1207(2)	1296(1)	1441(7)	1467(2)	1615(6)	3060(3)
CH_3	881–903(4)	1026(3)	1207(5)	1295(1)	1439(8)	1465(5)	1658(6)	3045(2)
C_6H_5	890–908(2)	(1033)(10)	1208(6)	1296(4)	1442(6)	1462(1)	1627(8)	(3061)(4)
$CH_2C_6H_5$	887–902(1)	(1030)(10)	1205(2)	1297(3)	1441(7)	1466(2)	1652(8)	3037(3)
CH_2OH	888(8)	1022(2)	1202(6)	1296(3)	1443(8)	1466(3)	1656(8)	3048(4)
CH_2OCOCH_3	889–907(4)	1025(3)	1206(3)	1296(1)	1443(8)	1466(6)	1658(8)	3058(3)
$CHOHCH_3$	893(10)	1026(1)	1207(4)	1294(2)	1444(8)	1468(5)	1651(8)	3051(3)
$CHOHC_2H_5$	895(7)	1029(2)	1206(2)	1294(2)	1441(8)	1464(5)	1650(7)	3052(2)
CH_2Br			1205(2)		1440(7)		1640(7)	
CHO	882(3)		1205(1)	1289(2)	1434(7)		1616(9)	Broad
$COOCH_3$	903(3)	1023(2)	1206(2)	1297(3)	1437(9)	1469(4)	1631(8)	3072(7)
CN	896(7)	1020(2)	1210(3)	1299(3)	1437(9)	1468(4)	1615(8)	3076(8)

CYCLOÖLEFINS

As would be expected, the cycloölefins have a frequency in the region corresponding to an ethylenic group. This is somewhat modified by the ring structure. Appearing at $\Delta\bar{\nu}$ 1615 in cyclopentene and $\Delta\bar{\nu}$ 1660 in the Δ^1 substituted derivatives, these compounds also give rise to a frequency near $\Delta\bar{\nu}$ 3060 characteristic of $=CH_2$. Cyclopentadiene shows a profound modification of the ordinary ethylenic frequency even as modified by the ring structure. This appears at $\Delta\bar{\nu}$ 1500. The constant frequencies and effect of substitution for cyclopentene and its derivatives are shown in Table 6. The higher homologues such as cyclohexene to cycloheptene give $\Delta\bar{\nu}$ 1650 for the normal compound, which is augmented to $\Delta\bar{\nu}$ 1675 by substitution in the Δ^1 position.

AROMATIC HYDROCARBONS

While benzene and its derivatives have been more extensively investigated than any other compounds, their spectra are very complex. Benzene shows the usual $=C-H$ frequency near $\Delta\bar{\nu}$ 3063 and exhibits $\Delta\bar{\nu}$ 1605 and 1584. Its derivatives exhibit one frequency for the double bond, namely, $\Delta\bar{\nu}$ 1600. This is quite appreciably lower than the shift observed in cyclohexene or in ethylene. While the effect of substitution is in the direction of reducing the ordinary ethylenic frequency, this effect is not so pronounced as in the case of cyclopentadiene. Presumably there are 10, or possibly 12, fundamental frequencies, at least one of which has been attributed to a carbon isotope of mass 13.

Attempts have been made to explain the structure of benzene on the basis of resonating bonds. So far as the Raman effect is concerned, the characteristic valence vibration is that of atomic motion along the line of directed valence which varies with the force constant and the mass of the atoms. Where resonance of bonds may be possible, it is the type of bonds which exist for the longest duration of time which determine the spectra. In short, if there is resonance between a double and triple bond, but the bond type is essentially that corresponding to a triple bond, then the Raman shift will occur near the usual position for this type of binding. The concept of resonating bond is based primarily on a change in atomic distances obtained from x-ray data. A conclusion based on this evidence is necessarily an extrapolation. In the case of benzene there is little doubt that the formula commonly used to represent benzene is too static and that there is a continuous resonating effect throughout the ring structure so that no particular atoms can be stated as being doubly bonded.

TABLE 7.—FUNDAMENTAL FREQUENCIES OF BENZENE AND ITS MONOSUBSTITUTION DERIVATIVES

Derivatives	$\Delta\bar{\nu}$						
C_6H_6	605(3)	992(10)		1178(3)		1605(1) 1584(3)	3057(1) 3060(5)
a. Hydrocarbon derivatives							
$C_6H_5CH_3$	622(2)	1002(8)	1029(1)	1154(1)	1209(3)	1604(2)	3054(5)
$C_6H_5CH_2CH_3$	620(2)	1003(8)	1029(1)	1157(3)	1203(2)	1604(5)	3052(5)
$C_6H_5CH=CH_2$	623(5)	999(7)	1029(1)	1154(1)	1205(8)	1601(10)	3057(8)
$C_6H_5C\equiv CH$	623(5)	1000(7)	1029(1)	1158(1)	1195(8)	1601(10)	3059(9)
$C_6H_5CH_2CH=CH_2$	623(5)	1000(7)	1029(1)	1158(1)	1205(5)	1599(10)	3057(8)
$C_6H_5CH=CHCH_3$	621(5)	999(8)	1031(1)	1149(5)	1210(8)	1599(10)	3055(8)
 $C_6H_5-\underset{\diagdown\ \diagup \atop CH_2}{CH-CH}$	623(5)	999(7)	1026(1)	1156(1)	1220(8)	1604(8)	3061(8)
$C_6H_5-CH_2-C\equiv CH$	623(1)	1000(8)	1033(1)	1158(1)	1200(5)	1601(7)	3059(8)
$C_6H_5C_6H_5$	611(1)	994(5)	1022(2)	1146(1)	1191(1)	1589(3) 1609(5)	3047(8)
$C_6H_5CH_2C_6H_5$	623(4)	1012(8)	1037(4)	1145(2)	1175(4)	1593(6)	3054(4)
$C_6H_5CH_2CH_2C_6H_5$	619(3)	1002(10)	1032(4)	1153(2)	1200(4)	1600(5)	3052(4)
$C_6H_5CH=CHC_6H_5$ (*trans*)	620(3)	1004(10)			1188(15)	1590(15)	
$C_6H_5CH=CHC_6H_5$ (*cis*)	615(2)	1000(10)	1027(2)	1150(4)	1190(4)	1596(10)	3059(4)
$C_6H_5C\equiv C_6H_5$	621(2)	997(15)	1028(1)	1140(15) 1155(2)	1174(2) 1188(2)	1590(20)	
b. Benzyl compounds							
$C_6H_5CH_2Cl$	619(4)	1000(3)	1034(1)	1159(1)	1211(1)	1600(1)	3054(3)
$C_6H_5NH_2NH_2$	622(4)	1001(8)	1028(2)	1156(4)	1201(4)	1606(4)	3055(8)
$C_6H_5CH_2OH$	610(0)	1000(3)			1196(1)	1594(2)	3050(3)
$C_6H_5CH_2NO_2$	623(4)	1005(8)	1029(3)	1160(2)	1197(3)	1596(5)	3059(4)
$C_6H_5CH_2CN$	620(2)	1007(4)	1030(1)		1187(2)	1597(2)	3057(4)

Nevertheless, it is precarious to consider that the average effect is a bond and a half. The Raman frequency would seem to indicate that in view of the modifications of the ethylenic frequency by ring structure in cyclopentene, in benzene there are double bonds with a slightly diminished force constant.

The effect of multiple substitution in benzene is to decrease the C=C shift with increasing substitution, but no two isomers are identical. The more or less constant frequencies observed in benzene and some of its derivatives are indicated in Table 7.

TERPENES, TERPENE DERIVATIVES, AND TERPINOIDS

The structure of these compounds may be extraordinarily complex. Particularly has it been difficult to differentiate the components of the various mixtures occurring in natural products. From a spectrographic standpoint, however, it has been shown that most of these mixtures contain some type of bonding which permits the determination of types of compounds in distillates and, in particular cases, their structures. Limonene has an external double bond which correctly falls in the neighborhood of $\Delta\bar{\nu}$ 1650, while the internal double bond $\Delta\bar{\nu}$ 1681 is similar to methyl cyclohexene. The compound *dl*-$\Delta\Delta^4$-carene gives $\Delta\bar{\nu}$ 1554, 1639, and 1670, as compared with 1641 and 1683 for *d*-Δ^3-carene. The *l*-Δ^3-carene has only $\Delta\bar{\nu}$ 1685. The sabinenes, on the other hand, give $\Delta\bar{\nu}$ 1653. Geranial and citronellal show very different shifts, as likewise do citronellol and linaloöl. Some of these differences are indicated in Figure 7.

Those compounds possessing a $=CH_2$ group, or equivalent, yield the C—H frequency characteristic of this type of binding. From carvone and limonene are observed $\Delta\bar{\nu}$ 3034 to 3085. Pulegone correctly exhibits no such frequency. The appearance of this higher frequency shift in these compounds is in contradistinction to the behavior of the substituted cyclohexenes.

Some examples of the use of Raman spectra are found in the analysis of many complicated mixtures of terpenes, and the indication of the existence of anethole, isoeugenol, and isosafrole as the *trans*- rather than the *cis*-compounds.

This is only a casual indication of the many applications of constitutional determination by means of the Raman effect to the delineation of the structure of the terpene derivatives. These are of great interest in the biochemical fields embracing vitamins, hormones, and compounds of biological significance.

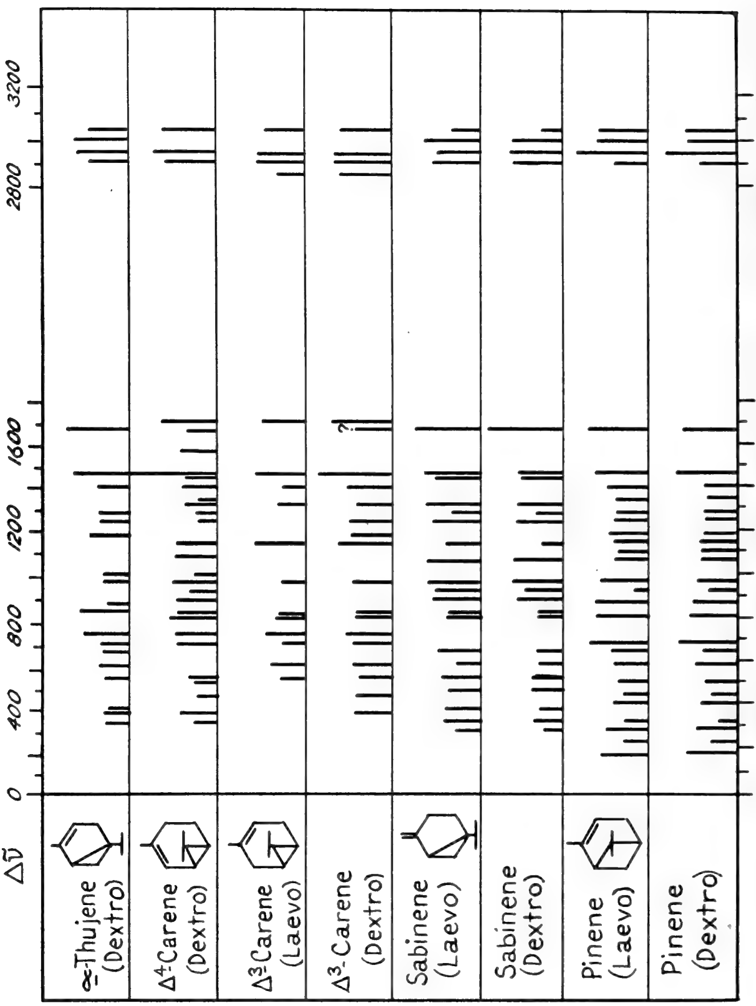


Fig. 7.—The Raman spectra of some polycyclic terpenes (after Nevgi and Jatkar).

POLYCYCLIC COMPOUNDS AND DIPHENYL DERIVATIVES

These compounds exhibit spectra of the expected kind in view of the tenets thus far promulgated. Some lines alter widely with substitution and others remain relatively constant. The ethylenic shift is slightly less than $\Delta\bar{\nu}$ 1600 in most cases.

ALIPHATIC ORGANIC SULFUR AND METALLO COMPOUNDS AND THOSE CONTAINING NITROGEN

The H—S linkage is as characteristic as any other so far described. It occurs at $\Delta\bar{\nu}$ 2573 in both organic and inorganic compounds. The C—S line appears at $\Delta\bar{\nu}$ 652, with the exception of methyl mercaptan which gives $\Delta\bar{\nu}$ 704. The determination of S—S in the polysulfides is not entirely satisfactory and the assignment of a particular frequency to a characteristic vibration is not without objection. Presumably this occurs at $\Delta\bar{\nu}$ 510. All the polysulfides and sulfides are easily distinguished from other types of compounds.

The N=O frequency appears at about $\Delta\bar{\nu}$ 1565 in the nitrites, and 1640 in the nitro compounds and nitrates. The C=N line appears at $\Delta\bar{\nu}$ 1650 as determined primarily from the oximes. The methyl derivatives of these compounds are the only ones showing a hydrogen frequency in excess of $\Delta\bar{\nu}$ 3000 for this type of compound.

The isonitriles exhibit two frequencies which appear in the triple-bond region, namely, $\Delta\bar{\nu}$ 2146 and 2161. The nitriles, on the other hand, exhibit a frequency which is approximately 100 wave numbers higher. The thiocyanates and isothiocyanates yield frequencies which occur within a relatively narrow range of $\Delta\bar{\nu}$ 2106 to 2182. The isothiocyanates, however, exhibit two frequencies like isonitriles. These compounds also give rise to a line near $\Delta\bar{\nu}$ 630 which has been pointed out as possibly characteristic of the C—S linkage.

Metallo derivatives such as zinc or mercury dimethl and tetraethyl lead have their principal frequencies at less than $\Delta\bar{\nu}$ 700. Those in excess of this amount are connected with the methyl radicals. There are usually about four frequencies concerned with the metal atom to carbon vibrations, which vary from $\Delta\bar{\nu}$ 130 to 700. There is no similarity in the frequency shifts in this region between any of these compounds.

The amines, amides, and imido compounds are characterized primarily by the hydrogen shifts which occur from $\Delta\bar{\nu}$ 3319 to 3378 in the aliphatic compounds and from $\Delta\bar{\nu}$ 3360 to 3420 in the aromatic ones. The C—N shift as determined for methyl amine occurs at $\Delta\bar{\nu}$ 1033. The carbonyl frequency in the amides is greatly reduced from the corresponding frequency in the ketones and appears at 1600 in lieu of 1710.

HETEROCYCLIC COMPOUNDS

The unsubstituted furanes, pyrroles, and thiophenes exhibit an anomaly somewhat similar to those observed in cyclopentene. There is no C=C shift in the normal position, but one occurs at $\Delta\bar{\nu}$ 1486 in furane, possibly at 1140 in pyrrole, and 1404 in thiophene as compared with 1500 in cyclopentadiene. The substitution of a radical in place of a ring hydrogen immediately causes the appearance of a reasonably normal ethylenic shift if due allowance is made for ring influence. The normal C=N frequency is also lacking in 3, 4-dimethyl furazan. Unfortunately, furazan has not been studied. The remaining furazans investigated, azoximes and oxdiazoles have at least one C=N shift. This group of compounds is also characterized by C—H lines from $\Delta\bar{\nu}$ 3070 to 3349 in some cases. The intercomparison between the spectra obtainable from some of these compounds is given in Table 8. The pyrroles give rise to approximately $\Delta\bar{\nu}$ 3140 in all cases, but, in addition, to 3380 when there is a hydrogen attached to a nitrogen atom.

TABLE 8.—THE RAMAN SPECTRA OF SOME FURAZANS, OXDIAZOLES, AND AZOXIMES

3, 4-Dimethyl furazan	2, 5-Dimethyl-oxdiazole	3-Methyl-4-phenylfurazan	2-Methyl-5-phenyloxdiazole	5-Methyl-3-phenylazoxime	3-Methyl-5-phenylazoxime
289(1)		283(1)			
649(1)	613(1)	621(1)	629(1)	635(1)	632(2)
709(2)					958(1)
964(1)	923(1)	998(2)	991(1)	989(2)	982(1)
	1043(1)		1030(2)	1020(1)	1036(2)
				1055(1)	1069(1)
	1108(2)		1102(2)		
		1168(2)	1175(2)		1183(2)
1308(2)		1278(1)		1305(2)	1320(1)
1396(3)					
1461(3)	1438(3)	1451(3)	1442(2)	1439(2)	1463(2)
		1502(2)	1482(3)	1483(2)	1499(2)
		1546(3)	1546(3)	1541(3)	1559(3)
	1579(3)	1598(3)	1591(2)	1576(2)	1601(2)
2938(2)	2957(2)	2936(2)	2919(2)	2928(2)	2940(1)
3070(1)	3082(1)	3083(2)	3071(2)	3065(2)	3091(2)
		3190(1)	3182(1)	3178(1)	
3217(1)					3204(1)
	3349(1)				

DEUTERIUM COMPOUNDS

If mass alone enters into the ratio of the frequency observed for deuterium to that of hydrogen it is as $1:\sqrt{2}$ or $\Delta\bar{\nu}_D = \Delta\bar{\nu}_H\ 1/\sqrt{2} = 0.707 \times \Delta\bar{\nu}_H$. For CD_4 is observed 2108, compared with 2915 in CH_4. CD_4

should give a calculated value of 2065. In $CHCl_3$ there are two frequencies whose counterparts in $CDCl_3$ are very different. These are $\Delta\bar{\nu}$ 1215 and 3019. In $CDCl_3$ these become $\Delta\bar{\nu}$ 908 and 2256, as compared with a calculated value from mass effect alone of 860 and 2140. Consequently, the observed frequency is higher than the mass effect allows, indicating an increased force of linkage in the deuterium compounds. Deuterium derivatives have a special usefulness in the assignment of doubtful vibrations. It will be remembered that in the region between $\Delta\bar{\nu}$ 1000 and 1400 there occur many lines whose origin is unknown. If these lines are due to the atomic vibrations of carbon as the principal participant, then these will be altered only slightly by the substitution of deuterium for hydrogen. On the other hand, if the lines correspond to a frequency chiefly concerned with the motion of the hydrogen atoms, then the substitution of deuterium will cause a profound modification of the frequencies as is indicated in the examples just given.

SOME APPLICATIONS OF THE RAMAN EFFECT TO ORGANIC CHEMISTRY

Thus far have been outlined the nature of the Raman effect, and the mechanism by which the observed Raman spectra may be used to delineate the structure of organic molecules. It has been indicated that in the simpler molecules the modes of vibration of the atoms can be determined, as well as their spacial configuration, their amplitudes of vibration, the forces involved in types of linkage, and the specific heats if all the types of vibration are known; and finally much light can be thrown upon the constitution of molecules by characteristic Raman shifts.

Since the known constitution of molecules should give rise to certain types of Raman spectra, it is possible to distinguish alterations of this constitution under different conditions. For example, no one has ever isolated methylene glycol, and yet an aqueous solution of formaldehyde indicates that formaldehyde continues to exist no longer and is converted to methylene glycol. The mechanism of the polymerization of polystyrene and acetaldehyde is demonstrable, and organic and inorganic complexes can be investigated by the change in spectra. These applications are of particular interest in the field of industrial plastics.

The number of molecules in higher vibrational levels at room temperature can be determined, in some cases, by the intensities of anti-Stokes lines. These are like ordinary Raman lines except for the fact that they are emitted by molecules already in a higher energy state than the ground level and consequently appear on the high frequency side of the exciting line rather than the low frequency side. In addition to the magnitude of frequency shifts and their intensities, there exists a third property of Raman spectra which is helpful in the assignment of different frequencies to their proper origin, and consequently in the determination of the types of vibration the molecules undergo. This is the measurement of the degree of depolarization of any given Raman line. Those lines corresponding to symmetrical oscillations are more or less polarized, while those which are unsymmetrical will be depolarized to a greater or less degree, depending on the character of the oscillation.

All the principles thus far set forth are equally applicable to inorganic chemistry.

THE RAMAN EFFECT IN INORGANIC CHEMISTRY

Ordinarily inorganic chemistry has been little concerned with interatomic forces or spacial configurations, and has been more or less content with classical formulae and percent composition of the elements. For the average practical purpose this is sufficient, but if one is interested in surface tension, vapor pressure, osmotic pressure, viscosity, and other factors for which the behavior and configuration of the molecules as well as the chemical composition are important, then the Raman-spectra method will give information of value. A perusal of any standard reference book in inorganic chemistry will readily convince the skeptic that in spite of the free use of simple formulae, there is a large field of inorganic chemistry concerning which there exists a most profound state of ignorance.

The inorganic groups have characteristic frequency shifts just the same as the organic ones and for the same reason. There is, however, a larger scale of diffuseness or lack of clarity which is attributable to a much wider scale of binding, ranging from the completely homopolar type found in organic chemistry to the completely heteropolar type which may exist in inorganic compounds. The latter type gives rise to no Raman lines. Hydrochloric acid solutions, for example, give no frequency shift, but HCl yields $\Delta\bar{\nu}$ 2880 in the gas and somewhat less in the liquid.

As is to be expected, crystals, liquids, solutions or gases yield shifts depending on the binding forces and on the spacial arrangement of the atoms, that is, tetrahedral, triangular, linear, etc. All ions or molecules of the type RO_4 or RO_3, etc. have their respective shifts somewhat similarly spaced. The number of lines and the exact magnitude, however, depend on the mass, force, and other considerations named.

The shifts observed in the SO_4 group, while characteristic of that group, are not wholly independent of the cation. The frequency near $\Delta\bar{\nu}$ 1000 decreases regularly with different cations in a given periodic group directly proportional to the mass of the cation. The difference is not more than 20 wave numbers.

The nitrites yield several lines the principal of which is $\Delta\bar{\nu}$ 1325, a symmetrical vibration. The nitrates give $\Delta\bar{\nu}$ 720, 1048, 1357, wherein 1048 is the symmetrical vibration. Sulfates yield $\Delta\bar{\nu}$ 440, 620, 984, and 1104. A comparison of the spectra of the various nitrates and sulfates is given in Tables 9 and 10.

All inorganic compounds (possessing at least a weak homopolar linkage) likewise exhibit entirely different spectra, depending on the atomic constituents, and it would serve no useful purpose to enumerate all of them. The method used to delineate structure in inorganic chemistry from the point of view of the Raman effect is the same, in principle, as that employed with organic compounds. A few of many possible examples will be given to illustrate some of the results obtained respectively in solution, from solids, gases, acids, and finally from that most peculiar of all compounds, water itself.

It has been more or less customary to consider a solution of SO_2 in water as sulfurous acid. While there no doubt is some H_2SO_4 present under these circumstances, in the main, this is principally SO_2 in water, as the spectrum of gaseous SO_2 is practically unaltered on solution. Similarly it can be shown that the anions of the compounds $NaHSO_3$ and $K_2S_2O_7$, in solution exist primarily as $S_2O_5^=$ and $KHSO_4$ respectively. The compound $TiCl_4$ in strong HCl solutions indicates the existence of H_2TiCl_6. The complex ammonium, cyanide, tungsten, and molybdenum compounds have particular frequencies.

In liquids it can be demonstrated that there are mixed compounds formed on addition of PCl_3 to varying quantities of PBr_3, while in the solid state the Raman spectrum from the solid eutectic of $NaNO_3 + KNO_3$ shows a single sharp frequency for the NO_3 group when freshly prepared, but reverts to two separate shifts after a period of several days. The polymerization of silica in glasses can be shown. The polymerization of gaseous SO_3 and the depolymerization of S_2O_6 can be quantitatively demonstrated since the spectra of the two compounds are quite distinct. Concentrated H_2SO_4 gives a spectrum which is quite different from that of dilute solutions of this acid. There are three lines, $\Delta\bar{\nu}$ 1048 characteristic of the HSO_4^- ion, 982 for the $SO_4^=$ ion and 908 probably for the un-ionized H_2SO_4 molecule.

TABLE 9.—RAMAN SPECTRA OF SOME SULFATES

Substance	Concentration	Raman shifts									
Li_2SO_4	18 per cent		442	593		984(10)	1110(5)				
Na_2SO_4	Saturated		460(5)	615		981(10)	1101				
K_2SO_4	Saturated		457(5)	619		981(10)	1090				
$(NH_4)_2SO_4$			454(5)	618		982(10)	1107	1285(2)		1467	
$K_2Al_2(SO_4)_4$			477	607	(790)[1]	977(5)	(1160)				
$CuSO_4$		279?	429	610(5)	717–754	980(10)	(1058	1110	1143)	1472	1665
$MgSO_4$			456(5)	617	(706)	982(10)	1116				
$BeSO_4$			442(5)	613		980(10)					
$ZnSO_4$			454(5)	620		982(10)	1106				
$CdSO_4$			451(5)	621		983(10)	1108				
$Al_2(SO_4)_3$			457(5)	614		980(10)	1104				
$MnSO_4$	1 *N*		452(5)	613		988(10)					
$FeSO_4$	3 *M*, Saturated	(381)		673		978(5)					
$NiSO_4$						980(10)					

[1] When the Raman shift is given in parenthesis it indicates a doubt as to the reality of the observation.

TABLE 10.—RAMAN SPECTRA OF SOME NITRATES

Substance	Concentration	Raman shifts									
$LiNO_3$	14 *N*					1050(10)					
$NaNO_3$	33 per cent			721(2)		1049(10)	1361(2)	(1389)	1414	1663[1]	
KNO_3	Saturated										
	(20 per cent)			730(2)		1049(10)	1357(2)		1413	1659	
$RbNO_3$	20 per cent					1048(10)					
$CsNO_3$	20 per cent					1046(10)					
NH_4NO_3	64 per cent				728(2)	1050(10)	1332(2)	1361	1400	1659	
$Cu(NO_3)_2$		279	442	717(5)–754(2)		1048(10)	1325(2)–	1421	1476	1654	
$AgNO_3$						1041(10)					
$Be(NO_3)_2$	3 *N*					1049(10)					
$CdNO_3$	8 *N*			716(2)	741(2)	1047(10)					
$Mg(NO_3)_2$	3 *N*	(376)				1049(10)	1346	–1427		(1655)	(1811)
$Ca(NO_3)_2$	Saturated		721	716(2)–741(5)		1050(10)	1349	–1441		1647	(1811)
$Sr(NO_3)_2$	Saturated			728(2)		1049(10)	1354(2)				
$Ba(NO_3)_2$	Saturated			720(2)		1049(10)	1350(2)				
$Zn(NO_3)_2$	3 *N*					1047(10)					
$Al(NO_3)_3$	3 *N*					1049(10)					
$Pb(NO_3)_2$	Saturated			730(2)		1047(10)					
$Bi(NO_3)_3$				730(2)	980	1036(10)	(1236)	1417(2)			

[1] The Raman shifts indicated in this column are due to the water present.

The intensity of these three lines varies with dilution. This is demonstrated in Figure 8. While NaHS exhibits an S—H line, neither H_3PO_4 nor H_2SO_4 shows any linkage between the phosphorus or sulfur and the hydrogen atoms.

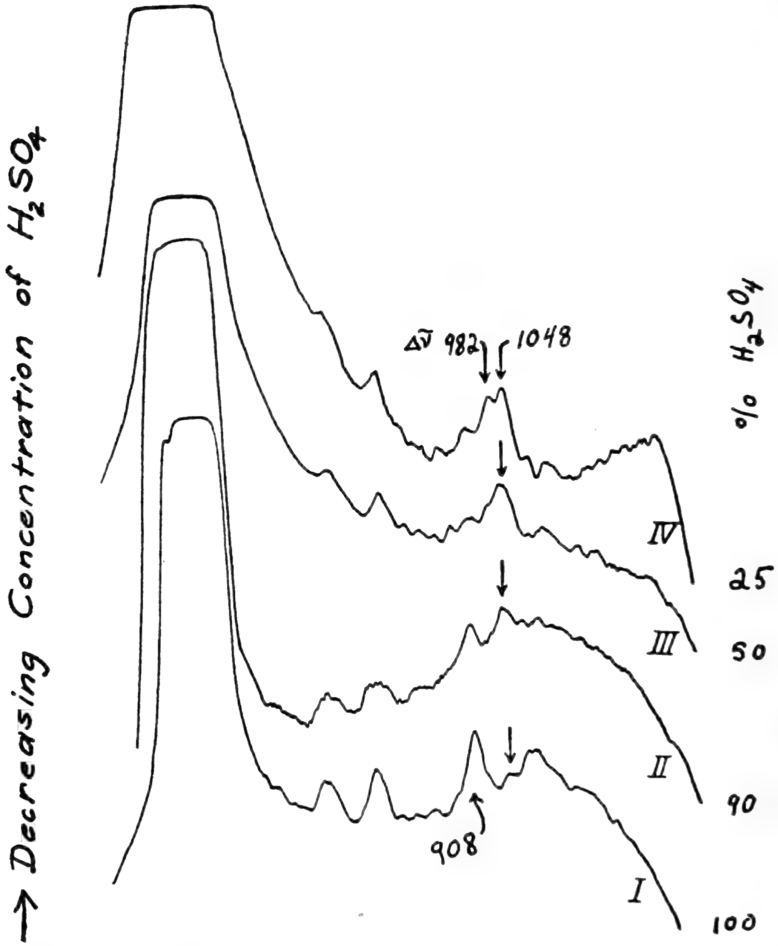


Fig. 8.—Changes in the characteristic Raman frequencies of sulfuric acid with varying concentrations. $\Delta\bar{\nu}$ 908 characteristic of sulfuric acid molecule decreases in intensity with dilution; $\Delta\bar{\nu}$ 1048 characteristic of HSO_4 ion, and $\Delta\bar{\nu}$ 982 characteristic of SO_4 ion increases in intensity with dilution (after Woodward).

Nitric acid also possesses different lines at varying concentrations. In dilute solution there is $\Delta\bar{\nu}$ 1046 for the NO_3^- ion which appears only very weakly, if at all, in the concentrated acid. On the other hand, as the acid becomes more concentrated there appear two frequencies $\Delta\bar{\nu}$ 1300 and 1665. These are more or less analogous to the similar frequencies appearing in CH_3-O-NO_2, and give some evidence of the existence of the ester form of nitric acid in concentrated solution. These changes are indicated in Figure 9. Stepwise dissociation is also shown from the spectra of selenious and selenic acid as well as for phosphoric acid.

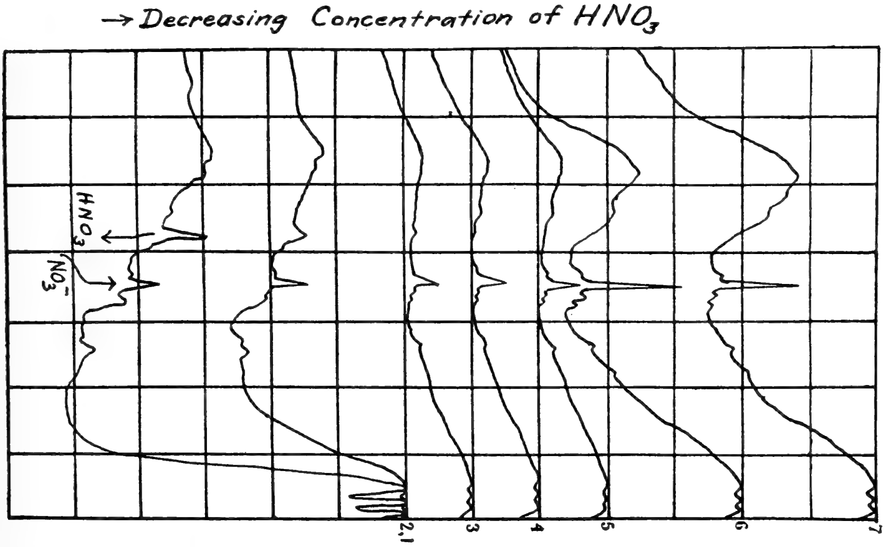


Fig. 9.—Changes in the characteristic Raman frequencies of nitric acid with vary ing concentration. Showing increase in nitrate ions and decrease in nitric acid mole cules with dilution (after Rao).

Perhaps one of the more interesting applications of the Raman effect in inorganic chemistry is in the investigation of the constitution of water. The anomalous behavior of water from the physicochemical point of view has long been ascribed to various types of polymers. The explanations have varied from postulating the existence of $(H_2O)_2$ and $(H_2O)_3$ to the assumption of a quasi-crystalline arrangement having respectively a tridymite, quartz, and close-packed ideal structure. It has been postulated that these modifications change as a function of temperature. The difference between these concepts is more illusory than real. The essential fact is that there is a profound influence on the Raman spectrum of water as changes in its constitution take place. This is prima facie evidence of the existence of the intermolecular interaction in water. Other methods of arriving at this conclusion are less direct and more susceptible to error. Water may have theoretically but three fundamental frequencies. These occur near $\Delta\bar{\nu}$ 1600 (δ_π), 3600 (ν_π) and 3757 (ν_σ) from the vapor. In the liquid the second of these three is lowered and split into three components. The last one, observable in infra-red absorption, is forbidden in the Raman effect. The Raman spectrum of water, however, has three other broad frequencies, namely, at approximately $\Delta\bar{\nu}$ 150, 450, and 2118. Of these $\Delta\bar{\nu}$ 2118 is probably a combination of the frequencies $\Delta\bar{\nu}$ 1630 and 450. This leaves the $\Delta\bar{\nu}$ 150 and 450 as impossible of existence, from a theoretical standpoint, in the simple H_2O molecule and therefore must be ascribed to intermolecular perturbation. The second of these, $\Delta\bar{\nu}$ 450, is probably due to the hindered rotation of the hydrogen atoms in a given molecule, and the first to the hindered translational motion of the molecules as a whole. Both of these effects are therefore directly attributable to the influence of one molecule on the other and constitute a phenomenon unique in Raman spectra unless there is a close chemical or physical combination. The assignment of vibrational and rotational motion to these two frequencies is further substantiated by the spectrum from deuterium oxide. In this compound the $\Delta\bar{\nu}$ 450 for hydrogen rotation is diminished, but $\Delta\bar{\nu}$ 150 is little affected.

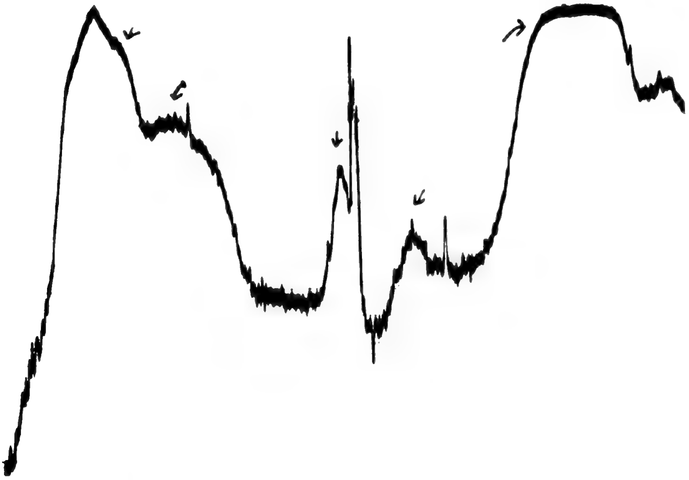


Fig. 10.—A microphotometer tracing of the principal Raman bands for water excited by the 2537 Å mercury line. The bands are indicated by arrows from left to right to correspond to $\Delta\bar{\nu}$ 150, 445, 1628, 2170 and the broad band extending from $\Delta\bar{\nu}$ 3220 to 3600.

A microphotometer tracing of the Raman spectrum of water is shown in Figure 10. Instead of reasonably sharp lines there are observed broad bands due to the lack of specific quantitization in the energy changes. The values given for the shifts represent the peaks of the bands. It may be pointed out that the maxima of the broad bands between $\Delta\bar{\nu}$ 3200 and 3600 change somewhat with temperature, and, as may be expected, the two lower frequencies, $\Delta\bar{\nu}$ 140 and 450, diminish markedly with an increased temperature. As ice is supposed to be polymerized, one would expect an increase in the intensity of the lower frequencies accompanying a change in state from water to ice. This is indeed the case, as is shown in Figure 11.

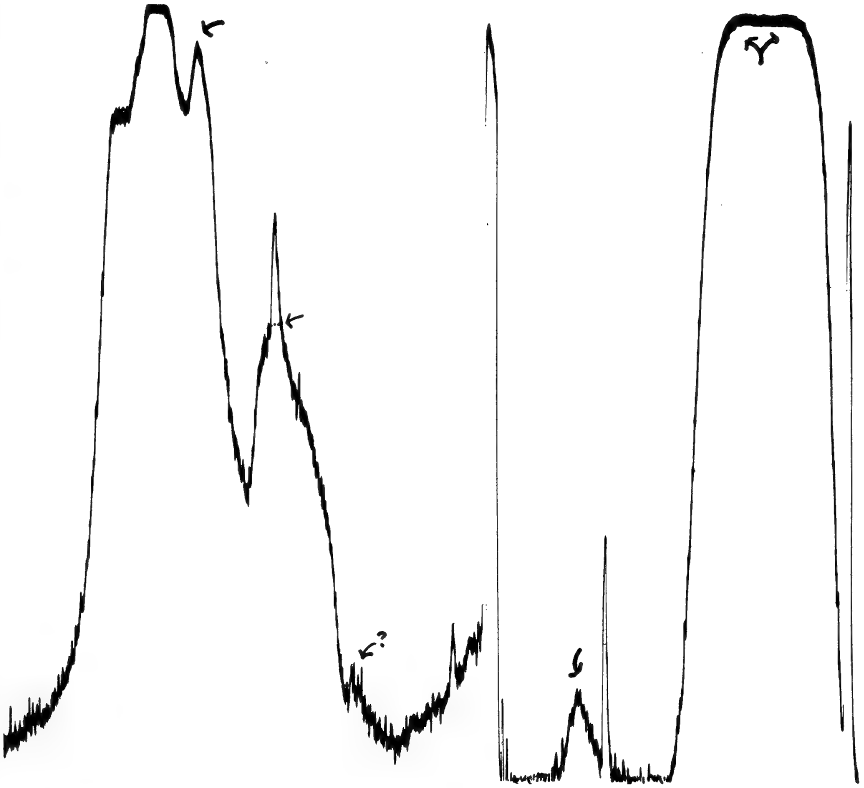


Fig. 11.—A microphotometer tracing of the Raman spectrum of ice showing the enhancement in intensity of the lower frequency shifts occurring in ice at $\Delta\bar{\nu}$ 205 and 601 as a result of intermolecular interaction.

Another interesting application from the point of view of inorganic chemistry is the demonstration of the common ion effect. This is shown in Figure 12. Zinc chloride has at least one strong line at $\Delta\bar{\nu}$ 280. The top curve in the figure represents a one-molal solution which shows the zinc chloride line with fair intensity. On further dilution the line practically disappears, indicating an increase in ionization which is more rapid than the corresponding dilution. However, as is shown in the lower curves, the addition of the common chloride ion by means of NaCl causes a suppression of this ionization, so that the actual concentration of un-ionized zinc chloride is greater in the half-molal $ZnCl_2$ solution under these circumstances than it was originally in the one-molal solution.

These examples will suffice to demonstrate that the constitution of inorganic as well as organic compounds can be determined in many cases. This is of particular interest in those examples where there is either a change in passing from a pure compound to solution or where there is an alteration in composition or constitution induced by any modification of environment.

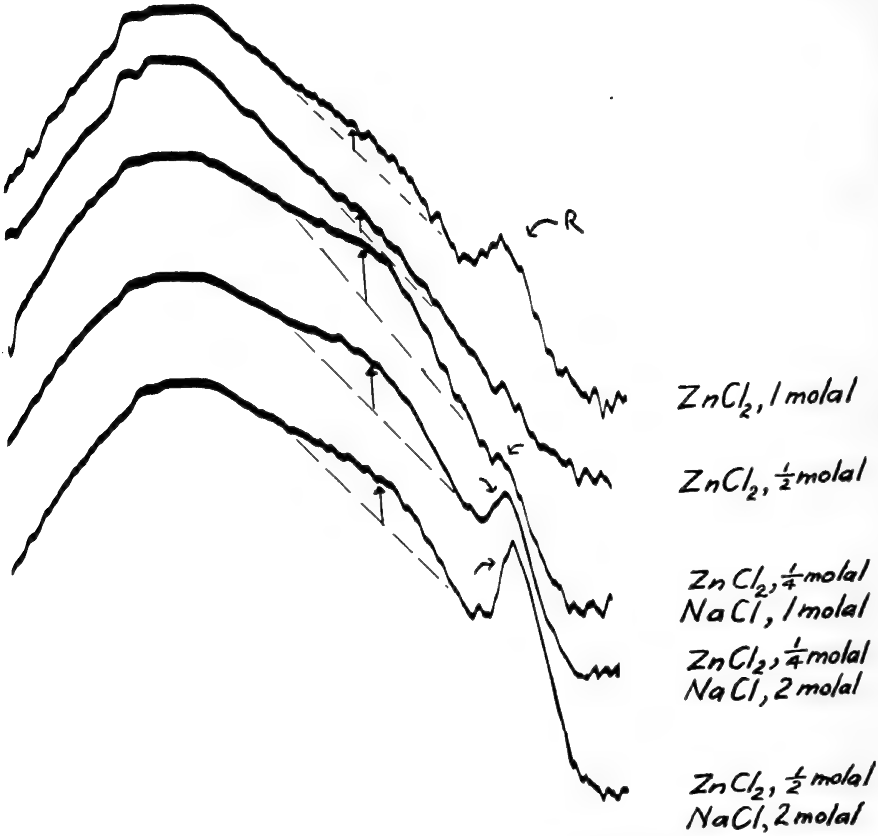


Fig. 12.—An enlarged microphotometer tracing of zinc chloride and zinc chloride-sodium chloride solutions showing the common ion effect which results in the repression of ionization in zinc chloride.

All the general types of Raman spectra investigations enumerated in the course of this presentation have been undertaken in the Geophysical Laboratory. This work has included a study of many organic and inorganic compounds from a structural standpoint, those compounds which exhibit peculiarities such as oxalic acid and formaldehyde solutions, and finally the mechanism of polymerization and association. It has been assumed that any method which will not yield logical results in the field of organic chemistry is inapplicable to the investigation of properties of inorganic compounds which are, in turn, more directly concerned with geophysics. Most of the common inorganic salts, bases and acids have been examined and the results applied to the constitutional problems of these substances, in solution, and as crystals, amorphous compounds and inorganic complexes. The demonstration of common ion effects and of the "association" of water and ice has likewise been realized. In brief, fundamental physical and chemical information has been obtained concerning those substances which compose the earth.

SUMMARY

It has been the purpose of this presentation to outline the interpretation, the development and application of Raman spectra and, to a certain extent, to analyze the data upon which such interpretations and applications are predicated. The contributions already made to physics and chemistry by the Raman effect are undisputed. It is of interest to the physicist, the crystallographer, and the chemist. It provides information concerning the behavior of atoms within the molecule and of the molecules themselves, which knowledge necessarily must be a prerequisite for the better understanding of the composition and behavior of all forms of matter.

NOTE.—No attempt has been made in the course of this presentation to recognize the contributions of individual workers, as the number of citations would be too numerous to be practicable. The reader is referred to the reviews by the author appearing in the Chemical Reviews **13**: 345. 1933 and **18**: 1. 1936 for most of the original citations.

MATHEMATICS.—*Population analysis: a theorem regarding the stable age distribution.*[1] ALFRED J. LOTKA, New York.

The author has elsewhere[2] stated without proof what amounts essentially to the theorem set forth below. As the proof is a little intricate it seems desirable to put it on record, as follows:

Theorem:—A closed population which is increasing at a constant rate r per head, under the régime of a constant age schedule of mortality and fertility, can have no other than the stable age distribution.

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[1] Received May 18, 1937.

[2] Human Biology **9**: 104. 1937.

(That is, it can not be merely *approaching* that distribution, the stable distribution must be actually established.)

Concentrating attention exclusively on the female population, that is, dealing exclusively with mothers and daughters,[3]

Let $N(t)$, $b(t)$ and $d(t)$ denote, respectively, the number of the (female) population, its birth rate per head and its death rate per head at time t.

Let $p(a)$ be the probability at birth of reaching age a, and let $p'(a)$ denote the derivative $dp(a)/da$, these quantities being independent of t.

Let $m(a)$ be the frequency of female births by women at age a, independent of t.

It is to be noted that $p(a)$ and $m(a)$ from their nature can never be negative, while $p'(a)$ can never be positive.

Putting

$$B(t) = b(t)\ N(t) \tag{1}$$

and

$$D(t) = d(t)\ N(t) \tag{2}$$

we have the well known and essentially obvious relations

$$N(t) = \int_0^\infty B(t+a)p(a)da \tag{3}$$

$$B(t) = \int_0^\infty B(t-a)p(a)m(a)da \tag{4}$$

$$D(t) = -\int_0^\infty B(t-a)p'(a)da. \tag{5}$$

Hence

$$\frac{B(t) - D(t)}{N(t)} = \frac{\int_0^\infty B(t-a)[p(a)m(a) + p'(a)]da}{\int_0^\infty B(t-a)p(a)da} \tag{6}$$

$$= \text{constant (independent of } t) = r \tag{7}$$

by hypothesis, since this quotient is the rate of natural increase per head.

Two trivial cases may first of all be disposed of.

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[3] As set forth in previous publications, e.g., Jour. American Statistical Association **20**: 307, 329. 1925.

1. The condition (7) would be satisfied if

$$p(a)\,m(a) + p'(a) = \text{constant (independent of } a). \qquad (8)$$

But this is contrary to biological facts.

2. The condition (7) is also satisfied if the numerator vanishes for all values of t. But in that case $r=0$ and hence

$$N(t) = \int_0^\infty B(t-a)\,p(a)\,da = \text{constant} \qquad (9)$$

that is,

$$B(t) = \text{constant} \qquad (10)$$

and we have simply the case of a stationary population under the régime of a constant life table.

Furthermore the equation

$$B(t) = \int_0^\infty B(t-a)\,p(a)\,m(a)\,da \qquad (4)$$

here becomes

$$1 = \int_0^\infty p(a)\,m(a)\,da \qquad (11)$$

so that

$$r = 0 \qquad (12)$$

satisfies the condition for stability of age distribution[4]

$$1 = \int_0^\infty e^{-ra}\,p(a)\,m(a)\,da. \qquad (13)$$

3. There remains to be considered the general case, when the numerator of (6) does not vanish, and $r \neq 0$.

If, under these conditions, the quotient (6) is to be constant, $B(t-a)$ must be the product of a factor containing only t and a factor containing only a, that is, we must have

$$B(t-a) = Q\,F(t)\,f(a) \qquad (14)$$

where Q is an arbitrary constant. We can so choose it that

$$f(0) = 1. \qquad (15)$$

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[4] A. J. LOTKA. Jour. American Statistical Association **20:** 329. 1925.

Then

$$Q\,F(t) = B(t) \tag{16}$$

and

$$B(t - a) = B(t)\,f(a). \tag{17}$$

Furthermore

$$B(\overline{t - a_1} - a_2) = B(t - a_1)\,f(a_2) \tag{18}$$

that is

$$B(t - [a_1 + a_2]) = B(t)\,f(a_1)\,f(a_2) \tag{19}$$

$$= B(t)\,f(a_1 + a_2) \tag{20}$$

Hence

$$f(a_1 + a_2) = f(a_1)\,f(a_2), \tag{21}$$

and similarly

$$f(a + a + a + \cdots) = f(na) = [f(a)]^n \tag{22}$$

$$= [f(n)]^a \text{ by symmetry.} \tag{23}$$

Again,

$$f(1 \times a) = [f(1)]^a \tag{24}$$

But $f(1)$ is a constant. Let us put

$$f(1) = e^{-s} \tag{25}$$

where s is a constant still to be determined. Then, by (24)

$$f(a) = e^{-sa} \tag{26}$$

and by (17)

$$B(t - a) = B(t)\,e^{-sa} \tag{27}$$

that is, the births per unit of time increase in geometric progression at the rate s.

Furthermore, this is also the rate of natural increase per head of the population, for according to (5), (6) and (27) we have

$$\frac{B(t) - D(t)}{N(t)} = \frac{B(t) + B(t)\int_0^\infty e^{-sa}\,p'(a)\,da}{B(t)\int_0^\infty e^{-sa}\,p(a)\,da} \tag{28}$$

$$= \frac{1 - \{1 - s\int_0^\infty e^{-sa}\, p(a)\, da\}}{\int_0^\infty e^{-sa}\ p(a)\ da} \tag{29}$$

$$= s. \tag{30}$$

But by hypothesis this quotient is equal to the constant rate of increase r of the population. Hence

$$s = r. \tag{31}$$

Now, according to (4), (27) and (31)

$$B(t) = B(t) \int_0^\infty e^{-ra}\, p(a)\, m(a)\, da \tag{32}$$

$$1 = \int_0^\infty e^{-ra}\, p(a)\, m(a)\, da. \tag{33}$$

Therefore r is a root of (33). But r, the rate of natural increase, is constant by hypothesis. Therefore it must be a *real* root of (33), for complex roots would introduce oscillations. But (33) has only one real root, because $p(a)$, $m(a)$ is nowhere negative. If we denote this real root by ρ, we have therefore

$$r = \rho \tag{34}$$

and the coefficient of age distribution is given by

$$c(a) = \frac{B(t - a)}{N(t)}\, p(a) \tag{35}$$

$$= \frac{B(t)\ e^{-\rho a}}{N(t)}\, p(a) \tag{36}$$

$$= b\ e^{-\rho a}\, p(a). \tag{37}$$

But this is the stable age distribution. Thus, the conditions of the problem fully determine the age distribution (37) and none other is possible.

The theorem enunciated at the outset is therefore established.

BOTANY.—*New species of Costa Rican plants.*[1] C. V. MORTON, U. S. National Museum. (Communicated by WILLIAM R. MAXON.)

During the last two years the region about El General in the Province of San José, Costa Rica, has been intensively explored by Dr. Alexander F. Skutch. The flora has proved of great interest and the author plans to publish later a general discussion of its composition and relationships. The following new species represent only a portion of those thus far discovered by Dr. Skutch within this comparatively small area. It may be noted with pleasure that Professor Pax and Dr. K. Hoffmann have dedicated to him an interesting new genus of Euphorbiaceae.

Dioscorea borealis Morton, sp. nov.

Sect. *Centrostemon.* Herba dextrorsum volubilis; folia alterna longe petiolata, petiolo ca. 6 cm longo glabro sulcato; lamina foliorum late ovata, maxima 11.2 cm longa et 9.8 cm lata, apice acriter acuminata, basi leviter cordata, membranacea, utrinque concolor glabra integra, nervis primariis 9–11; inflorescentiae ♂ axillares, geminae vel ternae, usque ad 17 cm longae, non ramosae, rhachibus rectis subglabratis, floribus racemosis solitariis, numerosis, pedicellis 1–1.5 mm longis minute puberulis basi bracteatis, bracteis minutis subulatis puberulis; perianthii segmenta purpurea ovato-oblonga, 1.75 mm longa, patula, glabra; stamina 6, filamentis in tubum 1 mm longum connatis, antheris connatis sursum dehiscentibus; rudimentum stylinum nullum; flores ♀ ignoti.

Type in the U. S. National Herbarium, no. 1,638,052, collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 880 meters, June, 1936, by Alexander F. Skutch (no. 2638).

The only previously known North American species of the section *Centrostemon*, *D. panamensis* Knuth, is quite different from the present, which doubtless finds its closest relationship with *D. larecajensis* Uline, of Bolivia, Peru, and Ecuador. Of this I have examined a specimen of the type collection (*Mandon* 1231) and find that the floral structure is essentially like that of *D. borealis*, but that the leaves are thicker, more prominently veined, and minutely puberulous on the nerves beneath. The leaves of *D. borealis* are perfectly glabrous.

Dioscorea remota Morton, sp. nov.

Sect. *Cryptantha.* Herba volubilis, caulibus dextrorsum scandentibus flavidis glabris striatis subangulatis; folia alterna longe petiolata, petiolo ca. 8.5 cm longo glabro paullo supra basin tumido; lamina foliorum late ovata, ca. 15 cm longa et 10.5 cm lata, integra, apice breviter (1.5 cm) acuminata, basi cordata, utrinque glabra, 7–9 nervia, nervis medianis areolam ovalem formantibus; inflorescentiae ♂ axillares, solitariae vel binae, perlongae, usque ad 90 cm longae, rhachi glabra non flexuosa,

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 1, 1937.

internodiis 1–6 cm distantibus, ramulis geminis simplicibus vel raro semel ramosis 4–11 cm longis, rhachibus interdum paullulum flexuosis basi bracteatis, bracteis lanceolatis ca. 5 mm longis; flores solitarii remoti sessiles bracteolati, bracteolis latis scariosis cucullatis concavis apiculatis glabris; perianthium purpureum glabrum, tubo cylindrico 2.75 mm longo, ca. 0.9 mm lato, lobis patulis ovatis 1.5 mm longis et 1 mm latis; stamina longe supra basin tubi perianthii inserta, filamentis alternatim inaequalibus, eis segmentis interioribus oppositis longioribus, ca. 1.2 mm longis, ceteris ca. 0.6 mm longis, antheris introrsis oblongis ca. 0.9 mm longis, ex fauce paullo exsertis; rudimentum stylinum nullum; flores ♀ ignoti.

Type in the U. S. National Herbarium, no. 1,642,272, collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 975 meters, December, 1935, by Alexander F. Skutch (no. 2197).

This, the first North American species of the section *Cryptantha*, need not be compared minutely with any of its Brazilian relatives, for it is well distinguished from all by its exceedingly long and relatively sparsely branched inflorescences, remote flowers, broad scarious bracteoles, and large flowers with elongate perianth tube, and by its large, ovate, deeply cordate leaves.

Costus formosus Morton, sp. nov.

Subg. *Eucostus*. Herba erecta caulescens 3.5 m alta; folia alterna, vagina brevi 4–5 cm longa inflata striata ubique brevissime puberulenta, ligula brevi usque ad 5 mm longa biloba margine longe ciliata; lamina foliorum sessilia oblanceolata vel oblonga, usque ad 23 cm longa et 7 cm lata vel verisimiliter majora, apice breviter acuminata, basi lata obtusa, supra glabra costa excepta, subtus ubique puberula; spica terminalis erecta sessilis cylindrica 19 cm longa et 4 cm lata, bracteis late ovatis obtusis dense imbricatis rubris (siccitate castaneis apice rubescentibus), ca. 4.7 cm longis, glabrescentibus, margine scariosis pilosulis, lineam dorsalem callosam flavam gerentibus; calyx ruber campanulatus glaber perspicue striatus, tubo 5 mm longo, 6 mm lato, lobis deltoideis ca. 5 mm longis margine scariosis pilosis; corollae tubus cylindricus 2–2.5 cm longus, 2.5–3.5 mm latus, flavus, lobis rubris oblanceolatis, ca. 4.3 cm. longis, 10–12 mm latis, glabris acutis; labellum flavum ca. 5.5 cm longum quam corolla brevius, glabrum, apice trilobum, lobis lateralibus ca. 6 mm longis et 5 mm latis apice leviter bilobulatis margine integris, lobo medio anguste lineari ca. 7 mm longo et 0.7 mm lato integro obtuso; stamen longissimum (ca. 7 cm longum), labellum et corollae lobos evidenter superans, filamento rubro petaloideo glabro 3–5 mm lato apice rotundato antheras 5 mm superante; ovarium 6–7 mm longum glabrum album; stylus gracilis glaber; stigma ca. 3.5 mm latum.

Type in the U. S. National Herbarium, no. 1,638,056, collected near El General, Prov. San José, Costa Rica, altitude 850 meters, July, 1936, by Alexander F. Skutch (no. 2775).

The most nearly related species is undoubtedly *Costus sanguineus* Donn. Sm., which agrees in corolla color, shape of bracts, and trilobed labellum, but nevertheless differs in many important characters, as follows:

Exterior corolla segment longer and broader than the remaining two, sericeous-pilose on the margins, about equaling the labellum; ovary densely pilose; middle lobe of the labellum shorter than the two lateral lobes; filament produced above the anthers in a triangular acutish apex, this often inrolled; corolla tube over 5 mm. side; calyx sparsely sericeous; leaves densely long-hirsute on both surfaces; sheath long, tightly appressed, long-hirsute........................*C. sanguineus*

Exterior corolla segment equal to the others, glabrous, much exceeding the labellum; ovary glabrous; middle lobe of the labellum linear, exceeding the lateral lobes; filament produced above the anthers in a semi-orbicular plane apex; corolla tube slender, not over 3.5 mm. wide; calyx glabrous, except on the margins; leaves glabrous above, minutely puberulous beneath; sheath short, inflated, puberulous.......*C. formosus*

For definite determinations in *Costus* it is usually necessary to have flowers. Several non-flowering specimens from Costa Rica and Panama that have been identified as *C. sanguineus* are certainly not that species, and may belong to *C. formosus*, but I do not cite them because the leaf and sheath characters listed above may not hold when further collections are available.

Costus Skutchii Morton, sp. nov.

Subg. *Eucostus.* Herba caulescens; folia distincte sed breviter petiolata, petiolo glabro ca. 15 mm longo, vagina glabra longissima striata, ligula ca. 7 mm longa, aequaliter biloba haud truncata vel fissa, infra petiolum puberula, marginem versus pilosa; lamina foliorum oblongo-oblanceolata 25 cm longa et 7.2 cm lata (inferiores verisimiliter longiores), apice acriter acuminata, basi obtusa, supra glabra (nervo mediano excepto), subtus glabra; spica erecta ellipsoidea obtusa terminalis, 9 cm longa et 3.5 cm lata, bracteis rubris, siccitate nigrescentibus, dense imbricatis coriaceis, ca. 3.5 cm longis, apice rotundatis scariosis ciliatis non appendiculatis, linea callosa non perspicua, externe apicem versus glabratis inferne sericeopilosis, intus glabris; calyx tubulosus 7 mm longus, coriaceus sericeus, leviter trilobatus; corollae tubus flavus ca. 2 cm longus, anguste cylindricus, lobis anguste obovatis coccineis, ca. 3 cm longis et 1.2 cm latis, integris glabris, apice rotundatis; labellum corolla longius, ca. 7 cm longum, cucullatum, rubro-purpureum, venis pallidis, non lobatum, apice ca. 4.5 cm latum subtruncatum perspicue lacerato-dentatum, basin versus squamiferum; ovarium cylindricum ca. 4.5 mm longum, glabrum.

Type in the U. S. National Herbarium, no. 1,638,054, collected near El General, Prov. San José, Costa Rica, altitude 850 meters, July, 1936, by Alexander F. Skutch (no. 2690).

The most nearly related species is probably *Costus cylindricus* Jacq., which has yellow corollas, with the tube only 1 cm long, and a smaller, yellow, entire labellum. *Costus spicatus* L. differs in its smaller, yellow, differently formed flowers, as well as in other characters. The corolla lobes of *C. sanguineus* Donn. Sm. are similar in color to those of the present species, but the labellum is entirely different in color, size, and shape. *Costus splendens* Donn. Sm. differs widely in the shape of the labellum, as well as in other characters.

Skutchia Pax & K. Hoffm., gen. nov.

Flores dioici, ♂ apetali, ♀ nudi. Sepala ♂4, ad medium fere connata, imbricata. Stamina 4, episepala; filamenta libera, sepalis longiore, in alabastro incurva; antherae biloculares, introrsae. Discus O. Ovarii rudimentum columnare. Ovarium biloculare, loculo uno abortivo; styli 2, fere liberi, papillosi; ovulum solitarium, pendulum.—Arbor, partibus juvenilibus et inflorescentiis exceptis, glabra. Folia alterna, petiolata, penninervia; stipulae deciduae. Inflorescentiae axillares, satis longae, ♂ amentiformes, squamis parvis, triangularibus, juxta vel interflores sitis onustae. Flores ♂ sessiles, ♀ pedicellati. Fructus ignotus.

Skutchia caudata Pax & K. Hoffm., sp. nov.

Arbor, ca. 18 m alta. Ramuli graciles, juveniles compressi breviter puberuli; rami teretes, glabri, striati, cortice rubro-brunneo tecti. Petiolus ca. 1 cm longus; limbus 10–12 cm longus, 3–3.8 cm latus, lanceolatus, leviter falcatus, caudato-acuminatus, basi acutus, integer, chartaceus, eglandulosus, reticulato-venosus; costae secundariae ca. 8, arcuato-adscendentes, prope marginem anastomosantes; stipulae ca. 1 mm longae, triangulares, breviter acuminatae. Inflorescentiae ♂ ca. 8 cm longae, satis densiflorae, ♀ ca. 10 cm longae, pendulae, utriusque sexus breviter puberulae et glandulis parvis adspersae. Flores ♂ ca. 2 mm lati. Calycis ♂ lobi ovati, acuti, basi subsaccati, extus parce pilosi, apice fimbriati. Filamenta ca. 3 mm longa, calyce duplo longiora. Ovarii rudimentum calyce brevius, pilosum. Pedicelli ♀ 1–3 mm longi. Ovarium verrucosum; styli ad 3 mm longi.

Type in the U. S. National Herbarium, no. 1,641,605, a pistillate plant collected near El General, Prov. San José, Costa Rica, altitude 950 meters, January, 1936, by Alexander F. Skutch (no. 2383). The staminate specimen collected at the same time and place is no. 2386.

"Mr. C. V. Morton, who is working on the Skutch collection, has already recognized that these specimens represent a new genus, which he believes related to *Tetrorchidium*. *Skutchia* belongs, to be sure, to the Gelonieae, but is nevertheless tolerably isolated in the group and is not more nearly related to *Tetrorchidium* than to other genera of this tribe. It is distinguished from all other Gelonieae by the naked pistillate flowers and by the ovary being one-celled through abortion of the second cell. Furthermore the inflexed stamens are remarkable."

Heliocarpus excelsior Morton, sp. nov.

Arbor altissima, 36 m alta, ramuli teretes stellato-puberulenti lenticellis conspicuis praediti; folia alterna stipulata (stipulis deciduis), petiolata, petiolo tereti usque ad 12 cm longo stellato-puberulento; lamina foliorum usque ad 19 cm longa et 18 cm lata, apicem versus sinuato-triloba lobo terminali et lobis lateralibus acuminatis, basi leviter cordata, appendiculata, appendiculis ca. 4, glanduliferis, membranacea serrulata utrinque concolor minute stellato-puberulenta, nervis 7 primariis digitatis; inflorescentia magna terminalis, 15 cm alta et 23 cm lata, rhachibus stellato puberulentis, pedicellis gracilibus usque ad 8 mm longis; alabastra obovata ca. 4.5 mm longa; sepala oblonga 6 mm longa, ca. 1.6 mm lata, acuta exappendiculata externe puberulenta; petala sepalis breviora spathulata ca. 4 mm longa glabra plerumque leviter crispa; stamina 16–19; stylus 2 mm longus, breviter bifidus, ovario longior; capsula cum radiis 6–8 mm lata, stipitata (5 mm), corpore capsulae anguste elliptico, 4 mm longo, 1.6 mm lato, dense piloso, radiis ca. 4 mm longis, longe pilosis.

Type in the U. S. National Herbarium, no. 1,642,302, a fruiting specimen collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 1100 meters, December, 1935, by Alexander F. Skutch (no. 2250). The flowers are described from *Skutch* 2266, collected near the same locality at an altitude of 825 meters.

The only related species are *Heliocarpus appendiculatus* Turcz. and *H. chontalensis* Sprague, both of which may be at once distinguished by their conspicuously discolorous leaves with a conspicuous, dense, whitish or yellowish tomentum beneath. The leaves of *H. excelsior* are concolorous and the hairs are minute, sparse, and scarcely visible except under a lens. The leaves of *H. excelsior* differ in shape also, being almost square in outline, with cordate base, trilobate apex, and lightly serrulate margins; on the contrary those of *H. appendiculatus* and *H. chontalensis* are ovate, usually unlobed and in *H. appendiculatus* coarsely serrate. Other differences are also apparent, such as the narrower capsule body, the fewer stamens, and the differently shaped leaf appendages. *Heliocarpus excelsior* is the largest known tree of the genus.

Begonia lignescens Morton, sp. nov.

Sect. *Ruizopavonia?* Caules elongati scandentes lignosi glabri, nodis incrassatis radicantes; folia alterna stipulata, stipulis caducis, cicatricibus perspicuis, petiolata, petiolo brevi ca. 3 mm longo fuscescente glabro; lamina foliorum anguste oblonga, 7–9 cm longa et 2–2.6 cm lata, obliqua, apice breviter acuminata, basi cuneata obliqua, membranacea apicem versus paullo denticulata utrinque glabra non squamosa, pennivenia, venis primariis 4–5-jugis subtus fuscescentibus; inflorescentiae monoicae terminales usque ad 16 cm longae et 20 cm latae, pedunculatae (pedunculo 3.5–4 cm longo), cymosae, multoties dichotomae, rhachibus glabris leviter angulatis, bracteis caducis longe lanceolatis acutis glabris; sepala floris ♂ duo alba lancolata, 15 mm longa et 5 mm lata, acuta glabra; petala 2 minuta ca. 2.5 mm longa; stamina numerosa, filamentis liberis quam antheris multo brevioribus; sepala floris ♀ alba duo elongato-lanceolata, fere 2 cm longa et 5 mm lata, glabra acuta; petala nulla; ovarium glabrum triloculatum trialatum, ala una (immatura) 1 cm longa cultriformi, alis ceteris reductis minimis, placentis bilamellatis ubique ovuliferis; styli tres basi connati sursum abrupte expansi bifidi, ramis spiraliter contortis ubique papillosis.

Type in the U. S. National Herbarium, no. 1,638,058–9, collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 1160 meters, August, 1936, by Alexander F. Skutch (no. 2853).

Although similar in leaves and habit to *Begonia estrellensis* C. DC., the large acute narrowly lanceolate sepals of *B. lignescens* are distinctive and like no other species of the genus that I know. The sepals of *B. estrellensis* are small, rounded, and orbicular. These two species seem to be most naturally placed in the section *Ruizopavonia*, as characterized by Irmscher, from which they differ, however, in having male flowers with petals.

Cavendishia Skutchii A. C. Smith, sp. nov.

Frutex epiphyticus; ramulis subteretibus glabris rugosis; petiolis glabris rugosis 5–10 mm longis; laminis tenuiter coriaceis, in sicco metallico-subcaeruleis, oblongis, 10–15 cm longis, 3.5–5 cm latis, basi subcordatis vel subtruncatis, apice obtusis vel breviter et obtuse acuminatis, margine leviter incrassatis, supra glabris nitidis, subtus parce brunneo-pilosis vel punctatis, 5-pli-nerviis, nervis prope basin orientibus, supra impressis (vel inferioribus elevatis), subtus prominentibus, venulis utrinque prominulis; inflorescentiis axillaribus aliquot ad apices ramulorum, racemosis, 15–20-floris, subglabris, basi bracteis deciduis instructis; rhachide 5–7 cm longa; floribus in axillis bractearum alternarum solitariis, bracteis membranaceis integris oblongis vel late ovatis, 18–23 mm longis, 12–15 mm latis; pedicellis subteretibus 6–12 mm longis, basi et apice incrassatis, prope basin bibracteolatis, bracteolis membranaceis oblongis, 3–4 mm longis, margine sparse fimbriatis; calyce coriaceo, 4–5 mm longo et diametro, limbo suberecto tubum subaequante, lobis 5 deltoideis 1–1.5 mm longis acutis, margine breviter glanduloso-fimbriatis; corolla membranacea vel tenuiter carnosa, cylindrica, basi et apice alba, medio rosea, maturitate 13–15 mm longa, 3–4 mm diametro, apice contracta, lobis 5 parvis subacutis; staminibus subaequalibus, filamentis ligulatis tenuiter carnosis, superne intus breviter pilosis, alternatim 2 mm et 5 mm longis, connectivis nigrescentibus carnosis, antheris membranaceis flavis, alternatim 12 mm et 10 mm longis, tubulis amplis quam loculis 3-plo longioribus, per rimas elongatas dehiscentibus; stylo corollam subaequante, stigmate capitato.

Type in the U. S. National Herbarium, no. 1,642,549, collected in forest in the vicinity of El General, Province of San José, Costa Rica, at 1100 meters altitude, in August, 1936, by A. F. Skutch (no. 2802).

The closest ally of the new species appears to be *C. crassifolia* (Benth.) Hemsl., of southern Mexico and Guatemala. The present species differs from that by its slightly larger and metallic-colored leaves, which are usually subcordate rather than cuneate at base. In floral characters the two species are very similar; *C. Skutchii* has larger bractlets of the pedicels and has the calyx glabrous rather than brown-pilose distally.

Ardisia Skutchii Morton, sp. nov.

Subg. *Graphardisia.* Frutex 7.5 m altus; ramuli subteretes ca. 3.5 mm diam. glabri leviter striati; folia alterna estipulata, subsessilia, lamina oblanceolata usque ad 26 cm longa et 7 cm lata, apice acuminata, basi longe attenuata, papyracea integra utrinque pallidi concolori glabra eglanduliferi, venis primariis ca. 12-jugis arcuatis; inflorescentia alba terminalis ca. 10 cm longa et 12 cm lata, brevissime pedunculata bracteis magnis obovatis ca. 25 mm longis suffulta, rhachibus plus minus flexuosis robustis glabris eglanduliferis, inflorescentiis ultimis corymbosis paucifloris bracteis oblongis vel obovatis magnis suffultis, pedicellis 12–15 mm longis gracilibus glabris apice incrassatis; sepala alba imbricata late ovata, ca. 5.5 mm longa et 4 mm lata, rotundata glabra punctis lineatis satis paucis perspicuis picta; corolla alba roseo-tincta, ca. 15 mm lata, rotata, tubo ca. 2 mm longo, lobis late ovatis ca. 7 mm longis, 5 mm latis, obtusis glabris punctis dissite pictis; filamenta ca. 2 mm longa, crassa eglandulifera, basin versus latioribus et in tubum brevem connata; antherae lanceolatae 3 mm longae, non exsertae, poris apicalibus dehiscentes; ovarium glabrum conicum; stylus gracilis 4.5 mm longus glaber.

Type in the U. S. National Herbarium, no. 1,638,053, collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 1070 meters, June, 1936, by Alexander F. Skutch (no. 2660).

The only related species is *Ardisia opegrapha* Oerst., which differs as follows:

Sepals oblong, 6 mm long, 2–3 mm wide; filaments and filament tube glanduliferous . . . . *A. opegrapha*
Sepals broadly ovate, 5.5 mm long, 4 mm wide; filaments and filament tube eglanduliferous . . . . *A. Skutchii*

Other differences also exist. The leaves of *A. opegrapha* are obviously petiolate, but those of *A. Skutchii* are almost sessile. The entire inflorescence of *A. opegrapha* is said by Mez to be deep rose and is so figured by Hooker (Bot. Mag. *pl. 6357*); that of *A. Skutchii* is, according to the collector, entirely white except for a faint pink tinge on the corolla.

Leiphamos lutea Morton, sp. nov.

Herba parasitica alba vel flavescens; caules 10–20 cm alti, ca. 1 mm lati, glabri teretes uniflori, bracteis 7–16-jugis lanceolatis ca. 6.5 mm longis, interdum apice unidenticulatis, basi fere ad medium connatis; pedunculus subnullus, vix 2 mm longus; calycis tubus ebracteatus 5 mm longus corollae arcte appressus, lobis 5 lanceolatis 2.75 mm longis, 1 mm basi latis, integris, acutis; corolla hypocrateriformis, tubo flavo 3.2–3.6 cm longo, basi et apice inflato, medio cylindrico, ca. 2 mm lato, glabro, fauce intus papilloso, lobis luteis late ovatis 6–9 mm longis, obliquis glabris cuspidatis patentibus; antherae sessiles exappendiculatae liberae faucem versus insertae; ovarium substipitatum ca. 13 mm longum glabrum eglanduliferum; stylus inclusus glaber ca. 15 mm longus; stigma compressum.

Type in the U. S. National Herbarium, no. 1,638,055, collected near El General, Prov. San José, Costa Rica, altitude 1130 meters, July, 1936, by Alexander F. Skutch (no. 2767).

Leiphamos aphylla (Jacq.) Gilg of the West Indies and South America is closely related but may be distinguished by its narrower, obtuse or merely acute corolla lobes; those of the present species are abruptly cuspidate-acuminate. *Leiphamos costaricensis* Standl. differs in its corolla lobes, as well as in its stamens. Another recent segregate from *L. aphylla* is *L. eximia* Sandw. of British Guiana, which also differs from *L. lutea* in its anthers and corolla lobes.

Columnea florida Morton, sp. nov.

Subg. *Collandra.* Frutex epiphyticus; caules crassi ca. 1 cm diam., pallidi vel rubescentes purpureo-maculati perspicue sulcati, hornotini hirsuti, pilis flaccidis multiseptatis, annotini glabrescentes; folia opposita valde inaequalia, majora breviter petiolata, petiolo 1 cm longo crasso densissime hirsuto; lamina foliorum majorum oblanceolata, maxima 35.5 cm longa et 10.5 cm lata, siccitate chartacea vel subcoriacea, apice breviter et acriter acuminata (ca. 2 cm), basi obtusa obliqua, margine integra, supra glabra vel basin versus pilis perpaucis instructa, apicem versus maculas 2 rubras gerens, subtus pallidior, apicem versus perspicue rubro-maculata, ubique appresso-pilosa, costa basi hirsuta, venis primariis ca. 12-jugis arcuatis; lamina foliorum minorum subsessilia anguste elliptica, ca. 3 cm longa, longe acuminata, supra glabra, subtus dense pilosa, venis paucis obscuris; flores axillares, in ramulis annotinis defoliatis et in hornotinis fasciculati, pauci vel plures, pedicellis crassis usque ad 1 cm longis, dense hirsutis, medio bracteatis, bracteis parvis lanceolatis dense hirsutis; calycis lobi 5 liberi, ambitu ovati, 2.3 cm longi, ca. 1 cm lati, utrinque densissime hirsuti, pectinato-incisi, dentibus numerosis anguste linearibus viridibus viridi-hirsutis corolla crassa flava (*fide* Skutch), ca. 25 mm longa, 9 mm lata, tubo cylindrico vix ventricoso externe densissime brunneo-hirsuto, intus sparse puberulo, fauce paullo contracto, limbo vix 5 mm lato, lobis parvis erectis suborbiculatis ca. 2.5 mm longis et 3 mm latis crassis glabratis; filamenta basi in tubum liberum postice fissum 5 mm altum connata, partibus liberis pilosulis contortis; antherae per paria leviter connatae, connectivo oblongo crasso, loculis contiguis oblongis discretis 3 mm longis glabris; discus ad glandulam dorsalem magnam crassam 1.5 mm altam 3.5 mm latam leviter trilobatam glabram reductus; ovarium conicum dense pilosum; stylus 12 mm longus pilosulus; stigma leviter bilobum; bacca globosa, ca. 12 mm diam., pericarpio coriaceo; placentae lamellae intus solum ovuliferae; semina rubra fusiformia, ca. 1.2 mm longa, 0.5 mm lata striata, striis leviter et spiraliter contortis.

Type in the U. S. National Herbarium, no. 1,642,394, collected in the vicinity of El General, Prov. San José, Costa Rica, altitude 915 meters, January, 1936, by Alexander F. Skutch (no. 2436). Additional specimens referable to this species are:

COSTA RICA: Type locality, January, 1891, *Pittier* 4020. Cañas Gordas, alt. 1100 meters, February, 1897, *Pittier* 11198.

PANAMA: Cerro de Garagará, Sambú Basin, southern Darien, alt. 500–974 meters, Feb. 7, 1912, *Pittier* 5664.

All these older specimens have been previously identified as *Columnea sanguinea* Hanst., but this West Indian species differs widely in its thinner, toothed leaves, these pilose above, in its differently shaped, fewer-toothed calyx lobes, and in several other important points. The related Costa Rican species, *C. consanguinea* Hanst. and *C. purpurata* Hanst., differ also in both leaves and flowers. The above description of the fruit and seeds is drawn from *Pittier* 5664.

Drymonia fimbriata Morton, sp. nov.

Frute 1.5 m altus; caules argute quadrangulati, hornotini minute strigillosi, annotini glabrescentes pustulati; folia opposita aequalia petiolata, petiolo usque ad 4.7 cm longo, strigilloso pustulato vel transverse corrugato, lamina foliorum late ovata 22 cm longa et 11 cm lata, obliqua, apice breviter acuminata, basi obliqua in petiolum longe decurrens, supra viridis fere glabra pilis paucis antrorsis appressis subsetulosis adspersa, subtus pallida in mesophyllo parcissime strigillosa, costa et venis pustulatis strigillosis, margine denticulata, venis primariis 6 vel 7-jugis; flores in axillis defoliatis aggregati numerosi, pedunculo communi nullo, pedicellis ca. 13 mm longis strigillosis apicem versus sulcatis basi bracteatis, bracteis lanceolatis integris puberulis ca. 5 mm longis, calycis lobi oblongi subaequales liberi, ca. 15 mm longi, 6 mm lati, accrescentes tum 20 mm longi et 9 mm lati, utrinque puberuli, longe pectinato-fimbriati, dentibus filiformibus puberulis inaequalibus usque ad 10 mm longis basi saepe furcatis; corolla alba basi longe calcarata (4.5 mm), tubo externe ubique pilosulo obliquo ca. 28 mm longo, basi 2.5 mm lato, sursum inflato fauce non contracto 10–12 mm lato, limbo rubro-venoso glabro obliquo bilabiato, lobo inferiore flabelliformi 11 mm longo apice 22 mm lato lacerato-dentato, lobis lateralibus integris late deltoideis 9 mm longis et

11 mm latis, lobis superioribus minoribus subrotundis 8 mm longis apice eroso-laceratis; filamenta in tubum 14 mm longum liberum postice fissum connata, partibus liberis glabris non contortis; antherae oblongae connatae; discus in glandulam posticam glabram 1.5 mm longam 3 mm latam reductus; ovarium conicum puberulum; stylus brevis crassus glaber ca. 12 mm longus; stigma latum bilobum; placentarum lamellae intus solum ovuliferae.

Type in the U. S. National Herbarium, no. 1,638,057, collected near El General, Prov. San José, Costa Rica, altitude 880 meters, August, 1936, by Alexander F. Skutch (no. 2839).

The filiform-pectinate calyx lobes of this species are unique in the genus *Drymonia.*

ZOOLOGY.—*A necessary change in an amphibian name.*[1] DORIS M. COCHRAN, U. S. National Museum. (Communicated by ROLAND W. BROWN.)

In 1935[2] I described some new species of frogs collected by P. J. Darlington in the La Selle Range of southwestern Haiti. It now appears that the frog which I named *Leptodactylus darlingtoni* (p. 372) is in reality an *Eleutherodactylus* with very narrow T-shaped terminal phalanges even though in the form of its digits it is a distinct approach to *Leptodactylus.* Dr. E. R. Dunn has pointed out this structural feature, and Dr. G. K. Noble has confirmed it. As I had already named a different frog from the same locality *Eleutherodactylus darlingtoni* on pl. 368 of the same publication, it becomes necessary to change the name of *Leptodactylus darlingtoni* Cochran. I therefore propose the name *Eleutherodactylus jugans* to take the place of *Leptodactylus darlingtoni* Cochran.

ENTOMOLOGY.—*Notes on Curculionidae (Coleoptera).*[1] L. L. BUCHANAN, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

Most of the following notes are here put on record as a basis for the use of certain names in forthcoming papers.

Trachyphloeus bifoveolatus Beck

Trachyphloeus bifoveolatus Beck 1817, Beitrage zur baierischen Insecten Fauna, p. 22.

The U. S. National Museum collection contains specimens of this European species from New York (Barneveld, 1917, and Oriskany, 1931); Nova Scotia (Riverport, 1936); New Brunswick (Chipman, 1936). The New York specimens previously were identified as *T. davisi* Blatchley, a species de-

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[1] Received April 29, 1937.

[2] Boston Soc. Nat. Hist. Proc. **40** (6): 367–376. 1935.

[1] Received March 17, 1937.

scribed from Staten Island, N. Y., in 1916 (Rhynchophora of Northeastern America, p. 115). Blatchley's species evidently is closely related to *bifoveolatus,* but differs, by description, in having only 2 spines at the apex of the front tibia (3 or 4 distinct spines, and often 2 or more shorter ones, in *bifoveolatus*), and presumably in lacking the pronotal foveae which are usually well developed, though sometimes encrusted, in *bifoveolatus. T. asperatus* Boh. 1843 (Genera et Species Curculionidum, VII, 1, p. 116) described from "America borealis ad Boston," remains unrecognized.

GYMNAETRON Schoenherr

Three species of this genus, all of European origin, are now known from North America. In the males of all three the tibiae are mucronate, the mucro of each tibia projecting at a right, or slightly obtuse, angle. In the females the front and middle tibiae are mucronate about as in the males; but the hind tibia is unarmed in *teter,* or armed in *netum* with a black spine which differs from the male mucro in being more slender and in being porrect or subporrect. In *antirrhini* the female hind tibia is virtually unarmed, although a minute spine is present in some specimens. The derm is black in all three species but in *teter* and *netum* the vestiture is paler, somewhat coarser, and more generally prostrate, and covers a greater proportion of the surface, resulting in a lighter ground color; whereas in the blackish appearing *antirrhini* the vestiture, besides being darker, is somewhat finer, and (at least on pronotum) more generally erect, thus leaving exposed a greater proportion of the dermal surface. In the following summaries the two varieties of *teter*—*subrotundatum* Reitter and *plagiellum* Gyll.—are not distinguished, the former apparently being no more than a depauperate form, the latter including specimens having the elytra more or less extensively dull reddish apically. The rostral length is the shortest distance between the apex of the rostrum and the front margin of the eye at its middle.

SUMMARIES OF DIFFERENTIAL CHARACTERS

1. Average length about 2.5 mm (extremes, 2.2–3 mm); ground color blackish; rostrum two-thirds to three-fourths as long as pronotum, rather strongly tapering in dorsal view from antennal socket to apex; rostrum in side view thick at base, tapering throughout, apical half (especially in male) more strongly tapering; prothorax about three-fourths as long as wide; scutellum about as long as wide; elytral striae half to two-thirds as wide as the intervals, the intervals flat and irregularly, biseriately punctate; femora similar in the sexes, of normal size, each with a minute tooth. Massachusetts, Connecticut, New York, New Jersey. Reared from seed pods of *Linaria vulgaris* by P. H. Timberlake and by D. H. Blake............................*antirrhini* Paykull

Length usually 2.7 mm or more; ground color brownish to gray; rostrum longer, often virtually as long as pronotum; prothorax about two-thirds as long as wide; elytral striae narrower, the intervals relatively much wider and normally with 3 very irregular rows of punctures (2 rows in some of the very small specimens)...........................2

2. Average length between 2.7 and 3.2 mm (extremes 2–3.5 mm); rostrum five-sixths to nearly as long as pronotum (longer in females); scutellum about as long as wide; femora not dilated, of subequal size in the sexes, each femur with a small to moderate sized tooth. ♂: No fringe on lower edge of hind tibia; rostrum, in dorsal view, very feebly tapering from antennal socket to apex. ♀: Rostrum slightly but obviously arcuate, apical half cylindrical, polished, and sparsely punctulate (often appearing smooth). Connecticut, New York, New Jersey, Pennsylvania, Virginia, Iowa. Reared from *Linaria vulgaris* by J. C. Bridwell and by A. B. Champlain............................*netum* Germar

Average length between 3.2 and 4 mm (extremes, 2.5–4.25 mm); rostrum averaging a little longer, often virtually as long as pronotum in female and only a trifle shorter in male; scutellum distinctly, usually much, wider than long. ♂: Femora dilated and strongly toothed (especially front pair); lower edge of hind tibia fringed with long, suberect hair in apical half; rostrum, in dorsal view, more distinctly tapering apically. ♀: Rostrum straight or nearly so, distinctly tapering from base to apex in side view, apical half rather strongly, not densely, punctate. Generally distributed east of the Mississippi River from southern Canada to Georgia; west of the Mississippi, specimens are at hand from Minnesota, Iowa, Missouri, Kansas, Oklahoma, Texas, Colorado, Washington, Oregon. On mullein.........................*teter* Fabricius

Ceutorhynchus punctiger Gyllenhal

Ceutorhynchus punctiger Gyllenhal (*C. marginatus* of American authors, not Paykull).

This European species seems to be established in North America. Specimens in the Museum collection are from Ontario, Quebec, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, Indiana.

Perigaster lituratus (Dietz), n. comb.

Coelogaster lituratus Dietz 1896, Trans. Amer. Ent. Soc. **23**: 457.
Perigaster longirostris Buchanan 1931, Jour. Wash. Acad. Sci. **21**: 323 (new synonymy).

Dietz did not describe the minutely toothed tarsal claws and the obsolescent antennal scrobe of *lituratus*, important characters in which it differs from *zimmermanni* Gyll., the genotype of (*Coelogaster*) = *Dietzella*. In *zimmermanni* the claws are strongly toothed and the scrobe is deep and complete. Although *lituratus* has an ocular lobe, a structure not found in the other species of *Perigaster*, its characters in general place it with *Perigaster* and not with *Dietzella*. *P. lituratus* is known from Ontario, New York, New Jersey, Michigan, Illinois, Iowa, Washington.

PHYTOBIUS Schoenherr, and allied genera

Different interpretations of *Phytobius* and allied genera have resulted in considerable confusion, and, at least in North America, misidentifications and omissions have further clouded published records. The data here assembled, though incomplete, tend to harmonize contradictions in the nomenclature.

Schoenherr erected *Phytobius* (evidently a Schmidt manuscript name) in 1836, citing in its synonymy *Hydaticus* Schoenherr 1826 (preoccupied by *Hydaticus* Leach 1817 in Dytiscidae). In his 1826 description of *Hydaticus* Schoenherr designated *velatus* Beck as type, but in his 1836 description of *Phytobius* he failed to set a type although it is obvious from the context that he intended *Phytobius* primarily as a substitute genus for *Hydaticus*, and that he intended *velatus*, the type of *Hydaticus*, to "carry over" and become the type of *Phytobius*. However, because *Hydaticus* 1826 and *Phytobius* 1836 are not co-extensive, and because Schoenherr did not set a type for *Phytobius* in unequivocal terms, it seems necessary to accept C. G. Thomson's 1859 type designations in *Phytobius*, *Pelenomus*, *Eubrychius*, and *Litodactylus*. On this basis, the American genera and species take the following arrangement:

PHYTOBIUS Schoenherr

Phytobius Schoenherr 1836, Gen. et Sp. Curc., III, 1, p. 458; genotype, *4-tuberculatus* F., designated by Thomson 1859, Skandinaviens Coleoptera, I, p. 138.

Pelenomus Thoms., ibid.; genotype, *comari* Hbst., designated by Thomson, ibid.

Phytobius thus becomes the valid generic name for the American species *cavifrons* Lec. to *pusillus* Dtz., inclusive, now listed in the Leng catalogue under *Pelenomus*.

EUBRYCHIUS Thomson

Eubrychius Thomson 1859, ibid., p. 138; genotype (*aquaticus* Thoms.) = *velatus* Beck, designated by Thomson, ibid.

Includes only the genotype species, which is apparently confined to Europe, though wrongly recorded from North America. The American species concerned is *Eubrychiopsis lecontei* Dtz. (See below.)

LITODACTYLUS Redtenbacker

Litodactylus Redtenbacker 1849, Fauna Austriaca, I, p. 399; genotype (*myriophylli* Gyll.) = *leucogaster* Marsham, designated by Thomson 1859, Skand. Coleop., I, p. 138.

Includes 1 American species, *griseomicans* Schwarz (*griseomicans* Dtz.) which is closely related to the European *L. leucogaster* Marsh. Specimens of *griseomicans* are at hand from Dane County, Wisconsin; Okoboji, Iowa; Wahpeton, North Dakota; Kansas; Richfield, Utah; Kahlotus, Washington; Medicine Hat, Alberta. Schwarz lists two localities (Kansas and Dakota) in the original description. The type specimen, now in the National Museum, is labeled "Ks" (Kansas).

EUBRYCHIOPSIS Dietz

Eubrychiopsis Dietz 1896, Trans. Amer. Ent. Soc., v. 23, p. 474; monobasic genotype, *E. lecontei* Dtz. (*Phytobius velatus* of American authors, not *Eubrychius velatus* Beck).

As far as known, *Eubrychiopsis* includes only the 2 American species, *lecontei* Dtz. and *albertanus* Brown. Specimens of *lecontei* in the National Museum are from Detroit, Michigan (type locality); Dane County and Madison, Wisconsin; Lake Okoboji, Iowa. The Massachusetts and Vancouver localities mentioned by Blatchley and Leng 1916, p. 464, may not refer to this species. Dietz's original description of *lecontei* calls for 2 small cusps on the anterior margin of the prothorax; but Dr. Darlington has examined Dietz's type and found no such cusps present, nor are they present on any of the specimens in the Museum collection. Specimens of *albertanus* in the Museum are from Creston, British Columbia, and Last Mt. Lake, Saskatchewan. The type locality is Waterton Lakes, Alberta.

For key to the 3 American species discussed above, see Brown, Can. Ent., vol. 64, 1932, pp. 10–12.

CONOTRACHELUS Schoenherr

Conotrachelus Schoenherr 1837, Gen. et Sp. Curc., IV, 1, p. 392.
Loceptes Casey 1910, Can. Ent. **42**: 130 (new synonymy).

Conotrachelus recessus (Casey), n. comb.

Loceptes recessus Casey 1910, Can. Ent. **42**: 130.
Conotrachelus atokanus Fall 1913, Trans. Amer. Ent. Soc. **39**: 65 (new synonymy).

Casey placed *Loceptes* in the Tychiini, although the monobasic genotype, *recessus* Csy., clearly belongs in *Conotrachelus*. Mr. Fall has compared specimens of *recessus* Csy. with the type of *atokanus* Fall and has verified the species' synonymy recorded above. Examples of *C. recessus* in the Museum are from Atoka, Oklahoma (type locality); Douglas County, Kansas; Aberfoyle, Bonham, Clarksville, Greenville, and Dallas, Texas. Mr. Fall has specimens from Oklahoma and Arkansas (Hope).

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JOURNAL

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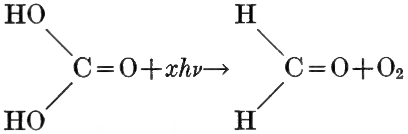
WASHINGTON ACADEMY OF SCIENCES

VOL. 27 AUGUST 15, 1937 No. 8

PHYSICS.—*The fundamentals of photosynthesis.*[1] JAMES FRANCK, The Johns Hopkins University.

For the topic of the lecture in honor of the memory of Joseph Henry which I have the great privilege to deliver today, I have chosen a discussion of photosynthesis in plants for two main reasons. The first is the importance of this photochemical reaction and the second that it belongs simultaneously to the fields of biology, chemistry, and physics, and may therefore be suitable for a discussion before this audience in which students of so many different branches of science are present. But being a physicist I cannot avoid laying the main emphasis on the physical side of the problem, and for this purpose I shall make use of an attempted theory which Dr. Herzfeld and I have worked out within the last year.

To remind you of the importance of photosynthesis, I only mention the well-known fact that photosynthesis in plants—the inverse process of animal metabolism—is the only source of all food which makes animal life possible on earth, furthermore it is responsible for the relatively great amount of molecular oxygen in our atmosphere. As we learn from the geochemists, the atmosphere contained, after the formation of the solid crust, hardly enough oxygen to make breathing possible, but a very great excess of CO_2 and water rendered conditions favorable for the development of plants. By reduction of CO_2 and water, to sugar and molecular oxygen, under the influence of light, plants have produced the conditions now prevailing in the atmosphere. We shall restrict ourselves in our discussion to processes by which CO_2 and water are reduced by light to the state of reduction of sugar, or expressed in the language of a chemical formula, to the reaction



$$\mathrm{(HO)_2C{=}O} + xh\nu \rightarrow \mathrm{H_2C{=}O} + \mathrm{O_2} \qquad (1)$$

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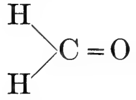
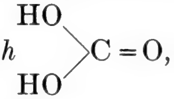
[1] The seventh Joseph Henry Lecture of the Philosophical Society of Washington, presented on March 13, 1937 in honor of Joseph Henry, first president of the Philosophical Society. Received March 25, 1937.

where $xh\nu$ is the symbolism for the number of light quanta used to take out one oxygen molecule from one molecule of carbonic acid, and  $\begin{matrix}H\\H\end{matrix}\!\!>\!C=O$ is formaldehyde, which has the state of reduction of sugar and is able to form sugar by combination of several of its molecules, the so-called process of condensation. (Whether formaldehyde actually occurs in the plant as an intermediate product is of less interest for the subject of our discussion.)

Since carbonic acid does not absorb the light available as sunlight filtered by the earth's atmosphere, the reaction has to be sensitized by a dye, which as its colour shows, absorbs visible light. This is the function of the chlorophyll in the plant, a green dyestuff with a molecular weight of about 1000 whose chemical constitution is entirely known, thanks especially to the work of Willstätter and his coworkers. Since, according to Willstätter, the chemical constitution of chlorophyll enables it readily to form loosely bound complexes with acids, the complex *Chph*-carbonic acid, *Chph*  $\begin{matrix}HO\\HO\end{matrix}\!\!>\!C=O$, is the compound which by absorption of light starts the photochemical reactions.[2] *Chph* acts, according to our present information, only as a sensitizer, and is not changed in the course of photosynthesis. The physical properties which make it specifically fit for photosynthesis are connected with the ability of *Chph*, under the conditions prevailing in the plant, to fluoresce. If molecules absorb light, they may reemit it as fluorescence, or convert the energy absorbed into heat, or use it for chemical reactions. Since reemission of light takes time, the occurrence of fluorescence shows that the conversion into heat or the use for a photochemical reaction does not take place immediately after the absorption act, but that the energy remains for a time in the molecule as excitation energy of the electronic system. One can show, for instance, that the lifetime is between 10^{-9} to 10^{-10} seconds if the plant is irradiated with red light in the presence of an excess of CO_2. Since under these conditions a dissipation of the energy into the degrees of freedom of thermal motion does not take place, the lifetime of the excited state must represent the time elapsed between the process of light absorption and the conversion of the energy absorbed in chemical energy. The lifetime of the excited state is 1000 times greater than the duration of molecular oscillations, therefore

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[2] *Chph* is used as an abbreviation for chlorophyll.

the atoms forming the complex *Chph*-carbonic acid have time to make all possible movements with respect to one another until the right relative position for the photochemical transition is reached. The ability to fluoresce reduces therefore possible influences of steric factors which otherwise would hinder the reaction. It also makes possible the use of a relatively large amount of thermal energy stored up in the many degrees of freedom of the polyatomic complex. In these complexes, the energy migrates from one bond to another, and it occurs sometimes that by so-called fluctuations an energy amount is transferred to a single bond which is many times greater than the average caloric energy for one degree of freedom. The lifetime of the excited state allows one to wait until some such unusual condition is reached; then the energy amount absorbed together with the thermal energy piled up in one bond is transferred into the potential energy of the chemical products. A calculation shows that with normal temperatures 6 to 7 kcal. per mole out of the caloric heat can be gained by fluctuation during the lifetime of the excited state and can be added to the energy of each light quantum within the lifetime mentioned above.

While these properties of the chlorophyll would also occur in every other fluorescent dyestuff built up out of many atoms, the nature of its absorption spectrum and its relations to its fluorescence spectrum are specific, and have also specific applications for photosynthesis. It has three main absorption regions, red, blue, and near ultraviolet, separated from one another by regions of weak absorption. If thick layers of chlorophyll are irradiated,—for instance the whole amount of leaves in a thick forest—practically all visible light can be used for photosynthesis. The red absorption band has a special interest. It shows a very steep rise on the long wave-length side at λ 6700 Å. Wave lengths longer than 6700 Å are absorbed only by those molecules which have some oscillation energy by thermal excitation. λ 6700 Å seems to produce the transition from the non-oscillating level of the normal electronic state to the non-oscillating level of the first excited state. The blue and the ultraviolet absorption regions correspond to transitions to higher excited electronic levels. Under all conditions the fluorescence lies in the wave-length region corresponding to the red absorption, whether it is excited by red, blue, or ultraviolet light. The interpretation of this fact is that the energy surplus of the second and third excited levels over the first excited level is transformed into oscillation energy by an internal transition—a process which, according to a recent paper of Teller, is possible in complicated molecules. Since the molecule in the liquid is always in a state of impact with its neighbors, the oscillation energy is immediately distributed as heat motion among the adjacent particles and is lost for photochemical reaction. The result is that the energy amount available for the photochemical process in the plant is always the same whether red, blue, or ultraviolet light is absorbed, and it corresponds to the energy quanta of λ 6700 Å, or 43 kcal., plus the amount of 6 to 8 kcal. from thermal agitation.

If we compare this energy with the known amount necessary for the reduction of carbonic acid to formaldehyde and molecular oxygen, it turns out that at least three quanta are necessary for this process. But if the oxygen molecule is not taken out in one single elementary act, it is more probable that the energy amount necessary for the photochemical processes becomes greater than that calculated for equation 1. The oxygen atoms taken out separately must, for instance, enter into intermediate compounds like peroxides which set free oxygen molecules by an exothermic reaction. Consequently it is not astonishing that, as Warburg found, even under the most favorable conditions, four quanta of light have to be absorbed for each carbonic acid molecule reduced. From the discussions on the lifetime of the excited *Chph* complex molecules, it is obvious that the energy absorbed stepwise can be stored up only as potential chemical energy. In other words, each absorption act has to result in an intermediate chemical product of photosynthesis which is stable enough to wait for the next photochemical step.

The question of which intermediate products are formed in the plant can be answered with certainty only by direct chemical analysis. But since this is for many reasons at best an exceedingly difficult problem, for the present one is forced to make hypotheses. But such hypotheses are not entirely arbitrary, for they must be in accordance with experience in chemistry and physics, and they must explain quantitatively and in a natural way all the well-established observations made hitherto on photosynthesis. In addition they may at least show that it is not necessary, as many authors believe, to assume that in this biological problem processes occur which are of quite another character than those so far observed in vitro.

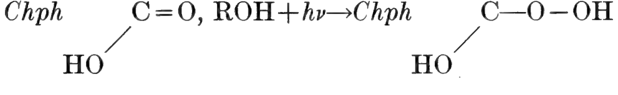
To show that such hypotheses can be made, we consider briefly the main observations on photosynthesis.

As mentioned above, Warburg has shown that four quanta are used to reduce one molecule of carbonic acid under the most favorable conditions. These conditions are that all chlorophyll is in working condition, that a great surplus of CO_2 is present, and that the light intensity is not too great. If one plots in a diagram the production of oxygen for a living leaf or algae, against light intensity, one gets first a linear relation; but in going to higher intensities the production of oxygen increases less rapidly; then, it is proportional to the light intensity; and finally becomes constant and independent of the intensity of irradiation. The occurrence of light saturation has been interpreted by the fact that in the course of photosynthesis not only photochemical reactions but also dark reactions play a role. Now the sequence of reactions cannot proceed more quickly than the slowest component reaction. If, in the present case, the photochemical partial reactions proceed with a velocity proportional to the light intensity, while the velocity of the dark reaction is of course independent of the illumination, there must be a light intensity for which the dark reaction becomes the slowest one and is alone responsible for the velocity of the total reaction. While this point of view is undoubtedly right, the application to the shape of the curve actually observed encounters difficulties. One can calculate the velocity of the photochemical reactions. It is inversely proportional to the time in which each chlorophyll molecule takes up four quanta of light. Furthermore, one can, as Emerson and Arnold have shown, measure directly the velocity of the dark reaction. In calculating the curve from these data, one predicts saturation with light intensities which are about 1000 times greater than the actually observed values for saturation. The measurements of the velocity of the dark reaction are made by studying the oxygen production by plants illuminated with light flashes of a very short duration and changing the time distance between the flashes. The amount of oxygen produced per flash will become independent of the duration of the dark periods between the flashes if they are longer than the time needed for the dark reaction. Emerson and Arnold found that at room temperature the time necessary for the course of the dark reaction is 2/100 of a second, and at 1° C it is 4/10 of a second. They studied also the influence of poisons on the velocity of the dark reaction, and found, for instance, that HCN slows it down considerably. The general behavior of the dark reaction in respect to poisons and temperature is in accordance with Warburg's statement that the dark reaction is apparently an enzymatic decomposition of peroxides into normal oxides and molecular oxygen. Arnold and Emerson's important results show indirectly that the saturation observed with continuous irradiation is influenced by the velocity of this dark reaction. The saturation production of oxygen is diminished by low temperatures and by HCN in the same way as is the velocity of the dark reaction, while on the other hand the oxygen production with low light intensities is practically uninfluenced by the lowering of temperature and adding of small doses of HCN.

We must mention another kind of light saturation which occurs with flash illumination if the intensity of the individual flashes is raised more and more. The shape of these saturation curves resembles that with continuous irradiation, but the saturation value is here only dependent upon the intensity in the single light flashes, and its time integral can, by using long dark periods between the flashes, be made many times smaller than the light intensity per unit of time which produces saturation with constant irradiation. Since enough time is left in the dark periods for the completion of the dark reaction, the flash saturation becomes independent of its velocity. Therefore Arnold tried to explain this type of saturation by the assumption that in a flash of very high intensity all carbonic acid in contact with *Chph* is reduced. The number of such carbonic acid molecules must then be equal to the number of O_2 molecules developed per flash. A comparison with the known number of *Chph* molecules present gave the unexpected result that in the presence of a surplus of CO_2 the number of H_2CO_3 molecules in contact with *Chph* should be several thousand times smaller than the number of *Chph* molecules. The deviation is here of the same order of magnitude as with the normal saturation curve, and Arnold and others tried to explain both deviations by the assumption that in the plant so-called photosynthetic units exist which contain about a thousand *Chph* molecules for each carbonic acid molecule. The *Chph* molecules should absorb the light practically independent of one another, but each quantum absorbed in the unit is used for the reduction of just one carbonic acid molecule. Such a state of affairs is not quite impossible, but certainly highly improbable. According to my opinion, it is in contradiction to the chemical instability of *Chph*, and to the fact that the *Chph* can give fluorescence in the plant, while *Chph* molecules coupled together do not. Nevertheless the existence of the unit was assumed as the only possible solution. The hypothesis of the photosynthetic unit has been further supported because it offered also an explanation for the lack of an induction period.

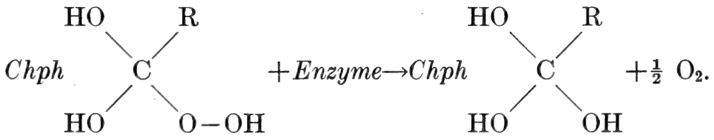
If after a dark period leaves are irradiated with weak light, the oxygen production starts immediately at practically the final rate, although one should expect that if four quanta have to be absorbed by the same *Chph* molecule before oxygen molecules are liberated, the time lapse between the start of irradiation and the start of oxygen production should be very great with low light intensity. The existence of a unit of about 1000 *Chph* molecules which cooperate would reduce this time by a factor 1000, and would make the induction period so short that it might easily have been overlooked.

According to the point of view of Herzfeld and myself, it is possible to explain quantitatively all the facts mentioned above, and many others not mentioned here, without the assumption of a photosynthetic unit. This we have done by using as photochemical intermediate reactions processes which are inverse to the established intermediate steps of autoxidation and photoxidation of organic matter. Since peroxides and peracids are formed by autoxidation, they should also occur in the stepwise reduction. The dark reaction is then, in accordance with Warburg, simply the enzymatic decomposition of the per-compounds to molecular oxygen and ordinary acids or aldehydes. The absence of an observable induction period forces us to the assumption that a peracid is formed out of the *Chph*-carbonic acid complexes by a single absorption act. One quantum of red light corresponding to 43 kcal. has enough energy to form a peracid, if the excited *Chph*-carbonic acid complex has always the chance to react with an organic molecule of the structure ROH. To secure such a reaction ROH has to be in contact with each *Chph* molecule. We assume, therefore, that the compound ROH is the bearer substance of the *Chph*, which will mean that a sphere, or a particle with a more complicated surface consisting of ROH, should have on its surface adsorbed *Chph* molecules which in the usual way may move around on the surface as a two-dimensional gas (as has been established for adsorbed molecules by Volmer). ROH should have the usual strength of binding between C and OH, and may perhaps be a protein. The first photochemical equation is



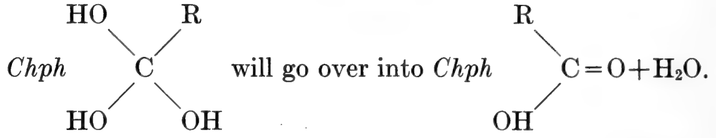
$$\mathit{Chph}\ (HO)_2C=O,\ ROH + h\nu \rightarrow \mathit{Chph}\ (HO)_2C(R)—O-OH \qquad (2)$$

followed by a dark reaction

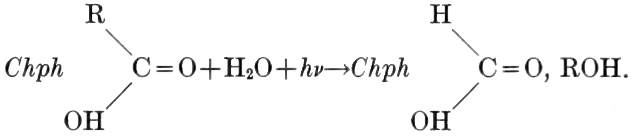


$$\mathit{Chph}\ (HO)_2C(R)(O-OH) + \mathit{Enzyme} \rightarrow \mathit{Chph}\ (HO)_2C(R)(OH) + \tfrac{1}{2}\ O_2. \qquad (3)$$

The expression $\frac{1}{2}O_2$ means, of course, that the enzyme has to react with two peracids to form one O_2 molecule. (The reaction can take place without triple collisions if the enzyme takes an O atom away from the peracid and transports it to the next peracid where the O_2 molecule is then formed.) By splitting off water



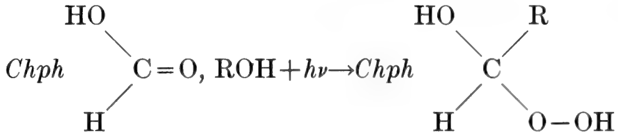
The second photochemical equation replaces, by a reaction with water, the R by an H atom and restores ROH. We have



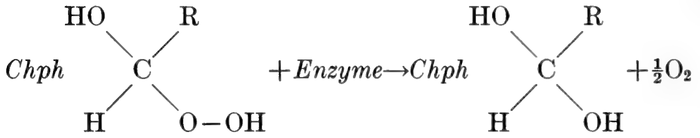
(4)

Thus formic acid is formed as an intermediate product, as was assumed by Willstätter and Stoll. (Dr. Rieke and I have started measurements on the quantum yield of a plant fed with formic acid instead of carbonic acid. We expect that two quanta will reduce formic to formaldehyde; see equations 5, 6 and 7.)

The following equations are entirely analogous to equations 2, 3 and 4:



(5)



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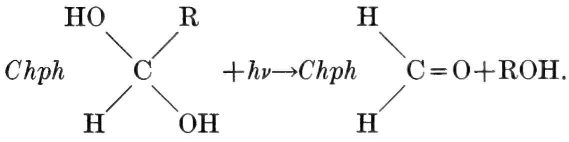


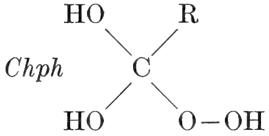
(7)

These transform the formic acid, in two light reactions and one dark reaction, into formaldehyde and oxygen.

This system of equations is at least a possible one. It offers, as far as our information goes, no difficulties with respect to the energy relations; it is in accordance with Warburg's quantum yield and with the experiments on the dark reaction; and explains the lack of an induction period for the experiments made with moderate illumination.

This set of equations also offers simple explanations for the occurrence of saturation curves for continuous and flash irradiation, and furthermore makes it possible to calculate their shape.

The deviation from a linear relation between oxygen production and light intensity is produced by the instability of the peracid and the peraldehyde toward light. Each light quantum absorbed by the complex



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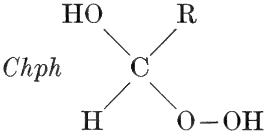

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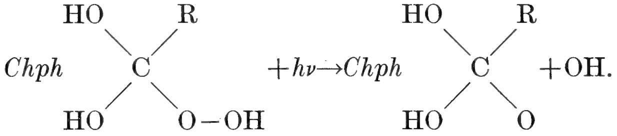
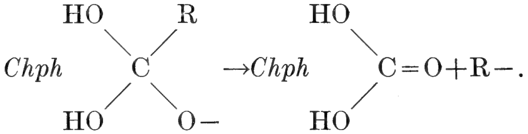
will break the bond between the O and the OH in the per-compounds, since this bond is a very weak one, as one can calculate from well known heats of reaction. The resulting peracid or peraldehyde radicals and OH radicals produce chains of back-reactions for which the following equations give an example.



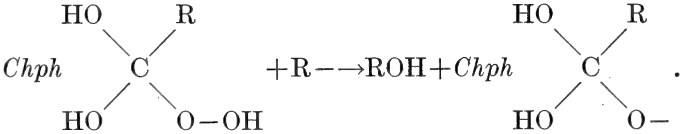
(8)

This reaction is followed by a spontaneous splitting off of the radical R– and the formation of a double bond between O and C



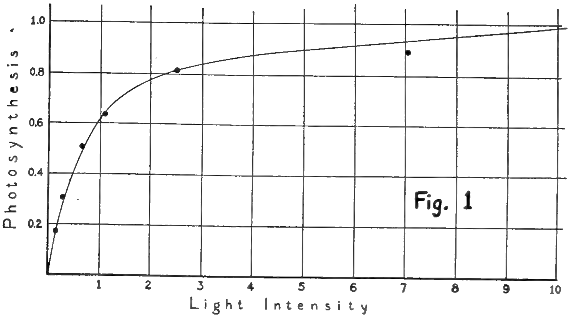
(9)

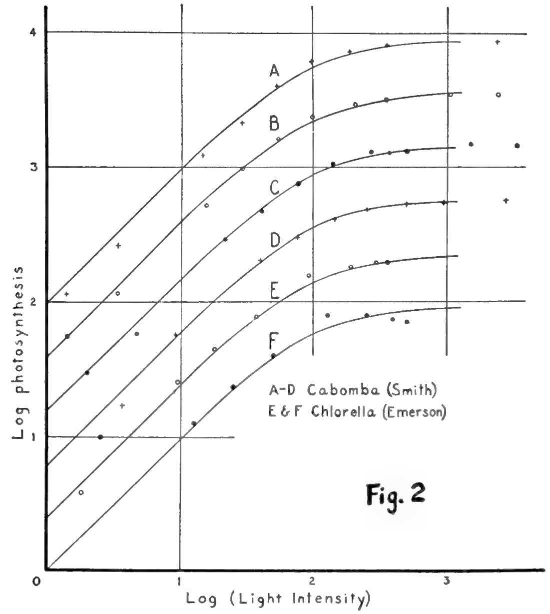
The radical R– will attack another peracid complex and continue the chain



(10)

The OH radical starts similar chains. The chains will break by side reactions in which R and OH are consumed. The result is that relatively rare absorption acts of *Chph* connected with peracids or with peralde-





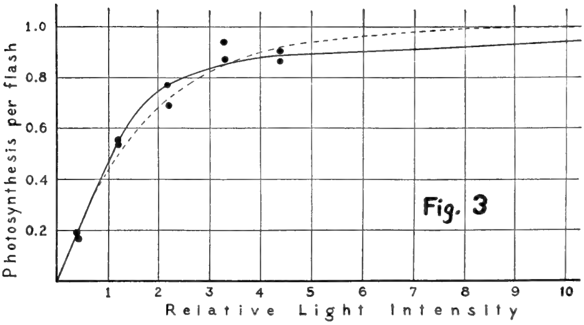


Fig. 1.—Warburg's results on photosynthetic oxygen production plotted against light intensity. Fig. 2.—Results of other authors plotted on a logarithmic scale. Fig. 3.—Flash saturation (points) compared with the theoretical curve (solid line).

hydes produce back reactions to carbonic acid and formic acid, which proceed in chains and therefore reduce the O_2 production considerably. With small intensities such absorption acts will not occur, since the average time between two consecutive absorption processes taking place in the same *Chph* molecule is large compared with the time used by the enzyme to reduce the peracid (time 1/50 sec.), but with rising intensity more and more chains start and finally produce saturation. These processes are, according to our viewpoint, responsible for flash saturation and for saturation with continuous illumination, the difference between them in respect to the saturation values being caused by the higher instantaneous density of light quanta in flash illumination. The following figures show the good agreement between observation and theoretical calculation. The points represent observed values, the drawn lines the results of theory.

Fig. 1 contains Warburg's results on photosynthetic oxygen production plotted against light intensity. The only point which deviates from the calculations is not very reliable, according to a remark by Warburg. Fig. 2 shows results of other authors plotted on a logarithmic scale. The data for this figure have been taken from a paper of Smith which contains Smith's own measurements and results of other observers. Deviations between theory and experiment are not greater than the possible error of the observations. Several points which correspond to measurements with very low light intensity have considerable possible errors, since according to Smith the correction necessary for respiration processes in the plant is here very large and not exact. In Fig. 3, observations on flash saturation (points) made by Emerson and Arnold are compared with the theoretical curve (solid line). The dotted line represents an empirical formula suggested by Kohen. The great reduction of the oxygen production at light saturation caused by HCN or low temperature fits very well in the theory, since every influence which lowers the velocity of the enzymatic decomposition of the peracid and peraldehyde increases the concentration of these substances and makes the starting of back reaction chains more frequent.

The proposed chemical mechanism has of course also a biological aspect. The back reactions proceeding in chains give us an understanding of how the plant protects itself against overfeeding. The plant, having no other possibilities to get rid of a surplus of food, uses the light which produces the food to destroy the excess.

There is not sufficient time to go further into details. I wish only to add that, according to the theory, not only carbonic acid and formic acid are photosynthesized, but also all plant acids which are produced as intermediate products of respiration which combine with chlorophyll in the way characteristic of acids. In this case also peracids and aldehydes will occur in the course of photosynthesis, and are reduced by the enzyme. But there is one striking difference between these plant acids on the one hand and carbonic and formic acids on the other.

The difference is that the plant acids, having a great number of $-\overset{|}{\underset{|}{C}}-H$ bonds, provide a great chance for photoxidation which again proceeds in chains. The result is that the $-\overset{|}{\underset{|}{C}}-H$ groups are partially replaced by $-\overset{|}{\underset{|}{C}}-O-OH$ groups, and these groups also give to the molecule the properties of a peracid. Consequently, a great excess of peracids is built up if photosynthesis and photoxidation of the plant acids take place as parallel processes. This will occur whenever the plant contains a large concentration of plant acids and is strongly illuminated in the presence of molecular oxygen. The plant acids are produced and consumed at a constant rate by respiration, but since with illumination there is an additional consumption of plant acids by photosynthesis and photoxidation, the equilibrium concentration is lower in the light than in the dark. The transition of the concentration of plant acids from the value in the dark to that prevailing in light takes time. This time will be longer with a weak illumination than with strong. Since in the transition period an excess of peracids is present, the probability of starting chains of back reactions by photolysis is enhanced, thereby diminishing the production of oxygen. Weak illumination should have only a small influence, since the enzyme is able to reduce the extra amount of peracids formed by photoxidation before they absorb light quanta and split into radicals. However, with strong irradiation, radicals are produced and the number of back reaction chains should become considerable. This explains Warburg's observation that there is a considerable induction period in the oxygen production if a plant after a dark pause is illuminated with strong light, although with weak illumination this phenomenon is not found. The induction period occurring with strong illumination is intimately connected with the abnormal behavior of the fluorescence of a living leaf strongly illuminated after a dark period. This phenomenon, first observed by Kautski and studied in more detail by R. W. Wood and myself, can be easily interpreted in terms of the photoxidation of plant acids. Time does not permit me to discuss this point in more detail.

I hope that this survey of the problem of photosynthesis, which could touch only the main points, will leave you with the impression that, while the problem is by no means entirely solved, many features are made understandable by the application of normal physical and chemical experience, and that one is no longer forced to assume that in this biological problem processes occur which are of an entirely different character from those with which we deal in studying inorganic matter. I wish again to express my thanks to the Philosophical Society for the great honor of being invited to give this Joseph Henry lecture, and to the audience for listening with such patience to my remarks.

GENETICS.—*Hybridity as a factor in evolution.*[1] Robert F. Griggs, George Washington University.

Of all the various factors that have been suggested as causes of evolution, hybridity looks, on first sight, the least probable. The limits within which species are cross-fertile are so narrow that there would seem to be little possibility of any such wholesale hybridization in nature as would appear to be demanded if the motive power of evolution is to be found in hybridity. In fact, the suggestion that hybridization may have been a major factor in evolution sounds to most people almost absurd.

The very idea of origin of species by hybridization involves almost a contradiction in terms. The best criterion of specific separability that can be framed is that the types in question will not interbreed. If, therefore, it is only exceptionally that hybrid intermediates between species can be obtained, how much less likely is it that new genera, families, orders, or classes could owe their origin to hybridization? The mere suggestion that even such closely related animals as dogs and cats could hybridize is too far-fetched to be considered by anyone. This being the case, we should perhaps drop the whole matter here and go no further.

Yet, since evolution by hybridization has been advocated by students whose biological contributions in other fields are respectable, it cannot be dismissed so cavalierly as that. The repute of the sponsors of the theory demands for it consideration on its merits.

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[1] Address to the Paleontological Society of Washington, March 17, 1937. Received April 1, 1937.

In the first place, we may observe that the apparent absurdity of a scientific theory does not necessarily throw it out of court. While biology is still on a basis where nothing that does not appeal to "common sense" can command a hearing, the physical sciences have long since passed beyond that stage. Indeed, we biologists might well ponder the fact, for it is a fact, that the recent revolution in physics, with its many brilliant theoretical advances and its equally spectacular practical applications, was made possible only by the willingness of physicists to follow theories which led them to tenets quite contrary to any common sense view of the universe. Einstein's doctrines that time is not the same at the same instant in different places, or that a straight line is not the shortest distance between two points certainly cannot be fitted into any common sense ideology. The interesting thing about these seemingly nonsensical ideas of modern physics is that they seem to be true in spite of their apparent absurdity.

The point for us, however, is not whether new ideas appeal to our common sense (which is, I fear, only another name for the complex of our prejudices and preconceptions) but whether they are susceptible of objective test, observational or experimental. That is the great feature of Einstein's ideas which the layman often overlooks. They were not such wild speculations as they sound, for, along with their very enunciation went concrete suggestions for quantitative experimental tests by which they could be established or rejected. We will do well in biology if we will consider new ideas in the same spirit.

In the past we have done our science great harm by hastily accepting ideas which appealed merely to our "common sense." A very large part of the success of the theory of Natural Selection lay in the vivid appeal of the phrases "struggle for existence" and "survival of the fittest." Everybody thought he knew what the struggle for existence was and that he understood the survival of the fittest, and he straightway adopted the ideas without critically thinking about them. The unfortunate fact is that three-quarters of a century after Darwin his ideas are still as he left them, mere phrases without experimental substantiation. As a matter of fact, nothing is less understood than the struggle for existence.

The proper way for us to examine the rôle of hybridity in evolution is, therefore, to inquire, first, what was the factual basis for its enunciation, and second, how can it be examined objectively. If we discover no way of attacking the problem, we should follow our first reaction and drop it. If it should become merely a speculative football it would do biology no good. But if it can be tested by a large body of data, experimental or otherwise, it may lead us somewhere. The question which I shall consider tonight, then, is whether any such objective approach to the idea is feasible.

Going a little further now with the negative side of the question, we may point out that the difficulty suggested of accounting for the larger groups—genera, families, orders, classes, and phyla—is not peculiar to the hybridity theory but is shared by most other theories of evolution.

It was not by accident that Darwin titled his book *The origin of species*. He supposed that he had discovered the factor responsible for the differentiation of homogeneous stocks into separate species, and he believed, or perhaps it would be more accurate to say that he hoped, that the operation of the same factor could, by something like extrapolation, account for the origin of genera, families, and larger groups.

The same might be said of Lamarck with even greater emphasis, for while the differences between species are to a certain extent due to adaptations which might, perhaps, be acquired by something like use or disuse, the characters which distinguish the great groups are very much less adaptive. For example, the aorta in birds turns to the left and in mammals to the right; the one has feathers and the other hair, and it would be very difficult to believe that either of these conditions was brought about by adaptation to environment.

As for mutation, we have plenty of experience with mutations involving superficial characters like pigmentation, but after all, a mutated cat is still a cat and we cannot imagine even so similar an animal as a puppy in a litter of kittens.

For orthogenesis the case is different, because with orthogenesis, as with creation, all things are possible. But also, orthogenesis has little more to offer in the way of circumstantial explanation than did special creation.

The fact that we cannot imagine hybridization to have played a rôle in the evolution of the higher categories of plants and animals does not, therefore, militate against the theory as heavily as might have been supposed.

Historically, the hybridity theory of evolution was propounded twenty years ago by Lotsy[2] of Leiden. Lotsy emphasizes the importance of the recombination of Mendelian factors, and in the mere reassortment of these factors sees the explanation of the evolution of

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[2] LOTSY, J. P. *Evolution by means of hybridization.* M. Nijhoff. The Hague, 1916.

many species. He specifically disclaims any attempt to explain the whole of evolution. For him the biological unit is the "Jordanon" or Jordanian species, a group of completly homozygous individuals. Any heterozygosity to him is proof of hybridity. "All individuals able to produce more than one kind of gametes, e.g. gametes of different constitutions, are hybrids" (p. 28).

Lotsy considers genera and all groups of a higher order as largely figments of the human mind, with only doubtful reality in nature. But he asserts that these higher orders also originated by crossing. "*Crossing was the origin of the new classes; selection, the result of extermination by the struggle for life, the cause of their gradual extinction.* [Italics in original.] Such extinction of classes must proceed continuously until a happy meeting between two sufficiently differently constituted gametes, causes the origin of a new class." (p. 135). But "A formation of new classes is not in action at the present moment, so that it is illegitimate to claim that one who wants to explain evolution must demonstrate how such a formation of new classes goes on" (p. 136).

Nor does he believe in any progress in evolution. "Consequently the geological record gives no support to progression either, and we are perfectly justified to say that progression is a human conception and that progressive evolution does not exist" (p. 118).

Lotsy thus considers only a small fragment of the problem of biological relationship. And even within the circumscribed field which he has undertaken to elucidate he submits almost no evidence that his theory does, in fact, explain the origin of the phenomena ascribed to it. Considering the vast body of evidence which might have been marshalled for his proposition, it is very surprising that he should have contented himself with so speculative, not to say dogmatic, a treatment of the subject.

Lotsy's ideas of what amount to miraculous origins of new forms by rare chance fertilizations and his consequent disbelief in the gradual origin of families and other larger groups led him to value lightly all the homologies by which the comparative anatomists have built up their conceptions of relationship.

Evidence that hybridism has something to do with variation and hence with evolution was brought forward half a century before Lotsy—before Darwin and before Mendel. Lotsy's whole proposition is obviously a reaction to Mendelian thinking, but Mendel himself did not indulge in any such speculation. Rather, in the latter part of his paper he shows how the supposed transmutation of one type into another through successive generations of hybrid stock is to be explained by the operation of the principles of heredity he had discovered.

Antedating Mendel's publication, however, is a paper by Naudin[3] on hybridism considered as a cause of variability. Naudin's work, unlike Mendel's, attracted such considerable attention at the time that it was translated in the newly established Journal of the Royal Horticultural Society. Naudin records what we now know as Mendelian segregation in the second generation of his hybrid plants, but failed to understand it. He also described hybrid vigor as regularly occurring in the first generation of his crosses and as disappearing in subsequent generations. He gave much experimental data, e.g. he made 130 hybrids of *Datura*. He recognized that reciprocal hybrids are identical, which was one of the great contributions of Mendel also. He believed that the variability of such genera as *Salix* was due to hybridity.

First-generation hybrids of *Datura ferax*×*laevis* were uniform and the reciprocal hybrids identical, but in the second generation "the most astonishing diversity succeeded the former great uniformity.... "I could bring forward many other examples of the excessive variability which arises in consequence of crossing."

He recorded striking hybrid vigor between *Mirabilis longiflora*×*jalapa*, whose progeny in the first generation "became enormous. Intermediate in the same degree between the parent species, which they far surpassed in stature, they resembled each other as exactly as possible, which might be expected as they belonged to the first generation." Of the second generation he said: "None of them acquired the large stature of the hybrids of the first generation; none, moreover, resembled them"—two were similar, the others very diverse.

More recently many writers have discussed hybridism as an evolutionary factor, and much controversy has developed as to the means of recognizing hybridity. Into this question it would not be appropriate to go in this place. The whole subject is in an incoherent amorphous stage. Doubtless, as more work is done, definite canons for research will crystallize out of the heterogeneous mass of facts and ideas floating around at present.

Meanwhile, further comparisons with other types of evolutionary theory may be useful.

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[3] Naudin, Ch. *On hybridism considered as a cause of variability in vegetables.* C. R. Nov. 21, 1864. Trans. Jour. Roy. Hort. Soc. **1**(1). 1866.

Natural Selection drew a large part of its support from analogy with Artificial Selection, the process by which the extremely diverse types of domestic animals and cultivated plants (*cultigens*, as they have been called) were supposed to have originated. It was because of the importance of this analogy to his theory that Darwin devoted so large a part of his time to searching out the origin of domesticated types. It is a curious fact that in all the battle over Darwinism nobody questioned the efficacy of Artificial Selection. The validity of the analogy between breeds and species was vigorously attacked but not the origin of breeds. Agassiz said: "Selection is no doubt the essential principle on which the raising of breeds is founded and the subject of breeds is presented in its true light by Mr. Darwin."[4] Yet we know now that the origin of cultigens was one of the things least understood in Darwin's time. The present knowledge of cultigens was, indeed, one of the chief agencies in undermining Natural Selection.

It was on the same rock that DeVries' theory of mutation struck. It was later proved that the true-breeding *Oenothera* mutants which DeVries had found, sprang, not as he supposed, from a wild species, but from a cultigen which, as he discovered later very much to his chagrin, grows wild nowhere in the world. *Oenothera lamarckiana* is a hybrid which has been reproduced by crossing two wild species, *Oenothera biennis* and *O. franciscana.*[5]

In the hybrid origin of DeVries' oenotheras we have, naturally, a strong suggestion of the possibility of the hybrid origin of mutants in general and so of the whole of evolution. We will return to this. Meanwhile, we may take the other hint given us by DeVries' experience and examine cultigens more closely.

It is hardly too much to say that the origin of a majority of our staple food plants is as much a mystery as the origin of Orders and Familes. No man has ever seen growing in the wild, maize, bananas, sweet potatoes, cocoanuts, garden peas, tobacco, peanuts, lentils, or cassava. Neither has any wild species ever been discovered which, by such selection as Darwin relied on, could give rise to them.[6] No wild plant bearing anything even remotely similar to an ear of corn has been found after the most thorough search of the territory in which

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[4] Agassiz, L. Am. Jour. Sci. **30**: 147. 1860.

[5] Davis, Bradley More. *Oenothera neo-lamarckiana.* Am. Nat. **50**: 688–696. 1916.

[6] The experiments of Johannsen (Ueber Erblichkeit in Populationen und in reinen Linien, Jena 1903) on garden beans and of many later workers on both plant and animal material have shown that within the limits of experimental experience, selection by itself is able to make practically no change whatever in an organism.

maize must have originated.[7] If we consider domestic animals, the case for nearly all of them, on Darwin's own showing, is nearly as bad.

There would be little profit for us here to go off into speculation as to the factors which have been at work in producing these old cultigens. But it may be worthwhile to look around among them for some whose origin is more recent and better authenticated.

Such are not to be found among the domestic animals or the staple crop plants of any people. All of these go back into the obscurity of antiquity, where they cannot be traced. But fortunately there is one type of cultigen which has been produced very recently and concerning which in some cases we have fairly detailed records. I refer to ornamental plants, nearly all of which have undergone great development within the past century.

Even among ornamentals of recent origin, recorded pedigrees of sufficient detail and accuracy for analysis are scarce. But wherever the facts have been obtainable the course of events has proved substantially the same.

In the beginning, nature lovers have dug up wild plants and grown them in gardens. Despite the belief entertained by Darwin and his contemporaries that domestication by and of itself in some mysterious way induced variability, many of these old species have been cultivated for centuries without undergoing much of any modification. Foxgloves and canterbury bells, geese and guinea fowl are very much as they were when first domesticated.

In contrast with such types others, like roses, dahlias, sheep, and dogs, show a diversity under domestication without parallel in the wild. When we search for the differences between the stable and the variable domesticated types, we find in every case where the facts are obtainable that hybridization has preceded the production of the polymorphic cultigens, while the stable types have no close relatives in domestication with which they could have been crossed.

A list of familiar cultigens which owe their character largely to hybridization includes azalea, begonia, calceolaria, cineraria, citrus, clematis, columbine, dahlia, delphinium, freesia, fuchsia, geranium (pelargonium), gladiolus, hibiscus, iris, ixia, peony, petunia, potato, rhododendron, rose, strawberry, sweet pea, tomato, tulip, verbena.

But polymorphic cultigens are not, for the most part, simple hybrids. Where their history can be made out the sequence of events has generally included three stages: (1) the collection of numerous wild

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[7] KEMPTON, J. H. *Maize, the plant breeding achievement of the American Indian,* Smithsonian Scientific Series. **11**: 319–349. 1931.

species of a group; (2) a preliminary period of hybridization in which the results follow the ordinary expectations of Mendelian segregation and recombination; (3) what the horticulturists call a "break," when suddenly and all at once a large number of new forms burst forth unexpectedly as a result of further crossings. These breaks are entirely unpredictable in the light of our present knowledge and they have usually arisen in the gardens of practical men who could better preserve and disseminate the wonderful new varieties they had found than analyze the biology of what had occurred.

I doubt if anything could be more conducive to one's understanding of the processes of evolution than detailed consideration of the history of a cultigen in which such a "break" has occurred. There is no time here to go into the minutiae of the case, but I shall recount briefly the history of garden cannas.

Because of their luxuriant tropical foliage, cannas early attracted the attention of connoisseurs of exotics. A number of species were introduced from the wild during the first half of the nineteenth century. Bouché in 1833 grew in Berlin 37 of the 48 known species. The cultivation of these wild unimproved forms, however, died out soon after the middle of the century, and many of them have since been lost. An index of the interest in this line is afforded by the plates of Curtis' Botanical Magazine, which made a practice of figuring the novelties that were brought to British hothouses. Between 1787 and 1904 this serial gives 12 plates of cannas. All were before 1856 and all but two before 1825. During this early period nobody thought of growing cannas except as foliage plants in the greenhouse. Outdoor culture was a daring innovation, as witness the following comment by Seeman in 1855 on *C. warscewiczii*, from Central America, one of the three most important parents of present varieties (see Fig. 1):

> In German gardens this canna is planted during the summer in open borders where it succeeds extremely well, as is also the case with other cannas, marantas, musas, begonias, bambusas, etc. In England this mode of culture has not yet been tried, probably from the prevailing notion that the difference of temperature of the two countries from May to October is too great to allow the experiment to succeed. There is no harm in trying it, especially as the case is not quite a hopeless one. The Germans formerly never dreamed that they should one day behold broad-leaved banana trees and cannas in their gardens flourishing with tropical luxuriance.[8]

The second period of canna culture centered about the work of Théodore Année who, enthused about cannas by a sojourn in South America, undertook to transform cannas from greenhouse curiosities

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[8] Curtis' Bot. Mag., table 4854, June, 1855.

to outdoor plants. A good measure of his success is the fact that 20,000 clumps of his best variety, *C. annéei*, were planted in the public grounds of Paris in 1861.[9] His spirit was that of an amateur lover of fine flowers rather than that of a scientist or even a commercial horticulturist. Consequently we have very scanty records of the parentage of his varieties. And as all later work was based on his, this becomes an irretrievable gap in our knowledge of the evolution of garden cannas. Nevertheless, there are few even of ornamentals for which the deficiencies in our knowledge are not worse.

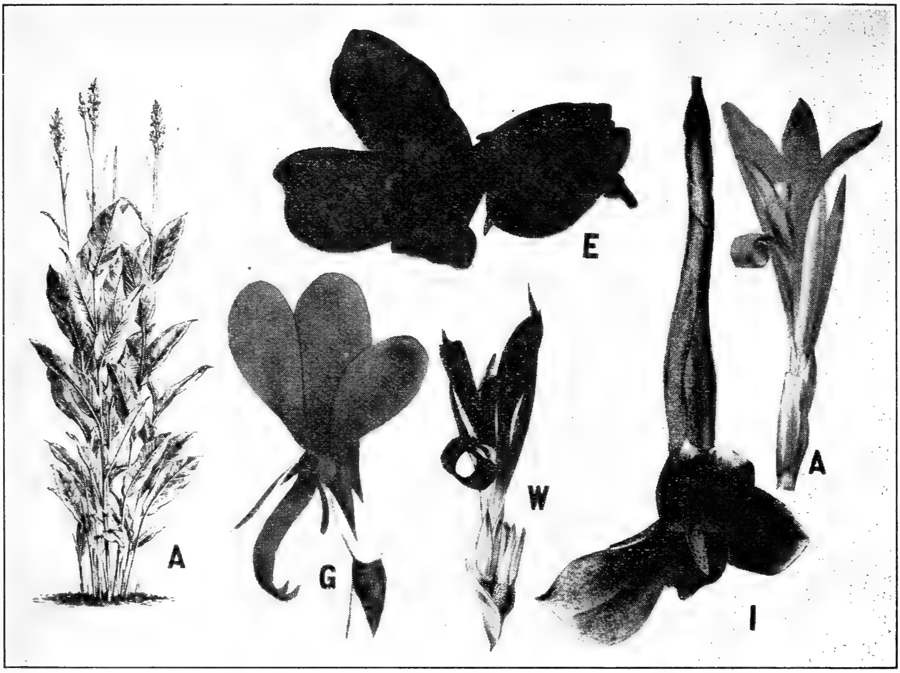

FIG. 1.—Ancestors of modern cannas—wild species and early hybrids. Flowers half natural size. A, *Canna annéei*, plant and flower. E, *C. ehemanni* (1 X W). Semipendent. G, *C. glauca*, source of the gene for yellow in cannas. I, *C. iridiflora*, pendent. W, *C. warscewiczii*, source of the gene for red in cannas. From the original figures. See text for citations.

Canna annéei was a lanky plant more than 13 feet tall with a few small salmon-pink flowers about the size of a snapdragon (Fig. 1). No one could imagine it being planted today, but it was a great favorite for several decades.

From the point of view of usefulness for further breeding and of beauty of its flowers the most noteworthy of the early hybrids was

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[9] Rev. Hort., p. 469, 1861.

C. ehemanni, which is also attributed, though somewhat doubtfully, to Année. Positive and definite reports have it that this came from a cross of the small-flowered, brilliant red *C. warscewiczii,* alluded to above, and the pale, large-flowered *C. iridiflora* from Peru (Fig. 1).[10] It is probably safe to conclude that it sprang from the parents reputed, for no other plants known at the time could well have produced it. But it is doubtful whether it was a simple hybrid between these species. The cross was said to have been made by Année in 1863, but the hybrid plant was not described until 1875 and it seems unlikely that the finest canna of its time could have remained in obscurity for twelve years.[11] In view of its remarkable advance over either of its reputed parents, it is most unfortunate that we have no exact record of the time and place of its origin and of the name of the hybridizer.

While *Canna ehemanni* might be classed as intermediate between its parents, its flowers far surpassed either in effectiveness. They were nearly as large as the larger (*iridiflora*) and twice as numerous as the more floriferous (*warscewiczii*). The staminodes of *iridiflora* measured about 15 sq. cm., those of *warscewiczii* 2 sq. cm., and those of *ehemanni* 12 sq. cm. The number of flowers in *iridiflora* was about 6, in *warscewiczii* about 20, in *ehemanni* 40. Again, in color it was superior to either parent, for the deep scarlet of the petals had spread over the calyx, which had scarcely a trace of color in either parent.

The important thing to keep in mind with *Canna ehemanni* is its progress beyond anything known in the wild. The "break" was coming. In the next decade, that following 1880, the French breeders, of whom Antoine Crozy was the most celebrated, developed what were known as "gladiolus-flowered" cannas. This name, said a horticultural periodical[12] of the time "has been suggested for a remarkably beautiful class of cannas whose blossoms are almost as large and showy as those of the gladiolus."

The tradition concerning the origin of these gladiolus-flowered or French cannas was given in a letter by Henry L. de Vilmorin, one of the leading horticulturalists of his day, as follows: "It is the current belief in this country [*France*] and it seems confirmed by experiment that the new breed of floriferous cannas (i.e. the French dwarfs) originated by the crossing of *Canna ehemanni* with *C. warscewiczii* and with *C. glauca*[13] (see Fig. 1), the former producing red flowers and

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[10] Rev. Hort. p. 111, 1861.

[11] Rev. Hort., pp. 291 and 321, 1875.

[12] Garden. March 2, 1889.

[13] SMITH. Exot. Fl. **2:** t102. 1805. *C. glauca* is an aquatic plant from the West Indies and South America.

the latter specially yellow-flowered varieties. Both original crosses intercross readily, and in later years I have had many crosses made every year and raised and named several dozen new seedlings using the best varieties of my own and Crozy's raising, without introducing new blood into the breed."[14]

Our credence of this straight-forward statement of "current belief" in the origin of French cannas must be modified by two circumstances: (1) Our knowledge that Année's early hybridization involving additional species had more to do with the foundation stock than Vilmorin realized. (2) From the species listed it is difficult to account for the numerous purple-leaved varieties of canna. This character, it would seem, must have come from *C. discolor*, which has such leaves. However, the flowers of that species (or perhaps it was itself a hybrid) have not had any discernible effect on modern cannas.

Turning now to a more detailed consideration of the methods used by the French breeders, we are told by the most famous of them, Antoine Crozy:

> As to the number of crosses raised by me, I suppose that I have raised without exaggeration some 180 to 200 varieties which, step by step, showed improvement over the older kind. Among my varieties not yet in commerce are cannas with flowers measuring from 4½ to 6 inches in diameter. These have all very glowing colors and bear immense flower trusses.
>
> My constant zeal for superior varieties shows successes every year in regard to color as well as size and number of flowers. The flowers now are borne more erect, are of better substance, and show broader, rounder petals, and some are of a size not known before.[15]

Examination of Crozy's catalogs shows that his claim of 180–200 varieties is not an exaggeration but an understatement. I have not been able to lay hands on the full series of catalogs, but among those available an even 200 novelties are listed as produced by himself before the date of his statement. It is clear from the literature that in the production of cannas, once the right foundation stock was obtained, there was very little artificial selection of the sort hypothecated by Darwin. Though Crozy says he threw away many inferior sorts, rejection of culls played a very small rôle.

Rejection likewise was of no importance in the next great step in the improvement of the canna. Sprenger,[16] who originated modern or "orchid flowered" cannas, fertilized the flower of the most celebrated of the French cannas, Madame Crozy (Fig. 2), with pollen

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[14] In a letter published by F. A. Waugh in the Tenth Ann. Rept. Vermont Expt. Station.

[15] Gard. Chron. Ser. III **21**: 362. 1897.

[16] SPRENGER, CHAS. Rev. Hort., p. 85, 1896.

from the wild *Canna flaccida*. There was produced only one pod with three seeds, each of which gave rise to a new variety with flowers of a size previously undreamed of. The average staminode in these flowers attained an area of about 27 sq. cm. as compared with 9 sq. cm. in one parent and 7 in the other.

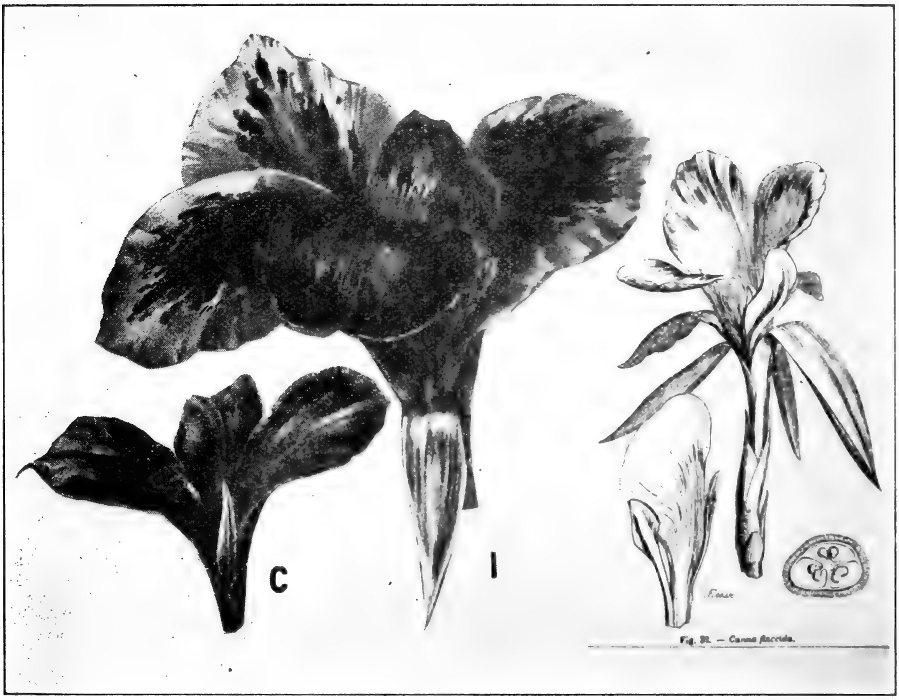

Fig. 2.—The first modern canna and its parents. Half natural size. C, Canna Madame Crozy (a complex hybrid involving the stocks shown in Fig. 1). I, *Canna italia*. F, *Canna flaccida*, native to Southeastern U.S.A. From the original figures.

Further testimony as to the small rôle played by rejection in plant improvement comes from Marion Shull, who relates (oral communication) the following experience with a cross between the iris varieties King and Julia Marlowe. A single pod with 8 seeds was obtained. Three of the plants from these received honorable mention among the novelties sponsored by the American Iris Society. Two more, though very fine varieties, were not sufficiently distinctive for exhibition, yet have been kept in the garden ever since for his own enjoyment. A sixth was practically identical with one of the parents, leaving only two to be rejected, and Shull adds that these were better than many of the "choice" varieties commonly grown. To one who supposes that selection on a large scale is a necessary part of plant improvement, a visit to Shull's garden is highly instructive. There, on a little plot of ground about 50×50 feet, have been originated probably more superior varieties of iris than in any other garden, and yet more ground is given over to the multiplication of old varieties than to the production of new ones, and a large fraction of the space is occupied by other plants grown entirely for ornament. Further, the rejects that are culled out are nearly all thrown away because they are not sufficiently different from older types rather than because they are inferior.

The most important feature of the origin of cultigens through hybridization is its progressive character, which is recognized by all breeders. The new forms cannot be interpreted at all as due to recombinations of characters already present. There is an emergence of new characters previously considered impossible. In the light of what has since occurred the following rebuke by André, the experienced editor of Revue Horticole, 1866, to the enthusiasm of Sisley, who encouraged by a preliminary success, dared predict cannas with flowers "as big as gladioli" is significant as well as amusing. He says that while he fully appreciates the marvelous improvements made by breeding, "the cannas already obtained clearly reveal the limit which we may not pass beyond—it is not possible to nourish the hope of those famous cannas with flowers like gladioli on which M. Année counted formerly but no more."[17] To appreciate the force of this opinion one must remember that it was written before even *C. ehemanni* was known.

The nature of the "breaks" by which cultigens rise out of the apparent limitations of their ancestry into new classes of utility in size or productiveness is not at all adequately understood. In some cases they are due to the incidence of polyploidy, as discussed below. The phenomenon of the break can be expressed in the terminology of genetics[18] by using the conception of latent genes. To speak of a latent gene does, however, little more than name a phenomenon which is as mysterious as ever. Yet it might perhaps provide a point of view from which experimentation could start.

In the light of our present knowledge of cultigens, then, it begins to appear possible once more that Darwin was right in supposing that the improvement of domestic plants and animals was the key to the origin of species.

Meanwhile, there are some other phenomena more or less con-

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[17] Gard. Chron., p. 537, 1866.

[18] R. K. NABORS. *Emergent evolution and hybridism.* Science **71**: 371–375. 1930.

nected with hybridity which have a very interesting relation to the origin of hereditary variants and are probably significant to evolution in the large, namely, polyploidy and various aberrations in the chromosome numbers. Each of these in itself is a very large subject which would demand a paper like this for its presentation even in a general way, so that they can be no more than alluded to here.

It is now well known that in many series of related plants the various species are characterized by chromosome numbers in some small (polyploid) multiple of a single number which appears to be the fundamental or original ancestral number for the group. The various types of wheat, for example, have 7, 14, 21, or 28 chromosomes. The chrysanthemums 9, 18, 27, 36, 45, or 90. Domesticated genera in which polyploids play a part include blackberries, blueberries, cannas, cottons, daturas, day-lilies, hyacinths, oenotheras, primulas, roses, solanums, and tomatoes, to name only a few, and the list is being extended every day.

For some reason not at all understood polyploidy is all but unknown among animals. Until this apparent divergence between the two kingdoms is accounted for one must, of course, have some reservations concerning the general importance of polyploidy because, assuredly, the forces at work in the evolution of plants and of animals are essentially similar.

Some polyploids originate through irregularities in chromosome reduction incident to partial incompatibility of hybrid plasmas. In this way triploids may occur when types having n and $2n$ chromosomes are crossed. Or, failure in reduction may result in $2n$ gametes and so in $4n$ or tetraploid individuals which differ from either of the parent stocks. Such irregularities as these may be found to account for much of the emergence of new characters in hybrids. But polyploidy is by no means exclusively a result of hybridization; it has been induced artificially a number of times by a sudden chill to a greenhouse in which plants were at the critical stages.

Partial incompatibility of germ plasms frequently results in more irregular differences in chromosome distribution whereby offspring arise which lack one or two of the parental chromosomes or have one or two supernumerary chromosomes. Once established, these irregularities are often hereditary, and they have a pronounced effect on the character of the offspring. Blakeslee's researches on the jimson weed are the most thoroughgoing and outstanding work of this field.[19]

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[19] Blakeslee, Albert F. *New jimson weeds from old chromosomes.* Jour. Hered. **25**: 81–108. 1934.

But enough has yet been done to permit a satisfactory opinion as to the importance of polyploidy and chromosome aberration in the grand sweep of evolution, but it is clear that there is here a field of very great interest and importance. Neither is the relation of these phenomena to hybridity entirely clear.

The cytologists who have done the work have been markedly reticent as to the ultimate origin of the plants in which they found this remarkable chromosome behavior. Some, like *Datura* and *Oenothera,* belong to groups in which hybridity is known to have occurred on a large scale. But no very definite correlations between the aberrant cytology and hybridity have been made. One of the most promising fields for research in the whole field of biology, so it seems to me, lies just here. A detailed understanding of what happens cytologically and genetically when horticultural breaks occur is very much needed and ought to throw a flood of light not only on the origin of cultigens but on the fundamental problems of evolution as well.

BOTANY.—Phyllostachys sulphurea *var.* viridis *var. nov. and* P. edulis (*Carr.*) *H. de L.*[1] Robert A. Young,[2] Bureau of Plant Industry. (Communicated by S. F. Blake.)

The name *Phyllostachys mitis* as used by A. & C. Rivière[3] has been a source of confusion. The name itself was based on *Bambusa mitis* Poiret,[4] which in turn was based on *Arundo mitis* Lour. Loureiro's species has not been identified; Merrill[5] refers it to *Dendrocalamus,* the species undetermined. Loureiro describes the flowers as having 6 stamens, the culms as terete, and the panicle as simple, whereas in *Phyllostachys* the stamens are always 3, the culms are flattened or grooved on one side of each internode, and the inflorescence is compound and not a simple panicle.[6] "*Bambusa edulis,*" without author,

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[1] Received March 1, 1937.

[2] The author is indebted to Dr. S. F. Blake, Mrs. Agnes Chase, the late Dr. A. S. Hitchcock, Dr. F. A. McClure, and Paul Russell, of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, for valuable assistance and counsel in the preparation of this paper.

[3] Rivière, A. & C. *Les Bambous* 231. 1879.

[4] Lam. Encycl. **8**: 704. 1808. The name as published there is *Bambos mitis* Lour., but Loureiro's name was *Arundo mitis.*

[5] Merrill, E. D. *A Commentary on Loureiro's Flora Cochinchinense.* Trans. Am. Phil. Soc. n. s. **24**(2): 85. 1935.

[6] The fact that *Bambusa mitis* Poir., the name-bringing synonym of "*Phyllostachys mitis* A. & C. Riv.," belongs to a different genus was pointed out by J. Houzeau de Lehaie, under the caption *Les Deux Phyllostachys mitis,* in Le Bambou, **1**: 38–40. 1906. He attempted to show that the Rivière species should have been based on *B. mitis* Hort. ex Carr. but this was an error, since on this species Carrière (Rev. Hort. **37**: 380. 1866) based his *Bambusa edulis.* In the paper by Houzeau de Lehaie, just cited, it was also shown that Carrière's *edulis* is an earlier valid name for the previously published *Phyllostachys pubescens* Mazel ex Houzeau de Lehaie.

cited as a synonym by A. & C. Rivière, is, if *B. edulis* Carrière is referred to, a very different species. If not Carrière's species, the name as given has no standing.

It is certain that A. & C. Rivière misapplied the name *mitis* and that another name must be found for the species in cultivation commonly known as *Phyllostachys mitis.* The detailed description given by the Rivières of their so-called *P. mitis* shows conclusively that it is a green-stemmed form closely related to *P. sulphurea* A. & C. Riv.[7] Study of living plants of the forms now known in Europe as *P. mitis* and *P. sulphurea* has convinced the writer that though varietally distinct the two belong to the same species, a conclusion tentatively reached by Freeman-Mitford[8] and Houzeau de Lehaie.[9] Among other characters, the buds of the rhizomes of these bamboos have been examined by the writer and they furnish confirmatory evidence of the specific identity of the two forms; the buds are of different shape from those of *P. bambusoides* Sieb. & Zucc., with certain varieties of which *P. sulphurea* has been confused in the literature. Such confusion could hardly take place if the student of bamboos were acquainted with the plants of *P. sulphurea* as well as with those of *P. bambusoides* and its varieties.

Makino[10] in 1912 erroneously identified *Phyllostachys sulphurea* A. & C. Riv. with a rare cultivated variety, Ogonchiku, or Kinchiku (golden bamboo), of *P. bambusoides* Sieb. & Zucc. (*P. reticulata* (Rupr.) C. Koch) and published the name *P. reticulata* var. *sulphurea* Makino. The brief description does not include characters that differentiate *P. sulphurea.* Takenouchi[11] in 1932 accepted Makino's judgment in the matter and repeated the statement that the variety is cultivated (in Japan). However, the well-known Japanese horticulturist and bamboo specialist, Isuke Tsuboi,[12] was unable to find

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[7] RIVIÈRE, A. & C. *Les Bambous*, 285. 1879. The plant of *Phyllostachys sulphurea*, upon which the somewhat meager description was based, received at the Jardin de Hamma, Algiers, in 1871, is stated not to have survived the first summer, hence the lack of details concerning it. The Rivières cited *Bambusa sulphurea* Hort., a name without standing. They do not refer to *Bambusa sulfurea* of Carrière (Rev. Hort. **45:** 379. 1873), which fact obviates any need to discuss in this paper the question of what the identity of that species may be.

[8] FREEMAN-MITFORD, A. B. *Bamboo Garden*, 122. 1896.

[9] HOUZEAU DE LEHAIE, J. *Le Bambou*, **1:** 57; **1:** 134. 1906; **2:** 214. 1907; **2:** 261; 288; pl. 8, 1908. Bul. Soc. Dendrol. de France, No. 14, 254. Nov. 15, 1909.

[10] MAKINO, T. Bot. Mag. Tokyo **26:** 24. 1912.

[11] TAKENOUCHI, YOSHIO. *Studies of Bamboos* (in Japanese, except scientific names) 145. 1932. (Tokyo).

[12] TSUBOI, ISUKE. *Monogr. of Bamboos* (Japanese text, 63 pp., and set of 109 colored plates), item no. 9; pl. 5. ed. 2. 1916. The author states that while Kinchiku was reported in older Japanese works to be growing in Satsuma, Ryukyu, and Abo he failed to find a single plant when he visited those localities. He illustrates culm, rhizome, and leaves but the yellow culm does not display the characteristic narrow green

(1916) the variety Kinchiku in any of the places in which it had been reported to be grown and had doubts of its continued existence in those localities. Houzeau de Lehaie,[13] indeed, once doubtfully suggested Japan as the country from which *P. sulphurea* had been introduced into Europe, but there appears to be no substantial evidence that it occurs in Japan.

Nakai[14] in 1933 erroneously referred *Phyllostachys sulphurea* to *P. reticulata* var. *holochrysa* Nakai, as a synonym. Nakai's variety, based on *P. bambusoides* var. *Castilloni holochrysa* Pfitzer ex Houzeau de Lehaie,[15] is not known to the present writer but the brief description precludes the possibility of its identity with *P. sulphurea.* Nakai[14] adds in a note (in Japanese) following the synonymy in his publication of var. *holochrysa* that it is of Chinese origin, is said to have been introduced into Europe from China in 1865, and that the history of the variety in Japan is not known. From this it may fairly be inferred that he had not seen a plant either of var. *Castilloni holochrysa* Pfitzer or of *P. sulphurea* A. & C. Riv.

Although the characters indicate that the plant hitherto known as *Phyllostachys mitis* probably represents the original wild form of the species and that known as *P. sulphurea* (biologically) a variety of it (as proposed and informally published by Houzeau de Lehaie),[9] under the rules of nomenclature the name *P. sulphurea* A. & C. Riv., published in 1879, becomes the specific name of the aggregate, whereas the plant until now known as *P. mitis* becomes the variety. For this the following name is proposed.

Phyllostachys sulphurea var. **viridis** R. A. Young, var. nov.

Phyllostachys mitis, as misapplied by A. & C. Rivière, Les Bambous 231. 1879.

Culmi omino virides, usque ad 14 m alti, quam ei formae typicae altiores sed infra tenuiores; folia viridia numquam striata.

Type deposited in the U. S. National Herbarium, nos. 1682470 and 1682471, collected in Plant Introduction Garden, Savannah, Georgia, Jan. 11, 1937, by D. A. Bisset; grown from material obtained from Gaston Negre, Generargues, France, under the name *Phyllostachys mitis.*

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stripe of *Phyllostachys sulphurea* on any of the internodes, and the other characters shown are not sufficiently distinctive to establish identity with any bamboo known to the present writer. The source of the material from which the illustration was prepared is not indicated and no description of the plant is given. Furthermore, the author finally expresses the opinion that the yellow color mentioned for the culm of Kinchiku probably was of a kind that he had observed in another bamboo to result from high summer humidity. (The foregoing is based on a translation by Saburo Katsura, Bureau of Plant Industry.)

[13] Houzeau de Lehaie, J. Le Bambou, **2:** 230. 1908.

[14] Nakai, T. Journ. Japanese Bot. **9:** 34. 1933. In his synonymy Nakai omits the name *Castilloni,* which was part of the full name as published by Houzeau de Lehaie.

[15] Houzeau de Lehaie, J. III Cong. Int. Bot. Brux. 228. 1910.

The varietal name *Phyllostachys sulphurea* var. *viridis* refers to the green color of the culm and branches as contrasted with the clear sulphur yellow of the species itself. There are also other distinguishing characteristics in the species, *P. sulphurea*, such as the presence of one or two narrow green stripes on the rounded part—never on the grooved or flattened side—of most of the internodes of the yellow culm, an irregular broken ring of green beneath each node, and a tendency of the evenly tapering culm to be larger in diameter at the base for its height than in the green-stemmed form. A single green stripe is present on many of the lower internodes of the main branches, and an occasional leaf has one or a few slender white or yellowish stripes. The green striping of the culm was observed by Lehaie,[9] though other authors fail to mention this character. Mitford[8] says of *P. sulphurea* that it is much hardier than "*P. mitis*" and of inferior stature, but no definite confirmation of the reported hardiness can yet be given from observations in the United States.

Phyllostachys sulphurea has never been adequately described, a fact which largely accounts for the uncertainty as to its identity and the resulting confusion in nomenclature. For this reason the following description of the vegetative characters is here offered.

Culms about 5 m (may later reach 10 m) high, not as tall as those of var. *viridis* but somewhat thicker at base for the height and tapering evenly to the tip. Supranodal rings of culm, except in upper part, only a little more prominent than the nodal rings. Culm and branches of a clear sulphur yellow, but frequently with 1 or 2 rather narrow green stripes variously situated on the rounded part of each internode of the culm and one stripe on some of the lower internodes of the branches, beneath each node of the culm a broken ring of green, jagged in outline on the lower edge, often later obscured by a sooty fungus. Rhizome buds circular in outline. Culm sheaths entirely glabrous, margins smooth, outer surface of lowest ones brownish yellow when fresh, blotched and spotted with brown, those above sixth node yellowish with green veins, irregularly and often sparsely speckled and spotted with paler brown; ligule distinctly truncate, membranaceous, 2.5 mm high at about the eighth node of a culm 2.5 cm in diameter at base, glabrous, margin slightly irregular, minutely fimbriate; pseudophylls linear, ribbonlike, about 4.5 cm long and 5 mm wide on sheath of eighth node, two-thirds the width of the ligule, glabrous, margins of uppermost slightly scabrous, others smooth, all without auricles or bristles at the base or, at most, with rudimentary auricles, all except the lowest pseudophylls tessellated. a narrow, bright-green stripe in center, pale maroon to salmon on margins. Branches two at each node, unequal, as usual in *Phyllostachys*. Leaves 2–3, proximate at tips of twigs (branchlets), the lower sheaths almost completely overlapping those above, the lowest slightly pubescent on upper part, occasionally with outer margins obscurely ciliate near summit, upper sheaths densely puberulent, especially at summit, the collar densely pubescent at first; auricles more or less prominent, with whitish radiating scabrous bristles (oral setae) 3–5 mm long; ligule rather prominent, about 1.5 mm high, except on uppermost sheath of twig, notched and minutely ciliate on margin, densely puberulent outside at base; petiole 3 mm long; blade lance-oblong to lanceolate, acuminate, somewhat rounded at the base, 4.5–12.5 cm long, 8–17 mm wide, green and glabrous above, rarely with one or a few slender white or yellowish stripes, paler, scaberulous, densely puberulent along the midnerve and toward the base beneath, otherwise scabrous, cilio-scabrous on one margin, secondary veins 5–6 pairs, rarely 4 or 7, intermediate veins 7–9, rarely fewer.

Since *Phyllostachys sulphurea* and its variety *viridis* have been confused with *P. bambusoides* Sieb. & Zucc. and some of its varieties, it may be well to mention a few characters that clearly differentiate the latter group from the former. In *P. bambusoides* the internodes of the young culms are at first a brilliant green, in contrast with the glaucous green of *P. sulphurea* var. *viridis*, and the rhizome buds are somewhat triangular in outline instead of circular. The culm sheaths from the eighth node upward bear conspicuous auricles with bristles, the sheaths are ciliate on the outer margin, and they commonly have a darker ground color and are more profusely spotted, blotched, and streaked than in *P. sulphurea* or its variety; the culm-sheath ligule is usually more or less obtuse rather than truncate. The leaves are 3–4 on a twig, usually larger and more undulate than in either of the forms of *P. sulphurea*, and the sheath ligule is less than 1 mm high.

This study of *Phyllostachys sulphurea* and its variety *viridis* is based on living material grown from plants obtained under the names *P. mitis* and *P. sulphurea* by the United States Department of Agriculture from French and English nursery firms between 1920 and 1930. They are growing at the Barbour Lathrop Plant Introduction Garden of the Department, at Savannah, Ga. Plants of *P. sulphurea* var. *viridis*, under the name *P. mitis*, were received twice, from nurseries in southern France. There are minor differences between these two introductions but the plants of both agree in essential respects with the Rivière description. It appears that the bamboos grown by the Rivières in the Jardin du Hamma at Algiers, were not kept labeled, hence the identities of these plants are now known only by imperfect tradition among the present gardeners at Hamma. Even with the hearty cooperation of Dr. R. Maire, of the University of Algiers, it has not been possible to obtain positive evidence from that source on the more difficult questions of identity concerning the Rivière bamboos now growing at Algiers. It has recently been learned from the Museum d'Histoire Naturelle, of Paris, that these species are not represented there by authentic specimens.

Allusion was made at the beginning of this paper to the confusing by A. & C. Rivière of a *Bambusa edulis* (without name of author) with their so-called *Phyllostachys mitis*. The Rivière publication naturally involved *B. edulis* Carr.[16] in the confusion. *Phyllostachys*

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[16] Carrière, E. A. Rev. Hort. **37**: 380. 1866.

edulis (Carr.) H. de L. based on that species, is an edible bamboo with hairy blackish sheaths, while the culm sheath of "*P. mitis*" was described by A. & C. Rivière as being entirely glabrous. Carrière's description of the sheaths of "*B. edulis*" applies fairly well to *P. edulis* (Carr.) H. de L. and does not well apply to any other known species. It is of interest that as early as 1897 Makino[17] had observed (presumably from the Rivière illustration of a young culm with heavily spotted sheaths) that "*P. mitis*," described by A. & C. Rivière, bore a strong likeness to Madake (*P. bambusoides*) but did not resemble Mosochiku (*P. edulis*, for which at that time Makino apparently had no scientific name). As his note on the question was published in Japanese, however, this important observation of the distinctness of Mosochiku from "*P. mitis*" seems to have remained unknown to European botanists until the facts concerning Mosochiku were recognized by Houzeau de Lehaie,[18] in 1906.

In 1906 Houzeau de Lehaie[19] published the name *Phyllostachys pubescens* Mazel, presumably because Mazel, the deceased horticulturist by whom it had been grown for many years, had called it by that name. In another article in the same publication Houzeau de Lehaie[18] showed that the correct name for the species was *Phyllostachys edulis*, based on *Bambusa edulis* Carr., and formally published it. He reverted shortly afterward to the name *P. pubsecens*, but instead of using Mazel's name as authority he gave his own initials and continued to use them in his later published references[20,21] to the species.

The specific name *edulis* was again taken up by Makino[22] in 1912 and was also used by Tsuboi[23] in 1916, though both authors erred in citing A. & C. Rivière instead of Houzeau de Lehaie as authority for the combination. The explanation for this appears to be that Makino was misled by the form in which the synonymy of "*Phyllostachys mitis*" was stated by the Rivières and assumed that " — *edulis*" meant "*Phyllostachys edulis* A. & C. Riv.," whereas it simply indi-

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[17] Makino, T. Bot. Mag. Tokyo **11**: 158. 1897. A translation by Saburo Katsura of the note by Makino reads: "*Phyllostachys mitis*, described by A. & C. Rivière, is in question as to whether or not it is Poiret's *Bambusa mitis*. It bears a striking likeness to Madake but does not resembleMosochiku."

[18] Houzeau de Lehaie, J. *Les Deux* Phyllostachys mitis. Le Bambou **1**: 38–40. 1906.

[19] Houzeau de Lehaie, J. *Phyllostachys pubescens* Mazel. Le Bambou **1**: 7. 1906.

[20] Houzeau de Lehaie, J. Le Bambou **1**: 97, 117, 129. 1906; **2**: 214. 1907; **2**: 290. 1908.

[21] Houzeau de Lehaie, J. III Cong. Int. Bot. Brux. **1**: 232. 1910.

[22] Makino, T. Bot. Mag. Tokyo **26**: 21. 1912.

[23] Tsuboi, Isuke. *Monogr. of Bamboos*, item no. 23; pl. 15, 71, 93. ed. 2. 1916.

cated a *Bambusa edulis,* without name of author. Carrière,[16] of course, was the author. The correct combination of name and authority, *P. edulis* (Carr.) H. de L., appears to have been used first by Galloway,[24] in 1925.

For reasons not entirely clear, T. Nakai[25] in 1933 reverted to the name "*P. pubescens* Mazel ex Houzeau de Lehaie," with the citation "*Bambusa edulis* (non Poiret) Carrière in Revue Hort. XXXVII, p. 380 (1866) cum. syn. *B. mitis* Hort." included in the synonymy. Again, however, explanation is perhaps to be found in a misinterpretation of the Rivière form of citation. Unlike Makino, Nakai assumes that *Bambusa edulis,* the second synonym of "*Phyllostachys mitis,*" was intended to be understood as a Poiret species, as well as *B. mitis* Poiret, the first synonym cited. This would account for the fact that Nakai ignores (1) the explicit and well-substantiated statement by Houzeau de Lehaie[18] that Carrière's name (*edulis*) for "Mosochiku" should be retained, and (2) the actual publication by Houzeau de Lehaie, in the same paragraph, of "*Phyllostachys edulis* nom. nov."

The facts cited in this account of *Phyllostachys mitis,* so-called by A. & C. Rivière, and *P. edulis* seem to constitute a veritable "comedy of errors." The former name is clearly invalid, as has been shown, but *P. edulis* (Carr.) H. de L. is obviously a valid name and must stand.

BOTANY.—*Notes on harmel, or "Syrian rue."*[1] William A. Dayton, U. S. Forest Service.

Messrs. W. L. Black and K. W. Parker of the New Mexico College of Agriculture and Mechanic Arts have published a very informing and valuable paper, *Toxicity tests on African rue.*[2] The Mediterranean-west Asiatic plant referred to is *Peganum harmala* L., which, the authors report, is introduced, established, and spreading in an area 4 miles east of Deming, New Mexico,—apparently the first record of its occurrence in this country. The species appears to have been considered promising for erosion-control experiments in our semiarid Southwest, because of its marked drought-resistance, somewhat matlike growth, and copious seeding. However, the authors (*op. cit.*, p. 11) sound a note of warning from Arthur B. Clawson, well-known toxicologist of the federal Bureau of Animal Industry, because of the

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[24] Galloway, B. T. *Bamboos: their culture and uses in the United States.* U. S. Dept. Agr. Bull. **1329**: 10. 1925.

[25] Nakai, T. Jour. Japanese Bot. **9**: 27. 1933.

[1] Received April 14, 1937.

[2] Black, W. L., and Parker, K. W. *Toxicity tests on African rue (Peganum harmala L.).* N. Mex. Agr. Expt. Sta. Bull. **240,** 14 pp., illus. 1936.

poisonous properties of the seed and herbage; Clawson fears "that African rue may cause losses in livestock, especially on ranges heavily populated with the plant," whose palatability, however, is admittedly very low.

In view of the interest that this plant has aroused in New Mexico and the possibility of a further extension of the range of this species in the Southwest, it seems desirable that, if possible, a generally acceptable English name for it should be adopted. Harmel is here recommended. The writer feels that the name "African rue" for this plant not only is unnecessary but is seriously objectionable, for the following reasons:

1. This plant, though apparently with a somewhat rue-like odor, does not have punctate leaves and is not a true rue (*Ruta*); by the majority of botanists it is not placed in the rue family (Rutaceae) but in the caltrop family (Zygophyllaceae). Asa Gray, in his *Synoptical flora of North America,* although placing *Peganum* in Zygophyllaceae, indicates that the genus is anomalous because of its relatively numerous (12-15) stamens, few (2 to 4) carpels, and numerous (45 to 60, *fide* Black and Parker, *op. cit.*, p. 5) seeds.
2. There are true species of *Ruta* indigenous to Africa. One or more of these conceivably may some day get into cultivation in this country and would be much more entitled to the name "African rue."
3. The recorded history of *Peganum harmala* seems to be concerned much more with Syria, Turkey, and Arabia than with Africa.
4. *Peganum harmala* already has other and better known English names. For example, Van Wijk, in his encyclopaedic *A dictionary of plant names,*[3] lists the names harmel, harmal, harmala, hurmul, and Syrian rue. Incidentally, the generic name *Peganum* is derived from the Greek πήγανον, a term used by Theophrastus both for the common, or garden rue (*Ruta graveolens*) and for "wild rue." *Harmala* (Greek, ἅρμαλα), used by Tournefort as a generic name, was employed by Dioscorides, and is said to be the Syrian (or Arabic) name for "wild rue,"—very likely *Peganum harmala.*

Peganum harmala is reported by Baillon[4] to be cultivated in French botanical gardens. Nicholson[5] states that it is "occasionally . . . met with in English gardens." As yet, the plant does not appear to have been cultivated in this country as an ornamental.

Black and Parker (*op. cit.*, p. 3) refer to the fact that "an eye oint-

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[3] VAN WIJK, H. L. GERTH. *A dictionary of plant names* **1**: 961–962. 1911.

[4] BAILLON, M. H. *Dictionnaire de botanique* **3**: 526. 1891.

[5] NICHOLSON, GEORGE. *The illustrated dictionary of gardening, a practical and scientific encyclopaedia of horticulture, for gardeners and botanists* **3**: 58. (1886).

ment was made from the seeds in Arabia"; that the plant is reputed to possess anthelmintic properties, and that it possibly contains a narcotic, hasheesh-like or marihuana-like alkaloid. It seems desirable to add that *Peganum harmala* is known to contain the alkaloids harmalin ($C_{13}H_{14}N_2O$) and harmin ($C_{13}H_{12}N_2O$), which have been employed as drugs in the treatment of cerebral paralysis, encephalitis lethargica, and Parkinson's disease. Baillon (*loc. cit.*) speaks of the plant as a sudorific, as well as vermifuge, and states that the French call the plant "armel." Lieut. W. F. Lynch, U. S. N.,[6] indicates that *Peganum harmala* is widely distributed in Judaea, and that its seeds are both intoxicating and soporific. Before the advent of aniline dyes, *Peganum harmala* was, at least in large part, the ultimate source of the brilliant scarlet dye known as "Turkey red" (alizarin). Engler, in *Die naturlichen Pflanzenfamilien,* speaks of the cells of the middle layer of the seed coats as the seat of this dyestuff as well as of the alkaloid harmalin. He also mentions the sudorific and vermifugal properties of the seed, and adds that the Turks use the plant as a condiment.

There is a native congener of this plant in our Southwest and northern Mexico, *Peganum mexicanum,* originally collected by the ill-fated Dr. Gregg. In his original description of this species Dr. Gray[7] quotes Gregg that it "is evidently well known to the Mexicans, who . . . call it *Garbanzilla, Romero del Campo,* or *Limoncillo,* and use a decoction of it for gonorrhoea. It is said to be poisonous to cattle."

PLANT PHYSIOLOGY.—*Rubidium and Strontium Toxicity to Plants Inhibited by Potassium and Calcium Respectively.*[1] ANNIE M. HURD-KARRER, Bureau of Plant Industry.

Last year the writer reported[2] that the toxicity of sodium arsenate to wheat plants varies inversely with the concentration of available phosphate. The possibility of such an effect had been postulated on the basis of the fact that the positions of phosphorus and arsenic in Group V of the periodic arrangement of the elements are analogous to those of sulphur and selenium in the adjoining Group VI. The hypothesis proposed to explain the selenium-sulphur antagonism[3]

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[6] LYNCH, W. F. *Examination of the Dead Sea.* Senate Exec. Doc. **34,** 30th Congress, 2nd Sess. 1849.

[7] GRAY, ASA. *Plantae Wrightianae Texano-Neo-Mexicanae* **1**: 30. 1852.

[1] Received July 1, 1937.

[2] HURD-KARRER, ANNIE M. *Inhibition of arsenic injury to plants by phosphorus.* Jour. Wash. Acad. Sci. **26**: 180–181. 1936.

[3] HURD-KARRER, ANNIE M. *Selenium injury to wheat plants and its inhibition by sulphur.* Jour. Agr. Research **49**: 343–357. 1934.

suggested that the injurious effects of a toxic element could be counteracted by an excess of a chemically similar nutritive element, the assumption being that such elements would enter the plant alike without selective discrimination (but with unlike effects on the plant). If the gradient established by the plant's metabolism of the nutritive element should determine the total absorption of the two, the amount of the toxic element taken in would decrease as the proportionate amount of the nutritive element in the substratum increased. The experimental results showing reproducible ratios associated with given degrees of injury to the plant in the case of arsenic and phosphorus as well as of selenium and sulphur were in accord with this supposition, and, in fact, could only be explained on some such line of reasoning.[4]

The confirmation of the idea supplied by the arsenate/phosphate relation led to the testing of other similarly related pairs of elements. The pairs that could be selected on this basis were very limited, since, other than sulphur and phosphorus, there are only five major mineral nutrients—nitrogen, iron, magnesium, potassium, and calcium. Next to potassium in Division A of Group I is the toxic element rubidium, and next to calcium in Division A of Group II is the moderately toxic strontium. These two pairs were accordingly chosen for experimentation.

The plants were grown in nutrient solutions, according to procedures described in the earlier papers. For the study of rubidium toxicity, low- , medium- and high-potassium solutions were made by varying the amounts of KCl in otherwise identical solutions. Their pH values were brought near 6.5 with equal amounts of NaOH. Controls without rubidium showed that plant injury in the low-potassium cultures containing rubidium was not due to the low KCl content. In some of the experiments duplicate series of the low-KCl cultures were set up, for one of which the low chlorine content was compensated for by adding sufficient calcium chloride to make the chlorine equal to that of the high-potassium solution. The plants of these cultures gave evidence that neither chlorine nor calcium was a factor in the results.

The characteristic symptom of the injury produced by rubidium chloride on both wheat and barley was a stunting and peculiar thickening of the roots, resulting eventually in stunting of the tops also. The

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[4] The antagonism is much more marked with selenates than with selenites, so it should be emphasized that only sodium arsenate ($Na_2HAsO_4 \cdot 7H_2O$) has been used in studying the arsenic/phosphorus relation.

degree of injury varied with the proportionate amount of potassium present, twice as much potassium as rubidium effectually preventing the appearance of the root injury. Thus with 60 p.p.m. of rubidium, injury could be detected in both wheat and barley with 60 but not with 120 p.p.m. of potassium; with 120 p.p.m. of rubidium, there was definite injury with 150 but not with 240 p.p.m. of potassium.

For the study of strontium toxicity, low- , medium- and high-calcium solutions were made by varying the amounts of calcium nitrate, the resulting differences in nitrogen being compensated for by the addition of requisite amounts of ammonium nitrate. The pH values of the low- and high-calcium solutions were both near 6.5. Controls without strontium showed that the peculiar injury attributed to strontium in the low-calcium solutions was not due to calcium deficiency.

The characteristic symptom of strontium injury was a stimulation of tillering with stunting, so that the plants were thick, short bunches of as many as twelve tillers instead of the usual four much taller tillers of the controls. The effect was extreme with 500 p.p.m. of strontium supplied as either $SrCl_2$ or $Sr(NO_3)_2$ in solutions containing but 50 p.p.m. calcium, slight with 230 p.p.m. calcium, and absent with 500 p.p.m. calcium. Controls with the same amounts of chlorine and nitrate in the form of potassium salts proved that the effect was produced by the strontium alone. Under the conditions of these experiments, then, strontium produced detectable injury with but half as much calcium as strontium present, but with the amounts equal it was nontoxic. The accuracy of these ratios may be questionable, however, because of a considerable precipitate in the high-calcium flasks, suggesting that the calcium did not all remain in solution.

Tests to determine the specificity of the relations by interchanging the nutrient solutions showed that excess potassium did not inhibit strontium toxicity, nor did excess calcium inhibit rubidium toxicity.

Insofar as the establishment of predicted relations by actual experiment constitutes evidence, the observed antagonism of arsenic, rubidium and strontium by phosphorus, potassium and calcium, respectively, substantiates the generalization suggested by the selenium-sulphur antagonism. Briefly stated, this hypothesis is that in proportion to its relative concentration an essential nutritive element reduces the absorption and consequent toxicity of a toxic element sufficiently similar chemically to preclude selectivity on the part of the plant.

ORNITHOLOGY.—*Descriptions of three new screech owls from the United States.*[1] HARRY C. OBERHOLSER, Bureau of Biological Survey.

The identification of screech owls, *Otus asio*, from various sources, including Texas, has made necessary the examination of a considerable number of these birds from various parts of the United States. In addition to the collection of the U. S. National Museum, including that of the Biological Survey, there have been examined a large number of specimens from other museums and from individuals. The writer is, therefore, indebted for the loan of comparative material to Dr. Frank M. Chapman, Dr. A. I. Ortenburger, Dr. Louis B. Bishop, Dr. Max M. Peet, Professor Myron H. Swenk, Dr. Joseph Grinnell, Dr. Josselyn Van Tyne, Dr. D. Elton Beck, Dr. John W. Sugden, Dr. Vasco M. Tanner, Miss Edith R. Force, Ralph H. Imler, C. D. Bunker, J. L. Peters, H. V. Williams, Edwin D. McKee, C. C. Presnall, E. R. Warren, and C. Lynn Hayward.

Study of the material thus brought together has resulted in the discovery of three apparently new subspecies of *Otus asio*, which it seems worth while to describe. Perhaps the most interesting, as well as the most beautiful, of these is:

Otus asio swenki,[2] subsp. nov.

Nebraska Screech Owl

Subspecific characters.—Similar to *Otus asio aikeni*, of central Colorado, but smaller; in gray phase much paler on the upper surface and somewhat so below, the face lighter, more whitish; both upper and lower parts more finely marked with blackish; in red phase also paler.

Measurements.—Adult male[3]: wing, 153–170 (average, 160.6) mm; tail, 75–82 (78.6); culmen from cere, 13.5–16 (15.2); tarsus, 35–40 (37.6); middle toe without claw, 17–20 (18.6). Adult female[4]: length in flesh (type), 221 mm; wing, 162–169 (average, 164.7); tail, 79–85.5 (82.2); culmen from cere, 14–17 (15.8); tarsus, 36–39.5 (37.6); middle toe without claw, 18–20 (18.9).

Type.—Adult female, collection of Prof. Myron H. Swenk; Chadron, Dawes County, Nebraska, altitude 3,450 feet; February 1, 1918; L. M. Gates.

Geographic distribution.—Resident and breeds in the middle United States, north to central southern Manitoba; west to western Nebraska and central western Oklahoma; south to central western Oklahoma, and central southern Kansas; and east to central Kansas, central eastern Nebraska, western Minnesota, and central southern Manitoba.

Remarks.—The discovery of this interesting new owl came as a decided

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[1] Received May 22, 1937.

[2] Named for Prof. Myron H. Swenk, of Lincoln, Nebraska.

[3] Thirteen specimens, from Nebraska, Kansas, Manitoba, Minnesota, and North Dakota.

[4] Ten specimens, from Nebraska, Kansas, Minnesota, and North Dakota.

surprise in the course of a study to determine the actual range of *Otus asio hasbroucki*. From that form it differs so decidedly in its much paler coloration that it scarcely needs comparison. From *Otus asio naevius* in gray phase it differs in its much paler and less coarsely dark-marked upper surface, paler and more whitish face; and in red phase by its decidedly lighter color. From *Otus asio maxwelliae* in gray phase it differs in its decidedly darker and more finely marked upper surface, less whitish face, and darker, i.e., more extensively black-streaked and barred lower surface.

Birds from eastern Kansas (Douglas County, and west to east central Kansas in Harvey County) are darker and mostly more brownish, thus verging so much toward *Otus asio naevius* that they are referable to that race. On the other hand, birds from eastern Nebraska (Lincoln and other localities) are rather darker and more brownish than typical *Otus asio swenki*, and thus verge a little toward *Otus asio naevius*, but they are decidedly nearer to *Otus asio swenki*. While no specimens of this new race from Colorado have been examined, it probably ranges at least to the eastern border of that state. It probably occurs also in the Panhandle of northwestern Texas (although no specimens from that region have been seen), since a specimen from Ellis County, Oklahoma, which borders on the Texas Panhandle, is *Otus asio swenki*.

The examination in this connection of a considerable number of screech owls from central and eastern Oklahoma, Benton County, northwestern Arkansas, with a few from central northern Texas, and from Greenwood County and Cedar Vale, southeastern Kansas, now shows that these areas are occupied by *Otus asio hasbroucki*.

It gives me great pleasure to name this handsome screech owl for Prof. Myron H. Swenk, of the University of Nebraska, who has done so much to advance the study of ornithology in the state of Nebraska. Furthermore, it is appropriate that the bird should be called the Nebraska screech owl, since it apparently reaches its maximum differentiation in that state.

Following is a list of the localities from which specimens of *Otus asio swenki* have been examined:

KANSAS: Stockton (Feb. 22, 1936); Hamilton County (Nov. 19, 1934); Wallace County (June 24 and 29, 1911); Comanche County (May 25 and 29, 1911); Coolidge (July 12, 1921).

MANITOBA: Winnipeg (June 4, 1930); Deer Lodge, Winnipeg (Nov. 12, 1928).

MINNESOTA: Beaver, Roseau County (Jan. 7, 1932); Stafford, Roseau County (Nov. 20, 1926); Poklitz, Roseau County (March 3, 1927); Badger, Roseau County (Feb. 27, 1927); Mickinock, Roseau County (March 8, 1930); Dieter, Roseau County (March 10, 1932); Jadis, Roseau County (Dec. 28, 1926).

NEBRASKA: Spencer (Dec. 14, 1931); Scottsbluff (June 28, 1916); Chadron (Feb. 1, 1918); Lincoln (Nov. 13, 1932; Dec. 26, 1934); Kearney (Dec. 14, 1924); Union (May 6, 1933).

NORTH DAKOTA: Grafton (May 18, 1933; Nov. 10, 1933; Dec. 6, 1923; April 25, 1923; Feb. 19, 1924); Hankinson (July 22, 1912).

OKLAHOMA: 7 miles south of Arnett, Ellis County (May 18, 1936).

Otus asio mychophilus, subsp. nov.

Grand Canyon Screech Owl

Subspecific characters.—Similar to *Otus asio inyoensis* Grinnell[5] from Inyo County, California, but upper parts darker, usually more brownish; lower parts more numerously vermiculated with blackish, thus appearing darker.

Measurements.—Adult male[6]: wing, 159–170 (average, 164) mm; tail, 81.5–94 (85.2); culmen from cere, 14–16 (15); height of bill at base, 12–13.5 (12.6); tarsus, 35–39 (37.3); middle toe without claw, 18–19 (18.4). Adult female[7]: wing, 168–173 (169.3); tail, 86–92 (89.5); culmen from cere, 15–16.5 (15.9); height of bill at base, 12.5–14 (13.3); tarsus, 36–40 (37.8); middle toe without claw, 18.5–21.5 (19.8).

Type.—Adult female, No. 340593, U. S. National Museum, Biological Survey collection; south rim of Grand Canyon, 6,900 feet altitude, Grand Canyon Village, Arizona; January 28, 1935; Russell K. Grater, original number, 23.

Geographic distribution.—Northern Arizona and southern Utah, north to north central Utah (Provo); west to southwestern Utah; south to northern Arizona; and east to central eastern Utah (Moab).

Remarks.—Specimens of this new race have heretofore sometimes been identified as *Otus asio aikeni*, but proper comparison indicates at once that they do not belong to this race, since they differ in their darker, more finely vermiculated upper parts, and more finely vermiculated and less streaked lower surface. From *Otus asio cineraceus* of southern Arizona this new race differs in much larger size, darker and usually more uniform and more finely vermiculated upper surface.

Specimens from Vernon and Jensen, northern Utah, are decidedly paler and less marked below than the birds from central and southern Utah, here referred to *Otus asio mychophilus*, and are apparently referable to *Otus asio inyoensis* from southeastern California, which would indicate that the range of the latter subspecies extends over Nevada as far north as Fallon and east to northeastern Utah.

The specimen of this new subspecies here made its type has been generously donated to the Biological Survey Collection by Edwin D. McKee, Park Naturalist of the Grand Canyon National Park, Arizona.

Seventeen specimens of *Otus asio mychophilus* have been examined, these representing the following localities:

ARIZONA: Grand Canyon, South Rim (Oct. 2, 1934; Jan. 28, 1935); Grand Canyon Village (May 4, 1931); 15 miles south of Grand Canyon Village (Nov. 30, 1934); 10 miles south of Grand Canyon Village (Oct. 29, 1934).

UTAH: Springdale (Jan. 27, 1935); Provo (Feb. 11, 1934; May 19, 1933;

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[5] The Auk, Vol. XLV, No.2, April 16,1928, p. 213.

[6] Six specimens, from southern Utah and northern Arizona.

[7] Six specimens, from southern Utah and northern Arizona.

July 19, 1933); Moab (June 9, 1927); Zion Canyon, Washington County (July 8, 1933); St. George (spring, 1937; Nov., 1933).

Otus asio clazus, subsp. nov.

San Jacinto Screech Owl

Subspecific characters.—Similar to *Otus asio quercinus,* but very much darker, more purely grayish (less brownish); lower parts more broadly streaked and more densely and numerously barred.

Measurements.—Adult male (type); length (in flesh) 212 mm; extent of wings, 560; wing, 160; tail, 90; culmen from cere, 16; height of bill at base, 13.5; tarsus, 36; middle toe without claw, 19. Adult female: wing, 167 mm; tail, ———; culmen from cere, 15.5; tarsus, 35.5; middle toe without claw, 19.5.

Type.—Adult male, No. 186186, U. S. National Museum, Biological Survey collection; San Jacinto Mountains, altitude 5,500 feet, California; April 28, 1903; Frank Stephens; original number, 6,221.

Geographic distribution.—San Jacinto and San Gabriel Mountains, southern California.

Remarks.—While we have seen only two specimens of this screech owl, these are so much darker than any of the races of *Otus asio* the ranges of which approach the San Jacinto Mountains, that is, *Otus asio quercinus* and *Otus asio inyoensis,* that they apparently represent a distinct race confined probably to this limited area. The bird here described as *Otus asio clazus* is, in fact, the darkest of all the California races of the species.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

546TH MEETING

The 546th meeting was held at the Cosmos Club January 13, 1937, President R. C. WELLS presiding.

Informal communications.—H. D. MISER spoke on some peculiar markings on surfaces of Pennsylvanian sandstone beds.

C. MAX BAUER described recent work in the Yellowstone National Park.

Program.—C. E. VAN ORSTRAND: *Temperatures in the lava beds of East Central and South Central Oregon.* Temperature records of 7 springs, 7 flowing wells, and 9 non-flowing wells were discussed with reference to the hydrology and volcanology of the area.

A new type of depth-temperature curve was introduced. The curve consists of a series of steps instead of the smooth uniform curves of sedimentary areas in which the temperature gradients increase with the depth. The horizontal portion of the step is supposed to be due to convection of water within and between the lava beds. The general rise of the series of steps varies from about 20 to 40 feet per degree Fahrenheit (1° C. in 11.0 to 21.9 meters).

At Lakeview, Oregon, a temperature of 190° F. was found at a depth of 600 feet in a well located on the mountain ridge at an estimated elevation of about 500 feet above the level of Goose Lake plain. This evidence suggests the possibility that the mountain ridge is the source of the heat and water in the hot springs and flowing wells located on the floor of the Goose Lake valley at a distance of about ½ mile from the well in which the high temperature was recorded. The temperature of the water is near the boiling point (203–4° F., 95.0–95.6° C.) at that elevation. The possibility that the hot water rose to the surface of the ground along the fault in the plain or that it originated in a magma at a moderate depth were considered. A final decision in regard to the three possibilities was not reached. (*Author's abstract.*)

G. R. MANSFIELD: *Erosional history of the Paradise Valley quadrangle, Idaho.* The Paradise Valley quadrangle, which lies a few miles southeast of Idaho Falls, Ida., adjoins on the northwest other areas previously studied and described by the writer. The Blackfoot River, which crosses it, connects by transverse canyons a series of intermontane valleys. Its present canyon in the Paradise Valley quadrangle is bordered by remnants of older and higher valley systems. In the higher parts of the quadrangle remnants of older valley systems are preserved also. These, together with those near the Blackfoot River, include a succession of 11 rather distinct erosion stages. The pattern of these remnant surfaces, together with other features of this and adjoining areas, suggests that the present drainage systems of the quadrangle have been developed by superposition from a former widely extended cover of Tertiary sediments, of which considerable remnants now remain in the quadrangle. The relations of the erosion surfaces here described to earlier published views of the erosional history of the region as a whole have not been worked out. However, it is believed that a number of the lower and newer surfaces are related to temporary base levels established by basalt flows, now more or less dissected, and that these base levels have served to protect and preserve in the Paradise Valley quadrangle records of brief stages in erosional history that in the higher adjoining county have largely been destroyed. (*Author's abstract.*)

547TH MEETING

The 547th meeting was held at the Cosmos Club January 27, 1937, President R. C. WELLS presiding.

Informal communications.—JEWELL J. GLASS: *Sodalite from Magnet Cove, Arkansas.* A specimen of a translucent light violet blue mineral was collected by Mr. H. D. Miser from a quarry owned and operated by Mr. J. W. Kimzey, at Magnet Cove, Arkansas, and submitted to the U. S. Geological Survey Petrology Laboratory for identification. On examination it was found that the mineral was sodalite. The sodalite is found in veins and lenses varying from a few to several inches in thickness in a dense dark-greenish gray tinguaite dike rock which is now being crushed and used as shingle material. The tinguaite dikes in which the sodalite is found are located near the extreme south rim of the Magnet Cove intrusive complex. This unusual blue mineral attracted the quarry owner's attention as a curiosity, but has proved of exceeding mineralogical interest, because among the minerals described from that unique assemblage of Magnet Cove minerals, this is the first occurrence of sodalite to be reported from that locality. (*Author's abstract.*)

F. L. HESS spoke on the peculiar odor of microcline from the Black Hills.

Program.—EUGENE CALLAGHAN: *Alunite deposits of the Marysvale region, Utah.* The alunite deposits are in the western part of the High Plateaus of

Utah. The rocks in the region range in age from Carboniferous to Recent. However, the alunite is restricted to the lower part of a series of Tertiary volcanic rocks, which lie upon Wasatch and older sedimentary rocks. The volcanic rocks are overlain by a sedimentary formation tentatively called the Sevier River, which contains diatoms regarded by Mr. K. E. Lohman, of the Geological Survey, as of Upper Pliocene or Lower Pleistocene age. The deposits are of two types, called the replacement type and the vein type. Those of the replacement type are chiefly altered volcanic rock with variable proportions of alunite, some of which is sodic. They commonly have a large proportion of impurities. Deposits of the vein type are mostly coarsely crystalline and much purer than those of the replacement type. Though there is evidently considerable alunite of both types in this region, work done thus far does not justify revision of earlier estimates of reserves. (*Author's abstract.*)

H. G. BYERS: *The distribution of selenium, with geologic implications.*

548TH MEETING

The 548th meeting was held at the Cosmos Club February 10, 1937, President R. C. WELLS presiding.

Informal communications.—E. INGERSON described an instrument for more accurate determination of structural features of rock specimens for petrographic studies.

F. C. CALKINS described gold deposits in the Slumbering Hills of Nevada.

Program.—G. A. COOPER: *The Centerfield limestone of New York and its equivalents in the midwest.*

RALPH TUCK: *The Matanuska coal field, Alaska.* The Matanuska coal field, one of the two commercial coal-producing fields in Alaska, is located in the south central part of the Territory, near the head of Cook Inlet, and on a branch line of the Government-owned-and-operated Alaska Railroad. Coal has been produced from this field since 1916, and although the production is relatively small as compared with the coal fields of the United States, it plays an important part in the economic development of this part of Alaska. From this field the railroad, as well as the towns situated along its southern part are furnished with a cheap and reliable fuel. A few thousands tons are also annually exported to coastal towns and canneries.

The coal field is in the Matanuska Valley, an east-west valley about 50 miles long and 5 miles wide, which lies between the Talkeetna Mountains on the north and Chugach Mountains on the south. Cretaceous sandstone and shale, and Tertiary (Eocene) rocks. of which the lower member is an arkose, the middle, sandstone and shale with interbedded coal seams, and the upper, a conglomerate, crop out in the valley. In the upper part of the valley, both the Cretaceous and Tertiary are intruded by diorite dikes and sills. The valley was occupied by a glacier during the Pleistocene, so that glacial deposits cover the valley floor, and in great part obscure the bedrock formations.

In general the Cretaceous and Tertiary formations of the valley are a downfaulted block between the dioritic rocks of the Talkeetna Mountains on the north, and the metamorphosed sediments, volcanics, and intrusive rocks of the Chugach Mountains on the south. The valley formations are folded and faulted to a high degree in the upper part of the valley, and progressively to a lesser extent in the lower part of the valley, likewise, the coal changes in rank from high rank bituminous and anthracite in the upper part to lignite and lower-grade bituminous in the lower part of the valley.

Considerable exploration and development has been done on the higher rank coal in the upper part of the valley, but at present they are not mined because of high mining costs resulting from the complex structure. All of the commercial coal production now comes from the lower part of the valley, in an area dominated by a distinctive topographic feature called Wishbone Hill, which is the surface expression of a southwest plunging syncline. The hill is capped by 1,200 feet of massive conglomerate, and underlying it is the coal bearing series, so that the coal crops out only around the margin of the hill. In the eastern part of the area, from which the greater part of the coal production has come, 2,000 feet of coal bearing formation is exposed. Over 20 coal beds with thicknesses of more than 3 feet are known to occur. Most of the seams are from 3 to 5 feet thick, and a high volatile bituminous coal is produced from them. Both the coal beds and the intervening sandstone and shale vary in thickness and composition within short distances, and the whole formation indicates rapid deposition in a number of small basins. Strike and transverse faults are common. The strike faults have small displacements, but the transverse faults—most of which are normal faults—have displacements up to 350 feet.

Geological work has shown that there are reserves of a number of million tons recoverable above the present mine workings, and a similar amount below—a supply sufficient for local needs for a long time in the future. (*Author's abstract.*)

549th Meeting

The 549th meeting was held at the Cosmos Club February 24, 1937, President R. C. Wells presiding.

Informal communications.—Taisia Stadnichenko gave a brief report on what is being done by Arctic Institute in Soviet Russia.

W. C. Alden spoke on condition of glaciers in Glacier National Park.

Program.—E. N. Goddard and T. S. Lovering: *Laramie fault pattern in the Front Range mineral belt, Colorado.*

C. H. Birdseye: *The uses of aerial photography.*

550th Meeting

The 550th meeting was held at the Cosmos Club, March 10, 1937, President R. C. Wells presiding.

Informal communications.—W. T. Schaller discussed consideration of candidates for President of the Washington Academy of Sciences.

J. P. Marble spoke on the age of Pitchblende from Great Slave Lake.

E. Ingerson discussed temperature range of formation of hydrothermal and pneumatolitic minerals.

Program.—N. H. Heck: *Geological factors in safeguarding against earthquakes.*

D. F. Hewett: *Environment and relations of the hypogene manganese minerals.*

551st Meeting

The 551st meeting was held at the Cosmos Club March 24, 1937, President R. C. Wells presiding.

Informal communications.—M. I. Goldman described corroded pebbles in the Morrison formation on north end of Henry Mountains, Utah.

Program.—J. H. Swartz: *Some resistivity determinations of salt water boundaries.*

C. F. STEWART SHARPE: *Physiographic research on soil erosion.* One phase of Soil Conservation research is the physiographic study of soil erosion. Investigations are under way in several representative areas. The most extensive work has been done in the southern Piedmont where conditions are particularly bad due to deep weathering and long cultivation of open-tilled crops. By combining physiographic, climatic, ecologic, and soil evidence, with field and library studies in erosion history since colonial times, the life histories of several selected gullies near Spartanburg, S. C., have been reconstructed.

Most gullying results from artificial concentration of flowing water. The gully hazard in the Piedmont is greatest in soils developed on acid igneous and metamorphic rocks. Such soils have porous sandy or silty topsoils, tight clay subsoils extending to a depth of three to five feet, and weak underlying parent material of rotten rock. Most gullies in these soils head in active "plunge pools" formed where a lip of subsoil projects over a recess in the weak parent material. During rains some of the run-off flows as a waterfall into the plunge pool, but an important part of the flow clings to the lip and and trickles back under the overhang, softening the parent material and causing it to fall or crumble away. The projecting lip is left unsupported and caves off in large blocks. Water seeping downward through tension cracks aids both softening and caving.

Many gullies which have long been stable are found to be threatened with rejuvenation resulting from an increased flow of water or a lowering of base-level which initiates headward migration of a fall or "knickpoint."

Sheet erosion, a less obvious process, attacks primarily the topsoil and removes the most valuable part of the land. Evidence of recent sheet erosion and an estimate of the amount is given by exposed tree roots, and miniature pillars of earth capped by stones, lichens, leaves, etc.

Small test plots are being studied to learn more about the method and rate of formation and removal of the loose granular surface layer of "crumb-mulch" characteristic of bare ground on certain soil types. Production of crumb-mulch is found to be greatly accelerated by the action of needle-ice during frost. Removal of as much as two and one quarter inches of this mulch in six weeks has been recorded.

The importance of mass movement, particularly soil-creep, in the Piedmont and southern Blue Ridge areas is shown by the very general presence of a line of rock fragments at the approximate base of the subsoil or B horizon and above the parent rock. Rock structure below and downhill flowage lamination in the soil above this "stone-line" indicate that it is the base of effective creep. (*Author's abstract.*)

552ND MEETING

The 552nd meeting was held at the Cosmos Club April 14, 1937, Vice-President F. C. CALKINS presiding.

Program.—D. A. ANDREWS: *Asymmetrical distribution of stream terraces in southeastern Montana.* Gravel terraces, many of which are of Pleistocene age, occur along most of the stream valleys in eastern Montana. These terraces have been mapped in considerable detail in the parts of Custer, Powder River, and Rosebud counties included in the coal reports on the Ashland, Rosebud, and Mizpah fields published by the U. S. Geological Survey. These terraces lie from a few feet to 500 feet or more above the alluvium levels of the streams. Many terraces are preserved along Yellowstone River flowing east and the Tongue River flowing northward; these are the largest streams in the area and the terraces on the right sides of each of these valleys equal in size and number the terraces on the left sides of each valley.

Terraces are few and widely separated along Powder River but are abundant on the west side of Mizpah, Pumpkin, and Rosebud Creeks, all of which flow northward; only a very few are preserved on the east side of these stream valleys. Several of the westward and northwestward flowing tributaries of these streams have terraces on the south and southwest sides but have few or none on the opposite side of the valleys. In contrast, terraces are preserved on the north and northwest sides and few or no terraces occur on the opposite sides of the east or northeast flowing tributaries of the same streams. There are no southward-flowing streams in the mapped portions of Custer, Powder River, and Rosebud Counties. In addition the profiles across these valleys are asymmetrical. The long gentle slope which bears the terraces is on the left side of the valleys. Tongue River, however, does not show this marked asymmetrical profile and inadequate information is available to draw conclusions about the profile of Yellowstone River. These observations show that the streams with asymmetrical valleys have migrated to the right and that they are still crowding their right banks.

The stream valleys of the area here described are carved in thick beds of soft sandstones and shales which have a regional dip of about 50 feet per mile to the west toward the axis of the Tongue River syncline which follows the valley of Tongue River. On the west side of Tongue River the beds have a comparable dip to the east toward this syncline.

The deflection of moving objects to the right in the northern hemisphere due to the rotation of the earth (a principle that is known in the United States as Ferrell's law and in Europe as Baer's law) is postulated as the dominant force that has caused the streams to migrate to the right. The application of Ferrell's law indicates that the effect of the deflective force due to the earth's rotation is greater in a stream whose flow has high velocity and whose course has meanders with small radii of curvature. The behavior of the streams in this part of Montana appears to be in accord with the application of Ferrell's law; the small streams, whose velocities are high and whose courses have meanders with small radii of curvature, have migrated strongly to the right and the larger streams—Tongue and Yellowstone Rivers—have not migrated dominantly either to the right or left. The approximate equal development of the high, intermediate and low terraces along either side of the streams may indicate that the force has been acting continuously since the formation of the high terraces. In addition the application of Ferrell's law indicates that this deflective force increases directly with the sine of the latitude of an area. (*Author's abstract.*)

W. G. Pierce: *The Heart Mountain Overthrust near Shoshone Reservoir, Wyoming.* Additional information on the nature of the Heart Mountain overthrust has been sought by the author in 1935 and 1936 by detailed plane table mapping of the areal and structural geology of the sedimentary rocks exposed in the valleys of the North and South Forks of Shoshone River. In 1916 Dake recognized two overthrusts, superimposed one above the other. The upper is the main thrust and the overlying block is mostly Madison limestone (Mississippian); the lower one is a thrust slice below the sole of the main Heart Mountain overthrust and contains over 5,000 feet of rock strata ranging in age from the Jurassic Sundance to the Tertiary Wasatch. The limestone on Sheep Mountain and Logan Mountain is part of the upper thrust block. The lower thrust slice is found on the southeast side of Sheep Mountain and a small mass is exposed on the east side of the Shoshone Reservoir, but it is most conspicuous and best exposed on the south side of the South Fork of Shoshone River in a belt from half a mile to four miles wide and about 15 miles long. Throughout a large part of its extent on the south side of South Fork Valley, the lower slice has been folded into a trough which roughly parallels the valley. Its trough-like form, which is the main controlling feature for the present areal distribution, is not easily discernible because the synclines, anticlines, faults, and overturned folds within the strata of the lower thrust slice tend to divert attention from the thrust fault at its base.

A transverse fault trending southeastward from Sheep Mountain passes beneath the upper thrust but cuts the lower thrust slice. Southwest of the transverse fault the lower thrust is deformed into the trough just described, but to the northeast the thrust plane is nearly horizontal. Evidence indicates that the block southwest of the transverse fault moved laterally southeastward. Slickensides observed on the lower thrust on the east side of Shoshone Reservoir indicate that there the lower thrust slice moved due east.

The relation of the lower thrust to the upper thrust is obscure. None of the formations found in one of the thrust blocks are repeated in the other. Therefore, the relationship of the upper thrust to the lower one is such that they do not form an imbricate structure. Another uncommon, although not a unique, feature of the thrust blocks is that the lower one is a slice below the main Heart Mountain overthrust. The western limit of the lower thrust slice has not yet been definitely determined, but it seems probable that it does not extend westward beyond Logan Mountain or Sheep Mountain. It is more extensive on the south side of the South Fork of Shoshone River, and west of Rock Creek it crosses from the south to the north side of the South Fork.

The early basic breccias are the oldest volcanic rocks in the area, except for tuffaceous beds in the Wasatch and some of the older formations. Although the greater part of the early basic breccia is composed of surface flows, a considerable amount of breccia was intruded as sills, plugs, and dikes of large size. The volcanic breccia is definitely later than the overthrusting, for not only does it rest on top of the upper thrust block, but fissures through which it rose to the surface cut through the upper block and continue down into the autochthon. Work by C. B. Read and others indicates that the early basic breccia is of upper Eocene or lower Oligocene age, and as the Wasatch formation is involved in the thrusting, the age of the overthrust is probably middle or upper Eocene. (*Author's abstract.*)

W. O. Field, Jr.: *Some recent changes in Alaskan Coast Glaciers.*

553rd Meeting

The 553rd meeting was held at the Cosmos Club April 28, 1937, President R. C. Wells presiding.

Program.—N. W. Bass: *Origin of the oil bearing shoestring sands of northeastern Oklahoma and southwestern Kansas.*

D. C. Barton: *Petroleum geophysics.*

M. N. Bramlette, *Secretary.*

Obituary

Arthur Brooks Clawson, physiologist in charge of investigations of stock poisoning by plants of the Bureau of Animal Industry, U. S. Department of Agriculture, suffered an attack of cerebral thrombosis while engaged in studying problems on the Utah deserts and died at his home in Washington, June 30, 1937.

Mr. Clawson was born June 18, 1878 at Green Lake, Wis. Specializing in biology he was educated at Ripon College, the University of Michigan from which he was graduated in 1904, and at the University of Wisconsin. He taught biology at Lake Forest College for two years and in 1909 joined the group studying plant-poisoning of livestock, then in the Bureau of Plant Industry. He was identified with these researches during the remainder of his life making many contributions of fundamental importance in that field. He was acknowledged the foremost American authority on stock-poisoning by plants and enjoyed the confidence of the livestock breeders as well as of his scientific associates. He published a number of papers reporting his observations among which special mention may be made of his work on locoweeds, larkspurs, lupines, cyanogenetic plants, milkweeds and Senecio poisoning. He had already made substantial progress in the solution of the problem of bighead in sheep, the study on which he was engaged at the time of his death, and had succeeded in demonstrating for the first time the causes of this condition which annually results in a large loss of livestock.

Mr. Clawson was in charge of the Experiment Station at Salina, Utah, operated by the Bureau of Animal Industry for the study of stock-poisoning plants. He was a member of the Washington Academy of Sciences, a fellow of the American Association for the Advancement of Science, a member of the Botanical Society of Washington, Biological Society of Washington, Illinois Academy of Science, Wisconsin Academy of Science, the Cosmos Club and Sigma Xi. He was interred at his old home, Green Lake, Wisconsin.

Paul Vere Roundy, geologist of the U. S. Geological Survey, died suddenly of heart failure June 21, 1937, at his home, Chevy Chase, Md., following many months of ill health caused by high blood pressure.

Mr. Roundy was born January 8, 1884, at Cooperstown Junction, N. Y. His collegiate education was begun at Syracuse University and completed at George Washington University, from which he received his A.B. degree in 1912. He was appointed to the U. S. Geological Survey in 1908, retaining that connection as geologist and paleontologist until his death. During the World War he collaborated with other members of the Survey in working out the geology of the Osage oil field in Oklahoma. Later he was employed with others in estimating the resources of the Elk Hills Naval Reserve No. 1, in California, and within the last two years he has been at work on a report upon the phosphate deposits of Florida. He is widely known for his contributions to the study of the ostracods and conodonts.

Mr. Roundy was a member of the Paleontological Society, the American Association of Petroleum Geologists, the Society of Economic Paleontologists and Mineralogists, the Geological Society of Washington, and the Washington Academy of Sciences.

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JOURNAL
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CHEMISTRY.—*Some aspects of the study of insulin.*[1] Vincent du Vigneaud, George Washington University.

Mr. President, fellow-members of the Washington Chemical Society, I wish to thank you for this award. I deeply appreciate it. There is nothing that so warms one's heart as the recognition of one's work by his fellow workers. In accepting this award, I should like to make sincere acknowledgment of the loyal and enthusiastic cooperation of a group of graduate and post-graduate students, whom I have had the pleasure of working with in these sulfur studies. I should like to mention particularly Lewis Butz, Wilbur Patterson, Hubert Loring, Helen Dyer, Chase Jones and Gail Miller. Your tribute I feel is as much to them and their work as to me and the part that I have played in the accomplishment of these researches. On their behalf as well as my own permit me to thank you once more.

In addressing you this evening, I shall not discuss with you the researches directly mentioned in your award, that is, the synthesis of glutathione, nor the fields closely allied to it on the cystinyl peptides and homocystine, for all of these researches have been presented before this society on former occasions. I thought I would discuss with you, instead, the problem out of which these researches arose and the possible significance that these studies may have in the understanding of the original problem. I think it is always interesting to trace the origin of research ideas. Seldom do ideas spring forth wholly formed as did the goddess Athena from the brow of Zeus; nor are they spontaneously generated. They are no more spontaneously generated than living matter itself. Ideas are propagated by other ideas, and develop slowly, nurtured by facts and observation. It is in this way, step by step, that a research program develops, and it is interesting and sometimes profitable to retrace the devious trail along which it has traveled. It is like tracing the family tree of research.

Most of our own researches in the field of sulfur chemistry have

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[1] Address on the occasion of the award of the Hillebrand Prize for 1936, delivered before the Chemical Society of Washington, March 11, 1937. Received March 29, 1937.

had their outgrowth from our studies on the chemistry of insulin. In some instances the new research problem has arisen unexpectedly, as did the homocystine problem through our trying to work out a particular phase of the chemistry of insulin; while in other instances the researches have come about through a realization that more fundamental knowledge was needed of the chemistry of certain compounds in order the better to understand the chemistry of insulin, as exemplified by our studies on cystine and cystinyl peptides. At first sight many of these sulfur problems might appear to have no connection with insulin. It is true they have seemingly wandered far afield, but there is an underlying connection. I shall endeavor to show you this connection and how some of these problems have arisen. I shall also try to interweave through this discussion some of the results of our own studies of insulin itself, and finally present to you a glimpse of our present chemical knowledge of this hormone and the effect which the study of insulin has had on our conception of proteins and certain other hormones.

Quite early in the study of insulin it was suspected by various workers that insulin might be a sulfur-containing compound. This was very shortly after the demonstration, with which you are all acquainted, of the presence of this hormone in the pancreas by Banting and Best in 1921. It was not until 1926, however, that the suspicion of its being a sulfur compound grew into a very definite possibility out of the work of Professor Abel of Johns Hopkins. It is rather interesting how this came about. Professor Abel had heated some insulin preparations with phenol in sealed tubes for some purpose, and, when one of the tubes was opened, Professor Abel noticed an odor of hydrogen sulfide. He followed this up and subsequently found that the amount of sulfur, labile to weak alkali, paralleled the activity of certain preparations, and that when the sulfur was split out, the activity was destroyed. Shortly thereafter he succeeded in isolating insulin in crystalline form. He found that the crystalline material likewise contained sulfur in a labile form. These findings led Abel to suggest that the Islets of Langerhans might be dependent upon the presence in our food of a special labile sulfur compound, a precursor indispensable for the elaboration of the hormone, in the absence of an adequate supply of which pathological alterations in the cells of the Islets of Langerhans would take place. It is quite clear that the question of the identity of the sulfur moiety became one of paramount importance.

At that time we were studying the problem at Rochester in Professor Murlin's department and had obtained evidence that the insulin contained cystine and that the labile sulfur could be accounted for on that basis. When the sulfur was split out, the disulfide linkage was destroyed and the test for cystine greatly reduced in intensity, indicating that the cystine was the source of the labile sulfur. Although the sulfur of the insulin was labile, the sulfur in the hydrolysate of the insulin became stable like that of free cystine. This change in lability upon hydrolysis was identical with what would be expected of amino acid derivatives of cystine based on the work of Brand on the lability of the sulfur of peptides of cystine. In this work at Rochester we were also able to confirm Abel's crystallization of insulin.

From our studies we came to the conclusion that the sulfur was present as the disulfide linkage and that insulin was most likely a derivative of cystine, and we suggested that cystine in insulin was linked to the rest of the molecule by peptide linkages.

The conclusive demonstration of the actual presence of cystine in crystalline insulin, however, had to rest on isolation; so later, when we had the opportunity of working in Professor Abel's laboratory, we took up the isolation of cystine from crystalline insulin. Of course, this isolation work had to be carried out on a very small scale and we had to work out our own methods. We hydrolyzed a gram of crystalline insulin and immediately ran into difficulties with the isolation of the cystine. We soon recognized that one of the difficulties was that we had partially racemized the cystine, and in looking into the literature we found that racemized cystine was far more soluble than *l*-cystine. It was here that our interest in the isomers of cystine arose. We found that in spite of the great amount of work that had been done on the problem, the isomers had not been isolated and, in fact, there was much difference of opinion as to whether the inactive material was the meso or racemic form or a mixture of the two. Somewhat later when the opportunity arose we undertook the resolution of cystine, and succeeded in isolating the other isomers of cystine, the dextrorotatory form, the racemic and the meso forms. We then became interested in the utilization of the isomers by the animal body and studied their ability to promote growth of animals on a cystine-deficient diet, finding that the *d*-isomer could not be utilized. This in turn led to studies of oxidation of these isomers and also to the behavior of the optical isomers of other amino acids in the body. It also made possible a study of the solubilities of the isomers, and we were finally able to show why the mixture of isomers was so soluble, which led us back to the point from which we had started some five years earlier in the insulin work.

To go back now to the isolation of cystine from crystalline insulin, I might say that this was readily accomplished when care was taken to avoid as much as possible the racemization of cystine, and when we had worked out a method which would separate tyrosine from cystine in such small quantities. Thus the isolation of cystine from the insulin demonstrated beyond any argument that cystine was present in the insulin molecule.

Knowing that cystine was present naturally brought many questions to mind. One of the first questions to arise was whether cystine peptides might affect the lowering of blood sugar. It was then we realized that as yet no peptide of cystine through the carboxyl group of cystine had been prepared, and that no method was available at the time for the accomplishment of this type of peptide synthesis. Cystinyl peptides were also necessary from other standpoints, both chemical and biological and, somewhat later, it was clear that such a step was vital for a convenient synthesis of glutathione. While continuing the insulin researches we, therefore, carried on parallel studies on the synthesis of peptides of cystine, the successful outcome of which placed us in a position to accomplish the synthesis of glutathione and isoglutathione.

The synthesis of glutathione, if I might say so, was really incidental to the larger study we were interested in, that is, cystinyl peptides. We were interested in the development of convenient and workable methods for getting these compounds and then in the study of their physiological and chemical properties. The experience gained with this tripeptide puts us one step further towards making more complicated peptides of cystine. What I should like to emphasize is that the glutathione synthesis was not an end in itself but merely a step in a general program.

In addition to knowing that cystine was present in insulin, it was important to know whether all of the sulfur was present as cystine sulfur or whether there was present some other sulfur-containing compound. We first determined the cystine content by the Folin-Looney method and by the amazingly specific Sullivan method. The Folin-Looney method gave much higher values than the Sullivan, and, in fact, higher than could be accounted for on the basis of the total sulfur. With the specific Sullivan method, only about three-fourths of the sulfur could be accounted for on the basis of cystine.

A number of possibilities might account for this situation. One, a strange sulfur compound might be present; two, a difficultly hydrolyzable peptide of cystine might have remained in the hydrolysate which would react in the Folin-Looney reaction but not in the Sullivan method; three, the cystine might be partially destroyed during hydrolysis; and, four, some substance might be generated during the hydrolysis which would account for the high Folin-Looney reaction; and, finally, various combinations of these possibilities might exist.

One of the first things we did when we undertook to settle this question was to heat various amino acids with hydrochloric acid and sulfuric acid to see if such treatment would produce substances that would be chromogenic with the Folin-Marenzi method, which was a modification of the Folin-Looney procedure.

Interestingly enough, methionine upon being heated with strong sulfuric acid was found to give a positive reaction with the Folin-Marenzi reagent for cystine. This was the start of our series of investigations concerning homocystine. In searching for the substance in the reaction mixture responsible for the positive test, we isolated a crystalline compound which we were able to demonstrate to be the next higher symmetrical homologue of cystine. The possibility of this compound being involved in the intermediary metabolism of methionine in the body immediately occurred to us. Investigations concerning the utilization of the homocystine by animals on a cystine-deficient diet and studies of the oxidation of the compound were therefore undertaken. Synthesis of the homocystine, resolution of it into its optical isomers, and the demonstration of the steric relationship between its isomers and those of methionine soon followed, as well as studies of the higher homologues of homocystine and methionine.

Although this observation of the effect of sulfuric acid on methionine led to some rather interesting results, it did not explain the particular thing we were after. In the first place, the difference between these reactions existed in hydrochloric acid hydrolysates, and hydrochloric acid did not yield a chromogenic substance from methionine; and, secondly, methionine was not present in insulin in more than traces, if at all. We still had the original question to solve, and we worked off and on on this problem during the next few years and just within the past few months we have obtained results which lead us to believe that we have finally accounted for the sulfur of insulin.

It is rather amusing that the entire homocystine work with which we have been engaged during the past six years would not have taken place had we been able to account for the sulfur of insulin at that time. It is indeed curious the path which research may take, and perhaps it is these queer turns and quirks that make it fun to try to follow the pathway.

Although this particular path of homocystine researches appeared to have no connection with insulin, a recent turn of events has brought the two fields back together again and serves as an interesting example of how offshoots of a research may wander away and bend back again, touch, and even aid the original research. I refer here to the recent work on the question of whether or not a trace of methionine is present in crystalline insulin, and to the fact that one of the methods for determining methionine depends on the determination of the homocysteine thiolactone formed from methionine by hydriodic acid. I shall refer to this again later.

Along with attempts to fractionate insulin hydrolysates to see if a strange sulfur compound were present, and testing for the presence or absence of known sulfur-containing compounds such as thiolhistidine, we have also studied the question of the completeness of hydrolysis of insulin and the prevention of destruction of the cystine during hydrolysis.

To make a very long story short, after trying various procedures, we finally found that if we hydrolyzed insulin with twenty per cent hydrochloric acid and 50 per cent formic acid we were able to account by the Sullivan method for all of the sulfur as cystine within the experimental error of the method. We were able, furthermore, to adduce evidence that the previous low results were really due to a destruction of the cystine on the one hand and incomplete hydrolysis on the other.

Whether or not a trace of methionine is present cannot be stated definitely. Our own results on the study would indicate that if it is present at all it is even less than that reported by Brand. You can readily understand the difficulty of proving the presence or absence of a very slight trace of methionine in dealing with such a compound as insulin. One is dealing with such small amounts that one is at the borderline of the accuracy of the methods. Much more work will be needed before reaching a final decision.

Another aspect of the sulfur of insulin that has intrigued us, which even more forcibly brings out the importance of the sulfur, is the effect of reduction upon the activity of insulin. Earlier work had shown that various reducing agents destroyed the activity, but the reagents used were quite vigorous ones and one would have reason to believe that groupings other than the disulfide may have been reduced. We thought it would be rather interesting to study the effect of such mild reducing agents as cysteine and glutathione, which were more specific for the disulfide grouping. Even with such subtle reducing agents as these the insulin became inactivated. From much experimentation we finally came to the conclusion that the reduction of the disulfide grouping was the cause of the inactivation. It is interesting that reoxidation did not restore the activity. These results have been confirmed and extended by other workers, and it has been found that the rate of inactivation proceeds faster than that of reduction. This has led some to conclude that there are certain groupings particularly sensitive to reduction and that one or two disulfide linkages have a special function in insulin.

Our own tendency is to regard the architecture of the molecule as a whole as the important factor with regard to its hypoglycemic action and that any change which would produce a change in this architecture is apt to produce a destruction of physiological activity. From this standpoint no one particular disulfide linkage is necessarily more important than another as far as being responsible for the activity. The rupture of a given disulfide linkage might modify the architecture sufficiently to destroy its ability to bring about the oxidation of carbohydrates. Although the disulfide linkage *per se* may not be responsible for the insulin action, I should like to emphasize the fact that so far no one has split out or changed the disulfide grouping without destroying potency.

I would like to add, parenthetically, that there are some who speak in terms of a prosthetic grouping being present in insulin, that is, the presence of some smaller grouping attached to the protein molecule which is responsible for the activity; while there are others who like to speak of a nucleus of certain amino acids responsible for the activity as an integral part of the protein molecule. I should like to emphasize that at the present time these are assumptions. Of course, I do not mean to intimate that these things can not be so. There simply is no evidence for them as yet and one should recognize these views for the assumptions that they are. No criticism can be leveled, of course, at anyone for using them as working hypotheses.

In summing up what we actually know of the chemistry of insulin, we might say that all the evidence points towards the fact that insulin is a protein. But we must admit that from the standpoint of actual chemical structure we know very little about it, even though we probably know more about the chemistry of this protein than of any other. In fact, it is one of the most thoroughly studied proteins.

In judging what is known of the chemistry of insulin one should compare it, not with certain of the other hormones such as adrenalin or thyroxin, but rather with what is known of other crystalline proteins.

In closing I should like to call to your attention the role that insulin has played in bringing the field to the realization that a protein may have hormonal properties, or should I say, that a hormone could actually be a protein.

We almost forget now the strong prejudice that existed at the time of the isolation of crystalline insulin, that the crystalline material could not be the hormone because it was, to all intents and purposes, a protein. Yet as the work progressed the conclusion began to take form that insulin was truly a protein-like substance. The actual isolation of various amino acids from the compound, the study of the nitrogen distribution, the studies on the heat precipitation, the crystallization by various methods, and many other studies all pointed inevitably in this direction. As time went on the idea of a hormone being a protein became less objectionable to the field as a whole, and the possibility that other hormones might be proteins became plausible. This was true of the parathyroid hormone which controls calcium metabolism and the hormones of the pituitary gland—both the anterior and the posterior lobes. Of course, these latter hormones that I have just mentioned have defied isolation as yet, and we must withhold final judgment until they have been isolated, but the available evidence indicates that they are polypeptide or protein-like compounds.

This realization that a hormone could be a protein has been hastened by the recognition of other physiologically active substances which have also appeared to be proteins or protein-like substances. Within the past few years we have had the isolation of a number of enzymes starting with the isolation of urease in crystalline form by Sumner and culminating in the isolation of certain proteolytic enzymes, such as pepsin and trypsin, in crystalline form by Northrop. All of these crystalline enzymes appear to be proteins and present chemical problems quite analogous to insulin. The crystalline plant virus recently isolated by Stanley also appears to be a protein. Furthermore, it seems that toxins, antitoxins, antigens and antibodies and the like are proteins. We have, therefore, a growing list of compounds possessing remarkable physiological action, all of which appear to be proteins.

The studies that have been carried out on insulin become, therefore, of more fundamental value because of their possible significance to the study of these other crystalline physiologically active proteins. It should also be apparent from what I have just said about this entire group of substances that one of the greatest needs of biochemistry today is an understanding of protein structure itself.

PALEONTOLOGY.—Clithrocrinus, *new name for* Clistocrinus *Kirk*.[1]

EDWIN KIRK, U. S. Geological Survey.

In this JOURNAL[2] I described a new genus to which I gave the name *Clistocrinus*. My attention has been called to the fact that Springer[3] had erected the genus *Cleistocrinus*. Incidentally, this latter name had previously appeared in print in error for *Cleiocrinus* Billings.[4]

Springer in describing the genus gave the Greek words from which he derived the name. They are the same as used by me. According to classical usage with these words as given, the generic name could be written *Clestocrinus* or *Clistocrinus*, with preference given the latter by the International Rules of Zoological Nomenclature. There is also a variant spelling in the Greek that would give *Clestocrinus* directly. *Cleistocrinus* is an improper transliteration of the words as given. However, there is an Ionic variant of the Greek that would give this spelling. It thus appears that properly transliterated *Clestocrinus*, *Cleistocrinus*, and *Clistocrinus* could all be derived from the Greek and with the same meaning. Pronunciation would vary with the nationality of the speaker.

There seems to be nothing in the Code clearly prohibiting the use of more than one of the variant spellings given above, although naturally their use should be discouraged. There is, however, owing to opinions handed down by the Commission, some doubt as to whether *Clistocrinus* Kirk is a homonym of *Cleistocrinus* Springer. In order to clarify the meaning of the Code and obtain a ruling from the Commission, I am proposing a new generic name to supplant *Clistocrinus*. I propose the name *Clithrocrinus*, with *C. pyriformis* (Kirk) as genotype. The genus and species thus stands as *Clithrocrinus pyriformis* (Kirk).

The doubtful status of *Clistocrinus* primarily rests on the incom-

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[1] Published by permission of the Director, U. S. Geological Survey. Received July 21, 1937.

[2] This JOURNAL **27**: 106. 1937.

[3] SPRINGER, FRANK. *The Crinoidea Flexibilia*. Smithsonian Inst. Pub. **2501**, 1930.

[4] LUDWIG, H. Zool. Jahresber. for 1905, *Echinoderma*, pp. 4, 8, 1906.

patibility of Articles 8 and 19 of the Code. It may be held under Article 19 of the International Rules that *Cleistocrinus* is an error of transcription (*seu* transliteration) or a *lapsus calami* and should be changed to *Clistocrinus*. On the other hand, under Article 8 *k* and *l* words formed by an arbitrary combination of letters, or names formed by anagram, are held to be in good standing. If such be the case, rigid adherence to classical orthography and transliteration in isolated cases would seem to be hypercritical. After all, an improperly transliterated word may legitimately be considered an arbitrary combination of letters and would fall under Article 8 *k*. In a somewhat similar case (Opinion 26) nearly a hundred years after publication the Commission changed the spelling of a generic name on the somewhat easy assumption that a typographical error was involved. In the present instance one could as well assume that the typographical error or *lapsus calami* lay in the printing of the Greek word and that Springer really intended to use *Cleistocrinus*.

BOTANY.—*Eleven new Asteraceae from North and South America.*[1]

S. F. Blake, Bureau of Plant Industry.

This paper contains descriptions of eleven new species of Asteraceae (two from the United States, four from Mexico, five from South America), as well as two new varieties and several new names and combinations.

Bipontia Blake, nom. nov.

Soaresia Sch. Bip. Pollichia **20–21:** 376. 1863. Not *Soaresia* Allem. Rev. Braz. **1:** 210. *pl.* 1857, and Arch. Palestr. Sci. Rio de Janeiro **1:** 142. *pl.* 1858 (1859?).

Argyrophyllum Pohl, ex parte; Baker in Mart. Fl. Bras. **6**^{2}: 150. 1873, as syn.

Bipontia velutina (Sch. Bip.) Blake.

Soaresia velutina Sch. Bip. Pollichia **20–21:** 377. 1863.

Argyrophyllum ovali-ellipticum Pohl; Baker in Mart. Fl. Bras. **6**^{2}: 150. 1873, as syn.

In selecting a new name for this rare Brasilian monotype of the tribe Vernonieae I have sought to commemorate the work of Karl Heinrich Schultz (1805–1867), its original describer, one of the most active and enthusiastic students of Compositae of the last century, who was known as Schultz Bipontinus (from Zweibrücken, his birthplace) to distinguish him from a homonymous botanist of Berlin as well as from other botanists of the same family name. The fuller and preferable form, *Bipontinia*, is not

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[1] Received June 23, 1937.

available for use, having been employed by Alefeld (1866) for a segregate from *Psoralea* now generally regarded as a synonym of that genus. The name *Bipontina* was published by Schultz[2] himself, but only as a section of *Matricaria*, and has never appeared in generic rank. Pohl's herbarium name *Argyrophyllum*, known only from its use in synonymy by Baker, deserves only to be passed over. It was employed by Pohl, according to Baker's synonymy, for two quite unrelated species, *Vernonia venosissima* Sch. Bip. (*Argyrophyllum lanceolato-ellipticum* Pohl; Baker, l. c. 30, a name omitted from Index Kewensis) and *Soaresia velutina* (*A. ovali-ellipticum* Pohl). The name *Argyrophyllum* is omitted from Engler & Prantl's Natürlichen Pflanzenfamilien and from Dalla Torre & Harms' Genera Siphonogamarum.

The earlier genus *Soaresia* Allemão is now referred to *Clarisia* R. & P. (Moraceae). The genus and its single species *Soaresia nitida* were published by Allamão (Archivos de Palestra Scientifica do Rio de Janeiro 1: 142. 1858 [1859?]) with a combined generic-specific description, which is valid publication according to the International Rules as revised in 1930. I have not seen the supposedly earlier publication of the same names in the Revista Brazileira, but it has been checked for me by Dr. L. R. Abrams in the Stanford University Library, and from his notes it would appear that the same text and plate that were published in the Archivos were published also in the Revista. The date of publication of both papers of Allemão is somewhat uncertain, but in any case is several years earlier than Schultz's use of the same name. In the Index Londinensis the date 1854 is assigned to Allemão's plate published in the Archivos, but this is merely the author's date at the close of his paper, which follows immediately another paper dated 1856. The title page date of the volume is 1858, but the Library of Congress copy bears in pencil the date 1859.

This change of name, obligatory under the International Rules, will cause little inconvenience, as the plant concerned is apparently very rare and has probably not been referred to in botanical literature more than half a dozen times. It is figured by Baker in the Flora Brasiliensis (6^2: *pl. 38*).

Alomia stenolepis Blake, sp. nov.

Herba, caule tenui glandulari-pilosulo et sparse longius piloso; folia opposita remota ovata acuminata basi subcordata dupliciter crenato-serrata utrinque viridia sparse pilosa et brevius glandulari-pilosa, petiolis aequilongis tenuibus glandulari-pilosis; capitula 105-flora per 3–8 in apicibus pedunculorum terminalium et e axillis superioribus orientium folia superantium subdense cymosa, pedicellis 3–6 mm longis; involucri paullum gradati 3–4-seriati 4 mm alti phyllaria angustissime linearia subsetaceo-acuminata parum pilosa et glandulari-pilosa; receptaculum nudum; achenia glanduloso-adspersa 1.4 mm longa.

"In a clump 0.6 m high and as broad"; stem with weak branches above, terete, striatulate, greenish, about 2 mm thick above, rather densely pilosulous

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[2] Ueber die Tanac. 26. 1844.

with spreading white hairs about 0.1–0.3 mm long, tipped with purplish glands, and, especially above, more sparsely pilose with many-celled eglandular hairs about 0.7 mm long; uppermost internode 15–17 cm long; leaves opposite, or the uppermost alternate but approximate; petioles very slender, unmargined, purplish, glandular-pubescent like the stem, 3–5.5 cm long; blades ovate, 5–6 cm long, 3.5–4.7 cm wide, acuminate, at base subtruncate or shallowly cordate and often slightly inequilateral, thin, 3–5-nerved from the very base (the veins prominulous, the veinlets scarcely so), simply or usually doubly crenate-serrate essentially to the base (the teeth about 12–20 pairs, 1.5–3 mm high, obtusely callous-mucronulate), above sparsely short-pilose on veins and surface with several-celled mostly eglandular hairs, glabrescent, beneath equally green, on the veins pilose and with a few shorter hairs tipped with purplish glands, on the surface thinly short-pilose with many of the hairs tipped with pale yellow glands, or the latter often subsessile; peduncles terminal and in the uppermost axils, 3–5 per stem, pubescent like the stem, naked or with a single leaf-like bract, 5–10.5 cm long, very slender, bearing 3–8 heads; heads (as pressed) 5–6 mm high, 5 mm thick, hemispheric; involucre 3–4-seriate, slightly graduate, the phyllaries all similar, very narrowly linear (0.2–0.3 mm wide), rather firm, greenish with purplish tips, 2-ribbed, sparsely pilose and glandular-pubescent much like the stem; corollas very slender, deep purple above, subsessile-glandular below and on the teeth, otherwise glabrous, 3–3.3 mm long (tube 0.8–1 mm, throat scarcely distinguishable from tube, 2 mm, teeth ovate, obtusish, about 0.3 mm long); achenes 5-angled, sessile-glandular chiefly above, 1.4 mm long, blackish-brown, with short whitish crustaceous base and terminal whitish collar, epappose; styles (dried) white.

Mexico: On rocks at water's edge, in Lower Sonoran zone, Canyon Guadalupe, Sierra Chiribo, Rio Mayo, Sonora, 11 March 1935, *Howard S. Gentry* 1434 (type no. 766039, Field Mus.; photog. and fragm., U. S. Nat. Herb.).

In characters of involucre and corolla, this species seems somewhat intermediate between the subgenera *Geissanthodium* and *Eualomia* as distinguished by Robinson. The corollas, as in the first group, are not differentiated into tube and throat, and the phyllaries are 3–4-seriate. They are, however, firm and only 2-ribbed, and the species, on the whole, seems best referred to *Eualomia*. It is readily distinguished by its foliage, its pubescence, and especially by its very narrow phyllaries.

Chrysothamnus nauseosus var. **psilocarpus** Blake, var. nov.

Rami arcte flavescenti-viridi-tomentosi vix striati; folia anguste linearia 4–5.5 cm longa 1.5–2.5 mm lata acuminata plana 1-nervia lutescenti-viridia subglabra v. tenuiter laxeque pilosula; capitula cymoso-paniculata, paniculis planiusculis 3–5 cm latis; involucri gradati 3-seriati (seriebus perpendiculatis sat distinctis) 8.5–10 mm alti phyllaria exteriora lanceolata acuminata interiora lineari-lanceolata acuta (ca. 1.3 mm lata) omnia praecipue ad apicem ciliata dorso glabra vittato-carinata; corollae 10 mm longae (dentibus ovatis 1–1.2 mm longis inclusis) in tubo et basi faucis sparse puberulae pilis clavellatis; achenia glaberrima 5 mm longa; styli ramorum appendices (2.2 mm longae) parte stigmatifera (1.5–1.6 mm longa) sesqui longiores.

Utah: Huntington Canyon, Emery Co., 21 July 1935, *A. O. Garrett* 7021 (type no. 1,679, 641, U. S. Nat. Herb.); also 7048, same data.

In Hall & Clements' monograph of *Chrysothamnus*[3] this plant keys out to C. *nauseosus* ssp. *leiospermus* (A. Gray) Hall & Clements.[4] In that plant the leaves are filiform or nearly so, the involucre only 6–8 mm high, the corolla 5–8 mm long, and its lobes only about 0.5 mm long. From the two other forms of *C. nauseosus* with glabrous achenes, *C. nauseosus* var. *glareosus* (Jones) Hall and var. *bigelovii* (A. Gray) Hall, var. *psilocarpus* differs in its merely ciliate, not dorsally tomentose phyllaries. Var. *glareosus* differs also in its obtuse phyllaries, var. *bigelovii* in its nearly or quite filiform leaves.

APHANOSTEPHUS PINULENSIS Coulter, Bot. Gaz. **16**: 98. 1891.

The type or type collection of this species, *J. D. Smith* 2407, from Pinula, Dept. Guatemala, Guatemala, alt. 1340 meters, came to the U. S. National Herbarium in the John Donnell Smith collection. It proves to be *Chrysanthemum parthenium* (L.) Bernh., a frequent escape from cultivation in Central America and Mexico.

Aster coahuilensis Blake, sp. nov.

Perennis bipedalis ubique (involucris exceptis) pilosus viridescens; folia inferiora ovata majuscula obtusa basi alte cordata papyracea grosse crenata longe petiolata, petiolis parum marginatis; folia media multo minora ovata acuminata crenato-serrata petiolis laminam semiaequantibus late marginatis prope basin saepe ampliatis; capitula vix numerosa (ca. 14–25 per caulem) mediocria corymboso-paniculata, bracteis ramealibus parvis linearibus v. subulatis; involucri turbinato-hemisphaerici 7 mm alti 4–5-seriati gradati phyllaria subappressa lineari-lanceolata acuta v. acuminata infra (circiter ad medium) indurata albida 1-sulcata supra herbacea (apice herbaceo anguste rhombico-lanceolato) sparse ciliolata ceterum glabra, exteriora calloso-apiculata; radii (sicc.) pallide violacea ca. 19 ca. 8 mm longa; achenia hispidula.

Herb 57 cm high, the stem (in the single specimen examined) bifurcate near the base, otherwise essentially simple below the inflorescence, green, subterete, not densely spreading-pilose with white hairs, eglandular; leaves rather crowded toward base of stem, the petioles of these leaves broad, flat, very narrowly or not at all margined, 6–10 cm long, 2–3 mm wide, widened and submembranaceous at base, rather densely spreading- or deflexed-pilose, the blades ovate, 8–11 cm long, 4.5–6.7 cm wide, very obtuse, rather deeply cordate (sinus 3–10 mm deep), coarsely crenate nearly throughout (the teeth about 10–15 pairs, very blunt, about 1 mm high, mostly 5–10 mm apart), feather-veined (chief veins 2–3 pairs), above rather

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[3] Phylog. Meth. Taxon. 210. 1923.

[4] *Chrysothamnus nauseosus* var. **abbreviatus** (Jones) Blake.—*Bigelovia leiosperma* A. Gray, Syn. Fl. 1^2: 139. 1884. *Aster leiospermus* Kuntze, Rev. Gen. **1**: 318. 1891. *Chrysothamnus leiospermus* Greene, Erythea **3**: 113. 1895. *Bigelovia leiosperma* var. *abbreviata* Jones, Proc. Calif. Acad. II. **5**: 693. 1895. *Chrysothamnus nauseosus* var. *leiospermus* Hall, Univ. Calif. Publ. Bot. **7**: 173. 1919. *Chrysothamnus nauseosus* [ssp.] *leiospermus* Hall & Clements, Phylog. Meth. Taxon. 217. 1923.—Jones's var. *abbreviata* is merely an insignificant form or condition of *leiospermus*, and his name, as the earliest published in the varietal category, must be adopted when the plant is treated as a variety.

light green, evenly but not densely spreading-pilose with several-celled hairs obscurely enlarged at base, soft or in age roughish to the touch, beneath rather lighter green, evenly but not densely pilose on surface with spreading hairs, densely so along costa; middle leaves not numerous, longer than the internodes, pubescent like the lower leaves, the blades ovate or lance-ovate, 4–6 cm long, about 2.2 cm wide, acute or acuminate, rounded at base, crenate-serrate mostly near middle with 3–7 pairs of teeth, the petioles 2–3.5 cm long, 2–5 mm wide; upper leaves (subtending the lower branches of the inflorescence) lanceolate, acuminate, narrowed at base, sessile, entire or nearly so, 3–5 cm long, 5–9 mm wide; inflorescence occupying about $\frac{1}{3}$ the height of the plant, corymbiform-paniculate, rather few-headed, about 13–18 cm long, 8–10 cm wide, the branches divergent-erectish, not densely short-spreading-pilose all around or more or less in lines, the primary branches mostly 2–5-headed, not in the least racemiform, the ultimate pedicels mostly 5–22 mm long, mostly with a few small subulate or linear bracts above; phyllaries 0.5–0.8 mm wide, the green tips somewhat thickened; heads about 2.2 cm wide; disk about 9 mm high, 6–8 mm thick (as pressed); rays about 19, the tube sparsely pilose above, 2.5 mm long, the lamina linear, 2–3-denticulate, 4-nerved, about 8 mm long, 1.8 mm wide; disk corollas essentially glabrous, soon purplish above, 7 mm long (tube 2.2 mm, throat 4 mm, teeth triangular-ovate, acutish, 0.8 mm long); achenes (immature) oblong, subcompressed, hispidulous, 5-nerved, 1.8–2.2 mm long; pappus rather copious, brownish white, 6.5 mm long.

Mexico: Moist wooded canyon on the eastern slope of the Sierra de San Manuel, Municipio de Musquiz, Coahuila, 30 June 1936, *F. Lyle Wynd & C. H. Mueller* 372 (type no. 1,638,865, U. S. Nat. Herb.).

Allied to *Aster drummondii* Lindl., but apparently specifically distinct in its longer pubescence, its merely crenate lower leaves, and particularly in its relatively few-headed and open corymbiform panicle with the heads conspicuously pedicellate and not at all racemosely arranged. The inflorescence, in fact, is more like that of the average *Aster laevis* than that of *A. drummondii.*

Aster intricatus (A. Gray) Blake.

Linosyris ? carnosa A. Gray, Pl. Wright. **2**: 80. 1853.
Aster carnosus A. Gray; Hemsl. Biol. Centr. Amer. Bot. **2**: 120. 1881. Not *A. carnosus* Gilib. 1781.
Bigelovia carnosa Benth. & Hook.; Hemsl. Biol. Centr. Amer. Bot. **2**: 120. 1881, as synonym.
Bigelovia intricata A. Gray, Proc. Amer. Acad. **17**: 208. 1882.
Linosyris carnosa Greene, Fl. Franc. 384. 1897.

The well known name of this very characteristic plant, *Aster carnosus,* must be changed, owing to the existence of an earlier homonym in *Aster carnosus* Gilib.[5] The latter is merely an illegitimate name, published with a description and with *Aster tripolium* L. cited as a synonym, but nevertheless, according to Art. 61 of the International Rules of Botanical Nomenclature (1930) precludes the use of the same name for a later described species. The species was redescribed as *Bigelovia intricata* by Gray in 1882, and this

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[5] Fl. Lit. **1**: 214. 1781.

specific name must be taken up for it. I am indebted to Dr. F. W. Pennell for a transcript of Gilibert's description from the copy of his work in the library of the Philadelphia Academy.

Aster horridus (Woot. & Standl.) Blake.

Herrickia horrida Woot. & Standl. Contr. U. S. Nat. Herb. **16**: 186. *pl. 50.* 1913.

Although this species, the type and sole member of the genus *Herrickia* Wooton & Standley, is not readily placed in any of the sections into which the genus *Aster* is divisible, it is certainly not worthy of generic separation. Its closest relationship, especially evident in the involucre, is apparently with *Aster wasatchensis* (Jones) Blake, a member of the group often separated under the generic name *Eucephalus* Nutt. *Aster wasatchensis* itself is anomalous in its group by reason of its herbaceous-tipped phyllaries, and could not be run down to *Eucephalus* by the generic key given in Rydberg's "Flora of the Rocky Mountains and adjacent plains."

Erigeron allocotus Blake, sp. nov.

Perennis caespitosus spithamaeus ubique patenti-hispidus et minute glanduloso-hispidulus subcinerascens; caules decumbentes paene e basi ramosi foliosi, ramis divergenti-erectiusculis; folia cuneata v. spathulata 3–5-fida v. 3-partita, lamina in petiolum multo longiorem sensim angustata, segmentis oblongo-ovatis v. lanceolatis v. linearibus obtusis v. acutis, folia superiora minora linearia v. lineari-spathulata integra v. 3–fida; capitula parva radiata apicibus ramorum et ramulorum solitaria longe pedunculata; involucri ca. 4–seriati parum gradati 4.5 mm alti phyllaria acuta v. breviter acuminata extima lineari-lanceolata herbacea interiora oblonga latiuscule subscarioso-marginata medio viridia; radii ca. 22–26 breves "albi" (sicc. pallide lavendulacei v. rosei); discus luteus; achenea compressa 2–nervia hispidula; pappus simplex fragilis.

Leafy-stemmed herb 13–18 cm high, many-stemmed from a slender, branched, apparently oblique caudex, the bases of the stems of the year covered with the imbricated marcescent bases of petioles, the whole plant moderately densely hispid with wide-spreading many-celled acuminate white hairs up to 1.5 mm long and also finely glandular-hispidulous; stems slender, subterete or subangulate; leaves (except the reduced upper ones) longer than the internodes, those toward base of stem crowded but not at all rosulate; lower leaves 1.7–3 (–4) cm long including petiole, light green, rather thick, the blade (about 4–8 mm long, 3–5 mm wide) 3–5-fid for about half its length or sometimes parted essentially to base, the segments mostly oblong or ovate-oblong, 1–6 mm long, 0.7–2.5 mm wide, acute or obtuse, entire or the lateral sometimes 2–lobed; middle stem leaves similar but more often deeply parted, sometimes with linear lobes; upper leaves much smaller, mostly 4–8 mm long, entire or 2–3-toothed or -fid; peduncles (naked tips of branches) mostly 3–4.5 cm long; involucre hemispheric, appressed, the outermost phyllaries herbaceous essentially throughout, 0.4–0.5 mm wide, spreading-hispid and glandular-hispidulous, the inmost about 0.8 mm wide, similarly pubescent on the green midline, this about equaling in breadth the subscarious whitish margin; heads 1–1.2 cm wide; disk 5 mm high, 6–8 mm thick (as pressed); rays about 6–7 mm long, the tube pilose above, 1.5 mm long, the lamina narrowly elliptic, subentire or 2-denticulate, 3–5-nerved, 4.3–5.3 mm long, 1.5 mm wide; disk flowers numerous, their corollas sparsely hispidulous on base of throat, papillose-crested on the teeth, 2.7 mm long (tube 0.5 mm, throat subcylindric, 1.8 mm, teeth ovate, 0.4 mm); achenes obovate, compressed, 2.3 mm long, 0.7 mm wide, nerved on the margin, appressed-hispidulous, whitish; pappus strictly simple, of about 22 fragile hispidulous white bristles 2.2–2.5 mm long, readily detergible, leaving a minute toothed crown.

Wyoming: Dry rocky hillside, near Grouse Creek, Shell Creek Canyon, Big Horn Co., Township 53 N., Range 89 W., alt. 2285 m, 8 July 1936, *Louis O. & Rua Williams* 3283 (type no. 1,684,047, U. S. Nat. Herb.).

The 3–5-fid or -parted leaves of this plant would seem to place it in the group of *Erigeron compositus*, but it differs from the several known members of that group in its freely branched leafy stems bearing rather numerous heads, as well as in details of foliage and pubescence.

Erigeron trihecatactis Blake, sp. nov.

Annuus erectus subvalidus infra inflorescentiam simplex dense foliosus ubique dense stipitato-glandulosus in caule patenti-pilosus; folia uniformia anguste oblonga v. oblanceolata obtusa apiculata sessilia amplectentia grosse serrata lutescenti-viridia ca. 5 cm longa 1 cm lata; capitula ca. 10 cymoso-paniculata mediocria brevissime radiata; involucri ca. 4-seriati paullum gradati 6.5 mm alti phyllaria lineari-lanceolata acuminata tenuia anguste pallideque marginata; radii numerosissimi 5–6-seriati albi non exserti, lamina suberecta ca. 1 mm longa elliptica; flores disci 31 flavi; achenia 2-nervia hispidula; pappus albidus simplex corollam subaequans.

Stem rather stout, subterete, inconspicuously striate, about 65 cm high, 4 mm thick at base, yellowish green, brownish green above, densely stipitate-glandular and more sparsely pilose with slender few-celled white hairs about 1 mm long; internodes about 1 cm long; leaves mostly with fascicles in their axils, the lower deflexed, the upper erectish; blades below the middle of stem somewhat smaller than the others, about 3.5–4 cm long, 5–8 mm wide, similar to the upper in shape and cutting; middle and upper leaves 4–5.8 cm long, 9–11 mm wide, shallowly cordate-amplexicaul at the not narrowed base, not decurrent, firm, plane or very narrowly revolute on margin, coarsely serrate except toward base (teeth about 4–6 pairs, obtuse, apiculate, 1–2 mm high, 5–10 mm apart), densely stipitate-glandular and (chiefly along margin) more or less pilose, feather-veined, the veins prominulous and loosely reticulate beneath; inflorescence rounded, about 8 cm long, 6 cm wide, the heads 1–4 at tips of the few branches, the principal bracts similar to the leaves but much smaller, the pedicels 3–22 mm long, pubescent like the stem, naked or with 1 or 2 subulate bracts; heads hemispheric, 1–1.4 cm wide (as pressed), 6 mm high; involucre densely stipitate-glandular and very sparsely pilose, inconspicuously graduated, the phyllaries erect, yellowish green with narrow yellowish white subscarious margin and tip, 0.6–1 mm wide; receptacle broad, flat, alveolate especially toward the center, the margins of the alveolae toothed; rays 333 (in 1 head), fertile, the tube 2.5–3 mm long, very sparsely puberulous with several-celled blunt slightly clavellate hairs, the lamina elliptic, emarginate, 1–3-nerved, 1–1.3 mm long, about 0.3 mm wide; disk flowers 31, fertile, their corollas yellow, puberulous above the middle like the ray corollas, 3.7 mm long (tube 1.4 mm, throat cylindric-funnelform, 1.6 mm, teeth 5, ovate, 0.7 mm long); achenes obovate-oblong, 0.8–1 mm long, 0.4 mm wide, nerved on the margin, whitish; pappus sparse, of about 17 hispidulous bristles about 3.8 mm long; style branches with deltoid-ovate obtuse papillose appendages.

Colombia: "Ad ripam rivi et in paramos," Chapinero, near Bogotá, on road to Usaquén, Dept. Cundinamarca, 12 Sept. 1926, *S. Juzepczuk* 6724 (type, Herb. Leningrad; photo. and fragm., U. S. Nat. Herb.); same locality, 28 May 1926, *Juzepczuk* 5015 (Herb. Leningrad).

This strongly marked species is a member of the Section *Caenotus*, and seems to be very distinct from any described species.

Clibadium glabrescens Blake, sp. nov.

Frutex; rami et ramuli glabri v. subglabri; folia ovata acuminata basi cuneata tenuiter petiolata serrata utrinque viridia tripli- vel quintuplinervia supra scabriuscula subtus sparse strigillosa; capitula mediocria mox remotiuscula subsessilia; phyllaria 4 late ovata v. suborbicularia obtusa saepius 9–11-nervia; receptaculum ubique paleaceum; flor. fem. 5–6, hermaph. 9–11; ovaria flor. fem. apice dense pilosa.

"Slender shrub, 4–6 ft."; branches slender, subterete, striatulate, 2–2.5 mm thick, olive-green, glabrous; branchlets glabrous or very sparsely strigillose; internodes 2–10 cm long; petioles very slender, unmargined, 2–2.5 cm long, sulcate above, strigillose in the sulcus, otherwise glabrous; blades 8–11 cm long, 4–5 cm wide, caudate-acuminate, acutely cuneate at base, serrate or serrulate from about the middle of the cuneate lower part to below the tip (teeth about 19–22 pairs, acutely callous-pointed, about 0.5 mm high, mostly 3–4 mm apart), thin-papery, above deep green, roughish, evenly but sparsely strigillose and short-strigose, beneath brighter green, evenly but sparsely strigillose on veins and surface, tripli- or usually quintuplinerved within 1–2 cm of the base; panicles terminating stem and branches, surpassed by the subtending leaves, strigillose or subappressed-puberulous, somewhat convex, at maturity 6–7 cm wide, the heads at first approximate, at submaturity mostly 2–4 mm apart; heads at submaturity (corollas fallen) depressed-subglobose, 2.5–3 mm high, 4.5 mm thick (moistened); phyllaries 4, broadly ovate to suborbicular, obtuse to very obtuse, ciliolate, toward apex sparsely strigillose, the outermost about 5-nerved, the others 9–11-nerved, 2.2–3.5 mm long, 2.5–4 mm wide; pistillate flowers 5–6, all paleate, their pales similar to the inner phyllaries, the corollas (scarcely mature) sparsely hirsutulous at apex, 1.8–2 mm long, the ovaries densely pilose at apex, the achenes obovoid, obcompressed, plump, rounded at base, densely villosulous toward apex, 2.4 mm long, 1.8 mm wide; hermaphrodite flowers 9–11, their pales much narrower than the pistillate and only 1–3-nerved, their corollas white, hispidulous toward apex, 3 mm long, their ovaries 2–2.3 mm long, pilose throughout or glabrous toward base, sometimes bearing near apex a few long gland-tipped hairs.

Colombia: Mountains between Mosoa and Sibundoy, Comisario del Putumayo, 19 May 1935, *W. A. Archer* 3415 (type no. 1,619, 557, U. S. Nat. Herb.).

A member of the section *Trixidium,* nearest *Clibadium terebinthinaceum* (Swartz) DC., in which the branches and branchlets are densely pubescent, the leaves larger, more coarsely serrate, and more densely pubescent beneath, and the heads larger.

Clibadium leiocarpum Steetz var. **strigosum** Blake, var. nov.

Rami petioli foliaque strigosa vel accumbenti-hirsuta.

Costa Rica: On brushy slope, Cerro de Piedra Blanca, above Escasú, Province of San José, 31 January 1924, *P. C. Standley* 32593 (type no. 1,225,816, U. S. Nat. Herb.).

Although this specimen may represent only a chance variation, it differs from other specimens of the species examined in a feature which is usually of considerable significance in the genus, and its separation as a variety seems advisable. The achenes in this specimen are sometimes merely clavellate-puberulous at apex, sometimes also sparsely villous.

Steiractinia lucidula Blake, sp. nov.

Frutex; rami dense strigosi, pilis basi incrassatis; folia magna ovata acuta v. acuminata basi rotundato-cuneata crenato-serrata firme pergamentacea triplinervia subtus reticulata utrinque asperula et lucidula; capitula radiata flava pro genera minuscula per 1–3 apicibus ramorum et ramulorum cymosa paniculam foliosam efformantia, pedunculis pollicaribus; involucri ca. 4-seriati gradati 9–10 mm alti phyllaria oblonga v. oblongo-ovata saepius obtusa exteriora herbacea parum strigosa et ciliata interiora tenuiora apice subscariosa et purpurascentia ciliolata; radii 5, ca. 7 mm longi; achenia alata.

Branching shrub 7–10 ft. high; stem (or branch) subterete, solid, pithy, olivaceous, 1 cm thick; leaves opposite; internodes 7–9.5 cm long; petioles stout, unmargined, densely strigose or strigillose with thickened-base hairs, those of the larger leaves 2–2.5 cm, of the leaves at base of inflorescence about 8 mm long; blades of the larger leaves ovate, about 15–18 cm long, 8–9.5 cm wide, of the leaves at base of inflorescence oblong-ovate, 9.5 cm long, 3.5 cm wide, the larger crenate-serrate from the upper part of the cuneate-rounded base nearly to apex (teeth about 20 pairs, bluntly callous-pointed, 0.5–1 mm high, mostly 5–8 mm apart), about equally green and somewhat shining on both sides, above evenly but not densely strigillose with mostly deciduous hairs with small lepidote-tuberculate persistent bases, beneath rather sparsely strigillose or antrorse-hispidulous especially along the veins and veinlets with slightly tuberculate-based hairs, triplinerved 0.8–2 cm above the base, the chief veins prominulous above, prominent beneath, the others impressed above, whitish and prominulous-reticulate beneath; peduncles in clusters of 1–3 at tips of branches and branchlets and in the upper axils, slender, mostly naked, densely erectish-hirsutulous (the hairs with small blackish tuberculate bases), 2.2–4 cm long, the whole forming a convex leafy-bracted panicle about 28 cm wide; heads about 1.5 cm wide; disk 9–12 mm high, about 7 mm thick in flower, 8–11 mm thick in fruit (as pressed); involucre campanulate, 9–10 mm high, appressed or the outermost phyllaries sometimes loose-tipped, the outermost phyllaries about 5 mm long, 1.8–2.5 mm wide, narrowly oblong or oblong-ovate, thick-herbaceous essentially throughout or pale and indurated at base, obtuse to acutish, rather sparsely strigose or strigillose and short-ciliate, the inner broader (3–3.5 mm), oblong, obtuse or rounded, above subscarious and purplish, erose, ciliolate, otherwise nearly or quite glabrous; rays yellow, neutral, sparsely ciliolate at base of limb, otherwise glabrous, the tube 2.5 mm long, the lamina oblong, bluntly 2–3-dentate, 8–9-nerved, papillate on upper surface and margin, 7 mm long, 2.5 mm wide; disk flowers not very numerous, their corollas yellow, glabrous outside, 7.5 mm long (tube 2 mm, throat funnelform, 5 mm, teeth ovate, strongly recurved, 0.5 mm long, densely papillose and almost hirsutulous inside); pales scarious, obtuse or acutish, usually winged on the keel, ciliolate toward tip and also on the keel, 6.5–8 mm long; ray achenes (immature) inane, trigonous, not winged, erect-hirsute on the angles, about 2.7 mm long, their pappus of about 27 unequal slender hispidulous deciduous awns 1–2.5 mm long; disk achenes cuneate-obovate, compressed, 5 mm long, 3.5 mm wide (including wings), the body mottled gray and brown, erect-pilose chiefly toward apex, 2-winged, the wings thin, olivaceous, ciliate, truncate at apex and there 1 mm wide, the body contracted into a short neck which is widened into the pappiferous disk, the pappus of about 33 slender hispidulous deciduous awns, mostly subequal and about 2.5 mm long.

Colombia: Edge of woods, Mesa de los Santos, Dept. Santander, Eastern Cordillera, alt. 1500 m, 11–15 Dec. 1926, *E. P. Killip* & *A. C. Smith* 15366 (type no. 1,351,249–50, U. S. Nat. Herb.).

Steiractinia lucidula is most nearly related to *S. schlimii* Blake, also from the Department of Santander (Ocaña), in which the leaves are densely pubescent beneath and not shining, and the outer phyllaries rather densely strigose or accumbent-hirsute, some of them usually equaling the inmost in length.

Helianthella ciliata Blake, sp. nov.

Herba perennis pedalis, caulibus suberectis simplicibus strigoso-hirsutis foliosis monocephalis; folia subuniformia elliptica v. elliptico-obovata v. suprema lineari-lanceolata ca. 4 cm longa 1.2 cm lata obtusa v. acuta basi cuneata subsessilia integra triplinervia margine tuberculato-hispido-ciliata in paginis minute hirsutula; capitulum breviter pedunculatum ca. 4 cm latum; involucri ca. 10 mm alti ca. 3-seriati vix gradati phyllaria lineari-lanceolata acuminata laxa omnino herbacea hispido-ciliata ceterum glabra; radii ca. 11–14 aurei ca. 1.5 cm longi; corollae disci apice purpureae; paleae infra scariosae apice subherbaceae; achenia ciliata et pilosa; pappi exaristati squamellae ca. 6–8 alte laciniato-ciliatae ca. 1.3 mm longae.

Perennial with short caudex; stems few, apparently erectish, somewhat curved, 27–38 cm high, slender, striate, whitish or somewhat purplish-tinged, rather densely or sparsely strigose or substrigose and also usually spreading or ascending-hispid with several-celled white hairs; lower leaves (2–4 pairs) opposite, the others alternate; internodes 3–20 (–28) mm long; lowest leaves much reduced, obovate, about 1 cm long, those just above them elliptic-obovate, 2.5–4.2 cm long, 8–14 mm wide, obtuse, the middle ones elliptic or oblong-elliptic, 3.5–5 cm long, 7–15 mm wide, obtuse to acutish, the upper lance-linear, 2.5–3 cm long, 3–6 mm wide, acute, all light green on both sides, tuberculate-hispid-ciliate, on both sides minutely hirsutulous along the veinlets, sometimes with a few stiff white hairs along costa beneath, 3- or obscurely 5-plinerved from near the base with whitish nerves and finely reticulate, the veinlets somewhat impressed on both sides; peduncle 1–3.5 cm long, pubescent like the stem; involucre 10 mm high, 2 cm wide (as pressed), the phyllaries loosely spreading or perhaps reflexed, 1.2–2 mm wide at base, inconspicuously 3-nerved; disk (as pressed) 1 cm high, 1.2–1.5 cm thick; rays neutral, oval or oval-oblong, rather deeply and irregularly 2–3-toothed (teeth up to 3 mm long), hirsute on tube above and hirsutulous on nerves of back, about 1.5–2 cm long, about 5–9 mm wide, about 12–

nerved; disk corollas purple on the teeth, glabrous except for the densely hirsutulous teeth, 5 mm long (tube 1 mm, throat cylindric-funnelform, 3 mm, teeth 1 mm long); pales rather soft and thin, scarious below, blackish-green toward the subherbaceous somewhat hooded tip, obtuse, carinate, ciliate on keel above and densely hirsutulous at apex, about 8 mm long; disk achenes (very immature) obovate, flatly compressed, 3 mm long, 1.7 mm wide, narrowly 2-margined, notched at apex, ciliate, pilose on the sides; pappus squamellae about 3–4 on each side of achene, deeply laciniate-ciliate, connate at base, 1–1.3 mm long, equaling or surpassing the long hairs at apex of achene; style branches hispid toward apex, the appendages short, deltoid, merely finely hispidulous, acutish.

Mexico: Majalca, Chihuahua, 6 Sept. 1935, *Harde LeSueur* 156 (type no. 837153, herb. Field Mus.; photog. and fragm., U. S. Nat. Herb.); same locality, 18–20 Aug. 1935, *LeSueur* 157 and 244 (Field Mus.).

Nearest *Helianthella mexicana* A. Gray, of San Luis Potosi and Coahuila. In that species the basal leaves are much longer than the cauline and drawn down into a petiole; the stems are less leafy, with the internodes mostly longer than the leaves; the leaves are more or less hispid on both faces as well as on the margin; and the phyllaries are hispid along the back above as well as on the margin.

Verbesina callilepis Blake, sp. nov.

Herba bipedalis; caulis simplex hispidulus usque ad medium foliatus, supra nudus; folia inferiora (4-juga) opposita obovata obtusa v. acuta basi cuneata sessilia non amplectentia crenato-serrata laete viridia supra scabre tuberculato-hispidula subtus in venis sparse hispidula, superiora 3 alterna multo minora oblanceolata; capitula 3 longe pedunculata mediocria radiata aurea; involucri late campanulati 7 mm alti 3-seriati phyllaria exteriora (2-seriata) subequalia cuneato-obovata v. spathulato-obovata herbacea subappressa obtusa v. rotundata subglabra v. in margine et sparse in dorso hispidula, interiora (radios subtendentia) paullo longiora spathulato-obovata rotundata submembranacea saturate viridia aurea-marginata supra erosa: radii 9, ca. 1.2 cm longi; achenia alata glabra epapposa.

Base not seen, but doubtless perennial; stem erect or erectish, slender, 68 cm high (including peduncles), subterete, striate, purplish toward base and there rather densely hispidulous with spreading few-celled hairs, green above and more sparsely hispidulous with shorter hairs, leafy about to middle; principal internodes 4–5 cm long; lowest pair of leaves obovate, 4 cm long, 2 cm wide; next 3 pairs similar but larger, 7.5–8 cm long, 3–3.8 cm wide, apiculate, gradually cuneate-narrowed to the sessile not clasping base, crenate-serrate above the subentire cuneate base (teeth about 9–11 pairs, 3–9 mm apart, under 1 mm high, callous-apiculate), plane, papery, light green with the costa purple-red at base above for half its length, evenly but not densely tuberculate-hispidulous above (the tuberculate bases of the hairs more conspicuous toward the margin), beneath somewhat paler green, smooth to the touch, very sparsely hispidulous on veins, featherveined, the lateral veins about 5–7 pairs, with the veinlets lightly prominulous-reticulate on both sides; upper leaves 3, alternate, remote, 2.3–5 cm long, 7–15 mm wide, oblanceolate, acute, followed by a couple of remote linear-oblanceolate bracts 1 cm long or less; heads 3, about 2.5 cm wide, single on slender terminal and subterminal remote peduncles 3.5–10.5 cm long, the subtending bracts minute, the peduncles naked, rather densely tuberculate-hispidulous below the heads; outer phyllaries 2–2.2 mm wide, the inner 2.2–2.8 mm wide; rays golden yellow, neutral, the tube hispidulous, 1.2 mm long, the lamina oval, 3-denticulate, sparsely hispidulous toward base below, 9-nerved; disk corollas (immature) golden, sparsely hispidulous on the short tube, 3.3 mm long; pales (immature) acute, sparsely hispidulous, with broad scarious margin below, above blackish green with golden yellow erect tip and margin; disk achenes (very immature) subquadrate-obovate, 1.7 mm long, 1.2 mm wide, narrowly winged, essentially glabrous, epappose.

Mexico: Infrequently scattered on tolerant pine slopes, Transition Zone, Los Cascarones, Rio Mayo, Chihuahua, 11 Sept. 1936, *H. S. Gentry* 2682 (type no. 862339, Field Museum; photograph and fragments, U. S. Nat. Herb.).

A species of the Section *Pterophyton,* nearest *Verbesina mixtecana* Brandeg. of Oaxaca. In *V. mixtecana* the stem is stipitate-glandular as well as spreading-hispid, the lowest leaves are narrowed into a petioliform base half as long as the blade, the leaf blades are smaller and much more densely pubescent with longer more or less spreading hairs, and the phyllaries are narrow, lance-oblong, and acute or subacuminate.

Coreopsis integra Blake, sp. nov.

Frutex dichotomus glaber, pedunculis et involucris subtomentoso-pilosis exceptis; folia opposita lineari-filiformia integra acuta sessilia 1.7–3 cm longa 0.5–0.8 mm lata; capitula mediocria solitaria pedunculata radiata aurea; involucri flavescenti-tomentoso-pilosi phyllaria exteriora 7–8 oblonga obtusa 4–5 mm longa, interiora 8 oblonga 9–10 mm longa; achenia longe ciliata in ventre dense pilosa in dorso subglabra; pappi aristae 2 dense antrorsim pilosae.

Shrub, 0.6 m high; stem and branches subterete, grayish brown, glabrous; branchlets greenish, striate, slender, glabrous; internodes 0.3–5 cm long, usually 1.5–4 cm; leaves acutely subulate-tipped, connate at base into a glabrous sheath 1 mm high, coriaceous, subterete in cross-section, above obscurely flattened, 1- or 3-sulcate, sordidly pilosulous along the impressed costa, beneath glabrous, rounded, (in the dried state more or less 1-sulcate), erect or ascending, light green, often with axillary fascicles; peduncles 1 or 2 at tips of branches, monocephalous, slender, pilose-subtomentose especially toward apex with flavescent hairs, naked or few-bracted, 2.3–3.2 cm long; heads 3–3.5 cm wide; disk 8–(fruit) 11 mm high, about 1 cm thick; involucre 2-seriate, 9–10 mm high, densely and flavescently subtomentose-pilose on the exposed surface of the phyllaries, the outer 1-seriate, 7–8, herbaceous, oblong, 4–5 mm long, 1.3–1.8 mm wide, obtuse, obscurely apiculate, 3-nerved, glabrescent above outside, inside densely stipitate-glandular and toward apex pilosulous, the inner 8, thick-membranous, oblong or oval-oblong, 3–4 mm wide, obtusely pointed, very many-nerved, deep brown, narrowly yellow-margined, glabrous or glabrate on margin, pilosulous toward apex inside; rays 8, neutral, golden yellow, the tube puberulous, 2.5 mm long, the lamina oval, 11-nerved, weekly 3-denticulate, 16 mm long, 6–8 mm wide; disk corollas golden yellow throughout, puberulous on upper part of tube, 5.8 mm long (tube 2 mm, throat funnelform, 2.8 mm long, teeth ovate, 1 mm); pales linear-lanceolate, 7 mm long, acuminate, about 5-nerved, pilose-ciliate, pilose dorsally; ray achenes (inane) linear, pilose-ciliate, glabrous on outer face, glabrous or pilose along midline on inner; disk achenes obcompressed, linear-oblong or linear-obovate, 4.8 mm long, 1.3 mm wide, blackish brown, densely long-pilose-ciliate on margins and at apex, on outer face glabrous or pilose toward margin, on inner face densely long-pilose; awns 2, densely upward-pilose, 2.8 mm long; style tips short-deltoid, hispidulous, apiculate.

Peru: On rocky eastern slope at San Carlos Mines, 6 miles west of Huallanca, Dept. Huánuco, alt. about 2745 meters (9000 ft.), 30 Sept. 1922, *J. F. Macbride & W. Featherstone* 2469 (type no. 518895, herb. Field Mus.; dupl. no. 1,198,895, U. S. Nat. Herb.).

Nearest *Coreopsis longula* Blake, from Chachapoyas, Peru, which has much longer and obtuse leaves, smaller heads (usually in 2's or 3's), much less pubescent involucre, and lance-subulate outer phyllaries.

Coreopsis sherffii Blake, sp. nov.

Frutex trichotome ramosus, ramis hexagonis glabratis, ramulis bifariam pilosulis; folia opposita internodiis saepius breviora ca. 2 cm longa, petiolo anguste cuneato-marginato ciliato, lamina ambitu deltoidea tripartita coriacea, lobis saepius anguste cuneatis 2–4 mm latis apice acute 2–3-dentatis, interdum oblongis v. oblongo-lanceolatis integris acutis; capitula mediocria usque ad 3 cm lata radiata aurea modice pedunculata in apicibus caulis et ramorum solitaria v. 3–5 cymosa; involucri glaberrimi v. solum basi ima pilosi phyllaria exteriora 8 crasse herbacea paullum obovato-oblonga obtusa v. acute apiculata 3.5–4.5 mm longa 1–2 mm lata, interiora duplo longiora membranacea oblonga rotundata saturate brunnea anguste aureo-marginata; achenia dense ciliata in ventre pilosa in dorso glabra; pappi aristae lanceolatae antrorsim pilosae.

Shrub ca. 7.5 dm high; stem subterete, striate, gray-barked, glabrous, 4 mm thick; branches of the year light brown, slender, hexagonal, pilosulous in 2 grooves, otherwise glabrous; internodes of branches mostly 2.5–4.5 cm. long, much exceeding the leaves, of the branchlets mostly 0.5–2 cm long and surpassed by the leaves; petioles very narrowly cuneate-margined to base, 5–11 mm long, pilose-ciliate with jointed hairs especially toward base, usually with fascicles in their axils, connate at base for 1–1.5 mm; blades deltoid in outline, 6–10 mm long, 6–12 mm wide, cuneate at base, 3-parted, the lobes mostly 4–7 mm long, 2–4 mm wide, plane, light green, the lateral usually acutely 2-toothed at apex, the terminal 3-toothed or 3-fid, sparsely short-pilose along costa above or usually glabrous; leaves of the branchlets mostly smaller and merely 3-fid, with linear-oblong or oblong-lanceolate entire acutely subulate-pointed lobes; peduncles 1-headed, densely spreading-pilose with flavescent hairs, 1–2.3 cm long; heads (as pressed) 2.7–3 cm wide; disk about 6–8 mm high, 7–10 mm thick (as pressed); involucre double, the outer phyllaries essentially 1-seriate, more or less obovate-oblong, appressed, pale green with 3 black vittae, the inner about the same number, 7–9 mm long, 3.5–4 mm wide, minutely erose ciliolate at the broadly rounded apex, densely brown-lineate; rays 8, neutral, golden yellow, subglabrous, the tube 1–1.5 mm long, the lamina broadly oval, shortly and bluntly about 3–4-dentate, 11-nerved, 11–14 mm long, about 7 mm wide; disk corollas golden yellow, glabrous, 4–4.5 mm long (tube 1.5 mm, throat campanulate or funnelform-campanulate, about 2 mm, teeth broadly ovate, 0.8 mm long); pales in flower oblong-obovate, obtuse, sometimes emarginate, about 4 mm long, short-ciliate toward apex, erect-pilose on middle of back, 5–7-vittate; ray achenes inane, oblong, sparsely short-ciliate above, glabrous on the faces, epappose, 2 mm long; disk achenes (submature) narrowly obovate-oblong, 4.5 mm long, 1.5 mm wide, densely long-ciliate, sparsely erect-pilose in middle on inner face, glabrous on outer, their pappus of 2 lanceolate basally antrorse-pilose, apically hispidulous awns 1.8 mm long; style branches with deltoid acute not penicillate-tufted hispidulous appendages.

Peru: Small neat very erect (2.5 ft.) clumps on steep grassy slopes, Chinchapalca, 6 miles above Mito, Dept. Huánuco, alt. about 2900 m (9500 ft.), 16–27 July 1922, *J. F. Macbride* & *W. Featherstone* 1596 (type no. 518100, herb. Field Mus.; dupl. no. 1,198,886, U. S. Nat. Herb.); in half-hanging ragged clumps on steep sunny slopes, with very brittle stems, Mito, Dept. Huánuco, alt. about 2745 m (9000 ft.), 8–22 July 1922, *Macbride* & *Featherstone* 1482 (Field Mus., U. S. Nat. Herb.).

This fine species, distinguished from most of its allies by the cutting of its foliage, appears to be nearest *Coreopsis microlepis* Blake & Sherff, from the Province of Chachapoyas, Peru. In that plant the upper leaves are very greatly reduced, so that the heads appear to be rather numerous in an essentially naked panicle; the leaves, although sometimes rather closely similar to those of *C. sherffii*, usually have the terminal segment of the ternately parted leaf so deeply 3-lobed as to give the appearance of a pinnately 5-lobed leaf; the heads are smaller; and the outer phyllaries are ovate or oblong-ovate, only 1.5–2 mm long, 0.6–0.8 mm wide. The dried heads of *C. sherffii* impart a deep orange color to the water in which they are boiled. The species is dedicated to my friend Dr. Earl E. Sherff, whose quarter century of botanical activity, devoted primarily to the study of the Coreopsidinae, has resulted in revisions of the genera *Coreopsis*, *Bidens* (in press), *Isostigma*, *Cosmos*, *Tetramolopium*, *Lipochaeta*, *Dubautia*, and *Railliardia*, and in papers on various other groups of plants.

Calea marginata Blake, nom. nov.

Meyeria longifolia DC. Prodr. **5**: 671. 1836.

Calea longifolia Baker in Mart. Fl. Bras. 6^3: 260. 1884. Not *C. longifolia* Gardn. 1848.

The name *longifolia* is not available for this species, having been used by Gardner for a species described from Goyaz. The new name assigned refers to the conspicuous thickened margins of the leaves.

Vasquezia oppositifolia (Lag.) Blake.

Villanova oppositifolia Lag. Nov. Gen. & Sp. 31. 1816.

Vasquezia titicacensis (Meyen & Walp.) Blake.

Wedelia titicacensis Meyen & Walp. Nov. Act. Acad. Caes. Leop.-Carol. Nat. Cur. **19**: Suppl. **1**: 269. 1843.

Villanova titicacensis Walp. Nov. Act. Acad. Caes. Leop.-Carol. Nat. Cur. **19**: Suppl. **1**: 206. 1843.

The name *Villanova* Lag. (1816) being preoccupied by *Villanova* Orteg.

(1797), it seems necessary to replace it by *Vasquezia* Phil. (1860), as has already been done by Rydberg (in the spelling *Vasquesia*). The few species of the genus are closely related, and require a revision based on examination of the types. The two names here proposed, together with *V. anemonifolia* (H.B.K.) Blake,[6] represent the only South American species that seem to be distinct on the basis of a preliminary survey of the genus. The name *Vasquezia titicacensis* (Meyen & Walp.) Blake has already appeared in print,[7] but without the name-bringing synonym necessary for proper publication.

The proper spelling of Philippi's generic name is uncertain. It occurs five times in his Florula Atacamensis (p. 1, 31 (twice), 62, and on pl. 5). In the formal description of the new genus, and in every other case except one, the name is spelled *Vazquezia;* in the description of the new species, it is *Vasquezia.* Years later, when treating his genus as a synonym of *Villanova,* Philippi[8] twice used the spelling *Vasquezia.* The derivation of the name, obviously personal, is nowhere explained. In view of Philippi's later use of the spelling *Vasquezia,* and particularly since there was an A. Vasquez,[9] for whom the genus was presumably named, who was publishing chemical analyses of plants at the time Philippi was preparing his Florula Atacamensis, it seems advisable to adopt the form *Vasquezia.* In any case, there is no evident excuse for the spelling *Vasquesia* used by Rydberg in the North American Flora; and Philippi's single species was *V. biternata,* not *V. biterna* as given by Rydberg. I am indebted to Dr. Ivan M. Johnston for assistance in this matter.

Helenium arizonicum Blake, sp. nov.

Bienne paene glabrum, radice perpendiculato anguste conico; caulis validus 5.5 dm altus foliosus ubique erecto-ramosus; folia basalia anguste oblanceolata acuminata in petiolum multo breviorem anguste marginatum angustata irregulariter sinuato-dentata, caulina anguste lanceolata v. lineari-lanceolata acuminata integra basi dilatata breviter decurrente sessilia; capitula mediocria ca. 7–15 per caulem in apicibus caulis et ramorum solitaria; radii flavi feminei ca. 12 mm longi; discus subglobosus purpureo-brunneus 1.5–2 cm diam.; receptaculum ovoideum obtusiusculum; achenia 2 mm longa in costis pilosa; pappi paleae ca. 2 mm longae e basi lanceolata longe aristatae.

Root biennial, vertical, slenderly conic, about 10 cm long, 1 cm thick above, with few strong rootlets; stem solitary, erect, stout, striate-angled and sulcate, greenish-white, erect-branched essentially from base to apex, obscurely incurved-puberulous below, nearly glabrous above, dotted with yellow-brown glands; lower leaves 8–10 cm long (including petiole, this about 2 cm long, narrowly margined, at base ampliate, purplish, and about 7-nerved), 6–10 mm wide, triplinerved, essentially glabrous, densely glandu-

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[6] Contr. U. S. Nat. Herb. **26**: 261. 1930.

[7] Herrera, Pl. Cuzc. Herrer. (Estud. Fl. Depart. Cuzco) 205. 1930.

[8] Cat. Pl. Itin. Tarapaca 47. 1891.

[9] Listed in the bibliography in Reiche, Grundz. Pflanzenverbr. Chile (Veg. der Erde **8**:) 45. 1907.

lar-punctate on both sides, pale green; stem leaves numerous, much exceeding the internodes, the larger 6.5–13 cm long, 4–10 mm wide, long-acuminate, at base usually abruptly widened (up to 1 cm wide), semi-amplexicaul, and decurrent for 1–4 mm, the uppermost linear or linear-subulate, 2.5–3.5 cm long; peduncles solitary at tips of stem and branches, enlarged just below the head, many-sulcate, 2–11 cm long; involucre soon reflexed, the phyllaries about 14, narrowly triangular, acuminate, 7–9 mm long, 1–1.5 mm wide at base, sparsely pilose below, densely so toward tip, punctate; disk subglobose, 12–17 mm high, 15–20 mm thick; submature receptacle 5 mm. long, 3 mm thick; rays about 12 or more, cuneate, deeply 3-lobed (lobes blunt, 2.5–3.3 mm long), 9–11-nerved, 12–13 mm long, 6–7 mm wide, densely gland-dotted outside; disk corollas yellow, tipped with purple-brown, short-pilose on teeth with several-celled hairs, 3.4 mm long (tube 0.2 mm, throat thick-cylindric, 2.6 mm, teeth ovate, 0.6 mm long); disk achenes erect-pilose on the ribs with rufescent hairs, sessile-glandular between the ribs, 2 mm long; pappus paleae 6–7, subequal, 1.8–2.3 mm long, the body lanceolate or lance-ovate, 0.6–0.8 mm long, gradually narrowed into the awn.

Arizona: Near Mormon Lake, about 20 miles southeast of Flagstaff, Coconino Co., 17 June 1892, *J. W. Toumey* 681 (type no. 212077, U.S. Nat. Herb.). Additional specimen in the Gray Herbarium, with same number and locality, but dated 18 July 1892.

Both the specimens cited have been identified as *Helenium bigelovii* A. Gray, the type being so labeled in the hand of the late Dr. Rydberg. *Helenium bigelovii*, which ranges from Oregon to southern California and is not known from Arizona (Rydberg's record in the North American Flora being presumably based on this specimen), is a perennial with short nearly horizontal rootstock, simply or above few-branched stems terminated by very long-peduncled heads, entire long-petioled basal leaves, and usually broader stem leaves not abruptly ampliated at base. In Rydberg's key in "North American Flora" *Helenium arizonicum* runs down to the group containing *H. linifolium* Rydb. and *H. laciniatum* A. Gray, both of which have a slender annual root, much smaller heads, and various other distinctive characters.

Culcitium ovatum (Schlecht.) Blake.

Gnaphalium uniflorum Lam. Encyl. **2**: 752. 1788. Not *G. uniflorum* Mill. 1768.

Lasiocephalus ovatus Schlecht. Ges. Naturf. Fr. Berl. Mag. **8**: 309. 1818.

Culcitium reflexum H. B. K. Nov. Gen. & Sp. **4**: 171. *pl. 362.* 1820.

Culcitium uniflorum (Lam.) Hieron. Bot. Jahrb. Engl. **19**: 63. 1894.

The genus *Lasiocephalus* Schlecht., with the two species *L. ovatus* and *L. lingulatus* Schlecht., was published in 1818.[10] Schlechtendal remarked

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[10] The date assigned in the Index Kewensis is 1814. In Dalla Torre & Harms' Genera Siphonogamarum the data 1818 is given on p. 562, and corrected on p. 637 to 1814. The title page date of vol. 8 of the Magazine is 1818. Schlechtendal's paper appeared in the "Viertes Quartal 1814. October, November, December," containing p. 241–312. As this number includes an article "Über die Witterung des Jahres 1816," beginning on p. 259, it is obvious that the number could not have been published in 1814, and, in the apparent absence of any evidence to the contrary, the title page date 1818 must be accepted.

that his material consisted of single branches from the collection of Humboldt and Bonpland furnished him by Prof. Willdenow, "der diese Gattung zuerst untersuchte, den Character essentialis feststellte und die Nahmen des Genus und der Species wählte." Despite this remark, the names have universally been attributed to Schlechtendal, and it seems as well to follow custom in this matter, since Willdenow's name is not further mentioned in connection with the descriptions. Lessing (1832), by some error, cites the name as *Oresigonia* Schlecht.

The genus *Lasiocephalus* has been referred by authors to *Culcitium* Humb. & Bonpl. (1809), but no attempt to identify Schlechtendal's two species seems to have been made. His first species, *L. ovatus*, from "monte Pichincha," is obviously the same as the later *Culcitium reflexum* H. B. K., described as from Mt. Antisana. His second *L. lingulatus*, from "America meridionali," is not so readily identified. It is natural to look for it among the six species of *Culcitium* described in the Nova Genera et Species. Among these, only *C. ledifolium* can possibly be identical. It is described as with simple, 1-flowered stem, whereas *L. lingulatum* is described as branching and with heads sometimes almost forming a panicle, sometimes solitary, binate, ternate, etc. On the whole, Schlechtendal's description is perhaps more suggestive of *Culcitium adscendens* Benth. than of *C. ledifolium*, which is known to me only from the original description. Hieronymus (l.c.), on the basis of an original specimen in the Berlin Herbarium, has referred *C. ledifolium* H. B. K. to *C. uniflorum* (*C. reflexum*), but the original descriptions indicate that the plants are specifically different, and one cannot help suspecting that some error is involved. Weddell (Chlor. And. **1**: 141. 1856), who examined original specimens of both *C. reflexum* and *C. ledifolium*, kept them distinct, and his descriptions indicate that this course was correct. Schlechtendal's descriptions of *L. ovatus* and *L. lingulatus* surely refer to two different species. Under the circumstances, it seems best to transfer Schlechtendal's second name, which has obvious priority, to the genus *Culcitium* for convenience in handling it, without attempting to identify it at present with any later described species. It is difficult to reconcile his account of the variability of the inflorescence with his statement that he had only single branches of the species described; perhaps this item came from notes of Willdenow.

Culcitium lingulatum (Schlecht.) Blake.

Lasiocephalus lingulatus Schlecht. Ges. Naturf. Fr. Berl. Mag. **8**: 309. 1818.

Hieracium dysonymum Blake, nom. nov.

Hieracium junceum Fries, Symb. Hist. Hierac. 144. 1848. Not *H. junceum* Bernh. Syst. Verz. Erf. 137. 1800.

Fries' name for this little known Mexican plant is preoccupied by Bernhardi's use of the same name, based on his transfer of *Chondrilla juncea* L. to *Hieracium*. I am indebted to the Lloyd Library for a copy of the entry from Bernhardi's work, which is not in any Washington library.

Hieracium junceum Fries was originally based on material collected by Liebmann in pine woods at Cambre de Ixlepec, Sierra de Oaxaca, Mexico, altitude 3050 meters (10,000 ft.). Later Fries[11] cited additional material from "Sierra de Moucayo (*Herb. Mart.* varietas angustifolia"). It is fairly clear from the general style of Fries' treatment that he was not formally naming a var. *angustifolia* here, but was merely stating that this specimen was a narrow-leaved form, and in any case no description was given. Zahn,[12] however, lists "subvar. angustifolium Fr. Epicr. 149," and adds the character "folis angustioribus, acheniis distincte attenuatis," although he does not indicate that he had examined material. He gives the locality as "Sierra de Moncayo (ex Fr. l.c.)."

BOTANY.—*A species of* Tridentaria *preying on* Difflugia constricta.[1]

CHARLES DRECHSLER, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry.

In earlier papers I described four fungi that subsist by the destruction of testaceous rhizopods inhabiting different vegetable materials undergoing decomposition in contact with the soil. Two of the fungi (4), *Cochlonema cylindricum,* endoparasitic on *Euglypha denticulata* Brown, and *Zoopage tryphera,* predacious on *Geococcus vulgaris* Francé, belong in the Zoopagaceae, a family of conidial Phycomycetes living for the most part on terricolous amoebae. The other two fungi both belong in an interrelated series of Hyphomycetes which has become known more especially, perhaps, through some widely distributed and comparatively robust members variously adapted for the capture of free-living nematodes. One of the two mucedinous forms in question (3), *Dactylella passalopaga,* preys on *G. vulgaris* and *E. laevis* Perty; while the other (2), *Pedilospora dactylopaga,* is predacious in *Difflugia globulosa* Duj. and *Trinema enchelys* Ehrenb.

A fungus strongly reminiscent of *Pedilospora dactylopaga* appeared recently in some old maizemeal agar plate cultures of *Pythium Butleri* Subr. to each of which had been added a small quantity of leaf mold collected in deciduous woods with an undergrowth of coarse herbaceous weeds. No special organs of capture could be discovered on the slender hyphae that made up its scanty mycelium. Nevertheless, when filaments on the surface of the agar substratum were traced for any considerable distance, they were found here and there to pass along the oral end of a shelled rhizopod, through the mouth of

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[11] Epicr. Hierac. 149. 1862.

[12] Pflanzenreich (Heft 79) **4**:^{280} 1109. 1922.

[1] Received June 20, 1937.

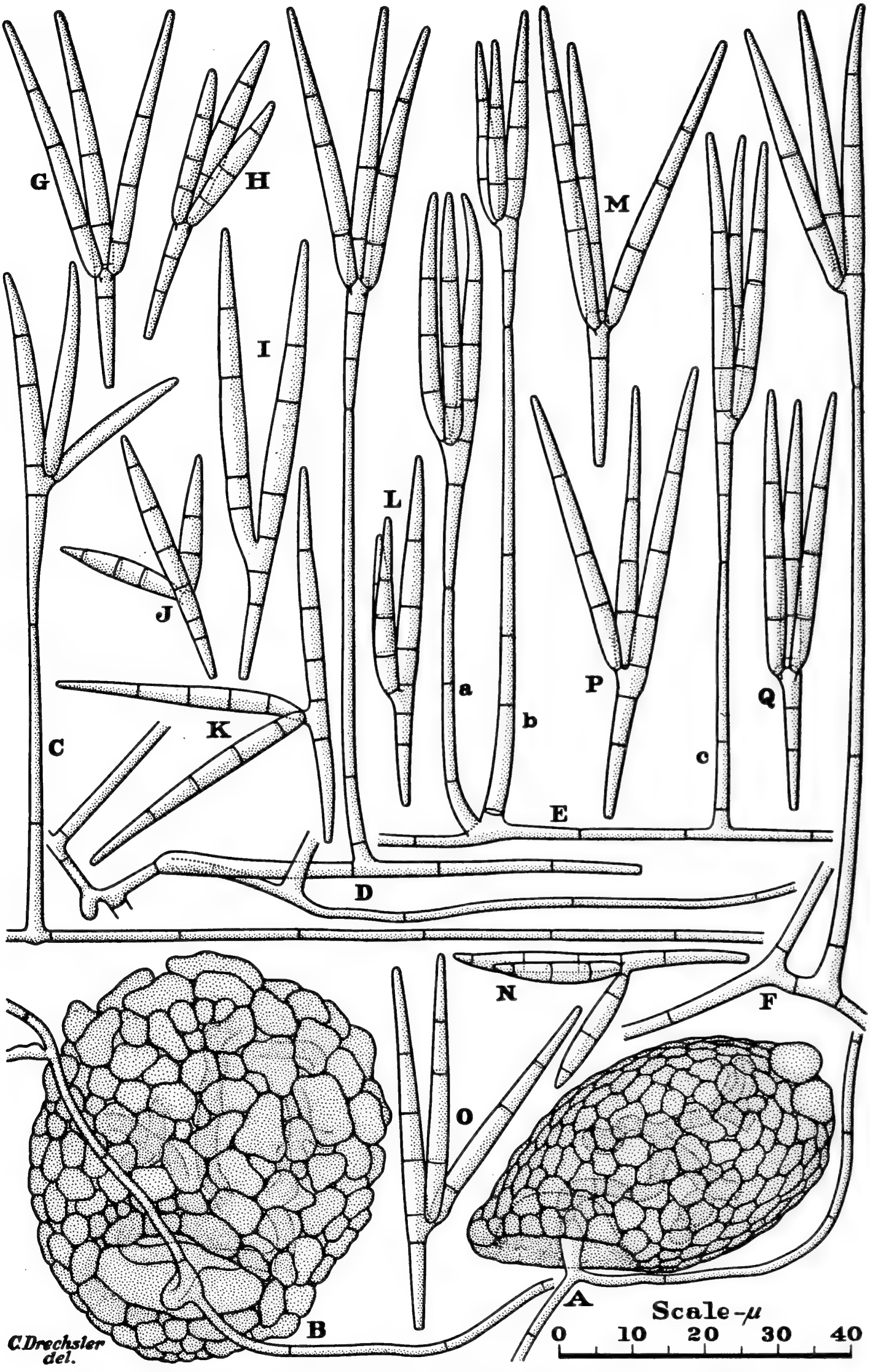

FIG. 1.—*Tridentaria carnivora.* For explanatory legend see opposite page.

which invariably a branch entered to ramify irregularly within the protoplasmic interior (Fig. 1, A, B). Manifestly the ramifying elements functioned in assimilating the fleshy contents since some of the invaded animals had been depleted to such an extent that nothing remained but the more or less crusty tests. Despite the sluggishness of their locomotion the animals presumably endured invasion and appropriation of their digestible substance only because they were prevented from escaping. Appearances indicated that capture very probably was effected through adhesion of the hypha to the extruded sarcode, although direct optical evidence of an adhesive secretion on the mycelial filaments has not yet been obtained.

In view of its normally slanting posture, much like that of *Trinema enchelys*, of its usually brownish or light brownish coloration, of its compressed ovoid shape, its inflexed mouth and its somewhat protruded anterior lip, the rhizopod destroyed by the fungus is clearly referable to the widespread *Difflugia constricta* (Ehrenb.) Leidy. Most of the specimens encountered measured about 55μ in length from anterior lip to fundus (Fig. 1, A), about 45 μ in width as viewed flatways from above or below (Fig. 1, B), and about 30 μ in thickness from front to rear at a right angle to the inclined axis (Fig. 1, A). In dimensions, therefore, they were comparable to the smaller spineless individuals of *D. constricta* figured by Leidy (11: plate 18, figs. 12, 14, 17, 18, 19,), by Penard (14: page 212, fig. 37), and by Cash (1: plate 19, figs. 14–16).

The conidiophores (Fig. 1, C; D; E, *a-c;* F) produced by the fungus in small numbers, show general similarity to those of *Pedilospora dactylopaga* with respect to stature, and like them also, bear curiously forked solitary conidia. A very pronounced difference however is at once apparent in that the spores terminate regularly in three rather than in two prongs. One of the prongs represents merely a prolongation of the basal portion of the conidium, with which portion it continues the axis of the conidiophore and forms an element analogous

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FIG. 1.—*Tridentaria carnivora*, drawn from material developed in mixed culture on maizemeal agar, with the aid of a camera lucida, at a uniform magnification; ×1000 throughout. A.—Portion of hypha with a captured specimen of *Difflugia constricta* in lateral view. B.—Portion of hypha with a captured specimen of *D. constricta* in oral-posterior aspect. C.—Portion of hypha bearing a conidiophore with conidium attached. D.—Portion of mycelium with an old conidiophore that has declined to the substratum; from the prostrate conidiophore has arisen a secondary conidiophore whereon is borne a conidium. E.—Portion of hypha with three conidiophores, each bearing a conidium. F.—Portion of mycelium from which has arisen a relatively tall conidiophore whereon a conidium has been produced. G–Q.—Conidia, showing variations in size, shape and arrangement of component elements; all being of the usual three-pronged type except the two-pronged specimen I.

to the entire conidium of *Dactylella passalopaga*. At a distance from its base often equal to about one-third of its length, this axial element bears laterally a broad process that immediately divides dichotomously in a transverse plane to provide the other two prongs. Though the paired prongs are sometimes rather widely divaricate especially in conidia that have been in contact with the substratum for some time (Fig. 1, J, K, N, O), they are more usually directed upward at narrowly divergent angles to one another as well as to the axial prong (Fig. 1, D; E, *a-c;* F, G-I; L; M; P; Q).

From the manner of its development the three-pronged conidium obviously is symmetrical with respect to only one plane, that being the plane passing through the axial element and bisecting the angle between the paired prongs. When viewed lengthwise from this plane, the spore (Fig. 1, G, H, Q), especially if considered together with the hypha supporting it, presents an appearance suggestive of a trident. The similitude is of consequence in encouraging, or, perhaps, even necessitating assignment of the fungus to *Tridentaria*, a genus erected by Preuss (15) in 1852 on a single species found by him on moist disintegrating stems of *Brassica oleracea* L. and described very sketchily under the name *T. alba*. The diagnosis of the genus likewise is exceedingly brief, consisting of only a dozen words. There can be no question, at least, that the conidia were intended to be described as simple and as being united in the form of a trident, but whether the conidiophore was considered as being included in the union remains open to speculation.

Owing to its inadequate characterization the genus has not been at all kindly received by compilers. Saccardo (16), who set forth the conidiophores as terminating in simple conidia joined together in the form of a trident—an arrangement certainly not easy to relate to ordinary modes of development—added the comment that the genus had been imperfectly and obscurely described by Preuss, and hence was dubious. Lindau (12) in his first treatment of the genus characterized it in part as having very short conidiophores, and as bearing on these conidiophores solitary triradiate conidia. The portion of the description concerning the shortness of the conidiophores appears to have been based primarily on inference. On the other hand, the reference to production of solitary triradiate conidia instead of simple conidia joined in the form of a trident, is evidently to be explained as expressive of an interpretation—I believe a justifiable interpretation—whereby the individual spore was looked upon as a more inclusive unit than originally. One is tempted to submit, possibly, that a structure held to resemble a trident might have been more accurately described by words meaning "three-pronged" or "three-tined" (as, for example "dreizackig" or "dreizinkig") than by the expression "3 strahlige"; since the proximal part corresponding to the shaft of a trident constitutes obviously a fourth radial and thus, strictly speaking, makes for a quadriradiate condition.

In his key to the genera of the Hyalostaurosporae in a later work (13: page 535) Lindau, indeed, referred to the conidia of *Tridentaria* as three-pronged and treated them as analogous in outward make-up to the two-pronged conidia of Pedilospora. Then, however, somewhat inconsistently, in defining the genus (13: page 543) he characterized the conidia as being simple and as concreted in the form of a trident,—exactly, therefore, as Saccardo had characterized them previously. Complaining, not without reason, that it was impossible to gather from Preuss' description how the conidia really look, he held that the genus might better have been rejected,—a course from which he was dissuaded by the small membership of the Mucedinaceae-Staurosporae, and the hope of arousing some profitable attention. Since its erection *Tridentaria* has had committed to it only one additional species, that being *T. setigera* published by Grove (8) in 1912. The original account of this species was accompanied by figures of compound branching structures which from the description were evidently considered as being composed individually of a three-celled conidiophore tapering toward its base and widening like a fan toward its apex, together with three conidia palmately united at their bases and collectively flanked on both sides by an acute seta. As Preuss made no mention of setae in his diagnosis of *Tridentaria*, the authors dealing with *T. setigera* in the "Sylloge fungorum" (17) quite properly raised the question whether the fungus might not perhaps better be regarded as a species of *Titaea*. The similarity of the branching structures to the conidia of *Tetracladium marchalianum* De Wild., especially as figured in a recent paper by Karling (10), suggests an alternative disposition, if, indeed, the distinction between *Titaea* and *Tetracladium* can still be maintained.

Undoubtedly the fungus preying on *Difflugia constricta* fits into *Tridentaria* better than does *T. setigera;* and better, too, than it fits into any other genus. Though its conidial prongs do not lie in one plane, and though the shoulders of its lateral prongs are comparatively narrow, yet the general resemblance of its reproductive apparatus to a trident seem more realistically suggestive than the resemblances underlying most of the names applied to fungi. The structural design here is conspicuously different from the triradiate design that was set forth by Fresenius (6) as characteristic of the conidia of *Trinacrium subtle* Riess, and that accordingly may be held more or less typical of the genus erected on this species. To be sure, in application *Trinacrium* has not been strictly limited to triradiate forms, having been made to include *T. subtropicale* Speg. with quadriradiate conidia, as well as *T. tropicale* Speg. with conidia composed mostly of three or four radial elements whereof the proximal one is pedicelliform and shorter than the others. The former species differs markedly from the fungus destructive to *D. constricta* in the greater width (5 to 6μ) and cruciate arrangement of its conidial branches, while the latter presents equally decisive differences in its shorter ascending conidiophores and shorter conidial radiants. The genus *Tetracium* P. Henn. with quadriradiate, elongate-fusoid, pluriseptate conidia may be dismissed from consideration, for although originally described as presumably eligible for inclusion in the Mucedineae, Höhnel's study (9) of its type species, *T. Aurantii* P. Henn., refers it definitely to the Tuberculariaceae.

From its thoroughgoing similarity in biological relationship and reproductive habit to some of the Hyphomycetes known to prey on animals, the fungus under discussion must be regarded as unquestionably a member of the same predacious series. Its distinctive conidial apparatus is easily derived from that of the genus *Dactylella* Grove through branching of the solitary conidium; thereby offering an analogy to *Pedilospora dactylopaga* and to the nematode-capturing species I have described elsewhere (5) under the name *Triposporina aphanopaga*. In *P. dactylopaga* such derivation comes about through a single bifurcation of a narrow elongate conidium of the type found in *Dactylella passolopaga* and *D. leptospora* Drechsl. (5), provided that the distal elements or prongs be oriented parallel to one another; in the present fungus a similarly narrow elongate conidium bears a lateral branch that immediately bifurcates into two prongs usually diverging little from the axial prong; in *T. aphanopaga,* on the other hand, a swollen conidium of the type produced in *D. ellipsospora* Grove (7), *D. gephyropaga* Drechsl. (5) and *D. bembicodes* Drechsl. (5), bifurcates twice successively, the four distal apices diverging widely from one another. As Preuss attributed to *Tridentaria alba* "Sporis oblongis vel clavaeformibus" it may be inferred that what would now be regarded as the complete conidium of his species could be derived through appropriate branching of a clavate spore of the type represented, for example, in *D. asthenopaga* Drechsl. (5).

In any event the clavate elements ascribed to the type species of *Tridentaria* sets it apart from the fungus subsisting on *Difflugia constricta.* Since this fungus appears specifically distinct also from the few other quadriradiate species in the Mucedinaceae-Staurosporae, it is described as new under a name suggestive of its predacious character.

Tridentaria carnivora sp. nov.

Mycelium sparsum, effusum; hyphis sterilibus hyalinis, parce ramosis, mediocriter septatis, 1–2μ crassis, hac illac animalcula testacea adhaerendo capientibus, ramulum in orem cujusque intrudentibus, hyphas intus evolventibus quae carnem assumunt. Hyphae fertiles sparsae, hyalinae, septatae, erectae, simplices sed post maturitatem procidentes diende tum saepius hyphas fertilis ordinis secundi proferentes, plerumque 32–85μ altae, basi 1.7–3.3μ crassae, sursum leviter fastigatae, apice .9–1.4μ crassae, in unicum conidium abeuntes; conidiis hyalinis, vulgo ex tribus partibus ad instar fuscinae compositis,—parte longissima quae lineam hyphae fertilis producit elongato-fusoidea, recta vel leviter curvata, 5–8- loculari, 35–63μ longa, 2.8–3.8μ crassa, deorsum in hastili 1–3- loculari, 12–21μ longo, sursum in dente 3–5- loculari, 23–43μ longo consistente, inter hastile et dentem unum ramulum lateralem ferente; hoc ramulo infimo furcato atque in duos dentes 1–6- loculares 17–44μ longos apicem versus attenuatos vulgo abeunte, rarius simplici manente tum conidium bidens faciente.

Difflugiam constrictam capiens consumensque habitat in humo silvestri prope Beltsville, Maryland.

Mycelium scanty, spreading; the vegetative hyphae hyaline, sparingly branched, septate at moderate intervals, 1 to 2μ wide, here and there capturing testaceous rhizopods by adhesion, thrusting a branch into the mouth of each captive and giving rise inside to assimilative hyphae that appropriate the protoplasmic contents. Conidiophores sparsely scattered, hyaline, septate, erect, typically simple though after maturity declining to the substratum and then often putting forth secondary fertile hyphae, in any case mostly 32 to 85μ (average 60μ) high, 1.7 to 3.3μ (average 2.5μ) wide at the base, tapering slightly upward, .9 to 1.4μ (average 1.2μ) wide at the tip, terminating in a single conidium. Conidia hyaline, usually composed of three elements in trident-like arrangement,—the longest element elongate-fusoid, straight or slightly curved, divided by septa into 5 to 8 (average 6.4) cells, measuring 35 to 63μ (average 52μ) in length, 2.8 to 3.8μ (average 3.2μ) in width, its axis prolonging the axis of the supporting hypha, its proximal portion of 1 to 3 cells forming a shaft 12 to 21μ (average 18μ) long, its distal portion of 3 to 5 cells forming a somewhat tapering prong 23 to 43μ (average 34μ) long, between shaft and prong bearing a lateral spur; the spur usually bifurcating near its base into two prongs, each divided by septa into 1 to 6 (average 4) cells and measuring 17 to 44μ (average 34μ) in length; occasional elongation of spur directly into a simple branch leading to development of atypical two-pronged conidia.

Capturing and consuming *Difflugia constricta,* it occurs in leaf mold near Beltsville, Md.

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BOTANY.—*Notes on the genus* Staurogyne.[1] E. C. Leonard, U. S. National Museum. (Communicated by William R. Maxon.)

Staurogyne, a genus of Acanthaceae, subfamily Nelsonioideae, was described[2] by Wallich in 1831. He published at that time a single species, *S. argentea,* citing as type a specimen collected in Sillet by F. D. Silva. The following year Nees established[3] the genus *Ebermaiera,* now considered a synonym of *Staurogyne,* describing four species, *E. humilis* and *E. thyrsoidea* from Burma, *E. axillaris* from Penang, and *E. mandioccana* from Brazil. Up to the present, various authors have recognized about 80 species. The majority of these however, were published under *Ebermaiera,* and although Kuntze[4] in

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 5, 1937.

[2] Pl. Asiat. Rar. **2**: 80. *pl. 186,* 1831.

[3] Pl. Asiat. Rar. **3**: 75. 1832.

[4] Rev. Gen. Pl. **2**: 497. 1891.

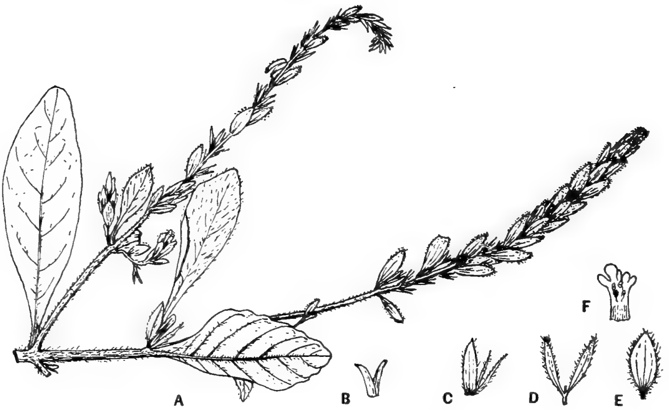

FIG. 1.—*Staurogyne agrestis* Leonard, sp. nov. A, portion of horizontal branch; B, capsule; C, the posterior calyx lobe and one of the lateral and anterior pairs; D, bractlets; E, bract; F, corolla, opened to show stamens. (All nat. size.)

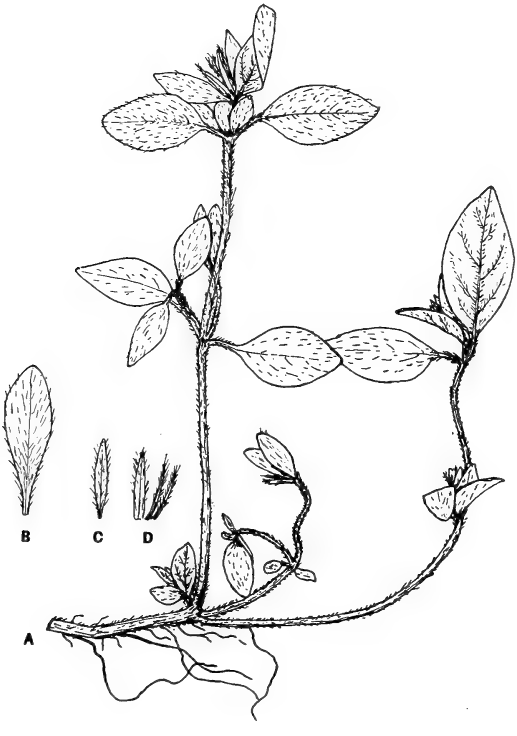

FIG. 2.—*Staurogyne trinitensis* Leonard, sp. nov. A, portion of plant, nat. size; B, bract; C, bractlet; D, posterior calyx segment and one of the lateral and anterior pairs. (B, C, D, twice nat. size.)

1891 made numerous transfers, a considerable number remain to be reclassified.

The genus *Staurogyne* consists of shrubby or herbaceous plants with usually yellow or purplish flowers borne in spikes or narrow racemes. It is readily distinguished from other genera of the subfamily by its 4 stamens (usually with a minute sterile fifth stamen or staminode) and by its irregular calyx, the posterior segment being broader and usually longer than the others.

The species of this genus are widely distributed in the tropics of both hemispheres; in America they are most numerous in the mountainous regions of eastern Brazil. Unfortunately many are still unrepresented in America herbaria.

Two new species are described in the present paper, one from Panama and Nicaragua, the other from Trinidad. Also, three are transferred from *Ebermaiera* to *Staurogyne*, one is renamed, and another is reduced to synonymy.

Staurogyne agrestis Leonard, sp. nov.

Herba; caules erecti vel procumbentes, subteretes, pilosi; folia ovata vel oblongo-ovata, apice obtusa, basi angustata, parce pilosa, petiolis pilosis; spicae terminales; bracteae oblongo-ovatae, apice acutae, basi angustatae, pilosae et glanduloso-pubescentes; bracteolae lanceolatae; calycis laciniae inaequales, pilosae et glanduloso-pubescentes, posteriore oblongo-lanceolata, 3-nervia, ceteris linearibus, acutis, 1-nerviis; corolla glabra, labio superiore bilobo, inferiore trilobo, lobis rotundatis; capsula oblonga, glabra vel apice minute pubescens; semina minuta, ovoidea, minute papillosa.

A low herb, becoming subligneous at base; stems much branched, erect or procumbent, subterete, often purplish, the lowermost branches spreading, up to 20 cm long, curved upward at tip, pilose, the hairs up to 1.5 mm long; petioles up to 7 mm long, pilose; leaf blades ovate to oblong-ovate, up to 3.5 cm long and 2 cm wide, obtuse at apex, narrowed at base, sometimes purplish with age, sparingly pilose, the hairs of the lower surface confined chiefly to the costa and lateral veins (6 to 9 pairs); flowers borne in narrow spikelike racemes (these terminating all the branches), crowded or the lowermost distant, the rachis pilose; bracts oblong-ovate, the lowermost about 10 mm long and 5 mm wide, thence successively smaller upward, acute at tip, narrowed at base, faintly 3-nerved, appressed-pilose or subglabrous above, the lower surface pubescent with short straight glandular hairs about 0.25 mm long or the costa bearing a few longer slender eglandular ones; pedicels up to 1.5 mm long, bearing at middle a pair of 1-nerved, lanceolate bractlets 5 mm long and 1.5 mm wide; calyx segments unequal, the posterior segment oblong-lanceolate, 5 mm long and 1 mm wide, 3-nerved, the anterior pair linear, 4.5 mm long, 0.5 mm wide, 1-nerved, the lateral pair subulate, 4 mm long and about 0.25 mm wide, 1-nerved, all pilose or shortly glandular-pubescent; corolla 5 or 6 mm long, glabrous, purple (?), the tube 1 mm in diameter below middle, thence enlarged to 1.5 mm at throat, the 2 upper lobes rounded, about 1 mm wide, the lower middle lobe obovate, 1.5 mm long, 1.75 mm wide, the lateral lobes oval and somewhat smaller; filaments

1 mm long, glabrous; anther lobes 0.5 mm long; staminode slender, 0.5 mm long; style 2 mm long, glabrous; capsule oblong, 1.5 mm wide at base, gradually narrowed to 0.75 mm near tip, glabrous or bearing a few minute hairs at tip; seeds ovoid, light brown, 0.5 mm long, minutely roughened.

Type in the U. S. National Herbarium, no. 1,225,111, collected in a wet field between Matías Hernández and Juan Díaz, Province of Panamá, Panamá, January 21, 1924, by Paul C. Standley (no. 31936).A plant collected in Nicaragua by Charles Wright on the U. S. North Pacific Exploring Expedition under Commanders Ringgold and Rodgers is of this species.

Staurogyne agrestis is probably a close relative of *S. repens* (Nees) Kuntze, from Matto Grosso, Brazil, but differs in its bushy habit and much larger leaves. The leaves of *S. repens* are described as oblong-lanceolate, 6 to 7 lines long and 2 to 2½ lines wide, and its habit as repent, but in *S. agrestis* we have a bushy herb with possibly the lower branches procumbent and the leaves ovate to oblong-ovate and as much as 3.5 cm long and 2 cm wide. The inflorescence, bracts, corollas, capsules, and pubescence of the two species are similar, however.

Staurogyne trinitensis Leonard, sp. nov.

Herba; caules decumbentes, pilosi; folia ovata, apice obtusa, basi angustata, utrinque parce pilosa; racemi compacti, breves, terminales; bracteae oblongae, apice acutae vel subobtusae, parce pilosae; bracteolael anceolatae, apice acutae, pilosae; calycis laciniae inaequales, pilosae, ciliatae, posteriore lineari, ceteris subulatis; corolla parva, glabra, labio superiore bilobo, inferiore trilobo, lobis rotundatis; capsula glabra.

Decumbent herb; stems about 30 cm long, rooting at the lower nodes, pilose, the hairs up to 1 mm long; leaf blades ovate, up to 3.5 cm long and 1.7 cm wide, obtuse at apex, narrowed at base, thin, sparingly pilose on both surfaces, the hairs of the lower surface confined chiefly to costa and lateral veins (4 or 5 pairs); petioles up to 1 cm long, pilose; flowers borne in short terminal spikelike racemes up to 1.5 cm long; bracts oblong, 7 to 12 mm long, 1.5 to 3 mm wide, acute to subobtuse at apex, sparingly pilose; pedicels 0.5 to 1 mm. long, bearing at middle a pair of lanceolate pilose bractlets 5 to 6 mm long and 1 mm wide, acute at apex; calyx segments 5 to 6 mm long, pilose and ciliate, the hairs up to 1 mm long, the posterior segment linear, about 0.7 mm wide, 3-nerved, the others subulate, barely 0.5 mm wide near base, 1-nerved; corolla 5 or 6 mm long, glabrous, the lobes of the upper lip rounded, about 1 mm wide, the middle lower lobe ovate, about 1 mm wide, the two lateral ones similar but somewhat smaller; filaments 2 mm long, glabrous; anther lobes barely 0.5 mm broad; style 2.5 mm long, glabrous; capsule (immature) glabrous, about 1 cm long.

Type in the Britton Herbarium, New York Botanical Garden, collected on the road to Caroni Estate, Arima, Trinidad, April 5, 1866 (Trinidad Herbarium no. 2900, the collector unknown).

Apparently unrelated to any other American member of the genus. An appended note by N. E. Brown states that the specimen does not match any American material at Kew but is near the Indian *S. zeylanica* (Nees) Kuntze.

Staurogyne brachiata (Hiern) Leonard, comb. nov.

Ebermaiera brachiata Hiern in Nat. For. Kjöbenhaven Vid. Medd. **1877**: 69. 1877.

Type collected at Rio de Janeiro, Brazil, by Glaziou (no. 3070).

Staurogyne wawrana Leonard, nom. nov.

Ebermaiera gracilis Wawra, Itin. Princ. Coburgi **1**: 94. *pl. 10.* 1883; not *Ebermaiera gracilis* T. Anders. (1867).

Type collected in "Wälder von Alto d'Imperador," Petropolis, Brazil (Coll. II. 55).

Staurogyne itatiaiae (Wawra) Leonard, comb. nov.

Ebermaiera Itatiaiae Wawra, Itin. Princ. Coburgi **1**: 93. *pl. 11*. 1883.

Type collected in "Hochwälder des Itatiaia," Brazil (Coll. II. 434).

Staurogyne warmingiana (Hiern) Leonard, comb. nov.

Ebermaiera Warmingiana Hiern in Nat. For. Kjöbenhavn Vid. Medd. **1877**: 68. 1877.

Type collected "in marginibus silvarum ad Serra da Piedade," Brazil, by Warming.

STAUROGYNE VAUTHIERIANA (Nees) Kuntze, Rev. Gen. Pl. **2**: 497. 1891.

Ebermaiera Vauthieriana Nees in Mart. Fl. Bras. **9**: 15. 1847.

Staurogyne macrantha Lindau in Bull. Herb. Boiss. **5**: 643. 1897.

Type collected at Villa Rica, Prov. Minas Geraes, Brazil, by Vauthier (no. 182). The type of *Staurogyne macrantha* was collected near Itacolumy, Prov. Minas Geraes, Brazil, by Schwacke (no. 10495).

ZOOLOGY.—*A new pocket gopher of the genus* Cratogeomys *from Mexico.*[1] E. A. GOLDMAN, Bureau of Biological Survey.

In a revision of the pocket gophers of the genus *Cratogeomys* by E. W. Nelson and the writer,[2] 25 geographic races assigned to four species were recognized. Since the revision was published I have had occasion to examine three specimens from near timber line on Mount Orizaba, Vera Cruz, the highest mountain in North America south of Alaska. The specimens were referred by Elliot[3] to typical

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[1] Received May 24, 1937.

[2] Proc. Biol. Soc. Washington **47**: 135–154. 1934.

[3] Cat. Coll. of Mammals in Field Columbian Mus., Pub. 115, Zool. ser. **8**: 310. 1907.

Cratogeomys perotensis but are now found to exhibit characters that are distinctive.

For the opportunity to describe this new subspecies I am indebted to Dr. Wilfred H. Osgood of the Field Museum of Natural History

Cratogeomys perotensis peraltus, subsp. nov.

Timber-line Pocket Gopher

Type.—From near timber line on Mount Orizaba, Vera Cruz, Mexico (altitude about 12,500 feet). No 13831, ♂ adult, skin and skull, Field Museum of Natural History, collected by Edmund Heller, July 5, 1904.

Distribution.—Known only from the type locality on the upper slope of Mount Orizaba, western Vera Cruz, Mexico.

General characters.—Similar in size and color to *Cratogeomys perotensis perotensis* of the higher slopes of the Cofre de Perote, and to *Cratogeomys perotensis estor* of Las Vigas, at a lower elevation on the eastern edge of the interior plateau in western Vera Cruz. Differing notably from both *perotensis* and *estor* in cranial details, especially the peculiar form of the nasals and adjoining bony elements.

Color.—*Type* (acquiring fresh pelage): Upper parts from top of head over back to rump near "sayal brown" (Ridgway, 1912) moderately mixed with black, becoming lighter and near "cinnamon" along sides, forearms, and thighs; under parts thinly overlaid with dull buff, the light plumbeous basal color showing through; middle of face and muzzle blackish; auricular patches deep black; a white patch at upper base of tail; fore feet brownish; hind feet white; tail thinly haired, dark brownish above, somewhat paler below.

Skull.—Very similar to that of *perotensis* in general form, but nasals shorter, barely reaching anterior plane of zygomata, less tapering and wedge-shaped, the posterior ends decidedly broader, more rounded; premaxillae narrower, less extended posteriorly, ending in plane of lachrymals (usually reaching slightly beyond this plane in *perotensis*); frontals broader between premaxillae and reaching farther forward along median line to meet correspondingly broad ends of nasals; squamosal portion of lambdoid crest lower, less trenchant, rising more nearly vertically over mastoid process, instead of strongly bent forward as in *perotensis;* jugal broader anteriorly, inserted farther forward in maxilla; lateral margins of palate more excised behind posterior molars; pterygoids rather broad, with more prominent lateral wings; molariform teeth slightly narrower; crown of last upper molar somewhat more quadrate, less triangular, the posterior lobe broader, and the outer side less oblique. Compared with that of *estor* the skull is similar in size, but departs in detail as follows: Nasals broader, less tapering and wedge-shaped posteriorly; premaxillae narrower, about equaling nasals in transverse plane near posterior ends of latter (premaxillae wider than nasals near posterior ends in *estor*); braincase broader anteriorly, tending to develop more prominent postorbital processes at fronto-parietal suture; zygomata lighter, slightly more squarely, spreading anteriorly, the upper surface of maxillary roots narrower; frontals broader anteriorly between premaxillae; palatal grooves shorter, ending at posterior palatine foramina which are placed farther forward near transverse plane between first and second upper molars (grooves longer and ending at palatine foramina near plane between second and third upper molars in *estor*); crown of last upper molar somewhat more quadrate, less triangular, the outer reëntrant angle little developed; tubercle over root of lower incisor less prominent.

Measurements.—*Type:* Total length, 315 mm; tail vertebrae, 90; hind foot, 42.5. Two adult male topotypes, respectively: 300, 305; 92, 82; 41, 41. *Skull* (type): Greatest length (median line), 57.6; zygomatic breadth, 41.3; width across squamosals (over mastoids), 36; interorbital constriction, 8; length of nasals, 21.3; maxillary toothrow (alveoli), 10.7; upper incisors (width of cutting edge), 8.2.

Remarks.—*Cratogeomys p. peraltus* is apparently restricted to the upper slopes near timber line (about 12,500 feet) on Mount Orizaba. Its range may be interrupted below by that of the much smaller pocket gopher, *Thomomys umbrinus orizabae,* which is very numerous, at least on the west slope, at 9,500 feet.

Specimens examined.—Total number four, three skins and skulls and one additional skull, all in the Field Museum of Natural History.

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JOURNAL
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HYDROLOGY.—*The chemical character of the ground waters of the South Atlantic Coastal Plain.*[1]

MARGARET D. FOSTER, U. S. Geological Survey. (Communicated by OSCAR E. MEINZER.)

The low-lying plain bordering the Atlantic Ocean from the Potomac River and Chesapeake Bay southward to the tip of Florida is here referred to as the South Atlantic Coastal Plain. On the west the plain is bounded by the Piedmont Plateau. The area is part of the Atlantic and Gulf Coastal Plain, a natural physiographic and geologic province of the United States extending from Massachusetts to the Rio Grande.

In the South Atlantic Coastal Plain most of the ground-water supplies are obtained from sedimentary deposits; few wells penetrate to the underlying crystalline rocks. These sedimentary deposits consist of gravel, sand, clay, marl, limestone, and chalk, laid down for the most part under the sea.

Although sodium chloride waters may be encountered near the coast, most of the ground waters obtained from these deposits are bicarbonate waters, with either calcium or sodium as the principal basic constituent. In some waters the proportions of these two basic constituents are approximately equal. Analyses of typical waters in this area are shown graphically in Figs. 1 and 2. The principal soluble material in the sediments is calcium carbonate, with some magnesium carbonate. The clastic constituents of the sands and clays, being the weathered residues of older igneous and sedimentary rocks, have already been more or less altered by hydrolysis and have been leached of their soluble materials. The primary action on the sedimentary deposits, therefore, of meteoric waters containing in solution carbon dioxide derived from the air and soil is solution of calcium and magnesium carbonates. The amount of these carbonates taken into solution depends on the carbon dioxide content of the percolating waters as well as one the calcium and magnesium carbonate content of the sedimentary beds.

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[1] Received August 18, 1937. Presented before the Division of Water Sewage, and Sanitation Chemistry at the 93d Meeting of the American Chemical Society, Chapel Hill, N. C., April 12 to 15, 1937. Published by permission of the Director, U. S. Geological Survey.

In deposits that are relatively calcareous, such as sand and clay formations that contain much calcareous cementing material or deposits of marl, limestone, and chalk, the capacity of the percolating waters to take calcium and magnesium carbonates into solution by virtue of their content of carbon dioxide is exhausted at shallow depths. Waters from such formations do not generally increase in mineral content with increasing depth in the formation. Wells 20 to 40 feet deep in these formations yield water containing as much dissolved mineral matter as those several hundred feet deep.

In formations that contain little calcareous material, however, the waters must travel farther to exhaust their capacity to take calcium carbonate into solution. Waters from shallow depths in such formations are usually low in dissolved mineral matter. As the waters percolate downward they continue to take calcium and magnesium carbonate into solution until their carbon dioxide content is exhausted. With greater depth the mineral content then tends to remain relatively constant.

Some formations that are apparently devoid of calcareous material yield waters of low mineral content, even from great depths. Some of these deep waters carry considerable carbon dioxide and are corrosive.

The solution of calcium and magnesium carbonates constitutes the primary action between the percolating meteoric waters and the rock materials. However, many waters of the area are sodium bicarbonate waters, and some contain approximately equal quantities of calcium and sodium.

The same formation may yield waters of all these different types. In such a formation the calcium bicarbonate waters are usually the shallower waters, and the sodium bicarbonate waters are the deeper waters. The waters undergo an alteration in character with depth. The calcium and magnesium content decreases, the waters become softer, and at the same time the sodium content increases, the bicarbonate and total mineral content often remaining about the same. This phenomenon is shown in Fig. 1 by diagrams F, G, H, and I, which represent analyses of waters from different depths in the Black Creek formation in South Carolina. These waters appear to be the result of a secondary action between the waters and the rock materials —exchange of calcium and magnesium in solution in the waters for sodium of base-exchange minerals in the rock materials. Descriptions of the lithologic character of the formations of this area in geologic reports frequently note the fact that a certain formation is "glauconitic." Glauconite, or greensand, is a green granular silicate of potassium and iron that has pronounced base-exchange properties. It is formed near the mud line off continental shores and is consequently often found in sedimentary deposits like those that underlie this area. Certain hydrous alumino-silicates that are capable of base exchange, derived from the weathering of crystalline rocks, may also make up part of the clastic material of these sediments.

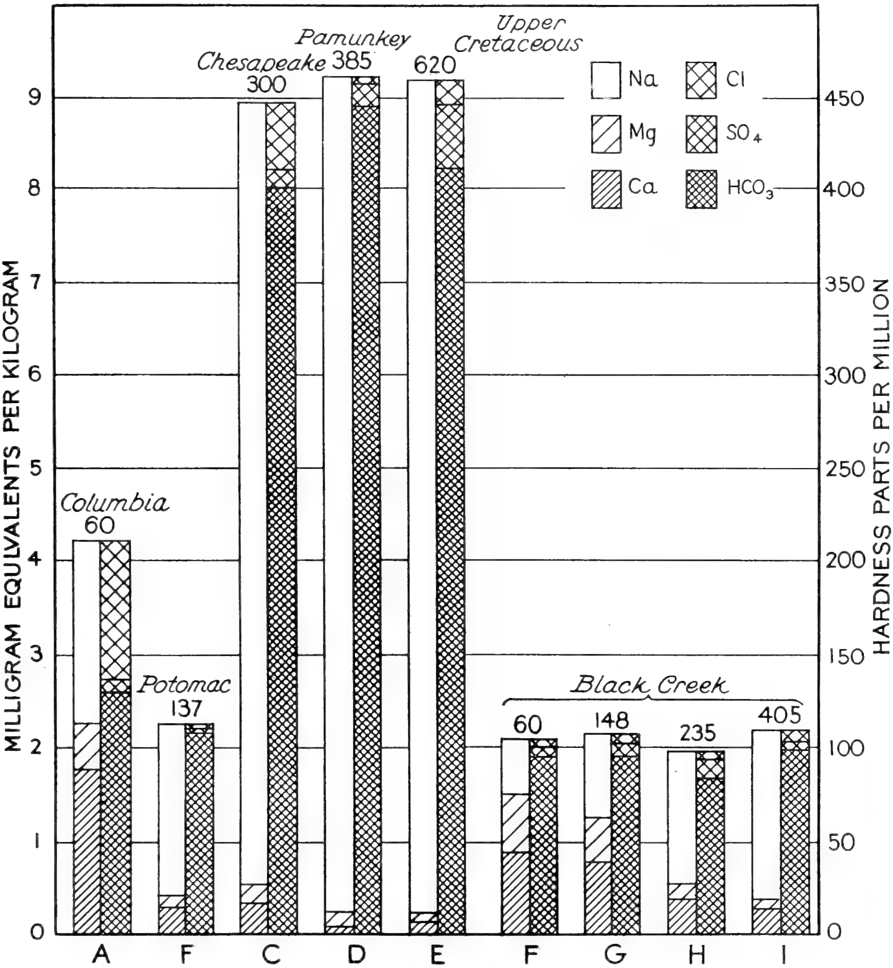

Fig. 1.—Composition of typical well waters in the Coastal Plain of Virginia and South Carolina. (Names above columns refer to stratigraphic units; numbers refer to depth of wells in feet.)

The depth at which softening begins varies with the relative proportion of calcium and magnesium carbonates to base-exchange minerals in the materials through which the water passes. If the base-exchange minerals are present in an amount at least proportional to the carbonates, the two processes are probably almost simultaneous, the calcium being exchanged almost as soon as it is taken into solution. If, however, the carbonates are present in the rock materials in amounts more than equivalent to the exchange minerals, or if the exchange capacity of the base-exchange minerals has been exhausted in the shallower materials, the ground waters must travel farther before being softened.

This phenomenon of natural water softening is particularly pronounced in the formations that underlie Virginia and North and South Carolina. In Virginia most of the waters from a depth of more than 100 or 150 feet are sodium bicarbonate waters, and many waters from even shallower depths contain some sodium bicarbonate, indicating that softening has begun to take place. The chemical composition of typical well waters in the Coastal Plain of Virginia from different depths in different formations is shown graphically on Fig. 1, A, B, C, D, and E. Many of the Virginia waters are characterized by a very high content of sodium bicarbonate, with as much as 250 to 350 parts per million of sodium and 500 to 700 parts of bicarbonate; the calcium and magnesium content of these waters is very low, and in many the sulfate and chloride are low (diagrams C, D, and E). The high content of bicarbonate in these waters and the comparatively shallow depths at which softening takes place indicate that (1) the percolating waters had, at the outset, a high content of carbon dioxide and, consequently, a high capacity for solution of calcium and magnesium carbonate, (2) the rock materials through which they passed were relatively calcareous, and (3) the proportion of base-exchange minerals to calcium and magnesium carbonates in the materials was relatively high.

There is little detailed information on the ground waters of North Carolina. The few analyses at hand indicate that softening is fairly complete at depths of about 100 or 150 feet.

The three most important water-bearing formations in South Carolina are the Tuscaloosa, the Black Creek, and the Peedee. Typical waters from different depths in the Black Creek formation are shown graphically in Fig. 1, diagrams F, G, H, and I. The waters from this formation are usually fairly low in dissolved mineral matter, generally containing less than 200 parts per million. The waters from the Tuscaloosa formation are similar in character to those from the Black Creek formation, although they generally contain less than 150 parts per million of dissolved mineral matter. The waters from the Peedee formation are more highly mineralized, usually having a mineral content of 500 to 750 parts per million. The deeper waters from the

Peedee formation are similar to the highly mineralized sodium bicarbonate waters in Virginia, shown diagrammatically in Fig. 1, C, D, and E. The predominating chemical constituent of the waters in all these formations shows a gradual alteration with increasing depth, from calcium bicarbonate, which characterizes the shallower waters, to sodium bicarbonate, which characterizes the deeper waters. The depth at which softening takes place differs in the different formations. In the Tuscaloosa it apparently takes place at less than 150 feet, in the Black Creek at about 150 to 200 feet, and in the Peedee at about 200 feet. The ground waters from the other formations of South Carolina show the same alteration in character with depth. In the Cooper marl and Santee limestone the softening apparently takes place at a depth between 200 and 300 feet.

The phenomenon of base exchange is much less pronounced in the formations that underlie Georgia. These formations contain a larger proportion of limestone than those in the area to the north. The deep waters, as well as the shallow waters, are for the most part calcium bicarbonate waters, although wells more than 800 feet deep may yield sodium bicarbonate water. This is brought out in Fig. 2, diagrams A, B, C, D, E, and F, which show graphically the composition of typical waters from different depths in different formations in the Coastal Plain of Georgia. The data at hand indicate that the ground waters of Georgia are remarkably uniform in chemical composition, regardless of the formation from which they come. The general range in total dissolved mineral matter for the waters from the various formations is 150 to 250 parts per million, and in total hardness 100 to 200 parts, although there are waters with more dissolved mineral matter or with less. Apparently there is, then, in Georgia, no formation which yields markedly superior or inferior water, and the choice of the proper horizon to tap for a water supply depends on local conditions.

The rocks of Florida are, properly considered, the southward extension of the formations in Georgia and Alabama. In Florida, as in Georgia, calcium bicarbonate waters predominate. The diminution of the tendency of the formations to soften the waters in them, noted in Georgia, is apparently carried to completion in Florida, where a sodium bicarbonate water is rare. Two have been noted in the Okeechobee area. These are from shallow wells, however, and may be considered a local phenomenon. The calcium bicarbonate waters of Florida do not show the same uniformity in chemical composition as those of Georgia. The range in total dissolved mineral matter is greater, and the relative content of the different constituents is much more variable. In this respect the relative amounts of calcium and magnesium are particularly to be noted. In some waters the calcium content is relatively high and the magnesium content is very low, as shown in diagram G in Fig 2; in others these two constituents are present in almost equivalent amounts, as shown in diagram H, Fig. 2. In general, waters containing more than 400 parts per million of total solids and having a total hardness of more than 400 parts have, proportionately, considerably more sulfate and chloride than waters containing less than 400 parts of total solids, although some waters

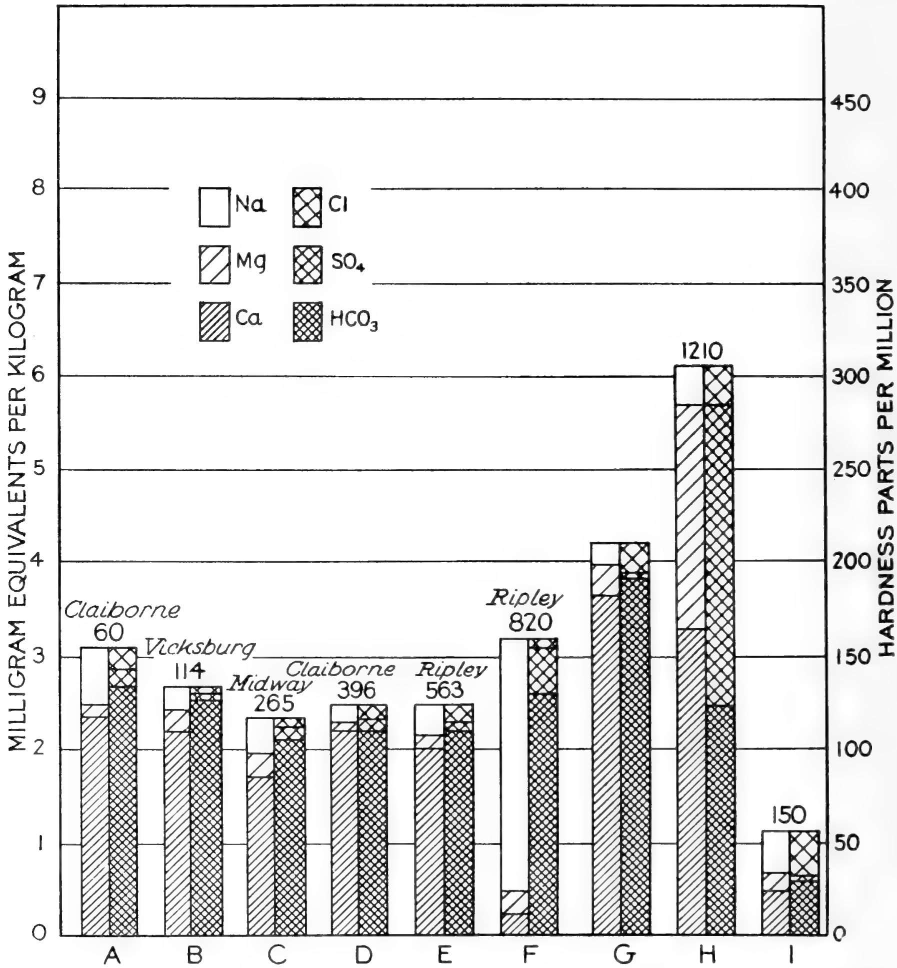

Fig. 2.—Composition of typical well waters in the Coastal Plain of Georgia and in Florida. (Names above columns refer to stratigraphic units; numbers refer to depth of wells in feet.)

with less than 400 parts of dissolved mineral matter also contain notable quantities of these constituents. The best water is generally obtained from the younger formations. These deposits usually yield soft water of low mineral content (Fig. 2, I), but in some areas they may not yield enough water for more than small domestic supplies.

Near the coast along the whole area another factor may enter in the determination of the chemical character of the waters. Most of the formations are assumed to have submarine outcrops. If the head of fresh water in a formation is sufficient to balance the head of heavier sea water, which tends to force salt water into the formation at its submarine outcrop, salt water will not enter the formation, and the normal chemical relations of the waters in the formation will be undisturbed. If, however, the fresh-water head is not sufficient, sea water will enter the formation to the point where it is balanced by the fresh-water head. If this point lies somewhere inland from the coast line, salty waters will be encountered by wells drilled into the formation between this point and the coast. The chemical composition of many of these salty waters shows them to be normal ground waters to which more or less sea water has been added. Formations containing fresh water may be found below those containing salt water. As a rule, however, the probability of finding fresh water below salty water is slight. The problem of finding sufficient fresh water for a municipal supply is a serious one for many cities on the coast. The deep formations may all yield salty water, and the superficial deposits, while yielding fresh water, may not yield a sufficient supply for the use of a city. Away from the coast salt water from deep wells may represent an admixture of meteoric water with sea water entrapped in the formation at the time of its deposition. Waters of high chloride content are also obtained from many shallow wells throughout the area. In many of these waters the high chloride is accompanied by high nitrate, which is usually derived from the oxidation of nitrogenous organic matter.

Waters in which sulfate is the predominant acidic constituent are comparatively rare in this area. They are usually of only local occurrence and the result of strictly local conditions. As a rule sulfate is a subordinate constituent in the ground waters of the South Atlantic Coastal Plain.

In general, then, the wells of shallow or moderate depths in Virginia and North and South Carolina yield calcium bicarbonate waters, the deep wells yield sodium bicarbonate waters; both shallow and deep wells in Georgia and Florida yield calcium bicarbonate waters;

but along the whole coast these normal ground-water relationships may be disturbed by the admixture of more or less sea water with the normal ground waters.

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BOTANY.—*New species of* Sphaceloma *on* Aralia *and* Mentha.[1]

ANNA E. JENKINS, Bureau of Plant Industry. (Communicated by JOHN A. STEVENSON.)

Four new American species of *Sphaceloma* were listed in a synoptic table (table 1) included in a paper presented at Rio de Janeiro, in January, 1936, giving the known species of *Elsinoe* and *Sphaceloma.*[2] Names and brief descriptions of the two North American species are here supplied. The two from South America will be named and described elsewhere.

Sphaceloma araliae sp. nov.

Produces conspicuous spots or galls on stems and leaves, including midrib and veins; spots solitary or closely grouped, linear to elliptical or elongate, or, particularly on leaves, circular to irregular, up to 12 mm long by 5 mm wide, ocher red,[3] becoming pale ochraceous buff in central region; acervuli erumpent superficial, 20–50μ in diam., often continuous over large areas; hyphae or stromata hyaline; stromata reaching 80μ in thickness; palisade of conidiophores compact, light fulvous, often 8–20μ thick; conidia oblong-elliptical, 1-celled, hyaline, 5–10μ×2.5–4μ (measurements include conidia in culture); on potato-dextrose-agar medium, thallus ochraceous tawny.

Macules vel gallas insignes, 5 mm latas, 12 mm longas, ochraceorubras, in centro ad ochraceo-alutaceas pallescentes, in caulibus et foliis producens; acervulis erumpente superficialibus, 20–50μ in diam., saepe per superficientem latam continuis; stromatibus saepe bene evolutis, usque 80μ crassis, hyalinis; palis conidiophorum compactis, crassis, pallide fulvis; conidiis unicellularibus, oblongo-ellipticis, hyalinis, 5–10μ×2.5–5μ.

On living stems and leaves of *Aralia spinosa* L., causing a scab disease, Edgewater, Md., July 2, 1934, Peter Bisset. In the Mycological Collections of the Bureau of Plant Industry (No. 69462, type), and in Phytopathological Herbarium, Instituto Biologico, São Paulo, Brazil.

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[1] Received September 14, 1937.

[2] JENKINS, A. E. and A. A. BITANCOURT, *Doenças das plantas causados por fungos dos generos* Elsinoe e Sphaceloma. Rodriguésia **2**: (Numero especial. Annaes da Primeira Reunião de Phytopathologistas do Brasil) 305–313. 2 tables. 1936.

[3] RIDGWAY, R. *Color standards and color nomenclature,* 43 pp. 1912.

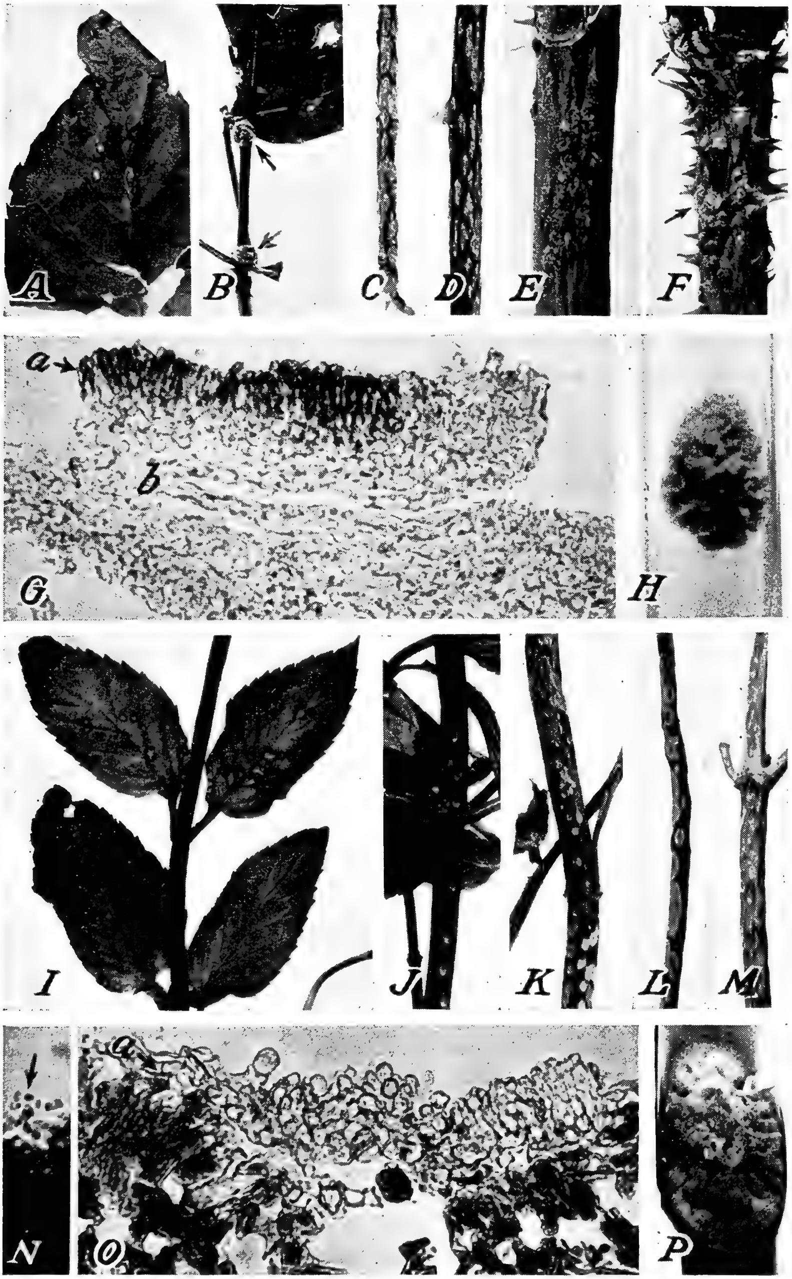

Fig. 1, A–G.—*Sphaceloma araliae* on *Aralia spinosa*. A–D, on leaf parts, E and F, on stem; G, acervulus, *a*, palisade of conidiophores, *b*, underlying stems. A–F, ×1; G, ×400. H, 25-day-old culture of the fungus on potato-dextrose agar. ×1.

I–O.—*S. menthae* on *Mentha piperata*. I, on leaves, J–N, on stems, M, on rootstock; N, conidia, and C, acervulus on upper surface of leaf; I–M, ×1; N and O, ×400. P, old culture on oatmeal agar. ×1.

Sphaceloma menthae sp. nov.

Produces spots on leaves, stems and rootstocks; spots often numerous, raisin black, central part becoming pallid to pale vinaceous drab, circular to elliptical or irregular, up to 3–5 mm in diam.; stem lesions at first sunken, sometimes elevated, often becoming crateriform with concavity light-colored; acervuli erumpent superficial, more or less hemispherical or flattened, 15–80μ or more in diam.; palisade of conidiophores compact, very light yellow, 10–25μ thick; conidia spherical to elliptical, hyaline, 3–8μ ×2.5–4μ. Characters of thallus in culture resembling those of *Myriangium.* Color of young thalli on potato dextrose agar medium Varley's brown surrounded by Hay's maroon, older pubescent thalli pallid to light brownish drab, medium becoming light yellowish olive (Fig. 1, I–P).

Maculis numerosis, in foliis, caulibus et radicibus, purpureo-nigris, in centro pallidis ad pallide vinaceo-griseis, ellipticis vel rotundis vel irregularibus, 3–5 mm in diam., vel in caulibus interdum extensis et saepe crateriformibus; acervulis erumpente superficialibus, 15–80μ in diam. vel amplioribus; palis conidiophorum compactis, 10–25μ crassis; conidiis sphaericis ellipticisve, hyalinis, 3–8×2.5–4μ.

On leaves, stems, and rootstocks of cultivated *Mentha piperata* L., causing the disease known as leopard spot, Lafayette, Ind., Aug. 21, 1934, R. C. Baines; Breeman, Ind., Sept. 1, 1937, H. A. Edson; Mentha, Mich., Aug. 3, 1937, Ray Nelson and Anna E. Jenkins; and July 31, 1935, and Aug. 20 and 29 (type), 1937, Ray Nelson. Type in the Mycological Collections of the Bureau of Plant Industry (No. 72538). Portions of the type collection also deposited in the following herbaria: Farlow Cryptogamic Herbarium of Harvard University, New York Botanical Garden, Herbarium of the University of Michigan, and the Phytopathological Herbarium, Instituto Biologico de São Paulo, Brazil.

PALEOBOTANY.—*Fossil legumes from Bridge Creek, Oregon.*[1] ROLAND W. BROWN, U. S. Geological Survey.

The reddish shales occurring along Bridge Creek, 9 miles northwest of Mitchell, Ore., and recognized as equivalent to the upper part of the Clarno formation (Oligocene, according to the usage of the U. S. Geological Survey), have long been noted for the abundant and well-preserved fossil plants they carry. This flora, together with that from similar rocks of the same or approximately the same age and horizon in the Crooked River basin, 35 miles southward, includes ferns, pines, firs, sequoias, cattails, willows, sweet-ferns, hazelnuts, hornbeams, ironwoods, alders, beeches, chestnuts, oaks, hickories, elms, hackberries, barberries, umbellularias, sycamores, mock-oranges, service-berries, hawthorns, lindens, black-gums, sweet-gums, dogwoods, and madrones. Although this flora is, relatively speaking, fairly large and well known, it is nevertheless possible to find new species, even among the old collections, as was my good fortune recently when, for other reasons than looking for a new species, I had

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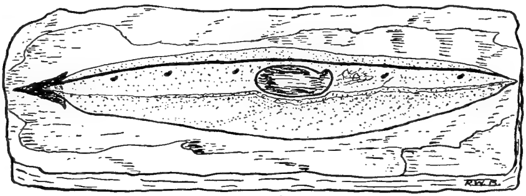
[1] Received July 29, 1937.

occasion to split a piece of the shale from Bridge Creek. To my surprise the unusually fine legume pod illustrated in Fig. 1 was uncovered. This pod belongs to a species of *Cladrastis*, a genus hitherto unreported from Bridge Creek, and may be described as

Cladrastis oregonensis Brown, n. sp. Fig. 1

Description.—A linear-compressed pod, 6.5 cm long and 1.2 cm wide, with acute apex and base, the latter surrounded by the remains of the campanulate calyx. The placental suture line is marked by a wide keel or wing, but the other margin does not appear to be appreciably winged. One large oblong seed, 1 cm long and 5 mm wide, has a position near the center of the pod. It is attached at the upcurved end to the placenta, the free rounded end pointing backward to the base of the pod so that the long axis of the seed is parallel to the placental line. Five minute aborted seeds of the same shape as the large seed are also present. Only a faint suggestion of reticulate veining is preserved on the pod in the region near the large seed.



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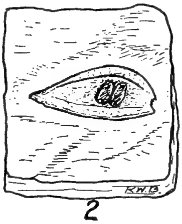

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Fig. 1.—*Cladrastis oregonensis* Brown, n. sp. Fig. 2.—*Micropodium ovatum* (Lesquereux) Brown, n. comb. Both specimens are from the reddish shales along Bridge Creek, 9 miles northwest of Mitchell, Ore. Natural size.

Occurrence.—In reddish shales along Bridge Creek, 9 miles northwest of Mitchell, Ore.

Type.—Deposited in the U. S. National Museum.

Remarks.—The characters displayed by this fossil pod are distinctive and indicate the genus *Cladrastis.* Confusion might be made with the pods of *Robinia,* which resemble those of *Cladrastis* closely, but the pods of *Robinia* are in general blunter at both ends, and its seeds are about two-thirds the size of those of *Cladrastis,* with their long axes somewhat oblique to the placental line. I have, however, been unsuccessful in matching the fossil exactly with typical pods from any of the 4 or 5 living species of *Cladrastis.* Most of the pods of *C. lutea,* the yellow-wood of a restricted area in the southeastern United States, have a comparatively narrow wing along the placental suture. The other species are natives of eastern Asia, and among these the best matches for the fossil are the pods of *C. amurensis,* which compare well in wing characters but are somewhat more rounded at the apex.

The leaves of *Cladrastis* are odd-pinnate, with leaflets that vary from broadly oval in *C. lutea* to oblong and lanceolate in some of the Asiatic species. It would seem that a scrutiny of the more or less doubtfully assigned fossil leaves from Bridge Creek might give a clue to the probable affinity of the fossil pod with living species of *Cladrastis*. At least two kinds of such leaves, present in the collections, may be leguminous. They are the leaves identified as *Fraxinus denticulata* Heer?[2] and some of those originally called *Fraxinus integrifolia* Newberry[3] but now *Umbellularia oregonensis* (Knowlton and Cockerell) Chaney.[4] The enlarged petioles and the secondary venation of *Fraxinus denticulata* can be matched fairly closely in some of the leaflets of *Cladrastis lutea* and some Asiatic species of *Cladrastis*. As for *Umbellularia oregonensis*, there seems to be little question that most of the leaves assigned to that species are *Umbellularia*. However, among these leaves in the collection at the U. S. National Museum are some that in shape, venation, and enlarged petioles resemble the lanceolate leaflets of *Cladrastis amurensis*. Thus, with two sets of leaves or leaflets as possible candidates for sharing specific relationship with the fossil pod, apparently no satisfactory conclusion can be drawn, and the question as to what leaflets go with the pod must wait for solution upon the finding of further evidence.

Among fossil species the pod called *Leguminosites* sp. by Dorf,[5] may be compared with *Cladrastis oregonensis*, but it has wide wings on both margins and thus resembles the living *C. platycarpa* of Japan. This pod also belongs to a later geologic horizon than *C. oregonensis*. The pod described as *C. eocenica* Berry[6] from the Eocene of Tennessee may belong to *Cladrastis*, but as figured it does not show the shape and posture of the seeds and thus fails to be entirely convincing.

Two other kinds of leguminous pods have been described from the shales of Bridge Creek and Crooked River, Ore. One of these is *Cercis* sp. from Crooked River.[7] This is the distal half of a pod showing a thick suture line and three elliptic to circular seeds. The shape of these seeds clearly distinguishes this pod from *Cladrastis oregonensis*. LaMotte[8] has synonymized *Cercis* sp. with *Cercis spokanensis* Knowlton[9] from the Latah formation. It seems to me, however, that La-

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[2] NEWBERRY, J. S. *The later extinct floras of North America.* U. S. Geol. Survey Mon. **35**: 128, pl. 49, fig. 6, 1896.—CHANEY, R. W. *Geology and paleontology of the Crooked River Basin, with special reference to the Bridge Creek flora.* Carnegie Inst. Wash. Pub. **346** (pt. 4): 132, pl. 19, figs. 5–7, 1927.

[3] NEWBERRY, J. S. Op cit., p. 128, pl. 49, figs. 1–3.

[4] CHANEY, R. W. *A record of the presence of* Umbellularia *in the Tertiary of the western United States.* Carnegie Inst. Wash. Pub. **349** (pt. 4): 60, pl. 1, figs, 1, 3, 5, 7, 1925.

[5] DORF, ERLING. *A late Tertiary flora from southwestern Idaho.* Carnegie Inst. Wash. Pub. **476** (pt. 2): 119, pl. 3, fig. 1, 1936.

[6] BERRY, E. W. *Revision of the lower Eocene Wilcox flora of the southeastern States.* U. S. Geol. Survey Prof. Paper **156**: 84, pl. 41, fig. 12, 1930.

[7] CHANEY, R. W. Op cit., Pub. **346** (pt. 4): 125, pl. 15, fig. 5, 1927.

[8] LAMOTTE, R. S. *The upper Cedarville flora of northwestern Nevada and adjacent California.* Carnegie Inst. Wash. Pub. **455** (pt. 5): 132, pl. 10, fig. 4, 1936.

[9] KNOWLTON, F. H. *Flora of the Latah formation of Spokane, Washington, and Coeur d'Alene, Idaho.* U. S. Geol. Survey Prof. Paper **140**: 43, pl. 29, fig. 9, 1926.—BROWN, R. W. *Additions to some fossil floras of the western United States.* U. S. Geol. Survey Prof. Paper **186**: 177, pl. 54, figs. 10–12, 1937.

Motte's figured specimen from 49 Camp, Washoe County, Nev. is not *C. spokanensis*, nor is it the same species as the Crooked River specimen, for the latter appears to be more membranous and lacks the wide wings on the margins. The other species of pod is that originally called *Ailanthus ovata* Lesquereux but now

Micropodium ovatum (Lesquereux) Brown, n. comb. Fig. 2

Ailanthus ovata Lesquereux, U. S. Geol. Survey Terr. Rept. **8**:254, pl. 51, figs. 7, 8. 1883. [Fig. 8 is a branch, probably unidentifiable, and therefore not further considered here.]

Knowlton, U. S. Geol. Survey Bull. 204: 69. 1902.

Description.—Small oblong-ovate pods, rounded at the apex, acute at the base, 1.5 cm long and 8 mm wide, with a broad wing on the placental suture line. In Fig. 2 the apex is broken and the base is slightly eroded. Seeds apparently one to several, elliptic, 2 mm long, with the long axis perpendicular to the placental line. No venation appears to be present on the specimens. Such markings or striations as have been reported seem to have been caused by the processes of fossilization.

Occurrence.—In reddish shales along Bridge Creek, 9 miles northwest of Mitchell, Ore.

Type.—The original figured specimens are at the University of California. Fig. 2 is in the U. S. National Museum.

Remarks.—These small pods are obviously those of a species of legume and not of *Ailanthus*, for they show neither the longitudinal veins and reticulations, nor the small notch or emargination that is usually present on the wing beneath the seed of *Ailanthus*. Characteristic samaras of *Ailanthus americana* Cockerell are present in the flora from the Green River formation and in that from the Florissant lake beds but they can be distinguished readily from these pods.

Because of their nearly uniform small size these pods seem to represent a single species distinct from that called *Cercis* sp. by Chaney, referred to above. Although *Cercis* leaves are known from the Florissant lake beds, the Latah formation, and other strata in the regions adjacent to the John Day Basin of Oregon, none have yet been identified as such from the shales of Bridge Creek and Crooked River in the latter area. Nevertheless *Cercis* sp. appears to be a true *Cercis*. It is possible that the small pods under discussion here may be the dwarf pods of that species, but until more conclusive evidence appears it seems desirable to regard them as distinct and to adopt Saporta's generic name for similar pods from the Tertiary of southeastern France, his type being *Micropodium oligospermum*.[10] Saporta himself found it difficult to distinguish his specimens from *Cercis* but concluded that because they were apparently produced in a raceme they should be considered as belonging to a different genus. If these fruits were produced in a raceme it is possible that they too may represent *Cladrastis*, resembling the smaller

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[10] Saporta, G. de. *Études sur les végétation du sud-est de la France a l'époque tertiare.* **1**: 137, pl. 14, figs. 8A, 8B, 1863.—Suppl. 1. *Révision de la flore des gypses d'Aix.* **3**: 221, pl. 18, fig. 1, 1873.

pods of *C. platycarpa* of Japan. What appear to be 2 or 3 closely spaced seeds may in reality be folds in the pod overlying a single large seed. If this interpretation be the correct one, then it is possible that the aforementioned specimen referred by LaMotte to *Cercis spokanensis* and the strikingly similar specimen called *Dalbergia? coloradensis* Knowlton[11] from the Florissant lake beds, may also be large specimens of this or a closely related species of *Cladrastis*.

Obviously, not having Saporta's specimens at hand, it is impossible to make detailed comparisons between them and *Micropodium ovatum*. Superficially they seem to be identical species, but only a comparison of the specimens can establish the fact.

The known fossil legumes from the shales on Bridge Creek and Crooked River, Ore., now appear to be: *Cercis* sp., *Cladrastis oregonensis*, and *Micropodium ovatum*—all represented by pods. No leaves have yet been identified as definitely leguminous, although suspicion rests upon several species now assigned to other genera.

ZOOLOGY.—*New rodents from Middle America.*[1]

E. A. GOLDMAN, Bureau of Biological Survey.

Studies of the genera *Heteromys* and *Nyctomys* have resulted in the detection of the new subspecies here described. Two of these were obtained by the veteran collector, C. F. Underwood, who has been making notable contributions to knowledge of the fauna of Costa Rica for many years. Specimens of a new subspecies of *Nyctomys*, from Salvador, have been made available through the courtesy of Mrs. Florence V. V. Dickey.

For the loan of other specimens required for comparison in this connection my thanks are due to Dr. Roy Chapman Andrews, Dr. H. E. Anthony, George G. Goodwin, and John Eric Hill, American Museum of Natural History, New York, and to Dr. Glover M. Allen, Museum of Comparative Zoology, Cambridge, Massachusetts.

Heteromys desmarestianus planifrons, subsp. nov.

Pirris Spiny Pocket Mouse

Type.—From San Geronimo, Pirris, western Costa Rica. No. 250348, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by C. F. Underwood, April 12, 1931. X-Catalog number 26914.

Distribution.—Western Costa Rica; limits of range undetermined.

General characters.—Closely resembling *Heteromys desmarestianus desmarestianus* of Guatemala; color, general size and proportions very similar, but dusky of forearms tending to extend farther down on wrists; pelage

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[11] KNOWLTON, F. H. *Fossil plants from Florissant.* U. S. Nat. Mus. Proc. **51** (2151): 278, pl. 19, fig. 4, 1916.

[1] Received May 24, 1937.

sparser; light tawny lateral line usually present as in *desmarestianus;* skull usually broader and differing in other details. Similar to *Heteromys desmarestianus fuscatus* of central Nicaragua, but larger; light tawny lateral line usually present (usually absent or indistinct in *fuscatus*); cranial features distinctive. Not very unlike *Heteromys desmarestianus repens* of the mountains of western Panama, but larger with relatively larger ears; pelage coarser and sparser; differing otherwise in about the same characters as from *fuscatus.* Smaller than *Heteromys oresterus* of the Cordillera de Talamanca; pelage more bristly; slender hairs among bristles deeper ochraceous buff; ears without white edging usually in *oresterus.*

Color.—Type: Upper parts blackish, becoming very dark brown or "mouse gray" (Ridgway, 1912) along flanks and outer sides of limbs, the slender light tawny hairs present but inconspicuous among the bristles; entire under parts, feet, and a line down inner side of hind leg to metatarsus white; a narrow but distinct light tawny line of demarcation along flanks; ears blackish; tail brownish above, whitish below, becoming dusky all around at tip.

Skull.—Large, with broad braincase and broad frontal and parietal regions. Closely resembling those of *desmarestianus* but usually broader, the lateral margins of frontals somewhat more prominent and projecting as supraorbital shelves; interparietal broader, more extended transversely, more evenly oval in outline, the anterior angle less developed; supraoccipital more produced on the median line, tending to bulge farther posteriorly over foramen magnum; dentition about the same. Similar to those of *fuscatus* and *repens,* but larger; interparietal relatively broader, with less evident anterior angle; supraorbital ridges more projecting and shelf-like. Compared with that of *oresterus* the skull is relatively shorter and broader; nasals about conterminous with premaxillae posteriorly (premaxillae extending well beyond nasals in *oresterus*); supraorbital ridges more projecting; angle of mandible more everted; tubercle over root of lower incisor more prominent; molariform toothrows narrowed posteriorly (sides of toothrows nearly parallel in *oresterus*); posterior upper molar smaller, the closure of the reëntrant angles through wear leaving smaller enamel islands.

Measurements.—Type: Total length, 303 mm; tail vertebrae, 169; hind foot, 35. An adult female topotype: 302; 174; 35. *Skull* (type): Greatest length, 37.7; zygomatic breadth, 18.1; interorbital breadth, 9.9; length of nasals, 16.3; width across squamosals in front of auditory meatus, 16.3; interparietal, 9.8×4.9; maxillary toothrow (alveoli), 5.5.

Remarks.— *Heteromys d. planifrons* is a rather slightly differentiated form bearing a closer resemblance to typical *desmarestianus* than to some of its nearer geographic neighbors. Comparison of 13 topotypes of *Heteromys desmarestianus psakastus* of Salvador with series of *desmarestianus* assumed to be typical from Chipoc and other localities in the Coban region of Guatemala, indicates that the two are identical and that, therefore, *psakastus* does not have to be considered in this connection. The new form requires no close comparison with *Heteromys oresterus,* which is a very distinct species assignable to the subgenus *Xylomys.*

Specimens examined.—Total number, 14, all from western Costa Rica as follows: San Geronimo, Pirris (type locality), 8; Jabillo, 1; Sabanilla, 1; San Ramon, Tres Rios, 4.

Heteromys desmarestianus subaffinis, subsp. nov.

Reventazon Valley Spiny Pocket Mouse

Type.—From Angostura, southern side of Rio Reventazon, opposite Turrialba, Costa Rica (altitude about 1,980 feet). No. 12904/38591, ♂ adult, skin and skull, U. S. National Museum, collected by José C. Zeledon, May 1876. Original number 98.

Distribution.—Rio Reventazon and Pacuare River valleys, eastern Costa Rica; limits of range unknown.

General characters.—Similar in size and color to *Heteromys desmarestianus planifrons* of western Costa Rica, but tawny lateral line apparently absent; cranial details, including the broader rostrum, distinctive. Resembling *H. d. fuscatus* of central Nicaragua, but larger, with broader, more massive skull. Somewhat similar to *H. d. repens* of the mountains of western Panama, but larger; ears relatively larger; skull heavier. Contrasted with *H. d. zonalis* of the Canal Zone, the slender hairs among the bristles are more tawny, and cranial features are quite different.

Color.—*Type:* Upper parts blackish or very dark brownish, finely mixed with light tawny due to the tone of the slender hairs among the dark bristles; outer sides of forearms, thighs, lower part of rump and scrotum mouse gray; under parts in general, inner sides of forearms, and feet white; light tawny lateral line usually present in some forms of the group absent; ears brownish; tail light brownish above, white below.

Skull.—Very similar in size and general form to that of *planifrons*, but rostrum broader; interparietal narrower, less extended transversely, with more prominent anterior angle; dentition about the same. Differing from those of *fuscatus* and *repens* mainly in decidedly larger size, the supraorbital ridges more strongly developed as projecting shelves. Compared with that of *zonalis* the skull is larger, with much broader braincase and more widely separated supraorbital and temporal ridges, but the rostrum is relatively narrower, the nasals less expanded anteriorly, and the maxillary root of the zygoma much less strongly developed; molariform teeth similar, but incisors relatively narrow.

Measurements.—*Type* (no body measurements available): Hind foot (dried skin), 34.5 *Skull* (type): Greatest length, 36.9; zygomatic breadth, 17.3; interorbital breadth, 10; length of nasals, 15.9; width across squamosals in front of auditory meatus, 15.8; interparietal, 8.9×5.3; maxillary toothrow (alveoli), 5.5.

Remarks.—Specimens on which this form is based were referred by me (North Amer. Fauna, No. 34, p. 28, 1911) to *Heteromys repens* with the statement that they seemed larger and somewhat different in cranial details. More extended knowledge of the group now seems to warrant their segregation as representatives of a lowland form inhabiting eastern Costa Rica.

Specimens examined.—Four, all from Costa Rica, as follows: Angostura (type locality), 3; Pacuare, 1.

Nyctomys sumichrasti pallidulus, subsp. nov.

Oaxaca Vesper Rat

Type.—From Santo Domingo, 8 miles west of Lagunas, on the Mexican National Railroad, Isthmus of Tehuantepec, Oaxaca, Mexico (altitude 900 feet). No. 73302; ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, June 13, 1895. Original number 8079.

Distribution.—Known only from the type locality in the Arid Tropical belt on the southern side of the Isthmus of Tehuantepec, Oaxaca; probably has an extensive range in the arid Pacific coast region of southwestern Mexico.

General characters.—Color palest of the known forms of the genus; size medium. Similar to *Nyctomys sumichrasti sumichrasti*, of the eastern slope of the mountains in Vera Cruz and to *Nyctomys sumichrasti salvini* of Dueñas, Guatemala, but upper parts decidedly paler than either—near cinnamon buff instead of tawny; pelage much shorter than in *salvini.*

Color.—*Type:* Upper parts near "cinnamon-buff" (Ridgway, 1912), purest on head and along sides, including outer surfaces of forearms and thighs, the back inclining toward very light tawny slightly darkened by a thin admixture of dusky hairs; entire under parts white, the line of demarcation along lower part of sides sharp as usual in the genus; ears brownish; fore feet white; hind feet with only a trace of the dusky metatarsal areas so conspicuous in the other subspecies, the toes white; tail unicolor, dark brown.

Skull.—Closely resembling that of typical *sumichrasti,* but broader, with more widely spreading zygomata. Similar to that of *salvini,* but smaller, with relatively smaller molars.

Measurements.—*Type:* Hind foot measured in flesh, 25 (no other external measurements available). *Skull* (type): Greatest length, 31.3; zygomatic breadth, 17.9; interorbital breadth, 6; greatest width between temporal ridges, 13.4; length of nasals, 11.2; length of anterior palatine foramina, 4.5; length of palatal bridge, 4.8; maxillary toothrow, 4.8.

Remarks.—The geographic races of *Nyctomys sumichrasti* are all very closely allied. *N. s. pallidulus* approaches typical *sumichrasti* which inhabits the humid mountain slopes of eastern Mexico, but the coloration is quite distinctive. As in other species the pale coloration of *N. s. pallidulus* is probably associated with its more arid environment.

Specimens examined.—Five, all from the type locality.

Nyctomys sumichrasti florencei, subsp. nov.

Salvador Vesper Rat

Type.—From Barra de Santiago, Department of Ahuachapan, Salvador (sea level). No. 12765, ♀ adult, skin and skull, collection of Donald R. Dickey, collected by R. A. Stirton, April 6, 1927.

Distribution.—Pacific coastal region of Salvador: altitudinal range from sea level to at least 2,600 feet.

General characters.—Size smallest of the known forms of the genus; color light tawny. Closely resembling *Nyctomys sumichrasti decolorus* of northern Honduras, but very much smaller. Similar to *Nyctomys sumichrasti pallidulus* of Oaxaca, Mexico, but much smaller and color brighter, differing from *Nyctomys sumichrasti salvini* of the high mountains of Guatemala in much smaller size and more vivid coloration.

Color.—*Type:* Upper parts, including outer surfaces of forearms and thighs, nearly uniform light, but rich tawny, the back faintly lined with black, the dark hairs scarcely numerous enough to alter the general tone; under parts, including inner surfaces of limbs, pure white; ears brownish; fore feet white; hind feet dusky over metatarsus, the toes white; tail unicolor, dark brown. Color varying to light brownish, less vivid tawny in some specimens.

Skull.—Very similar to those of *decolorus, pallidulus* and *salvini,* but much smaller than any of these; dentition very light.

Measurements.—*Type:* Total length, 238 mm; tail vertebrae, 127; hind foot, 21. Average of eight typical adults from Hacienda Chilata, Department of Sonsonate, Salvador (altitude 2,000 feet): 230 (208–255); 117 (107–130); 22.5 (22–23). *Skull* (type): Greatest length, 29; zygomatic breadth, 16.4; interorbital breadth, 5.5; greatest width between temporal ridges, 12.8; length of nasals, 9.2; length of anterior palatine foramina, 4.5; length of palatal bridge, 4.2; maxillary toothrow, 4.1.

Remarks.—The diminutive size and light, but vivid tawny coloration distinguish *Nyctomys s. florencei* from its allies. The type was taken by the collector on a leaning tree in a swamp forest at sea level. This handsome subspecies is named for Mrs. Florence V. V. Dickey, in recognition of her interest in furthering contributions to general knowledge of natural history initiated by her husband, the late Donald R. Dickey, in a wide field.

Specimens examined.—Total number, 14, all from Salvador, as follows: Barra de Santiago (type locality), Department of Ahuachapan, 1; Hacienda Chilata, Department of Sonsonate (altitude 2,000 feet), 10; Lake Olomega, Department of San Miguel (altitude 300 feet), 1; Puerto del Triunfo, Department of Usulatan (sea level), 1; Volcan de San Miguel, Department of San Miguel (altitude 2,600 feet), 1.

Nyctomys sumichrasti costaricensis, subsp. nov.

Costa Rican Vesper Rat

Type.—From San Geronimo de Pirris, hamlet on the main road to Pirris before reaching Jabillo, near the west coast of Costa Rica, about two miles before the abrupt descent to the lowlands of Pozo Azul and about 12 miles inland from Pirris (altitude about 100 feet). No. 250331, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by C. F. Underwood, April 12, 1931. X-catalog number 26896.

Distribution.—Valley of the Rio Grande de Pirris, western Costa Rica; limits of range undetermined.

General characters.—A large dark tawny subspecies; anterior palatine foramina about equal in length to palatal bridge (shorter than palatal bridge in neighboring subspecies of the genus). Closely allied to *Nyctomys sumichrasti nitellinus* of the lower slopes of the Volcan de Chiriqui, Panama, but somewhat larger; upper parts brighter, the general tone near tawny instead of cinnamon; incisive foramina distinctly longer. Similar to *Nyctomys sumichrasti venustulus* of the Caribbean coast region of Nicaragua, but somewhat paler, the back less obscured by dusky hairs and differing otherwise in about the same characters as from *nitellinus.*

Color.—*Type:* Upper parts near "tawny" (Ridgway, 1912), slightly darkened on top of head and over back by a fine admixture of black-tipped hairs; cheeks, flanks, outer sides of forearms and thighs, purer, paler tawny; entire under parts, including lips, inner sides of forearms and thighs white; ears blackish; fore feet white; hind feet dusky over metatarsus, the toes white as in the other members of the genus; tail unicolor, brownish black.

Skull.—Similar to those of *nitellinus* and *venustulus,* but larger than either; nasals more pointed and usually about conterminous with premaxillae posteriorly (usually exceeded by premaxillae in posterior extension in *nitellinus* and *venustulus*); anterior palatine foramina longer, about equal in length to palatal bridge (instead of shorter than palatal bridge); dentition similar.

Measurements.—Type: Total length, 270 mm; tail vertebrae, 139; hind foot, 24. An adult male topotype: 246; 126; 25. An old adult female from Jabillo, Pirris: 263; 139; 24. *Skull* (type and an old adult female from Jabillo, Pirris, respectively): Greatest length, 33.3, 31.7; zygomatic breadth, 17.7, 18.4; interorbital breadth, 5.8, 6.5; greatest width between temporal ridges, 14.1, 14.3; length of nasals, 11.6, 10.5; length of anterior palatine foramina, 5.3, 5.2; length of palatal bridge, 5.2, 5.2; maxillary toothrow (alveoli), 5, 4.9.

Remarks.—N. s. costaricensis is distinguished from the neighboring subspecies by rich tawny coloration, and the cranial detail of unusual length of anterior palatine foramina compared with the length of the palatal bridge. In point of size it is about equal to the geographically distant form *N. s. salvini* of Guatemala, but the back less obscured by dusky hairs is brighter tawny; the anterior palatine foramina are longer, and the molars smaller.

Specimens examined.—Total number, 10, all from Costa Rica, as follows: Jabillo, 5; San Geronimo (type locality), 5.

ZOOLOGY.—*Some parasitic copepods from Panama Bay.*[1]

Charles B. Wilson, State Teachers College, Westfield, Massachusetts. (Communicated by Waldo L. Schmitt.)

A small collection of parasitic copepods taken from marine fish in Panama Bay by Dr. A. O. Foster was recently sent to the author for identification. Dr. Foster is helminthologist at the Gorgas Memorial Laboratory of Panama and the copepods were captured during various laboratory investigations. Although the collection includes but eleven species, two of them prove to be new to science, and the male of a third species is here described for the first time. In addition, the host or the locality or both are new for every one of the species.

The Bay of Panama lies off the Pacific end of the Panama Canal and hence is traversed by such shipping as makes use of the canal. In recent years the Galapagos Islands have been a sort of Mecca for many scientific expeditions, the great majority of which have passed through the canal. But, as a rule, the scientists have been so intent upon reaching their ultimate goal that they have made but few investigations enroute.

A notable exception is the Third Hancock Expedition to the Galapagos Islands recently made by the University of Southern California. This expedition did not go through the canal, but went down the Pacific coast of Mexico, Central America, and South

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[1] This paper was prepared under the auspices of the Gorgas Memorial Laboratory, Panama, Dr. H. C. Clark, Director. Received August 30, 1937.

America, stopping at many places along the way and securing valuable specimens. The parasitic copepods of that expedition have been reported elsewhere[2] and included some from the Panama coast. This local collection from Panama Bay admirably supplements that list and should serve as an incentive to similar collections from the Pacific coasts of Mexico, Central and South America.

Caligus bonito Wilson

Taken in considerable numbers from the mouth and gill cavity of a bonito (*Sarda* sp.), and in a single instance from the mouth of another bonito identified as *Sarda velox*. The former host is probably the California bonito, *Sarda chilensis*, found on the Pacific coast from San Francisco to Patagonia.

Caligus coryphaenae Steenstrup & Lütken

Three females were taken from the mouth of a bonito (*Sarda* sp.) in company with the preceding species. This copepod is well distributed and has been reported from both sides of the Atlantic, as well as the Pacific.

Caligus diaphanus Nordmann

A single female was taken from the body of the common jack, *Caranx hippos*. This species is even more widely distributed than either of the preceding and infests a great variety of hosts, to which the present record adds one more.

Caligus monacanthi Krøyer

Krøyer founded his new species, *monacanthi*, in 1863 upon a single specimen taken from the skin of a leather fish (*Monacanthus* sp.) in the West Indies. He identified the specimen as a male and gave a detailed description accompanied by 5 figures. Up to the time of the present collection, no further specimens had been obtained during the seventy odd years since the original discovery. Krøyer was in error as to the sex of his specimen, which was certainly a female without egg strings, rather than a male. This mistake, coupled with the entire lack of further specimens, induced the present author, when dealing with the parasites of West Indian fish, to suggest that Krøyer's specimen might well be the undeveloped female of another species.[3] But twenty specimens, including both sexes, taken from the gills of a bonito (*Sarda* sp.) and included in the present collection, definitely prohibit such an inference. The females agree with Krøyer's description and figures in every detail with one exception and, in addition, carry ovisacs to show that they are fully developed. The exception lies in the fact that these Panama specimens have a two-segmented abdomen, while Krøyer's figure represents the abdomen as one-segmented and the text states that it shows no trace of segmentation. But Krøyer does say in parentheses that the abdomen is contracted for a distance at its base and then widens. The jointing is at the

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[2] University of Southern California Publications. The Hancock Pacific Expeditions **2** (4): 23–30, pl. 3. 1937.

[3] Proc. U. S. Nat. Mus. **28**: 607. 1905.

point where the diameter changes and might easily escape notice, and is scarcely visible in some of the present specimens. A female and male have been selected and given Cat. No. 69867 U.S.N.M.

Female.—Krøyer's statement that this species is marked by an elongation of the carapace, genital segment, and abdomen applies to both sexes. Carapace of female three-sevenths of the entire length and considerably narrowed anteriorly; lunules of medium size and not projecting. Median posterior lobe half the entire width of the carapace, its margin not evenly rounded but with the tip projecting a little. Lateral lobes curved inward and not quite reaching the tip of the median lobe. Free segment two-thirds as wide as the genital segment and strongly narrowed in front of the fourth legs. Genital segment elongate elliptical, three-fourths as long as the carapace, narrowed anteriorly into a short neck and lobed posteriorly. Each of the lobes is as wide as the abdomen, broadly rounded, and does not quite reach the joint in the abdomen. The latter is one-third as wide and nearly as long as the genital segment, and indistinctly two-segmented, the distal segment the longer. Caudal rami nearly as wide as long and well separated. Ovisacs attached to the ventral surface of the genital segment just inside the base of each posterior lobe and as long as the genital segment.

Second antenna large and sickle-shaped; terminal segment of second maxilla slender, longer than the basal segment, with two terminal setae but no lateral spine. Maxilliped with a swollen basal segment and a stout terminal claw. Basipod of first leg with a minute process representing the endopod; terminal segment of the exopod with 3 end spines and a long naked seta, but with no plumose setae on its posterior margin. The armature of the second legs is very peculiar; the basal segment of the exopod carries a long filose spine at the center of the outer margin and a stout spine at the distal corner, bent down across the ventral surface, with a fringe of long hairs between the two spines. The distal segment has 3 setae at its outer corner, flanged on their outer margins and plumed on their inner margins. The basal segment of the endopod has a fringe of small curved spines on the distal half of its outer margin. The second segment has a row of 6 stout spines along its outer margin; the bases of these spines are swollen, cover the whole length of the margin, and are somewhat imbricated. In the third legs the spine on the basal segment of the exopod is nearly straight and reaches the entire length of the second segment. The fourth legs are three-segmented with 5 spines, the second segment as long as the third and the two combined as long as the basal segment, which is moderately swollen. There are no rudiments of fifth legs anywhere visible. Small spherical spermatophores are attached in pairs at the opening of the sperm receptacle.

Total length 4.40 mm. Carapace 2 mm long, 1.90 mm wide. Ovisacs 2 mm long.

Male.—Carapace similar in shape to that of the female, but relatively longer, being just half of the entire length; lunules larger and suborbicular, but scarcely projecting. Posterior median lobe a little more than half the entire width and evenly rounded, extending a little beyond the lateral lobes. Free segment wider than the genital segment, greatly narrowed in front of the fourth legs. Genital segment barrel-shaped, not narrowed to a neck anteriorly and without posterior lobes. Abdomen distinctly two-segmented, the distal segment nearly twice the length of the basal, both segments of the same width throughout with straight sides. Caudal rami nearly twice as long as wide and curved inward. Appendages like those of the female with the following differences.

Maxillary hooks considerably enlarged and strongly curved; maxillipeds with a row of 3 short triangular spines on the inner margin of the basal segment, the terminal claw shutting down against the two distal spines. The claw itself has a slender spine at the center of its concave margin, which is close to the distal spine of the basal segment when the claw is closed. The terminal segment of the first legs carries the usual 3 plumose setae on its posterior margin. In the second legs the fringe of spines on the outer margin of the second segment of the endopod is here replaced by a row of 8 to 10 chitin scales closely imbricated.

Total length 4.50 mm. Carapace 2.25 mm long, 1.90 mm wide.

Remarks.—The armature of the second endopod segment of the second legs in both sexes is not known in any other species of the genus and evidently escaped Krøyer's notice. It lends a distinctive character to the species and with the other details fully establishes its validity after 75 years of waiting.

Caligus patulus, n. sp.

Twelve females were obtained from the outer skin of a milkfish (*Chanos* sp.) captured in the Bay. One of them bearing ovisacs has been chosen as the type of the species with Cat. No. 69869 U.S.N.M.

Female.—Carapace five-eighths of the entire length, almost as wide as long; frontal plates wide and separated by a deep median incision; lunules of moderate size and not projecting. Posterior median lobe half the entire width, with prominent posterior corners; lateral lobes broadly rounded and the same length as the median lobe. Free segment two-fifths as wide as the carapace and thickened through the bases of the fourth legs. Genital segment two-thirds as wide as the carapace and almost twice as wide as long, contracted to the width of the free segment where it joins the latter, Its posterior lobes are broadly rounded and carry rudiments of the fifth and sixth pairs of legs and wide processes at their inner corners, giving them a sinuous outline. The abdomen is quadrangular and one-segmented, as wide as long; the caudal rami are also as wide as long and well separated at the posterior corners of the abdomen. The ovisacs are a little narrower than the abdomen and two-thirds as long as the entire body.

The antennae and maxillae are of the usual pattern; the claw of the maxilliped is as long as the basal segment and abruptly bent near the tip. The basal segment of the first leg has at its posterior distal corner a finger process tipped with a short spine representing the endopod. The proximal segment of the exopod has a fringe of hairs on its posterior margin, and a spiny process at its anterior distal corner; the end segment has two terminal claws and three stout plumose setae. In the third legs the spine on the basal segment of the exopod is short and blunt, and the two rami are close together. The fourth legs are three-segmented with four spines; the second segment is longer than the third and the two combined are the same length as the basal segment. The fifth and sixth legs are represented by small processes tipped with minute setae. The base of the furca is longer than wide, the arms are shorter than the base, nearly parallel and flattened.

Total length 6 mm. Carapace 3.60 mm long, 3.59 mm wide.

Remarks.—The distinguishing characters of this species are the large and roomy genital segment (whence the specific name) with its sinuous posterior

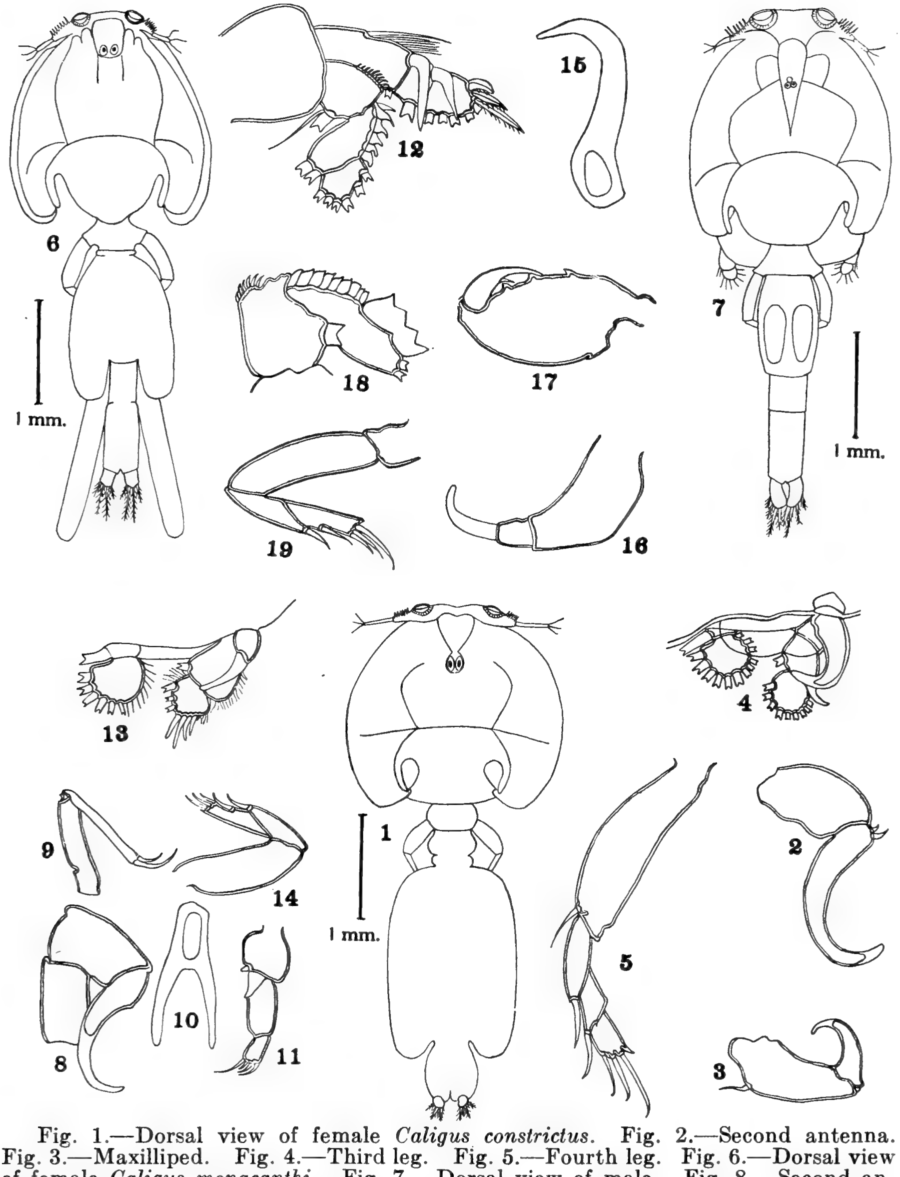

Fig. 1.—Dorsal view of female *Caligus constrictus*. Fig. 2.—Second antenna. Fig. 3.—Maxilliped. Fig. 4.—Third leg. Fig. 5.—Fourth leg. Fig. 6.—Dorsal view of female *Caligus monacanthi*. Fig. 7.—Dorsal view of male. Fig. 8.—Second antenna of female. Fig. 9.—Second maxilla. Fig. 10.—Furca. Fig. 11.—First leg. Fig. 12.—Second leg. Fig. 13.—Third leg. Fig. 14.—Fourth leg. Fig. 15.—Maxillary hook of male. Fig. 16.—Second antenna. Fig. 17.—Maxilliped. Fig. 18.—Second leg. Fig. 19.—Fourth leg.

lobes, and the long fourth legs, which reach beyond the posterior margin of the genital segment. The relative lengths of the second and third segments in these fourth legs are also useful for identification since it is usual for the third segment to be the longer.

Caligus constrictus Heller

Nine females were obtained from the gills of the crevalle, *Caranx hippos*, and three females from the gills of the dolphin, *Coryphaena hippurus*. This species, established by Heller 72 years ago upon a single male and not reported since then, was confirmed in the paper on the parasitic copepods of the Third Hancock Expedition, to which reference has already been made. It is pleasing to obtain so promptly these additional specimens from the same host and locality, and also the others from a new host. It is evident that the crevalle is to be regarded as the chief host and that the parasite is by no means as rare as the long intervals between its appearances would seem to suggest. These new specimens vary somewhat from those already described and the differences are as follows.

In the carapace the eye is visible, while it could not be located in previous specimens. The posterior corners of the median lobe project laterally and overlap the tips of the incurved lateral lobes. The genital segment has no attached spermatophores, the abdomen is as wide as long and the caudal rami are relatively larger. The base of the terminal claw of the second antenna is armed with two minute spines on its inner margin. The basal segment of the maxilliped has a small seta on its posterior margin near the proximal end. The basal segment of the fourth leg has a spine at its distal end similar to those on the other three segments.

These slight differences simply emphasize the validity of the species and show that it does exhibit certain variations.

Caligus tenuifurcatus, n. sp.

Nine specimens, including both sexes, were obtained from the gill cavity of the papagallo, *Nematisteus pectoralis* Gill. A male and female have been selected for types with Cat. No. 69874 U.S.N.M.

Female.—Carapace ovate, narrowed anteriorly, a trifle longer than wide and 40 per cent of the entire length; frontal plates wide and without a central incision; lunules large, circular and projecting considerably. Median posterior lobe more than half the entire width and evenly rounded; lateral lobes curved inward but not meeting the median lobe. Free segment short and one-fourth as wide as the carapace; genital segment a little longer than wide, subquadrangular, with rounded anterior and pointed posterior corners, and slightly convex sides. There are no posterior lobes and no visible leg rudiments. Abdomen nearly as long as the genital segment, tapering a little posteriorly and two-segmented, the distal segment longer than the proximal. Caudal rami twice as long as wide, close together and curved inward. Ovisacs as long as the urosome and somewhat divergent.

First antennae short and turned backward; second antenna stout, its terminal claw bent into a half circle. Basal segment of maxilliped also stout, the terminal claw half as long as the segment with two unequal small spines near the center of its concave margin. Rudimentary endopod of the first legs a very small triangular spine; end segment of exopod with three terminal claws and a much longer spine, and three plumose setae. Fourth leg three-segmented with six spines, including the very small one at the tip of the basal segment. Second and third segments of equal length and together as long as the basal segment.

Total length 5 mm. Carapace 2.10 mm long, 2 mm wide.

Male.—Carapace proportionally larger, a little more than half the entire length and longer than wide; frontal plates with even larger lunules than in the female. Free segment wider than the genital segment and strongly contracted anteriorly. Genital segment a parallelogram, one-half longer than wide, with straight sides. Abdomen a trifle longer than the genital segment and two-segmented, the distal segment one-third longer than the proximal. Caudal rami twice as long as wide and curved inward at their tips.

The antennae, mouth parts, and legs are like those of the female with minor differences. The furca, like that of the female, is more than four times as long as wide, with slender and slightly divergent arms about as long as the base.

Total length 5.40 mm. Carapace 2.81 mm long, 2.50 mm wide.

Remarks.—The relative size and shape of the genital segment and abdomen in both sexes are characteristic of this new species and will serve well for identification.

Gloiopotes costatus Wilson

Thirty specimens, including both sexes, were taken from the outside surface of a sailfish, *Istiophorus greyi*. Some of these were larger than the dimensions originally given for the species, but not otherwise different.

Lernaeenicus longiventris Wilson

Two mature females and a development stage were taken from the body wall of the common jack, *Caranx hippos*. As this is the first development stage of the female after attachment to the host to be reported for the entire genus, two figures and a brief description are here given.

Young female.—Head elliptical, narrowed anteriorly, slightly projecting on either side at the center, swollen and evenly rounded posteriorly and extended backward a little over the anterior thorax. The latter joins the head not at its posterior end but on the ventral surface a little in front of it, and without definite segmentation. Nearly as wide as the head where it joins the latter, and somewhat flattened dorsoventrally, it quickly tapers backward into a narrow cylinder and passes insensibly into the abdomen. This abdomen is cylindrical and exceptionally elongated to more than forty times the length of the head. It maintains the same diameter throughout its entire length without any traces of segmentation, and the posterior end is smoothly rounded with no caudal rami.

The first antennae are turned back along the surface of the head and are almost invisible. The second antennae have two short and stout basal joints and a strong terminal claw. They are situated just beneath the frontal margin of the head, and behind them on the midline of the ventral surface projects the short mouth tube, on either side of which is a maxilla with very long setae. Farther back the second maxillae project from the ventral surface of the head, each tipped with a bifid claw. The anterior thorax carries four pairs of legs which diminish in size backward; the first two pairs are biramose, the last two pairs uniramose, all the rami two-segmented.

Total length 25 mm. Head 0.50 mm long, 0.25 mm wide.

Remarks.—Evidently the first thing that happens to the young female after attachment to the host is the excessive elongation of the body behind the head. In this there is no differentiation of body regions; thorax, genital

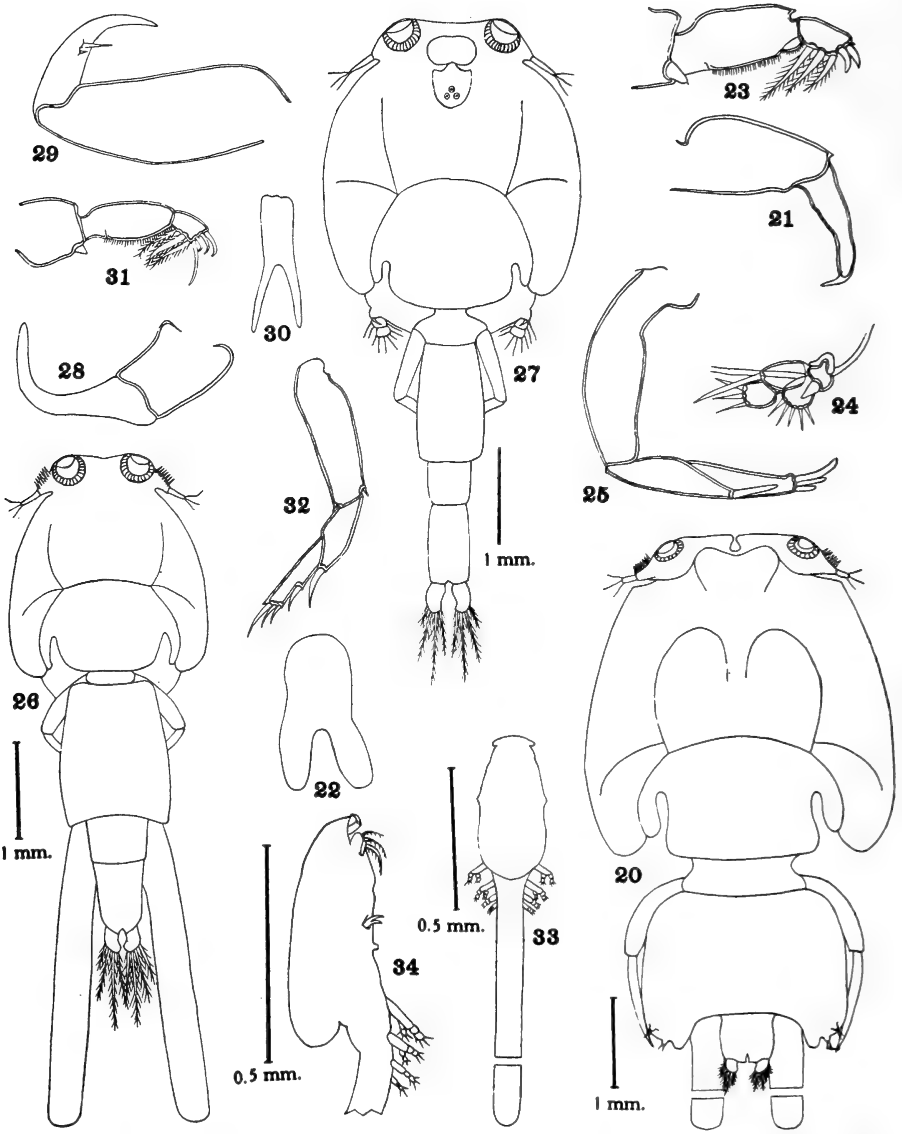

Fig. 20.—Dorsal view of female, *Caligus patulus*. Fig. 21.—Maxilliped. Fig. 22.—Furca. Fig. 23.—First leg. Fig. 24.—Third leg. Fig. 25.—Fourth leg. Fig. 26.—Dorsal view of female *Caligus tenuifurcatus*. Fig. 27.—Dorsal view of male. Fig. 28.—Second antenna of female. Fig. 29.—Maxilliped. Fig. 30.—Furca. Fig. 31.—First leg. Fig. 32.—Fourth leg. Fig. 33.—Dorsal view of a female *Lernaeenicus longiventris* just after attachment to the host. Fig. 34.—Side view of same more highly magnified.

segment, and abdomen are all the same diameter and just alike. Later, with the development of the ovaries, oviducts, and cement glands, the center of the long cylinder is swollen into the genital segment, while the anterior and posterior portions remain unchanged.

Pennella species

Two adult females were taken from the body wall of the same sailfish *Istiophorus greyi*, that yielded the Gloiopotes specimens. These were a large species, 150 mm in length or more, but as the heads were lacking in both specimens, the species could not be determined with certainty.

ORNITHOLOGY.—*Bird bones from archeological sites in Alaska.*[1]

HERBERT FRIEDMANN, U. S. National Museum.

The following collections of bird bones were gathered by Dr. A. Hrdlicka during archeological excavations in the summers of 1935 and 1936. Inasmuch as Kodiak Island was the only area worked in 1935 (also worked to a lesser extent in 1936), we may dispose of it first, and then go on to the Aleutian areas explored in 1936.

1. BIRD BONES FROM KODIAK ISLAND

During 1935, the whole season was spent on Kodiak Island, and a very large collection of bird bones was made. The bones were marked according to the depths from which they came, and therefore, by inference, dated chronologically. Dr. Hrdlicka tells me that the oldest may be 1,500–2,000 years old; the most recent are just pre-Russian, or about 150 years old. Previous collections of bird bones made in 1932 and 1934 have been reported on elsewhere[2] and a complete account of the avifauna of the island has also been published.[3]

The present collection adds but two new birds to the Kodiak list—the golden eagle and the red-legged kittiwake—a clear indication that the bird life of that area is now fairly well-known. The absence of bones of the white-winged scoter and the pigeon guillemot in the present collection is the chief point of contrast with the earlier series of bones collected on Kodiak.

The bones that were perfect enough to be useful as specimens, or that were of particular interest as records, have been saved and incorporated into the skeletal collections of the U. S. National Museum.

Gavia immer (Brunnich). Common Loon. In the 1935 excavations, bones of this bird were unearthed at all levels (superficial, intermediate, and deep)—2 humeri, 2 tibiotarsi, 3 tarsometatarsi, and 2 metacarpals. In 1936 a tarsometatarsus and a metacarpal were collected. It is not possible to identify these bones subspecifically, but the small form *elasson* Bishop is the one known (from skins) to occur on Kodiak Island.

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 30, 1937.

[2] This JOURNAL **25**: 44–51. 1935.

[3] Chicago Acad. Sci. Bull. **5**: 13–54. 1935.

Gavia adamsi (Gray). Yellow-billed Loon. All but the deepest layers exposed in 1935 revealed bones of this loon—1 humerus, 3 coracoids, 3 metacarpals, 1 femur, 2 tarsometatarsi, 1 pair of mandibles, and 2 tibiotarsi. A skull was unearthed in the course of the 1936 operations.

Gavia arctica pacifica (Lawrence). Pacific Loon. The presence of osseous remains in all depths excavated indicates the regularity of occurrence of the Pacific Loon in Kodiak Island. In 1935 2 tibiotarsi, 3 tarsometatarsi, and 5 metacarpals were collected; in 1936, 1 skull, 1 femur, and 1 tarsometatarsus.

Gavia stellata (Pontoppidan). Red-throated Loon. A single tibiotarsus was collected in 1936; no bones referable to this species were gathered in 1935.

Colymbus grisegena holboelli (Reinhardt). Holboell's Grebe. Ten humeri and 9 tarsometatarsi, representing all age levels, were taken in 1935; 1 humerus was found in the 1936 collections.

Colymbus auritus Linnaeus. Horned Grebe. Two humeri, one from the deepest and one from the superficial layer, were unearthed in 1935.

Diomedea albatrus Pallas. Short-tailed Albatross. Numerous osseous parts were found at all levels in 1935—2 tibiotarsi, 1 synsacrum, 3 skulls, 1 humerus, 1 coracoid, 3 metacarpals, 8 tarsometatarsi; in 1936—1 skull, 1 synsacrum, 3 metacarpals, 2 tarsometatarsi, 1 femur, and 1 ulna.

Puffinus sp. Shearwater. The following bones, obviously those of shearwaters and probably referable to *Puffinus tenuirostris,* cannot be identified with certainty, due to lack of named comparative material. In 1935 all levels revealed a total of 14 humeri and 3 tarsometatarsi; in 1936, 2 skulls and 6 humeri were obtained.

Fulmarus glacialis rodgersi Cassin. Pacific Fulmar. A lone skull of this bird was collected in 1936.

Phalacrocorax pelagicus Pallas. Pelagic Cormorant. An abundantly represented species with all levels yielding quantities of bones. In 1935, over 200 tibiotarsi, more than 100 femurs, 66 tarsometatarsi, 165 humeri, and 28 synsacra were collected; in 1936, the material involved 1 skull, 25 humeri, 9 tibiotarsi, 2 synsacra, 1 ulna, 1 coracoid, 3 tarsometatarsi, and 5 femurs.

Cygnus columbianus (Ord). Whistling Swan. The 1935 diggings unearthed 4 fragmentary humeri and 1 synsacrum, all from the more superficial layers.

Cygnus buccinator Richardson. Trumpeter Swan. A synsacrum and 2 tarsometatarsi were found in the superficial levels and another tarsometatarsus in the intermediate depths in 1935; in 1936 a metacarpal and the head of a humerus were collected.

Philacte canagica (Sevastianoff). Emperor Goose. All age levels yielded a small number of bones of this goose in the 1935 diggings—1 tarsometatarsus, 1 femur, and 5 tibiotarsi; the 1936 operations netted 3 skulls and 3 tibiotarsi.

Anser albifrons (Scopoli). White-fronted Goose. Two tarsometatarsi, one superficial and one deep, were exhumed in 1935. This bird is still known from Kodiak Island solely on the basis of osseous remains.

Glaucionetta clangula americana (Bonaparte). Golden-eye. During the 1936 diggings, 9 humeri referable to this duck were found. The subspecific determination is based merely on the knowledge that *americana* has been found to be the subspecies of golden-eye found on the island.

Clangula hyemalis (Linnaeus). Old-squaw. The intermediate layers worked in 1935 yielded 9 humeri of this duck; the 1936 operations likewise turned up 9 humeri.

Histrionicus histrionicus (Linnaeus). Harlequin Duck. Eleven humeri, from all but the deepest deposits, were taken in 1935. They probably belong to the subspecies *pacificus* Brooks.

Polysticta stelleri (Pallas). Steller's Eider. In the 1935 diggings, 34 humeri, representing all age layers, were collected; 3 additional humeri were dug up in 1936.

Somateria v-nigra Gray. Pacific Eider. Hrdlicka obtained 1 skull, 5 humeri, and 7 tarsometatarsi in the superficial diggings in 1935; in 1936 he collected 3 skulls.

Somateria spectabilis (Linnaeus). King Eider. Large numbers of bones were found in all the layers excavated in 1935—73 coracoids, 36 tarsometatarsi, 122 humeri. In 1936 some 25 humeri and 3 tarsometatarsi were obtained.

Melanitta perspicillata (Linnaeus). Surf Scoter. In 1935 Hrdlicka collected 12 humeri, 8 from superficial deposits, 4 from intermediate depths; in 1936 he obtained 3 humeri.

Oidemia americana Swainson. American Scoter. Eight humeri, representing all depths, were collected in 1935; in 1936, in a collection much smaller in extent, no fewer than 25 humeri and 1 skull were unearthed.

Aquila chrysaetos canadensis (Linnaeus). Golden Eagle. A sternum from the superficial layers excavated in 1935 is the only record for this eagle from Kodiak Island. There is nothing surprising, however, in the occurrence of this species there, as it occurs on the neighboring mainland.

Haliaeetus leucocephalus (Linnaeus). Bald Eagle. The bald eagle is very common on Kodiak Island, and its bones were found in good numbers in all diggings during both years. In all, some 5 skulls, 4 pairs of mandibles, 23 humeri, 95 metacarpals, 2 pairs of clavicles, 2 radii, 7 ulnae, 9 sterna, 1 scapula, 18 coracoids, 12 synsacra, 14 femurs, 27 tibiotarsi, and 35 tarsometarsi were collected.

Lagopus rupestris kelloggae Grinnell. Kellogg's Ptarmigan. A single humerus and a synsacrum taken in the superficial layers in 1935 represent this bird.

Haematopus bachmani Audubon. Black Oyster Catcher. In the superficial strata dug up in 1935, Hrdlicka found a humerus of this shore-bird.

Larus hyperboreus Gunnerus. Glaucous Gull. Six tarsometatarsi were found in the upper levels in 1935.

Larus glaucescens Naumann. Glaucous-winged Gull. All depths excavated in 1935 revealed osseous remains of this gull—1 skull, 6 tarsometatarsi, 9 coracoids, and 14 humeri; in 1936 another humerus was collected.

Larus argentatus smithsonianus Coues. Herring Gull. The herring gull is represented by bones from all age levels in the 1935 diggings—5 coracoids, 24 humeri, 12 tarsometatarsi; it is also represented by 3 humeri collected in 1936. The subspecific determination is a geographic inference.

Rissa tridactyla pollicaris Ridgway. Pacific Kittiwake. Twelve humeri from all depths in the 1935 diggings are referable to this gull.

Rissa brevirostris (Bruch). Red-legged Kittiwake. Two humeri from the superficial layers of the 1935 excavations appear to represent this species, and thereby constitute the first record for Kodiak Island and a noteworthy extension in range for the gull.

Uria sp. Murre. Undoubtedly both species of murres, *Uria aalge californica* and *Uria lomvia arra*, are represented, but it is not possible to distinguish them on the basis of osseous remains. All diggings yielded large quantities of murre bones—23 skulls, 13 coracoids, 3 sterna, 3 synsacra, and about 500 humeri.

Synthliboramphus antiquus (Gmelin). Ancient Murrelet. This species is represented by 3 humeri in the 1936 collection.

Cyclorrhynchus psittacula (Pallas). Paroquet Auklet. Bones of this auklet were found sparingly in all the diggings of both years—25 humeri in all.

Aethia cristatella (Pallas). Crested Auklet. Seven humeri of this form were taken from the superficial and intermediate levels, both years.

Fratercula corniculata (Naumann). Horned Puffin. Considering the abundance of this bird on Kodiak Island, it is surprising that so few of its bones were found—2 humeri from the superficial levels of the 1935 diggings are the only bones collected.

Lunda cirrhata (Pallas). Tufted Puffin. Found in all but the deepest levels, both years. Altogether some 8 tarsometatarsi, 1 skull, and 1 humerus were unearthed.

Surnia ulula caparoch (Muller). American Hawk Owl. A skull found in the upper layers in 1935 represents this bird.

Pica pica hudsonia (Sabind). American Magpie. In the superficial levels excavated in 1935, Hrdlicka collected a skull, 1 humerus, and 1 tarsometatarsus of the magpie.

Corvus corax principalis Ridgway. Northern Raven. Commonly represented in all diggings both years. The following bones were collected: 10 skulls, 3 synsacra, 40 metacarpals, 35 humeri, and 25 tarsometatarsi.

Corvus brachyrhynchos caurinus Baird. Northwestern Crow. Found in all diggings but in much smaller quantities than the previous species—4 skulls and 7 humeri.

In the Aleutian Chain excavations were made in 1936 in four islands—Unalaska, Little Kiska, Atka, and Attu.

2. BIRD BONES FROM DUTCH HARBOR, UNALASKA

Gavia adamsi (Gray). Yellow-billed Loon. One skull, 2 tibiotarsi, 2 metacarpals, and 1 pair of mandibles represent this species.

Gavia arctica pacifica (Lawrence). Pacific Loon. A single metacarpal of this bird was collected.

Diomedea albatrus Pallas. Short-tailed Albatross. This albatross is well represented by many bones—4 humeri, 3 synsacra, 1 ulna, 4 pairs of maxillae, 1 tibiotarsus, 5 metacarpals, 9 tarsometatarsi, and 7 femurs.

Puffinus griseus (Gmelin). Sooty Shearwater. Some 18 humeri are referable to this bird.

Puffinus sp. Shearwater. The bones here included are probably to be referred to *P. tenuirostris*, but in the absence of comparative, named material, I cannot be certain.

Fulmarus glacialis rodgersi Cassin. Pacific Fulmar. Two skulls were collected.

Phalacrocorax pelagicus Pallas. Pelagic Cormorant. Represented by 16 humeri, 3 tibiotarsi, 7 femurs, and 3 tarsometatarsi.

Philacte canagica (Sevastianoff). Emperor Goose. Three humeri of the emperor goose were collected.

Nyroca valisineria (Wilson). Canvas-back. Five humeri are referable to this duck.

Glaucionetta clangula americana (Bonaparte). American Golden-eye. The subspecific determination of the single humerus collected is based on geography alone.

Clangula hyemalis (Linnaeus). Old-squaw. Of this duck 8 humeri were found.

Histrionicus histrionicus (Linnaeus). Harlequin Duck. Twelve humeri. Probably of the western subspecies, *pacificus*.

Somateria v-nigra Gray. Pacific Eider. A skull and 4 humeri represent this duck.

Somateria spectabilis (Linnaeus.) King Eider. More commonly represented than the preceding species—24 humeri and 2 skulls were found.

Melanitta deglandi (Bonaparte). White-winged Scoter. Of this species 13 humeri were collected.

Melanitta perspicillata (Linnaeus). Surf Scoter. A single humerus appears to be of this species.

Oidemia americana Swainson. American Scoter. One humerus.

Mergus merganser Linnaeus. Merganser. One humerus; probably of the American subspecies.

Haliaeetus leucocephalus (Linnaeus). Bald Eagle. Represented by 3 coracoids, 2 metacarpals, and 3 tibiotarsi. Curiously enough, 2 of the tibiotarsi had been broken and healed.

Lagopus sp. Ptarmigan. Two humeri of a ptarmigan, probably *L. rupestris,* were found.

Larus hyperboreus Gunnerus. Glaucous Gull. One femur of this gull was found.

Larus glaucescens Naumann. Glaucous-winged Gull. Of this species, 1 skull and 4 humeri were unearthed.

Larus argentatus smithsonianus Coues. Herring Gull. Six humeri.

Rissa brevirostris (Bruch). Red-legged Kittiwake. A single humerus appears to be of this species and constitutes an interesting geographical record.

Uria sp. Murres. Undoubtedly the 2 species *aalge* and *lomvia* are here mixed, but it is not possible to tell their bones apart. All in all, 148 humeri, 1 skull, and 3 tibiotarsi were found.

Cepphus columba Pallas. Pigeon Guillemot. One humerus.

Synthliboramphus antiquus (Gmelin). Ancient Auklet. Four skulls appear to be referable to this species.

Aethia cristatella (Pallas). Crested Auklet. Five humeri.

Fratercula corniculata (Naumann). Horned Puffin. One humerus.

Lunda cirrhata (Pallas). Tufted Puffin. Two humeri.

Corvus corax principalis Ridgway. Northern Raven. Of this bird, 3 humeri and 3 metacarpals were dug up.

3. BIRD BONES FROM LITTLE KISKA

Gavia immer (Brunnich). Common Loon. One humerus, 1 metacarpal, 1 tibiotarsus.

Gavia adamsi (Gray). Yellow-billed Loon. One sternum, 1 humerus, 1 tibiotarsus.

Diomedea albatrus Pallas. Short-tailed Albatross. Four tarsometatarsi, 3 metacarpals, 13 fragments of synsacra, 3 fragments of sterna, 7 humeri (5 fragments only), 5 skulls, 15 pair of maxillae, 1 pair of mandibles, 1 pair of clavicles, 15 femurs, 1 tibiotarsus.

Puffinus griseus (Gmelin). Sooty Shearwater. Two humeri.

Phalacrocorax pelagicus Pallas. Pelagic Cormorant. Three tarsometatarsi, 62 humeri, 26 femurs, 6 skulls, 14 sterna, 12 synsacra, 1 coracoid, 8 tibiotarsi.

Cygnus columbianus (Ord). Whistling Swan. Two ulnae, 2 radii.

Branta nigricans (Lawrence). Black Brant. One skull, 2 sterna.

Philacte canagica (Sevastianoff). Emperor Goose. Forty-seven humeri, 1 ulna, 2 synsacra, 3 femurs, 4 metacarpals, 3 tarsometatarsi.

Anser albifrons (Scopoli). White-fronted Goose. Eleven humeri, 2 femurs.

Mareca americana (Gmelin). Baldpate. Three humeri.

Charitonetta albeola (Linnaeus). Buffle-head. One humerus.

Clangula hyemalis (Linnaeus). Old-squaw. One humerus.

Histrionicus histrionicus (Linnaeus). Harlequin Duck. Three humeri, 1 skull.

Polysticta stelleri (Pallas). Steller's Eider. Five humeri.

Somateria v-nigra Gray. Pacific Eider. Thirteen sterna, 8 skulls, 2 clavicles, 7 metacarpals, 3 coracoids, 1 ulna, 29 humeri, 2 synsacra, 1 tarsometatarsus, 2 tibiotarsi.

Somateria spectabilis (Linnaeus). King Eider. Three humeri, 1 femur, 3 metacarpals, 3 sterna, 1 synsacrum, 1 tibiotarsus.

Melanitta deglandi (Bonaparte). White-winged Scoter. Eight humeri, 1 skull.

Melanitta perspicillata (Linnaeus). Surf Scoter. One humerus.

Mergus serrator Linnaeus. Red-breasted Merganser. One skull.

Haliaeetus leucocephalus (Linnaeus). Bald Eagle. One humerus. 2 metacarpals.

Larus hyperboreus Gunnerus. Glaucous Gull. One skull, 1 femur.

Larus glauscens Naumann. Glaucous-winged Gull. Eight humeri, 1 femur.

Larus argentatus smithsonianus Coues. Herring Gull. Four humeri, 1 skull.

Uria sp. Murres. Probably both species *aalge* and *lomvia* mixed together. One skull, 13 humeri, 1 femur, 4 sterna.

Cepphus columba Pallas. Pigeon Guillemot. Two skulls, 8 humeri.

Brachyrhamphus marmoratus (Gmelin). Marbled Murrelet. One sternum.

Synthliboramphus antiquus (Gmelin). Ancient Murrelet. One humerus, 1 sternum.

Aethia cristatella (Pallas). Crested Auklet. Twenty-one humeri, 5 sterna.

Aethia pusilla (Pallas). Least Auklet. Three sterna.

Cerorhinca monocerata (Pallas). Rhinoceros Auklet. Three humeri.

Fratercula corniculata (Naumann). Horned Puffin. Twenty-nine humeri.

Lunda cirrhata (Pallas). Tufted Puffin. Twenty-one humeri, 4 sterna.

Nyctea nyctea (Linnaeus). Snowy Owl. One femur.

Corvus corax principalis Ridgway. Northern Raven. Eleven humeri, 3 metacarpals, 1 synsacrum.

4. BIRD BONES FROM ATKA ISLAND

Diomedea albatrus (Pallas). Short-tailed Albatross. One humerus.

Branta nigricans (Lawrence). Black Brant. One humerus.

Philacte canagica (Sevastianoff). Emperor Goose. One humerus.

Melanitta deglandi (Bonaparte). White-winged Scoter. One humerus.

Haliaeetus leucocephalus (Linnaeus). Bald Eagle. One synsacrum.

Larus glaucescens Naumann. Glaucous-winged Gull. One tibiotarsus.

Corvus corax principalis Ridgway. Northern Raven. Four humeri.

5. BIRD BONES FROM ATTU ISLAND

Diomedea albatrus Pallas. Short-tailed Albatross. Three skulls, 1 pair of maxillae, 2 synsacra, 3 tarsometatarsi, 2 metacarpals, 7 femurs.

Puffinus griseus (Gmelin). Sooty Shearwater. Five humeri.

Puffinus sp. Shearwater. Six humeri, probably *P. tenuirostris.*

Fulmarus glacialis rodgersi Cassin. Pacific Fulmar. One humerus.

Phalacrocorax pelagicus Pallas. Pelagic Cormorant. Four sterna, 3 synsacra, 4 skulls, 3 coracoids, 11 ulnae, 31 humeri, 1 tarsometatarsus, 26 femurs, and 16 tibiotarsi.

Branta nigricans (Lawrence). Black Brant. Four humeri.

Philacte canagica (Sevastianoff). Emperor Goose. One femur, 14 humeri.

Anser albifrons (Scopoli). White-fronted Goose. Two tarsometatarsi.

Somateria v-nigra Gray. Pacific Eider. One sternum, 4 skulls, 1 coracoid, 4 humeri.

Melanitta deglandi (Bonaparte.) White-winged Scoter. One humerus.

Larus hyperboreus Gunnerus. Glaucous Gull. Two skulls.

Larus glaucescens Naumann. Glaucous-winged Gull. Eleven humeri, 17 ulnae, 2 metacarpals.

Larus argentatus smithsonianus Coues. Herring Gull. Three humeri.

Larus canus brachyrhynchus Richardson. Short-billed Gull. Two humeri.

Uria sp. Murres. Four humeri, 1 skull.

Cepphus columba Pallas. Pigeon Guillemot. Two humeri.

Corvus corax principalis Ridgway. Northern Raven. Two humeri, 1 tarsometatarsus, 2 ulnae, 1 skull.

ENTOMOLOGY.—*The genus* Lysiognatha *Ashmead.*[1] R. A. CUSHMAN, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

Many "rare" insects are rare only until something of their seasonal and environmental habits is discovered. Until the spring of 1933 *Lysiognatha* was a "rare" insect. In 1895[2] Ashmead described the genus and its type species, *comstockii,* from three specimens collected near Ithaca, N.Y., in 1872 by H. H. Smith. No other specimens had been recorded, and so far as I know only one other, a specimen without abdomen taken in Colorado by C. F. Baker and for many years reposing among unclassified material in the National Museum, had been collected.

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[1] Received July 20, 1937.

[2] Proc. Ent. Soc. Wash. **3**: 276. 1895.

REDISCOVERY OF LYSIOGNATHA

In 1933 J. C. Bridwell became interested in the sawflies of the genus *Xyela,* and observed them ovipositing in the young staminate cones of the Virginia pine (*Pinus virginiana*) at Clifton, Va. He also collected some of the parasitic Hymenoptera that he found frequenting the pine trees. These he submitted to me for identification. Among them I was surprised to find four female specimens representing two species of *Lysiognatha,* collected about May 1, 1933.

SEASONAL HISTORY AND BIOLOGY

On April 28 and 29, 1934, Mr. Bridwell and I visited groves of young pine trees in Virginia a few miles from Washington, D. C., and found *Lysiognatha* very abundant. At this time a large majority of the specimens were males. A week later specimens were much less numerous and all were females. This indicates that the males emerge before the females, and also that April 28 was not far from the earliest emergence date for *Lysiognatha.* During this period the larvae of *Xyela* were reaching full growth, and about May 5 were leaving the cones in large numbers. Examination of the nearly 200 specimens of *Lysiognatha* collected disclosed the same two species taken in 1933 by Mr. Bridwell and also many specimens of a third species.

While examining larvae of *Xyela* for evidence of parasitization we found many bearing on or near their heads peculiar eggs, which we were able, by comparing them with ovarian eggs, to identify as those of *Lysiognatha.* The egg of *Lysiognatha* is comparatively large, white, elongate oval, slightly curved, and slightly larger at the cephalic end. It is attached to the host by a short pedicel thrust through the skin of the host. Imbedded in the foot of the stalk is a black heavily sclerotized body that apparently serves as an anchor. Fig. 1,*b*, shows an egg dissected from the ovary of *Lysiognatha* and Fig. 1,*c*, three eggs attached to a *Xyela* larva.[3] The position of the egg on the host suggests the surmise that the peculiar mandibles of *Lysiognatha* may be employed for holding the host during oviposition.

It is very evident that hatching never takes place until after the host has entered the soil for pupation, for of the many eggs that we observed on *Xyela* larvae just after their emergence from the cones, none had hatched. In fact, it was not until July 3, more than two months after the discovery of the egg, that a newly hatched larva was observed. In hatching the larval *Lysiognatha* does not entirely

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[3] Preliminary notice of the rediscovery of *Lysiognatha* and of the identity of its egg was published in Proc. Ent. Soc. Wash. **36**: 262. 1934.

emerge from the eggshell, but uses it as an anchor for holding to its host.

On August 6 the first full-grown larva was found. It is a typical ichneumonid larva of the externally parasitic type, as shown by the figure of the head, Fig. 1,*d*. Subsequently many larvae were found in their thin, shining, transparent cocoons within the cocoons of *Xyela*.

The first pupa was found on September 20 and by September 26 most of the larvae had pupated. Although *Xyela* cocoons were collected and examined as late as December 17, *Lysiognatha* had not advanced beyond the pupal stage, and it is evident that it hibernates in that stage.

TAXONOMY

Position in classification.—At the time of the original description of *Lysiognatha*, Ashmead created for it the subfamily Lysiognathinae, which he placed as the first subfamily of the Ichneumonidae. In 1900, however, in his *Classification of the ichneumon flies,* he treated it as a subfamily of the Alysiidae because of the position and form of the mandibles. The Spanish hymenopterist, G. Ceballos, examined the types of *L. comstockii* at the National Museum in 1928, and subsequently[4] expressed the opinion that it is ichneumonid.

In my opinion the cephalic and mandibular characters are adaptive, whereas the venation and the free second abdominal suture, together with the characters of the larva, are phylogenetic characters and hence of much more significance in determining the affinities of the group. In venation and abdominal structure there is no essential difference between *Lysiognatha* and many ichneumonid, especially ichneumonine, genera, and it is to the Ichneumonidae that I think it should be relegated.

The association of *Lysiognatha* with the primitive *Xyela* would seem to indicate a primitive position for it within the Ichneumonidae. On the other hand, the form of the head and of the mandibles and the method of reproduction indicate a much more recent origin than that of many other Ichneumonidae. Whatever the placing, the form of the head and of the mandibles would render the group anomalous. In the more conservative characters of venation, form of abdomen, and form of ovipositor it is perhaps most like the Ichneumonini, while its method of reproduction allies it with the Tryphonini. In my opinion the proper placing of the group is low on the phylogenetic line between the Ichneumonini and the Tryphonini. The anomalous form of the head and that of the mandibles are sufficient to warrant the recognition of the Lysiognathinae as a distinct subfamily.

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[4] Mem. Real Soc. Esp. Hist. Nat. **25**: 20. 1929.

Subfamily and generic characters.—Head in front view (Fig. 1,*a*) broader than long, with mouth very broad, mandibles articulating below eyes, the articulating membrane extending upward behind eyes; malar space obliterated; mandible nearly twice as long as broad at base, nearly parallel sided, with two large, slightly out-turned teeth, from each of which a prominent carina runs back along margin toward base so that outer face of mandible toward apex is concave; clypeus correspondingly broad, extending from eye to eye, ten or more times as broad as long medially, where it is shortest; maxillary palpus 5-jointed; labial palpus 4-jointed (erroneously given as 3-jointed by Ashmead); head behind eyes buccate, temple nearly or quite reaching outside tangent of eye, occiput deeply concave and margined by a distinct carina; antennae short, slender, filiform, about 22–25-jointed, scape semiglobose, squarely truncate at apex, first joint of flagellum shorter than second and slightly thickened toward base.

Fig. 1.—*a*, head of *Lysiognatha longicauda* Cushman; *b*, ovarian egg of *Lysiognatha* sp.; *c*, eggs of *Lysiognatha* sp. *in situ* on larva of *Xyela* sp.; *d*, head of larva of *Lysiognatha* sp.

Thorax stout, shining, weakly sculptured; epomia lacking; notauli shallow; sternauli lacking; prepectus defined; mesolcus deep, not closed posteriorly; propodeum incompletely areolated, median carinae diverging from base to apex, basal area small quadrangular, areola and petiolar area confluent; lateral carinae present or absent; spiracle very small, circular, situated somewhat before middle.

Legs stout, rather long; calcaria 1:2:2, short, inner calcaria on middle and hind legs not much longer than outer; claws small, simple.

Wings broad; stigma broadly triangular; areolet deltoid, oblique, sessile or petiolate; second recurrent with separated bullae; second discoidal cell broad at base; abscissula shorter than intercubitella; nervellus broken below middle.

Abdomen in female short and broad, sessile, little longer than thorax; first tergite large, slightly longer than broad, sides divergent, dorsal carinae extending well onto disk, spiracle basad of middle; other tergites strongly transverse, apical ones weakly sclerotized; ovipositor long, subsagittate but not serrate at apex; hypopygium rather prominent; venter entirely membranous. Abdomen in male more slender than in female, broadest near apex; first tergite much longer than broad; second nearly as long as broad; apical tergites more strongly sclerotized than in female.

KEY TO SPECIES

1. Vertex with a deep median, longitudinal sulcus extending back onto occiput and interrupting the occipital carina 2
   Vertex with at most a faint sulcus; occipital carina not interupted....3
2. Female largely ferruginous .... *comstockii* Ashmead
   Female largely blackish .... *sulcata*, n.sp.
3. Occipital carina sharply curved or angulate medially; ovipositor sheath nearly as long as body .... *longicauda*, n. sp.
   Occipital carina evenly and broadly curved medially; ovipositor sheath much shorter than body .... *bridwelli*, n. sp.

Lysiognatha comstockii Ashmead

Lysiognatha comstockii Ashmead, Proc. Ent. Soc. Wash. **3**: 276. 1895.

Known only from the three specimens of the type-series. The two females are in the U. S. National Museum, the holotype without wings and antennae and the paratype without abdomen.

This is the palest of the four species, at least in the female, being of a ferruginous color with abdomen almost stramineous. It also differs from the next following species, to which it is most closely related by the possession of the vertical sulcus, in having the thorax polished and virtually without sculpture and the tergites beyond the second evenly sclerotized throughout.

Lysiognatha sulcata, n. sp.

Closely related to *comstockii* and possibly not distinct, but judging from the meager material in both species it differs constantly in the female in the blackish head and thorax and the more distinctly sculptured and less polished thorax, and in having the tergites beyond the first so weakly sclerotized along the apical and lateral margins that in dried specimens they are much distorted. The last may be due to a teneral condition, but the fully developed color argues against this possibility. Furthermore, the difference of nearly two months in the collecting dates could hardly be accounted for by the difference in latitude.

Female.—Length 3.25 mm; antenna 2.75 mm; ovipositor sheath 1.75 mm.

Head polished, virtually without sculpture; a deep sulcus extending from between the ocelli nearly to the occipital foramen and interrupting the occipital carina.

Thorax subpolished, subtly alutaceous; mesoscutum weakly and sparsely punctate; propodeum more strongly alutaceous, the carinae faint; areolet sessile.

Abdomen beyond first tergite weakly sclerotized around margins of tergites, first tergite subpolished, distinctly longer than broad.

Black; face, clypeus, mouthparts (except mandibular teeth), lower margin of cheek, frontal orbit, under side of scape, of pedicel, and of base of first flagellar joint, tegulae, radices of wings, and front and middle coxae and all trochanters whitish; abdomen beyond first tergite brown fading to yellowish toward apex; wings hyaline, stigma testaceous, veins darker; front and middle femora pale stramineous, their tibiae and tarsi somewhat infuscate; hind coxa piceous with apex pale, femur stramineous, tibia and tarsus fuscous.

Male.—Essentially like female except that abdomen is narrower and evenly sclerotized; first tergite nearly twice as long as broad with sides parallel beyond spiracles; abdomen darker, with tergites except first margined with yellow; and stigma fusco-testaceous.

Type-locality.—Clifton, Va.

Type.—No. 52160, U. S. National Museum.

Two females from the type-locality Apr. 26–May 3, 1933; 2 males, Dalecarlia, D. C., June 1, 1934, and one male, Alexandria, Va., Apr. 28, 1934; all taken by J. C. Bridwell on *Pinus virginiana.*

Lysiognatha longicauda, n. sp.

Distinct from *sulcata* in the obsolete sulcus of vertex and merely angulated, not interrupted, occipital carina; and, in the female, in the completely sclerotized tergites and much longer ovipositor.

Female.—Length 3.25 mm; antenna 2.75 mm; ovipositor sheath 2.75 mm.

Head finely but distinctly punctate; sulcus of vertex distinct only just before occipital carina, which has a distinct angulation but is not interrupted medially.

Thorax shining, alutaceous especially on pleura and propodeum, mesoscutum and scutellum distinctly finely punctate; propodeal carinae distinct; areolet subsessile or petiolate.

Abdominal tergites completely sclerotized; first tergite distinctly alutaceous, very slightly longer than broad.

Color pattern the same as in *sulcata,* but the dark color more piceous, sometimes largely replaced by reddish; dorsal part of head, scutellum and the thoracic sutures frequently paler; legs usually darker; abdomen beyond first tergite, except apical 2 or 3 tergites, piceous; stigma fusco-testaceous, paler at base and apex.

Male.—Abdomen more slender than in female, first tergite nearly twice as long as broad; dark color of head and thorax black, rather than piceous; abdomen dorsally piceous, except narrow yellowish margins of tergites.

Host.—*Xyela* sp.

Type locality.—Alexandria, Va.

Type.—No. 52161, U. S. National Museum.

Forty-six females and 54 males taken on pine at Clifton, Va. (Apr. 26–May 3, 1933), Alexandria, Va. (Apr. 28, May 2 and May 6, 1934), and Barcroft, Va. (May 6, 1934), all by J. C. Bridwell, and at Falls Church, Va. (Apr. 29 and May 6, 1934) by R. A. Cushman.

Lysiognatha bridwelli, n. sp.

Female.—Length 3.0 mm; antenna 2.0 mm; ovipositor sheath 1.75 mm. Distinct from all of the other species in the evenly curved, neither interrupted nor angulated occipital carina and barely visible median sulcus of vertex; and from *longicauda*, which it most closely resembles, in the much shorter ovipositor. Otherwise the species agrees with the above description of *longicauda*, except that the ground color of head and thorax, whether piceous or reddish, is more nearly uniform.

Male.—Differs from the female as does the male of *longicauda* from its female.

Host.—*Xyela* sp.

Type locality.—Alexandria, Va.

Type.—No. 52162, U. S. National Museum.

Thirty-nine females and 38 males taken on pine at Alexandria, Va. (Apr. 28–29 and May 2 and 6, 1934), Barcroft, Va. (May 6, 1934), and Dalecarlia, D. C. (May 1, 1934) by J. C. Bridwell, and at Falls Church, Va. (Apr. 29 and May 6, 1934) by R. A. Cushman.

MALACOLOGY.—*Four new species of fresh-water mollusks from China.*[1] SUI FONG CHEN. (Communicated by PAUL BARTSCH.)

In a collection of Chinese fresh-water mollusks received by the U. S. National Museum from the Rev. D. C. Graham are four undescribed species which are here described and named.

I wish here to express my appreciation to the authorities of the U. S. National Museum and to Dr. Paul Bartsch, the Curator of the Division of Mollusks, for the privilege of studying the family Melaniidae from China in their collection.

Melania (Melanoides) suifuensis, n. sp. Figs. 1, 2.—1

Shell of medium size, stout, elongate-conic, turreted, pale yellow throughout excepting the interior of the aperture, which is whitish. The nuclear whorls are decollated in all the specimens before me. Postnuclear whorls well rounded, marked with axial crescentic ribs of which 14 occur on the second and third of the remaining whorls, 15 on the fourth, 17 on the fifth and sixth, 19 on the penultimate, and 18 on the last whorl. The spaces separating the ribs about equal them in width. The spiral sculpture consists of fine threads of which 16 occur between summit and periphery on the last whorl. The suture is strongly impressed. Periphery strongly angulated with the axial ribs terminating at the angulation. Base short, well rounded, and marked by the feeble continuations of the axial ribs; it is also marked by obsolete microscopic spiral threads. The aperture is elliptical; the peristome is thin, simple; parietal wall covered with a slight callus; columella arched. The operculum is thin with 3.2 turns and has left subcentral nucleus. The radula has the formula: 3-1-3:2-1-3:4:5.

The type of U.S.N.M. Cat. No. 365666, was collected by Rev. D. C. Graham at Suifu, Szechuan Province, China. It has 8 whorls remaining

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[1] Published by permission of the Secretary of the Smithsonian Institution. Received July 30, 1937.

which yields the following measurements: Length 21.1 mm; diameter 8.0 mm; length of aperture 6.6 mm.

Twenty-one specimens from the same source as the type, yield the following additional information: They have an average number of 7.9 whorls; the greatest number of whorls being 9.1, and the least 7.2. They present an average length of 18.6 mm; the greatest length being 20.9 mm, and the least 15.8 mm. Their average diameter is 7.0 mm; the largest is 7.8 mm. and the least 5.9 mm. The length of aperture averages 5.9 mm; the largest length of aperture is 6.5 mm, and the least 5.2 mm. They have an average number of ribs as follows: 14.7 on the second of the remaining whorls, 14.6 on the third, 14.8 on the fourth, 15.5 on the fifth, 17.0 on the sixth, 18.0 on the seventh and last whorls.

This species resembles *Melania ningpoensis* Lea, but lacks the spiral keels on the base.

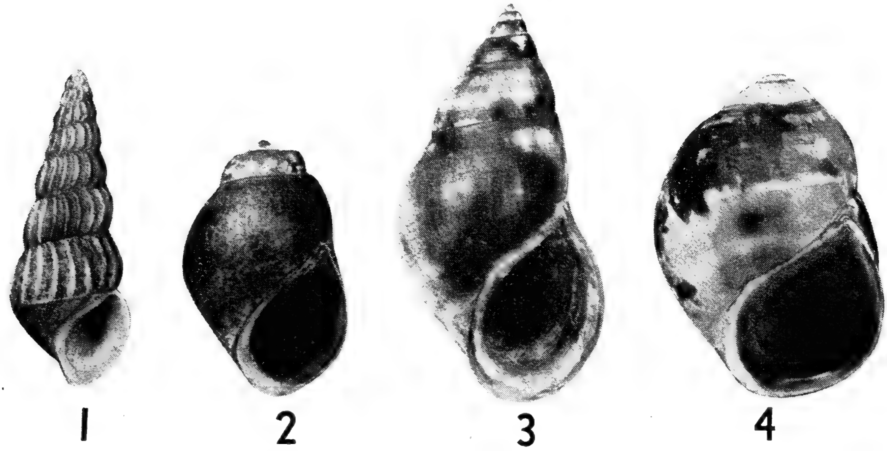

Fig. 1.—1, *Melania* (*Melanoides*) *suifuensis.* ×2. 2, *Paludomus* (*Hemimitra*) *yunnanensis.* ×5. 3, *Paludomus* (*Hemimitra*) *kweichowensis.* ×5. 4, *Paludomus minensis.* ×2.

Paludomus (Hemimitra) yunnanensis, n. sp. Figs. 1, 2.—2

Shell quite small, ovate-conic, olive brown. Nuclear whorls eroded in all the specimens before me. Postnuclear whorls inflated, strongly rounded, and marked with microscopic incremental lines; spiral sculpture absent. The last whorl shows three dark brown bands. The first which is much narrower and darker is a little below the summit, the second one is half way between the first and third, the latter being at the periphery; a lighter zone equalling the medium dark band separates this from the other two. The suture is well impressed. The last whorl is rather inflated with rounded periphery. The base is short, well rounded, with a dark brown median spiral band. Aperture pyriform; peristome thin, simple; parietal wall with a thin callus; columella arched. The operculum is thin, horny with 2.4 turns, bluntly pointed posteriorly, and broadening anteriorly with subcentral nucleus. The radula has the formula: 2-1-2:2-1-3:6:11.

The type, U.S.N.M. Cat. No. 467598, was collected by Rev. D. C. Graham in the Yangtze River, near Shiikiang, Yunnan Province. China, and yields the following measurements: Number of whorls 3.0; length 6.9 mm; diameter 4.5 mm; length of aperture 4.0 mm.

Twenty-nine specimens from the same source give us the following additional information: They have an average number of 2.9 whorls remaining; the greatest number of whorls is 3.3, and the least 2.3. They present an average length of 5.7 mm; the greatest length is 7.3 mm, and the least 3.6 mm. Their average diameter is 4.0 mm; the largest is 4.8 mm, and the least 2.6 mm. The length of aperture averages 3.4 mm; the largest length of aperture is 4.3 mm, and the least 2.2 mm.

This species is also found in Suifu, Szechuan Province, China. Twenty-two specimens, U. S. National Museum Cat. No. 467599, collected by Rev. D. C. Graham, give the following measurements: They have an average number of 3.0 whorls remaining; the greatest number of whorls is 3.6, and the least 2.1. They present an average length of 5.6 mm; the greatest length is 7.1 mm, and the least 4.5 mm. Their average diameter is 4.0 mm; the largest is 4.9 mm, and the least 3.2 mm. The length of aperture averages 3.3 mm; the largest length of aperture is 4.0 mm, and the least 2.5 mm.

This species resembles *Paludomus baccula* Reeve in many respects but it is much smaller, and the anterior end of the aperture is more pointed; it is also spirally banded.

Paludomus (Hemimitra) kweichowensis, n. sp. Figs. 1, 2.—3

Shell rather small, solid, smooth, elongate-conic, dark brown throughout excepting that part immediately below the suture which is greenish yellow. The apex is eroded. The postnuclear whorls are inflated, well rounded, and marked with fine lines of growth. Spiral sculpture is absent. Three spiral dark brown bands are present on each whorl; they are especially conspicuous on the last turn. One of these, much narrower, is slightly below the summit, the second one, much lighter than the other two, is half way between the first and third, the latter being at the periphery; a lighter zone equalling the medium dark band separates this from the other two; there may also be a more or less well developed basal band. Suture strongly impressed. Periphery well rounded. The base is moderately long and well rounded. The aperture is ovate-pyriform; peristome simple, slightly reflexed; parietal wall covered with a slight callus; columella arched. The operculum is thin with 3.2 turns, ovate, bluntly pointed posteriorly and broadly rounded anteriorly with subcentral nucleus, that is somewhat to the left of and below the center. The radula has the formula: 3-1-3:2-1-3:5:8.

The type, U.S.N.M. Cat. No. 467596 was collected by Rev. D. C. Graham at Shih-men-kan, Kweichow Province, China. It has 6.5 whorls and measures: Length 10.7 mm; diameter 5.7 mm; length of aperture 5.0 mm.

Ninety-three additional specimens from the same source give the following measurements: They have an average number of whorls 5.0; the greatest number of whorls is 6.5, and the least 3.8. They present an average length of 9.7 mm; the greatest length is 13.5 mm, and the least 5.6 mm. Their average diameter is 5.2 mm; the largest is 6.2 mm, and the least 3.5 mm. The length of aperture averages 4.6 mm; the largest length of aperture is 5.9 mm, and the least 3.0 mm.

This species is very much like *Melania leprosa* Heude, but is much smaller and has the columella more uniformly arched, and the body whorl larger; it is also spirally banded.

Paludomus minensis, n. sp. Figs. 1, 2.—4

Shell thick, stout, ovate, bluish purple covered with a greenish yellow periostracum; the interior of the aperture is chestnut colored. Nuclear

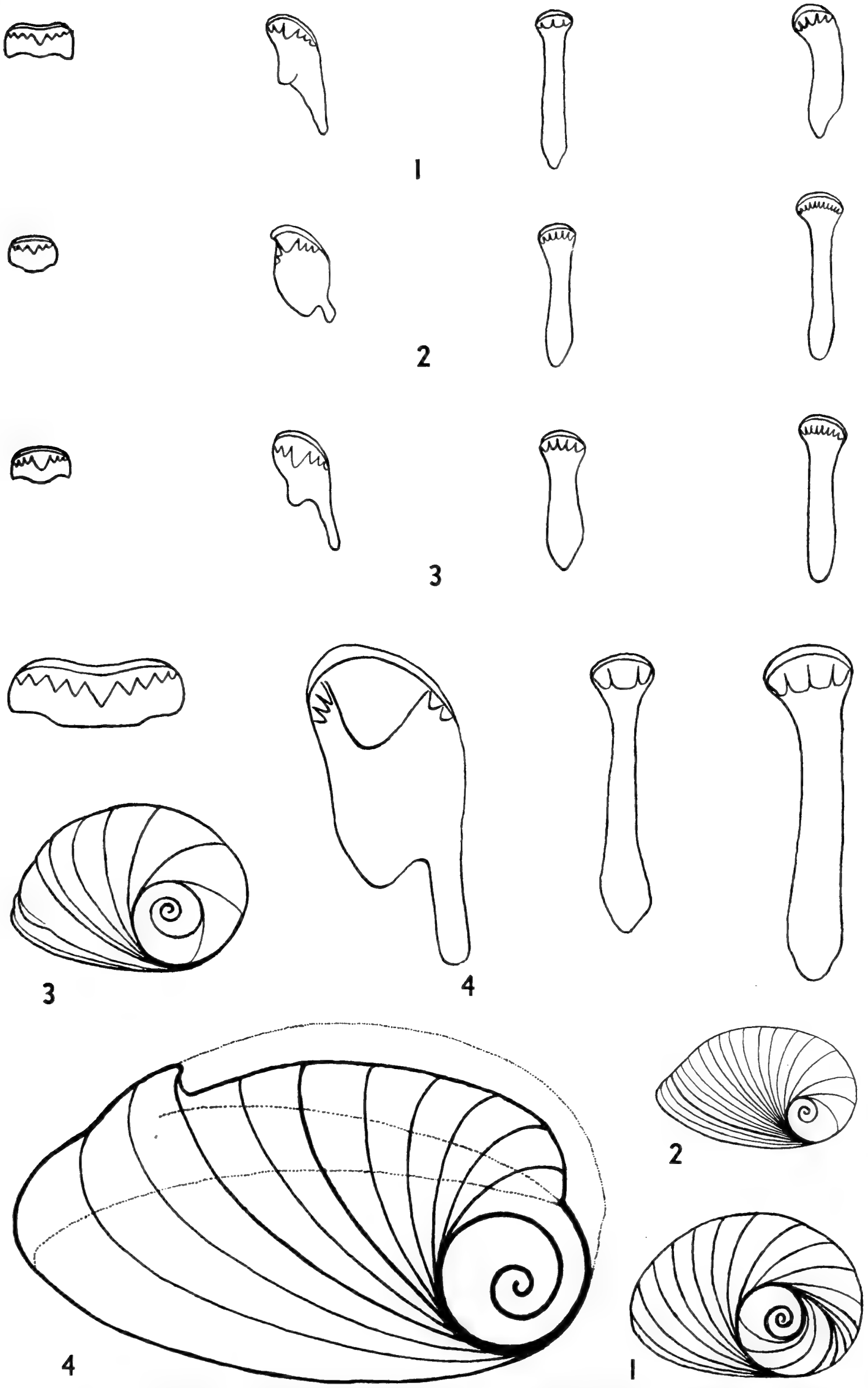

Fig. 2.—1, *Melania* (*Melanoides*) *suifuensis*. 2, *Paludomus* (*Hemimitra*) *yunnanensis*. 3, *Paludomus* (*Hemimitra*) *kweichowensis*. 4, *Paludomus minensis*. Radulae, ×200. Opercula, ×15.

whorls 2.0, smooth and well rounded, forming a blunt apex. Postnuclear whorls strongly rounded and marked with axial incremental lines. Spiral sculpture absent. Suture moderately impressed. Periphery well rounded. Base short and well rounded. Aperture ovate-pyriform, bluntly pointed posteriorly and broadly ovate anteriorly; peristome simple, slightly thickened internally; parietal wall heavily calloused; columella arched. Operculum ovate and moderately thick, with 2.7 turns. The radula has the formula: 4-1-4:3-1-2:3:4.

The type U.S.N.M. Cat. No. 467605, was collected by Rev. D. C. Graham in Min River near Kienway, Szechuan Province, China, and yields the following measurements: Number of whorls, 4.8; length 21.2 mm; diameter 15.1 mm; length of aperture 12.9 mm.

Three specimens from the same source yield the following additional information: They have an average number of 4.4 whorls; the greatest number of whorls is 4.6, and the least 4.2. They present an average length of 22.2 mm; the greatest length is 23.3 mm, and the least 21.6 mm. Their average diameter is 14.9 mm; the largest is 15.6 mm, and the least 14.1 mm. The length of aperture averages 13.4 mm; the largest length of aperture is 13.7 mm, and the least 12.9 mm.

The species, most closely resembling this form, is *Paludomus conicus* Gray. The present species, however, is stouter and has a smooth surface without sculpture.

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JOURNAL
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VOL. 27 NOVEMBER 15, 1937 No. 11

PALEONTOLOGY.—Linter, *a new taxodont genus from the Upper Cretaceous of Texas.*[1]

LLOYD WILLIAM STEPHENSON, U. S. Geological Survey.

An elegant little taxodont bivalve mollusk from the Nacatoch sand of the Navarro group of Texas appears to belong to a heretofore undescribed genus and species for which the name *Linter acutata* is now proposed. This shell has been found at three localities in Navarro County.

The genus is also represented by one specimen belonging to a distinct species, here named *Linter burrana,* from the San Miguel formation of Maverick County, Texas, a formation stratigraphically lower than the Nacatoch sand, and correlated with the upper part of the Taylor marl of central Texas.

These species belong to a group of taxodont shells having vertically striated ligamental areas, to which F. Stearns MacNeil, in an accompanying paper in this JOURNAL, and in a paper now in press as United States Geological Survey Professional Paper 189-A, applies the new family name Noetidae, based on the genus *Noetia* Gray, and the new subfamily name Trinacriinae, based on the genus *Trinacria.*

Genus LINTER Stephenson, n. gen.

Type species: *Linter acutata* Stephenson.

Etymology: Latin *linter,* a boat or skiff.

This genus is characterized by its long and sharply acute umbonal ridge, its short *Arca*-like hinge, and its broadly excavated triangular cardinal area situated mainly back of the beak; at the forward end of the area under the beak is a small, triangular, amphidetic, ligamental area, faintly striated at right angles to the hinge line; the rest of the area is smooth with only incremental lines showing. The hinge is slightly arched and is set with 10 or more irregular, short, transverse to slightly oblique teeth, separated by deep sockets.

The genus is represented by 8 specimens from Texas, 7 from the Nacatoch sand, described below under the specific name *Linter acutata,* and 1 from the stratigraphically lower San Miguel formation of Maverick County, described under the name *Linter burrana.*

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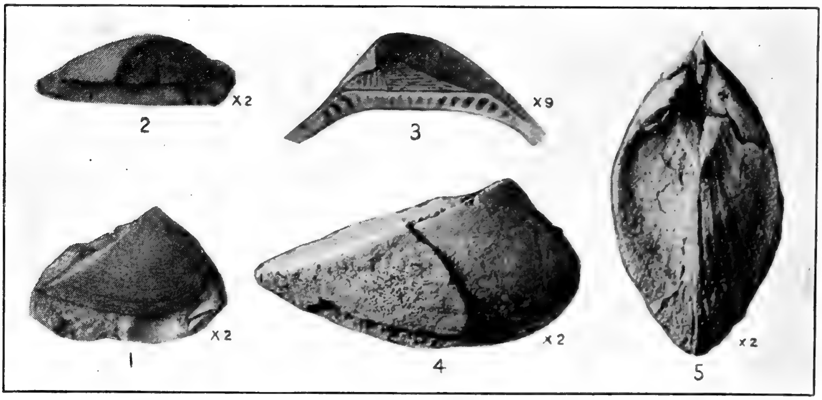
[1] Published by permission of the Director, U. S. Geological Survey. Received September 13, 1937.

Linter acutata Stephenson n. sp. Figs. 1–3

Shell small, subtrigonal in outline, strongly convex. Beaks prominent, opisthogyrate, slightly separated, situated about 3/10 the length of the shell from the anterior extremity. The umbonal ridge is sharply angular, the median surface meeting the postero-dorsal slope at an acute angle, the crest of the ridge slightly overhanging as it approaches the beak. A broad, very shallow radiating depression extends to the postero-ventral margin in front of the umbonal ridge. The umbonal ridge stands higher than any other part of the shell, and from it the surface rounds down gently to the anterior and ventral margins; the posterodorsal slope is long, broad, and broadly excavated, the concavity being slightly modified by a broad median swell; this surface meets the cardinal area at a broad, obtuse angle. The cardinal area is triangular and broadly excavated; its lower straight edge is about 2.25 mm long in the holotype, and its posterior edge meets the posterodorsal slope at an obtuse angle; the anterior edge is partly concealed by the incurving of the sharp tip of the beak. Under the beak is a small, shallow, triangular, ligamental pit, which bears 5 or 6 obscure, transverse striations; the rest of the area is smooth with the exception of fine incremental lines. The hinge plate is short and narrow; as seen on the holotype it is obscure but appears to be set with 10 or more irregular taxodont teeth which centrally are nearly transverse to the hinge line but toward the ends become more or less oblique; the anterior teeth are chevron-shaped. The inner surface is partly exposed posteriorly in one shell and exhibits radial striae which are strongest near the pallial line. The anterodorsal margin is steeply inclined but curves below into the regularly rounded anterior margin, which in turn curves into the broadly convex to nearly straight ventral margin; the long, nearly straight, though slightly sinuous, posterodorsal margin meets the ventral margin at a sharp acute angle, forming a pointed extremity; the posterodorsal margin is strongly inclined forward and meets the hinge line at a very wide obtuse angle. The surface is marked with fine,



Figs. 1–5.—*Linter acutata* Stephenson. 1, side view of the holotype, a right valve, ×2 (U.S.N.M. no. 75974). 2, dorsal view of the holotype, ×2. 3, an enlarged, somewhat generalized drawing of the hinge and cardinal area of the holotype, ×9. Figs. 4, 5.—*Linter burrana* Stephenson. 4, side view of the holotype, ×2 (U.S.N.M. no. 75978). 5, dorsal view of the holotype, ×2.

somewhat irregular incremental lines, crossed by very fine, obscure, radiating ridges which are a little stronger and wider apart on the antero- and posterodorsal slopes; the crossing of the two sets of lines tends to form a faint punctate sculpture; these features are too fine to show clearly in the illustration, and vary in strength on different individuals.

Dimensions of the holotype, a right valve: Length, 11.3 mm; height, 6.8 mm; convexity, 3 mm.

Types: Holotype, a right valve, U.S.N.M. no. 75974; 2 paratypes, U.S.N.M. no. 75975; 1 paratype, U.S.N.M. no. 75976; 4 paratypes, U.S. N.M. no. 75977.

Distribution in Texas.—Navarro group, Nacatoch sand: Public road south of the St. Louis Southwestern (Cotton Belt) Railroad, about 5 miles south-southwest of Corsicana, Navarro County (holotype and 2 paratypes, U.S. G.S. coll. 7573); from a small branch west of the Corsicana-Chatfield road, at the north end of M. R. and M. J. Thompson's property, 2 miles north of Corsicana, Navarro County (1 paratype, U.S.G.S. coll. 9553, collected by O. B. Hopkins in 1916); borrow pit just east of U. S. Highway 75, at foot of the north-facing slope of Chambers Creek valley, 4 miles north of the Court House at Corsicana, Navarro County (4 paratypes, U.S.G.S. coll. 17366).

Linter burrana Stephenson n. sp. Figs. 4, 5

One incomplete individual from the San Miguel formation, Maverick County, differs from *Linter acutata* mainly in its proportionately greater length and in its greater size, being nearly twice as long. In *L. acutata* the height is about 0.60 or 0.61 times the length, whereas in *L. burrana* the height is about 0.53 times the length. The specimen is an internal mold of both valves with the thin shell peeled off and lost from more than half the surface; the portion of the shell that remains is badly corroded, but shows the growth lines fairly completely; the posterodorsal slopes also show a series of fine, obscure radiating lines which are strongest near the acutely angular umbonal ridge, and become fainter inward toward the margin. The shell is gone from the beaks, and also from the forward portion of the cardinal area. The posterodorsal slopes are long, broad, broadly excavated, and extend with a moderately steep descent to the posterior extremity. The anterior adductor scar is proportionately small and elongated and is bordered posteriorly by a narrow radial internal rib that appears on the mold as a groove. The mold bears the impressions of fine, somewhat irregular, radiating, internal lines that are strongest toward the marginal ends.

Dimensions: Length 20.8 mm, height 11 mm, diameter 10.8 mm.

The species is accompanied at its type locality by a goodly number of poorly preserved pelecypods and gastropods (U.S.G.S. colls. 1887 and 8233), most of which have been only generically identified; among them are shells of *Ostrea saltillensis* Böse, and *Polinices rectilabrum* (Conrad).

Holotype: U.S.N.M. no. 75978.

Occurrence.—San Miguel formation (upper Taylor age): From layers of indurated calcareous sandstone in the north-facing slope of Sauz Creek, just north of the abandoned stone headquarters house of the old Burr Ranch, 2 miles northwest of Paloma siding, 23 miles north by east of Eagle Pass, Maverick County, Texas (U.S.G.S. coll. 8233).

PALEONTOLOGY.—*The systematic position of the pelecypod genus* Trinacria.[1]

F. STEARNS MACNEIL, U. S. Geological Survey. (Communicated by LLOYD W. STEPHENSON.)

During the course of some researches into the structure and evolution of the ligament of arcid pelecypods the writer was fortunate enough to find, in a collection recently acquired by the U. S. National Museum, a few specimens of *Trinacria cancellata* (Deshayes) from the Calcaire Grossier, on which the fibrous ligament was perfectly preserved. These throw new light on the relationships of this genus. In addition some specimens of a new genus from the Upper Cretaceous of Texas, collected and described in manuscript by L. W. Stephenson of the U. S. Geological Survey, were recognized as representing a primitive type of Trinacriinae. It is the purpose of this paper to make the structure of the ligament of *Trinacria* known, to outline briefly the evolution of the genus, and to delimit the subfamily Trinacriinae which was recently proposed by the writer in U. S. Geological Survey Professional Paper 189-A.

The writer is indebted to the authorities of the U. S. National Museum for the privilege of studying Museum collections and to Dr. L. W. Stephenson for making the name of his Upper Cretaceous genus, *Linter,* available under separate title in this publication.

NOMENCLATURE

The availability of the name *Trigonocoelia* Nyst and Galeotti (1835) for the group of shells generally referred to as *Trinacria* Mayer (1868) has been a subject for difference of opinion since Deshayes usage of the former in 1860. Wood and Stoliczka expressed the opinion, which was probably shared by Conrad and Newton, that, inasmuch as the original list for *Trigonocoelia* contained two distinct genera, and one of them, the "pectunculacés" species, belonged to the genus *Limopsis* Sasso (1827) (type by monotypy, *Arca aurita* Brocchi), the name *Trigonocoelia* was still available for the "nuculacés" species. Mayer was apparently unaware that the original list for *Trigonocoelia* was divided into shells of two types, for he accused Deshayes of applying the name to an entirely different type of shell than that for which it was proposed. Mayer believed that Nyst and Galeotti's name was proposed as a substitute for *Limopsis,* because the latter was a hybrid name, and accepted the substitution on that

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[1] Published by permission of the Director of the U. S. Geological Survey. Received September 8, 1937.

ground. He was thus incorrect in suppressing *Limopsis* and for the reasons he gave he was equally incorrect in proposing the new name *Trinacria.* His name is a valid one, however, by virtue of Herrmannsen's designation of *Arca aurita* Brocchi as the type of *Trigonocoelia* in 1849 (1). This is the first and only valid designation of a type for *Trigonocoelia* the writer has been able to find, and curiously enough it appears not to have been mentioned by later authors. On whatever nomenclatorial errors the name *Trinacria* has gained acceptance, Herrmannsen's designation settles the problem unless a contrary designation made between 1835 and 1849 is discovered. Dall raised the question as to whether *Trigonocaelix* Conrad (1865) [a typographical error] was not to have priority over *Trinacria.* Had not Conrad later corrected it to *Trigonocaelia* (2) a telling case might be made for it. Conrad's correction differs from Nyst and Galeotti's spelling by the diphthong *ae* for *oe*. Inasmuch as the name had been spelled indiscriminately before, Deshayes spelling it *ae* in the generic discussion and *oe* in the systematic text, and Chenu spelling it *oe* in his index and *ae* in the text it appears best to disregard both *Trigonocaelix* and *Trigonocaelia.*

RELATIONSHIPS OF TRINACRIA

Type (by subsequent designation, Gardner, U. S. Geol. Survey Prof. Paper 142-A, p. 21, 1926), *Trigonocoelia crassa* (Deshayes). Eocene, Paris Basin.

The almost universal assignment of *Trinacria* to the Limopsidae has been based on its possession of a deep ligamental pit, the assumption being that both *Trinacria* and *Limopsis* possessed a simple ligament connection partly submerged in the shell. A critical study of the structure of the ligament in these genera revealed that they are of two distinct types, that of *Limopsis* being a modification of the chevroned type, whereas that of *Trinacria* is a highly specialized form of the vertically striated type. This knowledge, along with the discovery of the Upper Cretaceous genus *Linter* (Fig. 1*a*), makes it possible to trace almost without interruption the steps in the evolution of *Trinacria* from its ancestral form to the highly specialized Miocene species occurring in the Alum Bluff group of Florida.

Presumably *Linter* was derived from some early member of the Striarcinae. It differs from *Breviarca* principally in being considerably lighter and in being strongly opisthogyrate, with a sharp umbonal keel and a small ligament area, nearly all of which is restricted to the part of the cardinal area anterior to the beaks. The cardinal area is also well developed posterior to the beaks but devoid of ligament except for a narrow, sub-umbonal wedge. This posterior cardinal area appears to be slightly out of the plane of the ligament area. The vertical ligament elements of *Linter* are delicate, being of about the same texture as in *Breviarca.*

Development of *Trinacria* from *Linter* consisted of the beaks becoming more opisthogyrate and nearer the hinge line so as to cut off the anterior extension of the ligament. The posterior end of the cardinal area became shorter and more out of the plane of the ligament area, merging directly with the posterior slope. With the anterior part of the area cut off and the posterior end obsolete the narrow, subumbonal, posterior wedge of ligament remaining had to become thickened and submerged to retain strength. The central teeth on the types of *Linter* are not well preserved but there appears to be a break between the anterior and posterior rows. In *Trinacria,* owing to a much shortened hinge line, the two rows often come together but are sharply divided by a difference in direction.

Two species referable to *Trinacria* have been described from the Cretaceous, *Trinacria galeata* (Müller) (3) from the Greensands of Vaals, Aachen; and *Trinacria cor* Popenoe (4) from the Upper Cretaceous of California. A line drawing of the latter made from specimens kindly loaned the writer by W. P. Popenoe is shown in Fig. 1*b.* This species shows the characters mentioned above for early forms of *Trinacria.* The beaks are completely opisthogyrate, the umbonal keel very sharp, the ligament restricted and slightly entrenched, the cardinal area narrow and indistinct posteriorly, and the hinge line short.

Evolution within the genus *Trinacria* consisted of a secondary lengthening of the shell, orthogyration of the beaks and greater removal of them from the hinge line, lessening angulation and final rounding of the umbonal ridge, deeper entrenchment of the ligament with a tendency to grow more to the anterior in later species, and a greater separation of the anterior and posterior rows of teeth.

Trinacria deltoidea (Lamarck) (Calcaire Grossier) (Fig. 1*c,* drawn from a specimen from Houdan, France) shows the secondary orthogyration of the beaks with the consequent widening of the anterodorsal growth lines. The ligament is more deeply entrenched and extends more to the anterior than in the extremely opisthogyrate Cretaceous species. This species is very similar to *T. cuneus* (Conrad), from Claiborne, Alabama.

Trinacria cancellata (Deshayes) (Calcaire Grossier), the species in which a perfectly preserved ligament was found, is very similar to *T. deltoidea*, differing mainly in being less inflated, more elongate, and in having more pronounced radial sculpture.

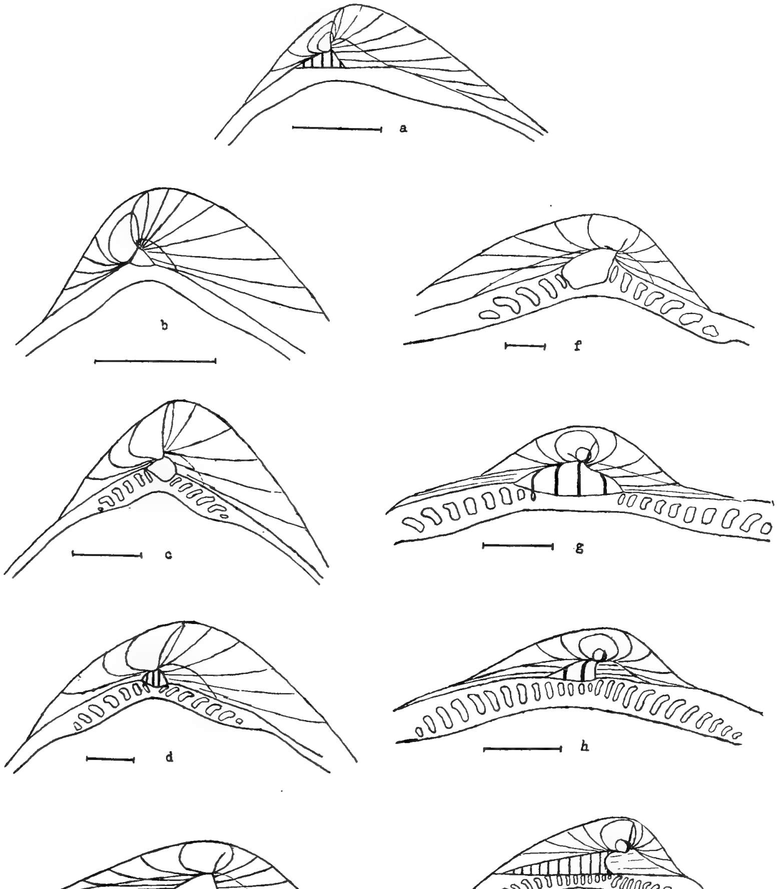

Fig. 1.—*a. Linter acutata* Stephenson. *b. Trinacria cor* Popenoe. *c. Trinacria deltoidea* (Lamarck). *d. Trinacria media* (Deshayes). *e. Trinacria meeki* Dall. *f. Trinacria pectuncularis* (Lea). *g. Halonanus* (*Trinacriella*) *cossmanni* (Dall). *h. Halonanus* (*Trinacriella*) *perplana* (Conrad). *i. Halonanus pulchra* (Gabb). The lengths indicated by the straight lines below the individual figures are over-all dimensions of the shell, natural size.

Remnants of the fibrous layer have also been observed in specimens of *T. media* (Deshayes) (Fig. 1*d*, Bartonian, Ezanville, France), a species closely related to *T. ledoides* (Meyer) from Claiborne. In these specimens the ligament material is somewhat disarranged but three ligament grooves are quite clearly indicated on one specimen.

This species is more elongate than *T. deltoidea* and the beaks are more orthogyrate. The umbonal ridge is not sharply carinate but sharply rounded and approaches that of *T. crassa* (Deshayes), the genotype, in which the umbonal ridge is definitely rounded in adults. *Trinacria media* and *T. crassa* approach the Miocene species from Florida, *T. meeki* Dall (Fig. 1*e*), in the rotundity of the umbonal ridge but differ in being more trigonal and in that the rows of teeth are not widely separated as in the latter. In *T. meeki* the umbonal ridge is broadly rounded in adults and the beaks have returned to a nearly orthogyrate attitude. The base of the ligament is more expanded. *Trinacria meeki* might be regarded as subgenerically distinct from typical *Trinacria,* but it seems just as satisfactory to regard it as a terminal species of the genus. *Trinacria pectuncularis* (Lea) (Fig. 1*f*) from Claiborne has a moderately expanded, somewhat anteriorly directed ligament pit and separated rows of teeth, but differs from *T. meeki* mainly in being higher and subquadrate rather than elongate and subovate.

In addition to the typical species of *Trinacria* found in the Claiborne group of the southeastern United States there exist two other groups of shells that appear closely related to them. It will be difficult to discuss these forms specifically until they have been monographed, but they are typified by *Noetia pulchra* Gabb (Fig. 1*i*) from Texas, for which the generic name *Halonanus* (5) has been proposed, and *Pectunculus perplanus* Conrad (6) from Claiborne; and *Trinacria perplana* (Conrad) Harris (7) (Fig. 1*h*) for which the subgeneric name *Trinacriella* is here proposed under the genus *Halonanus.*

Trinacriella ranges in shape from subquadrate to subelliptical or subovate, some forms being nearly circular. Aside from the difference in shape it is distinguished from *Trinacria* by its heavier shell and wider cardinal plate. The widening of the cardinal plate enabled the anterior and posterior rows of teeth to reestablish contact with each other and a series can be seen ranging from *T. cossmanni* Dall (Fig. 1*g*), in which the rows are well separated, to *T. perplana* (Conrad) (Fig. 1*h*) in which they run together. In addition the ligament pit exhibits a series ranging from nearly equilateral in *T. cossmanni* to more anteriorly directed as in *T. perplana* and *T. ellipsis* (Lea). The former pattern is regarded as aberrant whereas the latter bears resemblance to that of some species of *Trinacria,* especially the Claiborne species *T. pectuncularis* (Lea), through which the two genera may be connected. The ligament pattern of *T. perplana* also approaches that of typical *Halonanus.*

Halonanus differs from both *Trinacria* and *H.* (*Trinacriella*) in being definitely noetiform with a well developed cardinal area, although *H. decisa* (Conrad) (not figd.) appears to be intermediate between the typical form and *Trinacriella perplana. Halonanus* differs from the Noetinae in that its sculpture consists of only one set of ribs whereas the Noetinae are characterized by both primary and secondary ribs. Its ligament differs from that of *Noetia* in that in that genus there is an initial vertical element beginning directly beneath the umbo whereas in *Halonanus pulchra* there is an initial anterior diagonal groove which later develops into a vertically striated ligament. This condition has been observed nowhere else among the prionodont bivalves and is accounted for by the fact that the cardinal area of *Halonanus* is a secondary structure analogous to the primary cardinal area of *Linter*, the initial anterior diagonal ligament groove being a remnant of the anteriorly directed ligamental pit observed in *Trinacriella* and still well developed in *Halonanus decisa.* The ligament material is usually lost in specimens of *Trinacriella* and *Halonanus decisa* but a few specimens seen by the writer retain enough to show that the ligament contained vertical elements, even in the forms with more oblique pits. The secondary cardinal area of *Halonanus, sensu stricto,* is foreshadowed in the incipient cardinal area observed in some species of *Trinacriella,* particularly *T. perplana.*

CLASSIFICATION[2]

A partial classification of arcid Pelecypoda to include the subfamily Trinacriinae follows. This arrangement is based primarily on ligament structure but is correlated with dentition, orientation, sculpture, and other shell characters.

Order FILIBRANCHIA Pelseneer
Suborder PRIONODONTA MacNeil
Superfamilies CYRTODONTACEA, PARALLELODONTACEA, GLYCYMERACEA, ARCACEA
Superfamily GLYCYMERACEA MacNeil
Families GLYCYMERIDAE, CUCULLAEIDAE, NAVICULIDAE, LIMOPSIDAE, NOETIDAE

The superfamily Glycymeracea exhibits much less stability in ligament structure than the Parallelodontacea and Arcacea, and most of the aberrant types of ligaments are found here. It is interesting to note that all

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[2] This classification is based on *Arca antiquata* as type of *Arca.* If the Commission should accept a recommendation before it at the present time to regard *Arca noae* as type, the following changes would become necessary: *Glycymeracea* would become *Arcacea; Arcacea* would become *Anadaracea;* and *Naviculidae* would become *Arcidae.*

opisthogyrate shells and all shells bearing a flange on the muscle scars fall in this superfamily.

Family NOETIDAE MacNeil

Subfamilies STRIARCINAE, TRINACRIINAE, NOETINAE

The family Noetidae includes all of the forms having vertical ligament elements.

Subfamily TRINACRIINAE MacNeil

This subfamily includes the three genera, *Linter* Stephenson, *Trinacria* Mayer, and *Halonanus* Stewart, and the subgenus *Trinacriella* MacNeil (under *Halonanus*).

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6. Conrad, T. A. Acad. Nat. Sci. Philadelphia Jour., 1st ser., **7**: 134. 1834.
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PALEOBOTANY.—*On the presence of the fern* Weichselia *in Colombia, South America.*[1] Edward W. Berry, Johns Hopkins University.

Some months ago I received from Phillip L. Merritt, under the label of the Ministerio de Industrias y Trabajo, Bogota, Colombia, a package of fossil plants. These were collected near Mutiscua, which is between 10 and 11 miles slightly south of west of Pamplona in the northern part of the Department of Santander, and is shown on Hettner's map of the Cordillera of Bogotá.[2]

This material is of considerable interest and comprises 6 specimens which are covered with the impressions of the rachis and fronds of the fern known as *Weichselia*, which was almost world-wide in its distribution during the Mesozoic. The matrix is a rather soft, grayish mudstone, very similar to the shales on the Island of San Lorenzo, off the port of Callao, Peru, which are also packed with *Weichselia*, the only apparent lithologic difference being that the shales from Peru are slightly lighter in color.

The Colombian matrix has not been studied petrographically, but from its somewhat soapy feel, and its general similarity to that containing the Peruvian fossils, I regard it as probably representing a carbonaceous pyritiferous mudstone in which, because of tectonic

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[1] Received August 23, 1937.

[2] Hettner, Alfred. *Die Kordillere von Bogotá.* Petermann's Mitt. Ergänzung Bd. **22**, No. 104, 1891.

movements and circulating waters, the carbon and the sulfide were oxidized.

The plant impressions are typical of *Weichselia*, the larger frond fragments showing a stipe of about 3.5 millimeters diameter, and elongated parallel pinnae of lengths up to 10 or 11 centimeters, with the characteristic netted venation of the pinnules frequently in excellent preservation. Associated with the frond fragments are impressions of the sort that have often been interpreted as stems of *Equisetites*, as by Neumann, Schlagintweit, and others, which Zeiller considered, in the case of the Peruvian material, as the larger stems or petioles of *Weichselia*. Impressions of this sort, indistinguishable from the Peruvian material, are associated with the frond fragments in the present collection in lengths of about 11 centimeters, and with diameters of 2.5 to 3 centimeters.

The impression material of this frond genus, first described as a species of *Pecopteris* by Stokes & Webb in 1824, and named by Stiehler in 1857, is rather readily recognizable, and has been discovered in many parts of the world. It has been discussed by many authors, the bibliography amounting to upwards of fifty titles. In the latest discussion, that by Edwards in 1933, a rather good case is made out for correlating the impressions known as *Weichselia* with the structural material of stems, or more probably petioles, which have been described under the name of *Paradoxopteris*.[3] Despite all the available evidence and this correlation, the botanical affinity of *Weichselia* is not settled beyond a strong presumption that it is to be found in the family Marattiaceae, or in an allied and wholly extinct group.

A number of different species of *Weichselia* have been proposed. In describing the Mesozoic flora of Peru I followed Zeiller in using the specific designation *Weichselia peruvianum*,[4] which was based in the first instance on the impressions of large petioles which Neumann had mistakenly described as *Equisetites peruanus*. Although I saw no fertile specimens from Peruvian localities such as Zeiller thought he had, I considered that the reflexed basal pinnules might serve to differentiate the Peruvian from the European material. Edwards has shown, however, that this feature occurs also in some specimens of the European genotype *Weichselia reticulata*.

In spite of the lack of definite distinguishable characters I find it

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[3] Edwards, W. N. *On the Cretaceous fern* Paradoxopteris *and its connection with* Weichselia. Annals of Botany **47**: 317–341. 1933.

[4] Berry, E. W. Johns Hopkins Studies in Geology **4**: 52–55. 1922.

hard to believe that a single botanical species ranged over five continents—Europe, Asia, Africa, North and South America—and from at least the dawn of the Lower Cretaceous[5] to the Cenomanian stage of the Upper Cretaceous. Peruvian material was recorded in 1922 from ten different localities, and subsequently in the collections made by the Ellsworth Expedition from the coal measures of Huallanca in the Department of Ancachs, this species was found to be exceedingly abundant.

I may add that the North American occurrence of *Weichselia* in the Black Hills, about which I expressed some doubt in 1922, is perfectly authentic. I have since had a large amount of typical but very fragmentary material from that region.

Karsten, years ago, collected *Weichselia* at Santa Maria in northeastern Venezuela. This find was discussed by Schlagintweit[6] who concluded that its age was Neocomian. From Santa Maria through Mutiscua via the Andean geosyncline to the southernmost of the abundant Peruvian occurrences is a distance of about 2,500 miles. Occurrences of this species in Texas and in the Black Hills region of South Dakota carry its range northward to 44° north latitude, so that its known north-south range in the western hemisphere covers about 55° of latitude.

Regarding the exact age of the new material from Colombia no conclusion based upon paleobotanical evidence is possible. The European type is more common at Neocomian and Barremian horizons than later in the Cretaceous, but according to Edwards it ranges up through the Aptian to the Albian (upper Greensand) in England. In eastern Asia an Aptian age is supposed, and some of the north African occurrences have been regarded as Cenomanian. The Black Hills occurrences in North America are associated with a dicotyledonous flora and have been regarded as of Albian age. All that can be said of the age of the Mutiscua specimens is that they are probably Lower Cretaceous, but whether early or late in that period can not be determined, although, if the Peruvian occurrences have any weight, which is by no means certain, the balance of evidence would point to an earlier rather than a later Lower Cretaceous age.

Schuchert's map of the early Lower Cretaceous in the Caribbean and northern South America shows no seaway on the site of the

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[5] The horizon of the Peruvian material in the Department of Lima has been incorrectly termed Wealden. It is considered by Peruvian geologists to be Neocomian, but it may well be as old as Portlandian. Probably Tithonian would be the proper designation.

[6] SCHLAGINTWEIT, O. Centralblatt f. Min. Geol. & Pal. **19**(20): 315–319. 1919.

Venezuelan Andes, such a seaway first appearing on his map of the early Middle Cretaceous, whatever that may mean.[7] It is, of course, impossible to criticize such generalized maps covering such synthetic geologic time, but it is certainly a fact that Lower Cretaceous is present throughout the extent of the Venezuelan Andes from Colombia eastward to Trinidad.

ZOOLOGY.—*The Nearctic spiders of the family Heteropodidae.*[1]

Irving Fox, Iowa State College, Ames, Iowa. (Communicated by C. F. W. Muesebeck.)

The spiders of the group under discussion are generally held to comprise a distinct family having affinities with the Thomisidae and the Clubionidae; from the former they are distinguished particularly by the possession of teeth on the cheliceral margins and from the latter chiefly by the laterigrade legs and the more or less distinct membranes at the apices of the metatarsi. They are further characterized by the possession of a carapace which is as wide as long or slightly longer than wide, and by the scopulate tarsi which are armed with two claws. The eyes are eight in number and arranged in two transverse rows of four each.

The conception that these characters are of sufficient importance to warrant the maintenance of a distinct family is generally subscribed to by modern arachnologists, but there yet exists some disagreement concerning the proper family denomination. Two names have been commonly used, Heteropodidae Thorell and Sparassidae Simon; the former name appears to be the correct one. Thorell in 1873 suggested that *Heteropoda* and related genera be separated from the Thomisidae and combined into a new family, Heteropodidae.[2] In 1874 Simon revised the European species of this group under the family name Sparassidae,[3] and this and subsequent revisions had the effect of making Sparassidae the more extensively used name. On the basis of priority, however, Heteropodidae is the correct family name and Sparassidae is its synonym.

There is evident considerable confusion among authors concerning the proper usage of the names, *Sparassus, Olios,* and *Eusparassus.* The genus *Sparassus* was erected by Walckenaer in 1805,[4] and *S.*

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[7] Schuchert, Charles. *Historical geology of the Antillean-Caribbean region,* maps 4 and 5. 1935.

[1] Received August 18, 1937.

[2] *Remarks on the Synonyms of European Spiders,* Upsala, p. 606, 1870–1873.

[3] Ann. Soc. Ent. France **4**: 243. 1874.

[4] *Tableau des Araneides,* p. 40, 1805.

argelasius Walck. was subsequently designated as type by Thorell.[5] *S. argelasius* was re-described by Walckenaer in 1806,[6] by Latreille (under *Micrommata*) in 1818,[7] and again by Walckenaer in 1837.[8] Simon considered *S. argelasius* Walck. 1805 to be a *nomen nudum* and accepted *M. argelasius* Latreille 1818 as the earliest available name.[9] At the same time he decided that *M. argelasius* Latreille represented a group distinct from any previously described and made it the type of his new genus *Eusparassus*. Since publication of these views Simon's arrangement has been generally accepted, and *Eusparassus* has been considered a good genus, while *Sparassus* has been completely ignored.

Walckenaer's original description of 1805, while not detailed enough to permit recognition of the species, is sufficient to constitute a valid description, hence *S. argelasius* Walck. 1805 can not correctly be regarded as a *nomen nudum*, but must be considered a valid name. Latreille in his description of 1818 indicated conclusively that he was re-describing Walckenaer's species rather than describing a new one of his own, and further states that the species was recognized by Walckenaer as his *argelasius*. If the species that Latreille described in 1818 was different from the one described in 1805 by Walckenaer, as Simon apparently believed, the later name rests upon an error of identification and is invalid under Article 31 of the International Rules of Zoological Nomenclature. Since Latreille expressly states that Walckenaer recognized the species as the one he himself had described, there seems to be little reason to assume that Walckenaer's descriptions of 1805, 1806, and 1837, and Latreille's of 1818 do not refer to the same species. From this discussion it is apparent that the genus *Sparassus* Walck. is available and has as a synonym *Eusparassus* Simon; its type is *Sparassus argelasius* Walck., which name is to be used for the not uncommon European species now known as *Eusparassus argelasius* (Latreille).

The genus *Olios*, as it was originally described by Walckenaer in 1837 included an extremely heterogeneous assemblage of several genera. In 1880 Simon restricted it to the species congeneric with *O. spongitarsus* (Dufour) which he selected as the type.[10] He also indicated that *Sparassus argelasius* Walckenaer 1805 was the same as

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[5] Nova acta. Reg. Soc. Sc. Upsaliae **7**: 176. 1869–1870.

[6] *Histoire Naturelle des Araneides*, facic. **4**: fig. 2. 1806.

[7] *Nouveau Dictionnaire d'Histoire Naturelle* **20**: 516. 1818.

[8] *Histoire Naturelle des Insectes Apteres* **1**: 584. 1837.

[9] *Histoire Naturelle des Araignees* **2**: 1020. 1903.

[10] Act. Soc. Linn. Bordeaux **34**: 297. 1880.

Dufour's species, yet he retained the later name. Subsequent authors were divided in their usage of the names *Olios* and *Sparassus*, some considering *Olios* a good genus, while others reasoned that since *O. spongitarsis* (Dufour), the type of *Olios*, was a synonym of *S. argelasius* Walck., the type of *Sparassus*, then *Olios* was a synonym of *Sparassus*.[11] However, Simon in 1903 stated that the previous synonymization of *O. spongitarsis* (Dufour) with *S. argelasius* Walck. was entirely gratuitous, as Walckenaer's original description was too brief to permit identification. On this account *Olios* is, in the present paper, regarded as the proper name for the species related to *spongitarsus* Dufour, while *Sparassus* is applied to the *argelasius* Walckenaer group.

The following pages are concerned with only the nearctic species of Heteropodidae; three new species and a new genus are described, and keys to the nearctic genera and species are given. The family is represented in the United States by three genera of which two, *Tentabunda* and *Heteropoda*, contain but one species, while the third, *Olios*, comprises six species.

I wish to express my appreciation to the authorities of the United States National Museum for the courtesy shown me while studying the collections in their charge. I am deeply obliged to Miss Elizabeth B. Bryant of the Museum of Comparative Zoology, to Dr. W. J. Gertsch, and Mr. H. K. Wallace of the American Museum of Natural History, and to Professor R. V. Chamberlin of the University of Utah for their generosity in lending material for study.

KEY TO THE NEARCTIC GENERA OF SPARASSIDAE

1. Spinnerets set upon a distinct basal segment........... *Tentabunda*
   Spinnerets normal, not set upon a distinct basal segment............ 2
2. Anterior median eyes as large as or larger than the anterior lateral. Clypeus much lower than the diameter of an anterior median eye.. .... *Olios*
   Anterior median eyes smaller than the anterior lateral. Clypeus higher than the diameter of an anterior median eye............ *Heteropoda*

TENTABUNDA, n. gen.

A genus in the subfamily Sparianthidinae. Cephalothorax robust, longer than wide. Eyes in two rows, with the anterior row straight or slightly procurved, the posterior row very procurved and broader than the anterior. Anterior median eyes slightly larger than the anterior lateral; posterior eyes subequal or with the posterior lateral eyes slightly larger than the posterior median. Median ocular quadrangle wider than long. Clypeus equal in height

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[11] CAMBRIDGE, F. Biologia Centrali-Americana **2**: 122. 1905.

to at least more than half the diameter of an anterior median eye. Lower cheliceral margin armed with six or seven small denticles, upper margin armed with three or four robust teeth. Anterior tibiae provided with 2-2-1 or 2-2-2 spines below; anterior metatarsi provided with one pair of spines below. Spinnerets six in number, set upon a distinct common basal segment.

Genotype.—*Pseudosparianthis cubana* Banks, 1909, known from Cuba and Florida.

Tentabunda cubana (Banks), n. comb. Figs. 5 and 11

Pseudosparianthis cubana Banks. Second Rep. Centr. Exper. Sta. Cuba, p. 165, pl. 45, fig. 4, 1909.

Pseudosparianthis cubana Bryant, Bull. Mus. Comp. Zoo. Cambridge, **74**:192. 1933.

Female.—Total length, 10.69 mm. Carapace, 5.45 mm long, 3.86 mm at the widest place, 2.77 mm wide in front. Abdomen, 5.25 mm long, 2.97 mm wide. Carapace uniform reddish brown above without distinct markings, clothed with sparse pubescence. Sides concolorous with the dorsum, lacking distinct submarginal stripes. Chelicerae dark brown, much darker than the carapace. Sternum and coxae light yellowish brown, labium and endites reddish with white distal patches. Legs clear light yellow below and reddish above, without annulations. Dorsum of the abdomen with a grayish ground color upon which is a dark pattern consisting of a series of six or seven chevrons continuing to the spinnerets. Venter much lighter than the sides being light gray with sparse dark punctations. Spinnerets six in number, set upon a distinct common basal segment.

Anterior row of eyes slightly procurved, narrower than the very procurved posterior row (17/21). Anterior median eyes slightly closer to each other than to the anterior lateral and somewhat larger than the latter. Eyes of the posterior row subequal and equidistant, separated by more than two diameters. Median ocular quadrangle wider than long (18/15), narrower in front than behind (16/18), the posterior eyes about four-fifths as large as the anterior. Clypeus equal in height to about four-fifths the diameter of an anterior median eye. Chelicerae, 2.07 mm in length, lower cheliceral margin armed with seven small denticles, upper margin armed with four robust teeth. Tibiae I and II with 2-2-1 spines below, metatarsi I and II armed with one pair of spines below. Tibia and patella I, 6.24 mm long (tibia alone, 3.96 mm); tibia and patella IV, 5.25 mm long (tibia alone, 3.47 mm).

Epigynum wider than long (25/20), anteriorly provided with a wide atrium from which a distinct median suture extends posteriorly dividing the caudal portion of the epigynal plate into two equal halves. For further details regarding the structure of the epigynum see Fig. 5.

Described from a female specimen collected by T. H. Hubbell fourteen miles west of Palm Beach, Florida, October 29, 1934 and in the possession of the American Museum of Natural History.

Male.—Total length, 7.00 mm. Carapace, 3.56 mm. long, 3.27 mm at the widest place, 1.68 mm wide in front. Abdomen, 3.56 mm long, 2.48 mm wide. Carapace lighter than in the female, being yellowish rather than reddish and having a sparser pubescence. Chelicerae light yellowish brown, concolorous with the carapace. Sternum, coxae, labium, and endites whitish without distinct markings. Legs clear, concolorous with the sternum below, above yellowish and concolorous with the carapace. Dorsum of the abdomen as in the female, but in general somewhat lighter.

Anterior row of eyes slightly procurved, narrower than the very pro curved posterior row (12/14). Eyes of the anterior row subequidistant with the anterior median slightly larger than the anterior lateral. Eyes of the posterior row subequal and equidistant, separated by about one and one-half diameters. Median ocular quadrangle wider than long (14/12.5), narrower in front than behind (12/14), the posterior eyes about four-fifths as large as the anterior. Clypeus equal in height to about four-fifths the diameter of an anterior median eye. Chelicerae, 1.19 mm long; lower cheliceral margin armed with seven small denticles, upper margin armed with four robust teeth. Tibiae I and II with 2-2-2 spines below, metatarsi I and II with one pair of spines below, and unlike the female with a basal and submedian lateral spine on each side. Tibia and patella I, 5.35 mm long (tibia alone, 3.86 mm); tibia and patella IV, 4.75 mm long (tibia alone, 3.27 mm).

Tibia of the palpus wider than long (22/15), expanded retrolaterad and more or less triangular in shape, tribranchiate with the tarsus articulated to the prolateral branch. For further details regarding the structure of the palpal organ see Fig. 11.

Described from a male specimen collected by M. Broyles at Coronado Beach, Volusia Co., Florida in August, 1935 and in the possession of the American Museum of Natural History.

The genus *Tentabunda* according to the present interpretation includes also the species described as *Pseudosparianthis variabilis* Cambridge,[12] known from Mexico, and *Pseudosparianthis antiguensis* Bryant,[13] known from the West Indies. The members of *Pseudosparianthis* are distinct from those of *Tentabunda* particularly in that the anterior metatarsi are armed with two pairs of spines rather than with one pair. The genus *Pseudosparianthis* is not known to occur in the nearctic region.

OLIOS Walckenaer

Ins. apteres, **1**: 563, 1837. Genotype: *Micrommata spongitarsis* Dufour.

Cephalothorax robust, not at all or but slightly longer than wide. Eyes in two rows, each of which may be procurved, straight, or less commonly recurved, with the anterior row narrower than the posterior. Eyes of the anterior row subequal or with the anterior median eyes slightly larger than the anterior lateral and closer to the latter than to each other. Eyes of the posterior row subequidistant and subequal or with the posterior median eyes slightly smaller than the posterior lateral. Clypeus much narrower than the diameter of the anterior median eyes. Lower cheliceral margin armed with three or four teeth. Anterior tibae normally armed with 2-2 spines below.

KEY TO THE NEARCTIC SPECIES OF OLIOS[14]

1. Chelicerae yellowish or reddish brown, not contrasting strongly with the dorsum of the carapace....................2
   Chelicerae jet black, contrasting strongly with the dorsum of the carapace....................*O. fasciculatus*
2. Males....................3
   Females....................5

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[12] CAMBRIDGE, F. Biol. Centr. Amer. **II**: 119, pl. VIII, fig. 21. 1900.

[13] BRYANT, E. B. Univ. Iowa Studies **X**: 13, pl. I, fig. 4. 1923.

[14] It has not been possible to place *Olios franklinus* Walckenaer because of the inadequate original description

3. Tibial apophysis divided into two distinct branches which are not longer than the tibia 4
   Tibial apophysis not divided into two distinct branches, and as long as the tibia .... *O. schistus* (Fig. 10)
4. Distal spinose process of the tibia about two and one-half times as long as either of the branches of the tibial apophysis.... *O. bibranchiatus* (Fig. 8)
   Distal spinose process of the tibia not longer than the branches of the tibial apophysis .... *O. abnormis* (Fig. 2)
5. Epigynal atrium much wider than long...... *O. bibranchiatus* (Fig. 6)
   Epigynal atrium as long as or longer than wide 6
6. Epigynal atrium much longer than wide...... *O. mohavensis* (Fig. 4)
   Epigynal atrium about as wide as long 7
7. Anterior border of the epigynal atrium with a large posteriorly directed lobe .... *O. albinus* (Fig. 3)
   Anterior border of the epigynal atrium without such a lobe. . *O. schistus* (Fig. 7)

Olios fasciculatus Simon Figs. 1 and 9

Olios fasciculatus Simon. Act. Soc. Linn. Bordeaux **34:** 307. 1880.
Olios giganteus Keyserling, Verh. Zool. Bot. Ges. Wien **33:** 681, pl. XXI, fig. 28, 1883.
Olios concolor Keyserling, Verh. Zool. Bot. Ges. Wien **33:** 682, pl. XXI, fig. 29, 1883.
Olios fasciculatus Banks, Proc. U. S. Nat. Mus. **23:** 585. 1901.
Olios pragmaticus Chamberlin, Proc. California Acad. Sci. **12:** 659, fig.102. 1924.

Female.—Total length, 19.00 mm. Carapace, 6.93 mm long, 7.43 mm at the widest place, 4.65 mm wide in front. Abdomen 11.78 mm long, 9.00 mm wide. Carapace irregular light reddish brown above, pars cephalica with a median longitudinal light narrow band extending from a short distance anterior to the thoracic groove to a point midway between the posterior median eyes; pars thoracica provided with a deep groove from which light bands radiate. Sides of the carapace with light submarginal bands. Chelicerae black, contrasting strongly with the carapace. Sternum and coxae light yellowish brown; labium and endites somewhat darker bearing white distal patches. Legs concolorous with the sternum being light yellowish brown without distinct annulations. Dorsum of the abdomen lighter than the carapace, grayish with brown streaks and spots, provided with a basal white mark outlined with dark which extends caudad in the form of a dark line reaching to the posterior termination of the abdomen. Venter lighter than the sides with indications of two median parallel dark lines.

Anterior row of eyes slightly recurved and narrower than the procurved posterior row (22/27). Eyes of the anterior row subequal, the anterior median eyes closer to the anterior level than to each other, being separated from each other by more than a diameter, from the anterior lateral by two-thirds of a diameter. Eyes of the posterior row subequidistant, separated by more than twice the diameter of a posterior median eye, the posterior median eyes two-thirds as large as the posterior lateral. Median ocular quadrangle slightly wider than long, slightly wider in front than behind, the posterior eyes about two-thirds as large as the anterior. Clypeus equal in height to about two-thirds the diameter of an anterior median eye. Chelicerae, 3.56 mm in length; lower cheliceral margin armed with four teeth of which the basal two are small and weak while the distal two are large and robust, upper margin armed with two small teeth, one large and one small. Tibiae I and II with 2-2 spines below. Tibia and patella I, 11.39 mm long (tibia alone, 7.43 mm); tibia and patella IV, 9.41 mm (tibia alone, 6.24 mm).

Epigynum very small, about as long as wide with the atrium about as wide in front as behind and provided with an incomplete median septum which extends barely half-way down its length. Side pieces lightly or not at all chitinized. For further details regarding the structure of the epigynum see Fig. 1.

Described from a female specimen collected at Oracle, Arizona, July, 1898 by E. A. Schwartz and in the possession of the United States National Museum.

Male.—Total length, 12.00 mm. Carapace, 6.44 mm long, 6.04 mm at the widest place, 3.56 mm wide in front. Abdomen, 5.94 mm long, 3.47 mm wide. Dorsum of the carapace somewhat darker than in the female, but with the same markings. Chelicerae dark brown to black. Sternum orange brown lighter than the legs which are dark brown. Dorsum, sides, and venter of the abdomen colored as in the female.

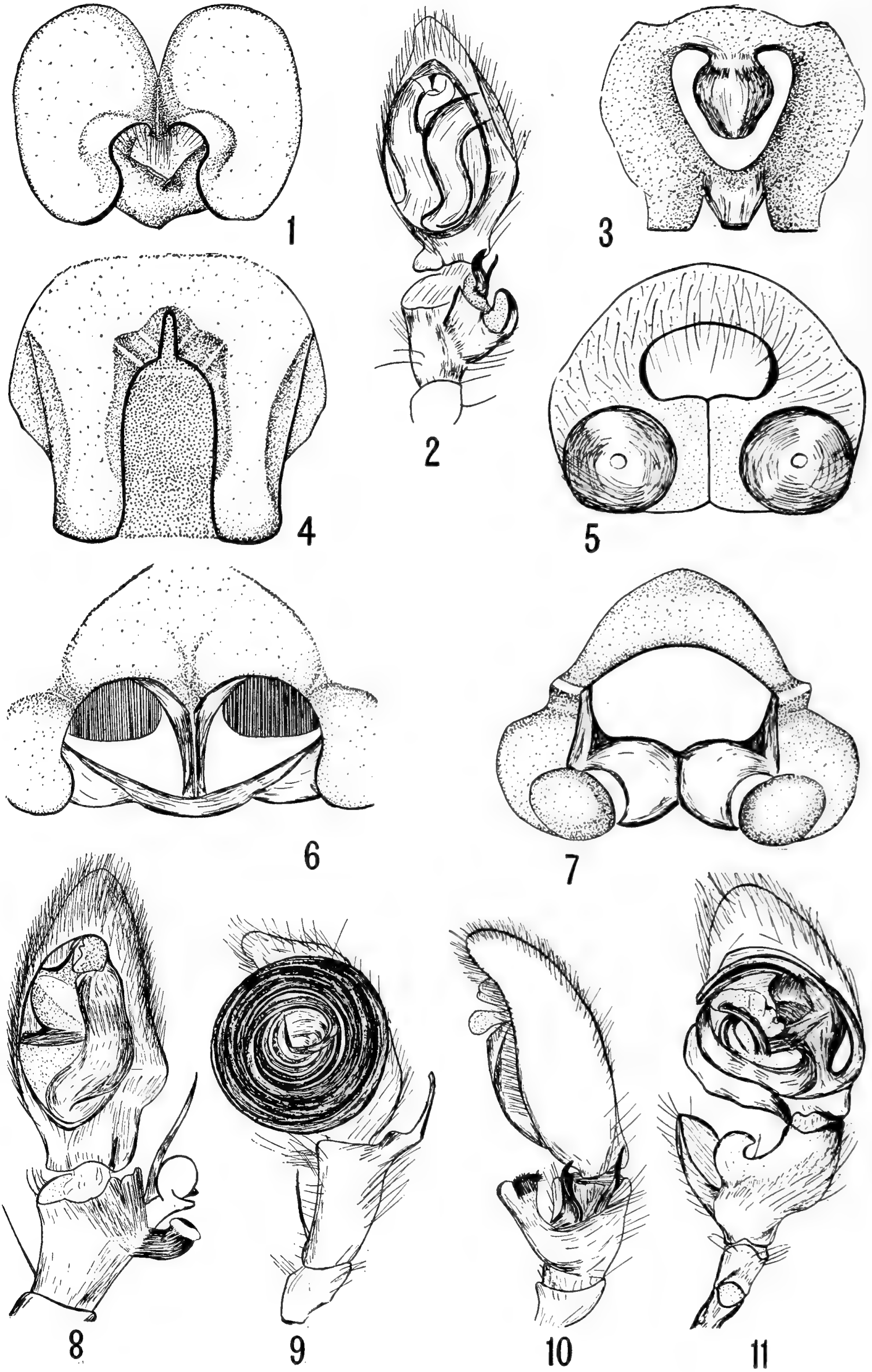
Anterior row of eyes slightly recurved or straight, narrower than the procurved posterior row (22/27). Anterior median eyes slightly larger than the anterior lateral, closer to the anterior lateral than to each other being removed from each other by one-half a diameter, from the anterior lateral by one-third of a diameter. Eyes of the posterior row subequidistant, separated by more than twice the diameter of a posterior median eye, the posterior median eyes two-thirds as large as the posterior lateral. Median ocular quadrangle about as wide as long, about as wide in front as behind, the posterior eyes two-thirds as large as the anterior. Clypeus equal in height to one-third the diameter of an anterior median eye. Chelicerae, 2.38 mm long; lower cheliceral margin armed with three robust teeth, upper margin armed with two teeth. Tibiae I and II with 2-2 spines below. Tibia and patella I, 11.48 mm long, (tibia alone, 7.92 mm); tibia and patella IV, 9.90 mm long (tibia alone, 7.13 mm).

Patella of the palpus longer than wide (11/8), tibia longer than the patella (15/11), armed with a subapical apophysis extending retrolaterad which is longer than the width of the tibia and more or less hook-like distally. The tarsus is wide and provided with an embolus that completes at least five turns. For further details regarding the structure of the palpus see Fig. 9.

Described from the holotype of Keyserling's *O. concolor*, collected at Punta del Aqua, New Mexico and in the possession of the United States National Museum.

Records.—Arizona: Fort Yuma, immature female; Madera Canyon, Santa Rita Mountains, June, 1898, male (E. A. Schwartz, collector). Mexico: Sonora, female (H. M. Stanley, Collector); Guanajuato, two females, September 1, 1886 (Alfred Duges, Collector); Guaymas, female, (all in the United States National Museum). Utah: Zion Park, 1937, male and female (A. M. Woodbury, Collector) in the Collection of Prof. R. V. Chamberlin.; St. George, July 6, 1931, several males and females (W. J. Gertsch, Collector) in the American Museum of Natural History.

I wish to express my appreciation to Miss Elizabeth B. Bryant of the Museum of Comparative Zoology for comparing specimens of *O. fasciculatus* Simon with the paratype of *O. pragmaticus* Chamberlin.



Figs. 1–11. (See opposite page for explanation.)

Olios schistus Chamberlin Figs. 7 and 10

Olios schistus Chamberlin, Pomona College Jour. Ent. and Zoo., **12**:10, pl. 4, figs. 2 and 3, 1920 (Advance Reprint in 1919).

Female.—Total length, 12.5 mm. Carapace, 4.95 mm long, 4.55 mm at the widest place, 3.17 mm in front. Abdomen, 7.5 mm long, 5.64 mm wide. Carapace irregular dark reddish brown above, the pars cephalica noticeably lighter than the pars thoracica; dorsal groove distinct, from it light bands radiate to the sides which are provided with light sub-marginal bands. Chelicerae reddish brown more or less concolorous with the pars cephalica. Sternum orange brown, lighter than the coxae which are dark brown; labium and endites reddish bearing white distal patches. Legs reddish with numerous small punctations on all the joints, the tibiae with indications of a narrow dark annulus basally. Dorsum of the abdomen irregular-reddish brown streaked with light and dark, and in this specimen, without distinct markings. Sides densely provided with dark spots and streaks; venter somewhat lighter, with a broad median dark band extending from the epigynum to the spinnerets.

Anterior row of eyes slightly recurved, narrower than the slightly procurved posterior row (19/23). Eyes of the anterior row subequal, the anterior median eyes closer to the anterior lateral than to each other, being separated from each other by more than a diameter, from the anterior lateral eyes by five-sevenths of a diameter. Eyes of the posterior row subequal and subequidistant, separated from each other by about two and one-half diameters. Median ocular quadrangle about as long as wide, slightly wider behind than in front, the posterior eyes about five-sevenths as large as the anterior. Clypeus equal in height to slightly more than one-half the diameter of an anterior median eye. Chelicerae, 2.08 mm long; lower cheliceral margin armed with four teeth of which the basal two are small and weak, while the distal two are large and robust; upper margin armed with two teeth, one large and one small. Tibiae I and II with 2-2 spines below. Tibia and patella I, 7.23 mm long (tibia alone, 4.74 mm); tibia and patella IV, 5.64 mm long (tibia alone, 3.56 mm).

Epigynum consisting of a more or less oval atrium flanked by heavily chitinized side pieces. For further details regarding the structure of the epigynum see Fig. 7.

Described from a female specimen collected at San Diego, California and in United States National Museum. A female from San Jacinto is also in that institution.

Male.—Total length, 8.10 mm. Carapace, 4.00 mm long, 4.16 mm at the widest place, 2.48 mm wide in front. Abdomen, 4.85 mm long, 3.46 mm wide. Carapace light brown above with distinct reddish punctations. Chelicerae concolorous with the carapace, bearing reddish punctations. Sternum and coxae yellowish brown with minute punctations; labium and endites reddish with distal white patches. Legs light brown, densely provided with dark punctations, tibiae with an annulus basally. Dorsum of the abdomen

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Fig. 1.—*Olios fasciculatus* Simon, epigynum. Fig. 2.—*O. abnormis* Keyserling, male palpus, ventral view. Fig. 3.—*O. albinus*, n. sp., epigynum. Fig. 4.—*O. mohavensis*, n. sp., epigynum. Fig. 5.—*Tentabunda cubana* (Banks), epigynum. Fig. 6. —*Olios bibranchiatus*, n. sp., epigynum. Fig. 7.—*O. schistus* Chamberlin, epigynum. Fig. 8.—*O. bibranchiatus*, n. sp., male palpus, ventral view. Fig. 9.—*O. fasciculatus* Simon, male palpus, ventral view. Fig. 10.—*O. schistus* Chamberlin, male palpus, lateral view. Fig. 11.—*Tentabunda cubana* (Banks), male palpus, ventral view.

gray with dark brown maculations; the distinct design consists of a basal gray lanceolate mark outlined in dark which extends to the posterior termination of the abdomen in the form of an irregular dark band. Sides and venter streaked with reddish maculations.

Anterior row of eyes slightly recurved, narrower than the procurved posterior row (32/39). Eyes of the anterior row subequal, the anterior median eyes separated from each other by slightly more than a diameter, from the anterior lateral by about one-third of a diameter. Eyes of the posterior row subequal and equidistant, separated by more than two diameters. Median ocular quadrangle about as long as wide, slightly wider behind than in front, the posterior eyes about two-thirds as large as the anterior. Clypeus equal in height to about one-half the diameter of an anterior median eye. Chelicerae, 1.68 mm long; lower cheliceral margin armed with four teeth of which the basal two are small and weak, while the others are large and robust; upper cheliceral margin armed with two teeth, one small and one large. Tibiae I and II with 2-2 spines below. Tibia and patella I, 7.23 mm long (tibia alone, 5.15 mm); tibia and patella IV, 6.53 mm long (tibia alone, 4.46 mm).

Patella of the palpus about as long as wide, tibia more than twice as long as the patella, with a broad distally expanded apophysis which is as long as the joint, and two distal processes of which one is longer than the other. For further details regarding the structure of the palpal organ see Fig. 10.

Described from a male specimen collected at Claremont, California and in the Collection of Prof. R. V. Chamberlin.

This species is most closely related to *O. peninsulans* Banks, known from Baja California, and is distinguished from the latter primarily by the character of the tibial apophysis of the male palpus which is distally truncate and bifid instead of sloping to a point. In general structure and appearance it resembles *O. abnormis* Keyserling from which it may also be differentiated by the structure of the tibial apophysis.

Olios bibranchiatus, n. sp. Figs. 6 and 8

Sparassus minax Banks, Proc. U. S. Nat. Mus. **23**:585. 1901. (Not *Olios minax* (Cambridge))

Male.—Total length, 11.00 mm. Carapace, 5.25 mm long, 4.95 mm at the widest place, 2.97 mm wide in front. Abdomen, 5.45 mm long, 3.96 mm wide. Dorsum of the carapace orange brown with lighter bars and streaks. Clypeus and chelicerae more or less concolorous with the carapace, the claws blackish. Sternum and coxae clear light brown, without dark markings; labium and endites somewhat darker, bearing white distal patches. Legs reddish brown with minute dark punctations but without annulations. Abdomen irregular brown and gray above, with evidences of dark chevrons posteriorly. Venter and sides lighter than the dorsum, clear yellowish without dark markings.

Anterior row of eyes slightly recurved, narrower than the procurved posterior row (17/21). Anterior median eyes slightly larger than the anterior lateral, separated from each other by about a diameter, somewhat closer to the anterior lateral than to each other. Eyes of the posterior row subequidistant and separated by about twice the diameter of a posterior median eye, the posterior lateral eyes somewhat larger than the posterior median. Median ocular quadrangle about as long as wide, wider behind than in front, the posterior eyes about five-sevenths as large as the anterior. Clypeus equal in height to about five-sevenths the diameter of an anterior median eye. Chelicerae, 2.18 mm long; lower cheliceral margin armed with four teeth of which the basal is small and weak while the distal three are large and robust; upper margin armed with two teeth, one large and one weak. Tibiae I and II with 2-2 spines below. Tibia and patella I, 10.30 mm long (tibia alone, 7.33 mm); tibia and patella IV, 8.81 mm long (tibia alone, 6.34 mm).

Patella of the palpus longer than wide, tibia slightly longer than the patella; tibial apophysis bibranchiate, the anterior branch with a conspicuous node distally, from the base of this branch a pointed process as long as the tibia itself extends anteriorly. For further details regarding the structure of the palpus see Fig. 8.

Female.—Total length, 14.85 mm. Carapace, 6.44 mm long, 5.74 mm at the widest place, 3.66 mm wide in front. Abdomen, 8.22 mm long, 5.00 mm wide. Carapace yellowish brown above without dark markings, clothed with a white pubescence. Clypeus and eye region concolorous with the dorsum; chelicerae dark brown, the claws blackish. Sternum and coxae yellowish brown without dark markings; labium and endites darker, with white distal patches. Legs concolorous with the dorsum of the carapace being clear light yellowish brown without annulations. Abdomen light brown, with indications of a basal dark median lanceolate mark; venter lighter than the dorsum, unmarked.

Anterior row of eyes recurved, narrower than the procurved posterior row (21/26). Eyes of the anterior row subequal, the anterior median eyes closer to the anterior lateral than to each other, being separated from each other by slightly more than a diameter, from the anterior lateral by five-eighths of a diameter. Eyes of the posterior row subequidistant, separated from each other by about twice the diameter of a posterior median eye, the posterior lateral eyes slightly larger than the posterior median. Median ocular area wider than long (23/18), somewhat wider behind than in front, the posterior eyes about five-eighths as large as the anterior. Clypeus equal in height to five-eighths the diameter of an anterior median eye. Chelicerae, 3.46 mm long; lower margin armed with four teeth, of which the basal is small while the distal three are large, upper margin armed with two teeth of which one is large and the other small. Tibiae I and II with 2-2 spines below. Tibia and patella I, 9.00 mm long (tibia alone, 5.94 mm); tibia and patella IV, 7.72 mm long (tibia alone, 5.25 mm).

The epigynum is subject to some variation; in some cases a distinct median inverse T-shaped septum is present (as in the allotype, Fig. 6), while in others the longitudinal bar of the septum is indistinct or lacking. Paratypic material in the American Museum of Natural History exhibits this difference, but the transverse bar of the septum is the same in each case.

Type locality.—Arizona: Male holotype from Madera Canyon, Santa Rita Mountains, May, 1898 (E. A. Schwartz, Collector), in the United States National Museum (U.S.N.M. Cat. No. 1274). Female allotype from Santa Fe, New Mexico, also in the United States National Museum. Two male paratypes and three female paratypes from Oro Blanco Mts., 12 miles from Nogales, Arizona, July, 1937, in the American Museum of Natural History.

Olios abnormis Keyserling Fig. 2

Olios abnormis Keyserling, Verh. Zool. Bot. Ges. Wien **33:** 679, Pl. XXI, Fig. 27. 1883.

Male.—Total length, 8.10 mm. Carapace, 4.36 mm long, 3.96 mm at the widest place, 2.28 mm wide in front. Abdomen, 3.96 mm long, 2.87 mm wide. Carapace light reddish brown above, with streaks of dark brown on the pars cephalica, sides without submarginal light bands. Clypeus, eye region, and chelicerae concolorous with the dorsum. Sternum yellowish, with minute reddish punctations; coxae and endites clear yellowish brown, without reddish markings, labium somewhat darker. Legs reddish brown with numerous minute punctations; tibia with a dark annulus at their proximal ends. Abdomen yellowish brown, provided with a distinct median design which consists of a basal lanceolate white mark outlined with reddish brown which extends to the posterior termination of the abdomen in the form of an irregular dark brown line. Sides and venter densely provided with reddish maculations.

Anterior and posterior eye rows slightly procurved, the former shorter than the latter (35/42). Anterior median eyes separated from each other by about a diameter, from the anterior lateral by about three-fifths of a diameter and larger than the latter (6/5). Eyes of the posterior row subequal and equidistant separated from each other by about two diameters. Median ocular quadrangle wider than long (17/15), about as wide in front as behind; the posterior eyes about five-sevenths as large as the anterior. Clypeus equal in height to about three-sevenths the diameter of an anterior median eye. Chelicerae, 1.68 mm long; lower cheliceral margin armed with four teeth of which the distal three are large and the basal is weak; upper margin armed with two teeth one large and the other small. Tibia I and II with 2-2 spines below. Tibia and patella I, 6.43 mm long (tibia alone, 4.36 mm); tibia and patella IV lacking in the specimen.

Patella of the palpus longer than wide (15/12), tibia about twice as long as the patella, with a thick retrolateral bibranchiate apophysis, about as long as the width of the joint, and two distal processes, one of which is spinose while the other is distinctly hook-like. For further details regarding the structure of the palpus see Fig. 2.

Described from a male specimen collected at Kits Peak, Rincon, Baboquivari Mountains, Arizona, July 31–Aug. 3, 1916, by F. E. Lutz and in the Collection of the American Museum of Natural History. A single male in poor condition from Los Angeles, California, is in the United States National Museum.

Olios mohavensis, n. sp. Fig. 4

Female.—Total length, 16.80 mm. Carapace, 6.83 mm long, 6.04 mm at the widest place, 4.06 mm wide in front. Abdomen, 9.91 mm long, 5.60 mm wide. Dorsum of the carapace muddy brown, the pars cephalica much lighter than the pars thoracica and provided anteriorly with two parallel lines which extend forward between the posterior median eyes. Clypeus and chelicerae concolorous with the pars cephalica, the claws blackish. Sternum and coxae light yellowish brown; labium and endites somewhat darker, bearing white distal patches. Legs uniform light yellowish brown without annulations. Abdomen orange brown above, provided with a dark basal lanceolate mark from whose sides project several dark lines; this mark is flanked on each side by a submedian and a subterminal punctation. Venter lighter than the sides, provided with two short dark lines.

Anterior and posterior rows of eyes slightly procurved, the former narrower than the latter (22/27). Eyes of the anterior row subequal, the anterior median eyes closer to the anterior lateral than to each other, being separated from each other by more than a diameter, from the anterior lateral by five-eighths of a diameter. Eyes of the posterior row subequidistant, separated by more than two times the diameter of a posterior median eye, the posterior lateral eyes somewhat larger than the posterior median. Median ocular quadrangle about as wide as long, as wide in front as behind; the posterior eyes about two-thirds as large as the anterior. Clypeus equal in height to about five-eighths the diameter of an anterior median eye. Chelicerae, 3.00 mm long; lower cheliceral margin armed with four teeth of which the basal is small and weak while the distal three are large and robust, upper margin armed with two teeth, one large and one small. Tibiae I and II with 2-2 spines below. Tibia and patella I, 10.49 mm long (tibia alone, 7.52 mm); tibia and patella IV, 9.41 mm long (tibia alone, 6.73 mm).

Epigynum about as long as wide, consisting of a deep chitinized atrium flanked by heavy side pieces. For further details regarding the structure of the epigynum see Fig. 4.

Type locality.—California: Female holotype from Mohave Desert (no further data) in the United States National Museum (U.S.N.M. Cat. No. 1273).

Olios albinus, n. sp. Fig. 3

Female.—Total length, 12.87 mm. Carapace, 4.95 mm long, 4.65 mm at the widest place, 3.17 mm wide in front. Abdomen, 7.43 mm. long, 5.94 mm wide. Dorsum of the carapace whitish, the pars cephalica outlined with minute punctations. Eye region, clypeus, and chelicerae tinged with orange, the claws of the chelicerae blackish. Sternum and coxae white, labium and endites light brown with whitish distal patches. Legs uniform white below, above whitish with sparse punctations except for the metatarsi and tarsi which are brown contrasting with the other joints. Dorsum of the abdomen whitish tinged with brown, a basal lanceolate mark is outlined by brown spots and continues posteriorly in the form of an irregular median longitudinal. band. Venter lighter than the dorsum and sides, being white and unmarked.

Anterior row of eyes straight, narrower than the slightly procurved posterior row (19/23). Anterior median eyes closer to the anterior lateral than to each other, separated from each other by about a diameter, from the anterior lateral eyes by about five-sevenths of a diameter and larger than the latter. Eyes of the posterior row subequal and equidistant, separated by about two diameters. Median ocular quadrangle wider than long (20/17), slightly wider behind than in front, the posterior eyes about five-sevenths as large as the anterior. Clypeus equal in height to about one-half the diameter of an anterior median eye. Chelicerae, 2.18 mm long; lower cheliceral margin armed with three teeth, upper margin armed with two. Tibiae I armed with 2-2 spines below; spination of the animal's left tibia II irregular, apparently involving 2-1r-2-1r spines below, spination of the right tibia normal, involving 2-2 spines below. Tibia and patella I, 7.13 mm long (tibia alone, 4.65 mm); tibia and patella IV, 5.45 mm long (tibia alone, 3.66 mm).

Epigynal area small, the atrium more or less heart shaped, provided with a lobe which extends caudally from the anterior border and divides the anterior three-fourths of the atrium into two parts. For further details regarding the structure of the epigynum see Fig. 3.

Type locality.—Arizona: Female holotype from Phoenix, May, 1935, in the Collection of Prof. R. V. Chamerlin.

HETEROPODA Latreille

Nouv. Dict. Hist. Nat., **XXIV:** 135. 1804. Genotype: *Aranea venatoria* Linnaeus.

Cephalothorax about as wide as long or slightly longer than wide. Eyes in two rows with the anterior row straight or procurved and narrower than the straight or slightly recurved posterior row. Anterior median eyes smaller than the anterior lateral and usually closer to the latter than to each other. Posterior median eyes usually smaller than the posterior lateral. Clypeus higher than the diameter of an anterior lateral eye. Lower cheliceral margin armed with four teeth, upper margin armed with two or three teeth. Anterior tibiae armed with 2-2-2-2 spines below.

Heteropoda venatoria (Linn.)

Aranea venatoria Linnaeus, Syst. Nat. 12th Ed. p. 1035, 1767.

This often-described cosmopolitan tropical species has long been known to occur in our Southwestern states and in Florida. Inasmuch as it has been considered by many authors and good descriptions and figures are generally available, it is not redescribed at this time.[15]

ENTOMOLOGY.—*The cinerosus group of the genus* Laevicephalus (*Homoptera: Cicadellidae*).[1]

P. W. OMAN, Bureau of Entomology and Plant Quarantine.

The six species treated in this paper form a remarkably homogeneous group on the basis of habitus, coloration, and certain structural details of the genitalia, and by these characters may be distinguished from other members of the genus *Laevicephalus.* The ground color of the head is pale cinereous to pale, sordid yellow; never green or greenish tinged. The crown has a pair of oblique fuscous or brown dashes at the apex and two pairs of similarly colored, irregularly quadrate spots on the disk. The facial sclerites are usually fuscous, the clypeus, at least laterally, is marked with transverse bars of brown or fuscous, and the thorax and abdomen are variously marked with fuscous.

The male valve is large and triangular, the plates broad and rather short and furnished laterally with a few spine-like setae. The distal portion of the style is definitely foot-shaped in outline and serrate on the posterior margin. The base of the aedeagus is furnished with a more or less flaring, submembranous portion for muscular attach-

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[15] Excellent figures may be found in F. Cambridge's *Biologia Centrali-Americana,* **II:** 120, pl. VIII, figs. 22*a–c*, 23*a–f*. 1905. For the synonymy of this species see also Petrunkevitch's catalogue in Bull. Amer. Mus. Nat. Hist. **29:** 488. 1911.

[1] Received August 12, 1937.

ment. The pygofers of both sexes are densely set with numerous stout setae and the seventh sternite of the female has the posterior margin either incised or emarginate and bordered with fuscous or black medially.

With the exception of specimens from southern Utah and south central Washington, all the available distribution records for members of the cinerosus group are from California.

KEY TO THE SPECIES OF THE CINEROSUS GROUP

1 Posterior margin of seventh sternite of female broadly emarginate; male plates bluntly rounded distally . . . . *incongruus*, n.sp.

Posterior margin of seventh sternite of female not broadly emarginate; male plates pointed distally 2

2(1) A rather short and robust species, fore wings not extending beyond tip of abdomen . . . . *pacificus*, n.sp.

Elongate and slender species, fore wings extending beyond tip of abdomen 3

3(2) Male plates not contiguous for entire length, the tips diverging. Posterior margin of seventh sternite of female with two pairs of dentate projections, the inner pair nearly as large as the outer pair . . . . *cinerosus* (Van D.)

Male plates contiguous for entire length. Posterior margin of seventh sternite of female either not quadridentate or, if so, with inner pair of projections much smaller than outer pair 4

4(3) Processes of aedeagus reduced to short, dentate projections. Posterior margin of seventh sternite of female triangularly produced and narrowly incised . . . . *joaquinus*, n.sp.

Processes of aedeagus longer, not dentate. Posterior margin of seventh sternite of female not narrowly incised 5

5(4) Aedeagus with two pairs of pointed processes distally. Inner pair of dentate projections on posterior margin of seventh sternite of female rudimentary . . . . *angelus*, n.sp.

Aedeagus with one pair of pointed processes distally. Inner pair of dentate projections on posterior margin of seventh sternite of female small but distinct . . . . *siskiyou*, n.sp.

Laevicephalus incongruus, n. sp. Figs. 1, 7, 13

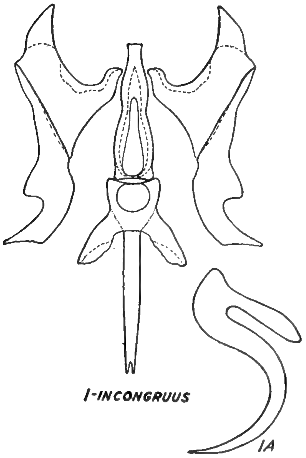
Larger and paler than *cinerosus*, with the male plates blunt and the posterior margin of the seventh sternite of the female broadly emarginate. Length of male 4–4.5 mm, of female 4.5–4.9 mm.

Ground color sordid yellowish white, oblique dashes on anterior margin of crown fuscous, marks on disk of crown pale brown, fuscous borders of cells of fore wing faint or absent, fore wings subhyaline.

Seventh sternite of female rather short, the median one-half of the posterior margin emarginate about one-third the distance to base. Male valve unusually large; plates short and blunt, not contiguous on median line.

Distal portion of aedeagus slender and strongly decurved, apex bifurcate. Basal portion of aedeagus unusually large and flaring. Style slender.

Holotype male, allotype female, and 85 paratypes, including specimens of both sexes, collected above Mint Canyon, Calif. June 8, 1935, by the writer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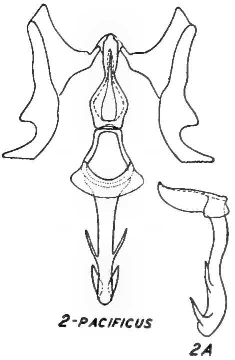
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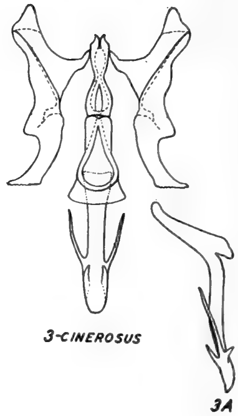
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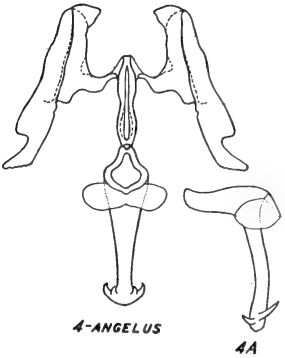
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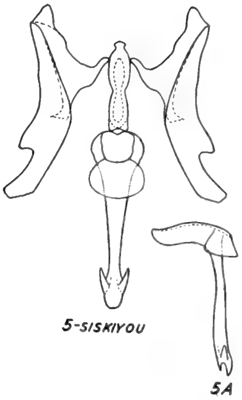
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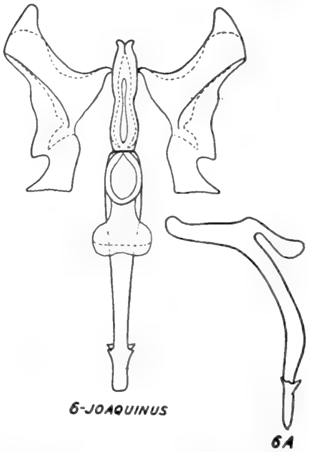
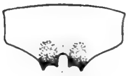
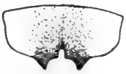

6-JOAQUINUS

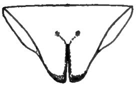

7-INCONGRUUS

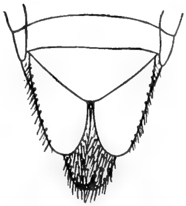

8-PACIFICUS

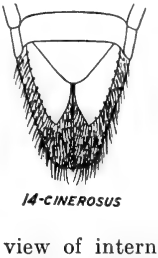

9-CINEROSUS


10-SISKIYOU


11-ANGELUS


12-JOAQUINUS


13-INCONGRUUS


14-CINEROSUS

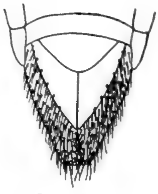

15-PACIFICUS

Fig. 1.—*Laevicephalus incongruus*, dorsal view of internal genital structures of male; 1A, lateral view of aedeagus. Fig. 2.—*L. pacificus*, dorsal view of internal genital structures of male; 2A, lateral view of aedeagus. Fig. 3.—*L. cinerosus*, dorsal view of internal genital structures of male; 3A, lateral view of aedeagus. Fig. 4.—*L. angelus*, dorsal view of internal genital structures of male; 4A, lateral view of aedeagus. Fig. 5.—*L. siskiyou*, dorsal view of internal genital structures of male; 5A, lateral view of aedeagus. Fig. 6.—*L. joaquinus*, dorsal view of internal genital structures of male;

and Mrs. Oman. Types in the collection of the United States National Museum (No. 52203). In addition to the type series, there are specimens at hand from Mint Canyon, Calif. (Oman), and Mt. Diablo, Calif. (Oman).

Laevicephalus cinerosus (Van Duzee) Figs. 3, 9, 14

Deltocephalus cinerosus Van Duzee, Trans. Amer. Ent. Soc. **19**: 305, 1892.

Length 3.5–4 mm. Ground color pale, sordid yellow; markings varying from pale brown to fuscous. Marks on disk of crown faint, longitudinal lines on pronotum indistinct. Cells of fore wing bordered with fuscous, veins pale. Fore wings extending beyond tip of abdomen.

Seventh sternite of female short laterally, posterior margin with a small median emargination and on each side of this a pair of short, angled, dentate projections. Male plates rather short, diverging posteriorly, tips pointed.

Aedeagus rather stout, with three pairs of pointed projections arising from near tip and extending basad and slightly outward as follows: An elongate, slender pair laterally, a short, slender pair latero-ventrally, and a short pair latero-dorsally. Style relatively slender.

Originally described from 1 male and 4 females collected in California by Coquillett. The male of this series, which is in the collection of Iowa State College, Ames, Iowa, is here designated lectotype. I am indebted to Mr. L. D. Tuthill for drawings of the aedeagus of this specimen.

Material from the following California localities has been examined: Los Angeles County (Coquillett), Warner Springs (Oman), Cajon Pass (Oman), Del Mar (Oman), Newton (Oman), and Perris (Oman). Two females from southern Utah are referred here also.

Laevicephalus pacificus, n. sp. Figs. 2, 8, 15

Smaller and more robust than *cinerosus,* with the male plates contiguous for their entire length and the aedeagus with only two pairs of processes. Length of male 3–3.25 mm, of female 3.5–3.75 mm.

Ground color as in *cinerosus,* oblique dashes at apex of crown short, markings on disk of crown pale brown. Fore wings of male equalling abdomen in length, those of female shorter than abdomen, cells marked with fuscous especially around edges. Hind wings of both sexes much shortened.

Posterior margin of seventh sternite of female with a small median emargination, and a pair of blunt, dentate projections on each side of this. Male plates rather broad, contiguous on median line, and tapering abruptly to pointed apices.

Aedeagus rather stout, with two pairs of pointed processes as follows: A slender pair arising laterally on shaft before apex and extending laterad and basad, and a stout pair arising from a latero-ventral position near the apex and extending ventrad, basad, and slightly laterad. Style slender.

Holotype male, allotype female, and 17 male and 19 female paratypes

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6A, lateral view of aedeagus. Fig. 7.—*L. incongruus*, seventh sternite of female. Fig. 8.—*L. pacificus*, seventh sternite of female. Fig. 9.—*L. cinerosus*, seventh sternite of female. Fig. 10.—*L. siskiyou*, seventh sternite of female. Fig. 11.—*L. angelus*, seventh sternite of female. Fig. 12.—*L. joaquinus*, seventh sternite of female. Fig. 13.—*L. incongruus*, external genitalia of male. Fig. 14.—*L. cinerosus*, external genitalia of male. Fig. 15.—*L. pacificus*, external genitalia of male.

from Montara, Calif., June 13, 1935, collected by the writer and Mrs. Oman. Types in collection of the United States National Museum (No. 52204). In addition to the type series there are specimens at hand from San Francisco, Calif. (Oman).

Laevicephalus siskiyou, n. sp. Figs. 5, 10

Related to *pacificus* by the shape of the male plates, but less robust; similar to *cinerosus* in general form; markings darker than in either of those species. Length 3.6–4.2 mm.

Ground color as in *cinerosus.* Oblique fuscous dashes at apex of crown fused posteriorly with the anterior pair of marks on disk of crown. Posterior pair of marks on crown brown. Longitudinal stripes on pronotum distinct. Fore wings subhyaline, veins whitish cinereous, cells bordered with brown or fuscous.

Seventh sternite of female similar to that of *cinerosus,* but with median emargination smaller and inner pair of dentate projections shorter. Male plates as in *pacificus,* but shorter and more sharply pointed.

Aedeagus relatively slender and elongate, with a single pair of short, stout, pointed processes extending basad and laterad from near the tip. Style rather broad, outer point very blunt.

Holotype male, allotype female, and 2 male and 36 female paratypes from Mt. Shasta City, Calif., June 29, 1935, collected by the writer and Mrs. Oman. Also 3 male and 8 female paratypes from south of Mt. Shasta City, same date and collectors. Types in collection of the United States National Museum (No. 52205). In addition to the type series there are specimens at hand from the following localities in Siskiyou County, Calif.: north of Weed (Oman), Bray (Oman), and Dunsmuir (Oman). Specimens of this species are also at hand from Cliffdell, Wash. (Oman), and Cottonwood Flats, Mt. Ranier, Wash. (Oman).

Laevicephalus angelus, n. sp. Figs. 4, 11

Superficially identical with *siskiyou,* but with the dentate projections of the seventh sternite of the female even shorter and the aedeagus with two pairs of pointed processes. Length 3.75–4.25 mm.

Color as in *siskiyou* but with marks on crown either fused or divided and usually not so dark as in that species.

Seventh sternite of female as in *cinerosus* but with median emargination and dentate projections of posterior margin even smaller than in *siskiyou.* Male plates as in *siskiyou.*

Aedeagus shorter than that of *siskiyou* and with two pairs of rather short, curved processes arising from near the tip, one pair extending dorsad, laterad, and slightly basad, the other pair extending laterad and basad and slightly ventrad. Style relatively slender, outer point blunt.

Holotype male, allotype female, and 10 male and 37 female paratypes from above Mint Canyon, Calif., June 8, 1935, collected by the writer and Mrs. Oman. Also 3 male and 11 female paratypes from Mint Canyon, June 7, 1935, same collectors. Types in collection of the United States National Museum (No. 52206).

Laevicephalus joaquinus, n. sp. Figs. 6, 12

Larger, paler, and with less definite markings than *cinerosus,* and with the posterior margin of the seventh sternite of female produced medially. Length of male 4 mm, of female 4.5 mm.

Ground color pale creamy white, oblique, dashes at apex of crown short, markings on disk of crown pale brown. Fore wing subhyaline brown; veins white, occasionally bordered with brown or fuscous.

Seventh sternite of female very short laterally, postero-lateral portions somewhat membranous, posterior margin produced medially and with a very narrow median incision which extends nearly half way to base of segment. Male plates rather broad and short, similar to those of *pacificus* but slightly broader near tips. Pygofer longer than in *pacificus*.

Aedeagus rather slender, bearing near the tip two pairs of short, toothlike projections in the dorso-lateral and ventro-lateral positions. Style broad.

Holotype male, allotype female, and 1 male and 6 female paratypes from Califa, Calif., June 12, 1935, collected by the writer and Mrs. Oman. Types in collection of the United States National Museum (No. 52207).

ENTOMOLOGY.—*Some new North American Membracidae.*[1] E. D. BALL, University of Arizona.

The writer is planning a revision of the tribe Ceresini along similar lines to that of his Telamoninae and finds as usual that a number of new species must be characterized before it can be completed. The occasion is taken to describe a number of new forms in the different groups.

Ceresa ancora Ball, n. sp.

Larger than *bubalus* with much longer, heavier and strongly recurved horns. The metapodium convex in both diameters. Length 10 mm, width across horns 7–8 mm.

Metapodium widening more rapidly than in *bubalus* to the stout recurved horns that are about twice as long as those in that species, as seen from above the metapodium across the horns is straight in *bubalus* but strongly convex in this species. As soon from the side, the pronotum is arched about as in *bubalus,* not nearly as strongly as in *testacea.* Female segment with a deep triangular notch reaching to the base. Male genitalia of the *testacea* pattern with the genital box usually open, the plates vertical, the styles flat tapering to acute black tips and are incurved and pressed against the plates. The oedaegus long, spatulate, with an acute apex and a pair of backward pointing spines at the base. In *testacea,* the styles are much narrower and more curved, the oedaegus is spoonshaped and the basal spines curve out.

Color green with a submarginal light line on pronotum which broadens and runs up under the horns. The posterior face of the horn and the tip of pronotum brown.

Holotype ♂ and a paratype male Patagonia, Oct. 5, 1935, allotype ♀ and two paratype females Atascasa Mt., Sept. 29, 1935, four paratypes Nogales and four Patagonia taken from the 7th of September till the 20th of October. All taken along the Mexican border in Arizona by the writer.

Ceresa infantilis Ball, n. sp.

Smaller than *vitulus* or *constans,* the smallest species known. With the metapodium strongly convex, shining, and the horns reduced to mere points, scarcely longer than the humerals. Length 6 mm, width 2 mm.

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[1] Received September 20, 1937.

Metapodium short, rapidly expanding to the blunt horns, as seen from the side the pronotum slopes to the middle, with a stronger arch than in *vitulus.* The disc of the metapodium is convex, the lateral margins thick and rounding, resembling a *Stictocephala* but with the small but definite horns of a *Ceresa.* Female segment rather long with a deep triangular notch reaching nearly to the base. Male plates short, stout, triangular, held almost vertical by the broad stout styles that are black-tipped and obliquely truncate, behind them an anchor-like structure appears, and then the long oedaegus resembling the head of a needle.

Color (green in life) fading to tawny, the nervures darkening toward the tip. A white margin to the apical part of the pronotum and a white arch on each side starting behind the horn and bordering the curve of the pronotum till it joins the lateral white line.

Holotype ♀ and three paratypes labeled Acapulco, Mex., Aug. 24, 1936, taken at kilometer post 299, allotype ♂ and four paratypes taken at kilometer post 426, three at post 382 Aug. 29, 1936; all taken on the Mexico City to Acapulco Road by Ball and Stone, and five paratypes labeled Guacimo, Costa Rica, June 16, 1903 J.C.C.

This species is described at this time to call attention to the fact that there are two widely different types of male genitalia found in the material that has been included under *vitulus* Fab. This is the oldest (1775) described species and one of the smallest, and as now determined has the widest distribution (from the sand hills of Dakota and Nebraska through both Mexico and the West Indies to most of South America). Goding lists ten synonyms and there are probably others. No one has mentioned the male genitalia in descriptions (although Fowler mentions as a generic character "The elongate styles of the male." He must have seen them in *vitulus,* his first species and assumed that they were generic), but the widely distributed tropical and subtropical species that fits the size, shape of horns and the white arch on the sides of the pronotum of *vitulus* has the plates compressed and the styles extending as long, double curved horn-like appendages, two or three times their length beyond them, while in *infantilis* the styles are flat, swordlike and stand at right angles to the pygofers on either side of the plates. There is a wide variation in horn length in both groups but as far as observed the genital characters are constant.

Stictocephala fulgida Ball, n. sp.

Resembling *collina* Van D. in the smooth, rounding pronotum, still broader and more shining. Pale green with milk-white mottling and a milky "Y" on the dorsum. Length 6–7 mm, width 3 mm.

Metapodium nearly one-half broader than in *collina* and much lower, as low as in *gillettei* but with the metapodium smoother than in *collina* instead of much rougher and more deeply pitted as in *gillettei.* Female segment very short with a broad rectangular notch. Male plates broad at base, slightly inflated before the two tall, curved brown-tipped pygofer spines, then constricted and almost parallel to the broad slightly divaricate tips.

Color pale greenish and milky, polished, the pronotum with milky spots and a definite "Y" running from the shoulders nearly to the apex. The male with the last abdominal segment usually black.

Holotype ♂ allotype ♀ and five paratypes St. Johns, Arizona, Aug. 27, 1934 seven paratypes Granite Dells, Oct. 6, 1929, and two Huachuca Mts., June 15, 1930, all taken in the mountains of Arizona by the writer.

Stictolobus juniperinus Ball, n. sp.

Resembling *trilineatus* Funk, smaller, narrower with the three white lines replaced by five broken lines in front and three pair of white flecks posteriorly. Pale green, lined and mottled with white. Length 6 mm, width 2 mm.

Metapodium low, overhanging the face instead of vertical as in *trilineata*, pronotum slightly sinuate anteriorly, then nearly straight to the slightly depressed apex, transversely rounding instead of laterally compressed. Elytra with three discoid cells as in *subulata*, the apical cell large, triangular, with the petiole usually shorter than the cell instead of longer as in *trilineata*. Female segment long, deeply, acutely notched. Male plates small constricted and depressed between immense flat black-tipped erect pygofer spines, that are narrowed to blunt points and expose a dark anchor-like structure and a long needle-like oedaegus.

Holotype ♂ allotype ♀ and 10 paratypes, Patagonia, Sept. 20, 1930, and eight paratypes Tucson Oct. 20, 1929, all taken in the mountains of Arizona by the writer.

This species is strikingly distinct in its color pattern and unique male genitalia.

Atymna reticulata Ball, n. sp.

Resembling *simplex* Van D. much smaller with a lower crest, size of *querci*, nearly, but with a very different male. Pale green, unmarked except for a row of dots along crest. The elytra with a number of extra cells in the apical part. Length ♀ 6 mm; ♂ 5 mm.

Metapodium much less elevated than in *simplex*, very similar to *querci* but with the apex much more produced. The clypeus produced into an acute point. Venation typical; the apical cell large, almost oval, an irregular number of supernumerary cells in the apical part. Color pale green, the male slightly tawny, a row of fine dots along the crest.

Holotype ♀ and paratype female Santa Rita Mountains, July 13, 1930, allotype ♂ Santa Rita Mountains, July 5, 1933, and a paratype female Tucson, Sept. 29, 1929. All taken in the mountains of Arizona by the writer.

The acute clypeus will at once separate this from any other described species.

Xantholobus arenatus Ball, n. sp.

Resembling *coconinus* Ball in size and general form of the rounding crest, much narrower and less inflated posteriorly and with a "ten pin" color pattern like *nigrocincta*. Female gray with a double saddle. Male tawny gray with a white margined red "ten pin." Length ♀ 4.8 mm; ♂ 4.5 mm.

Pronotum from the side a uniform crescent in the female, low and but slightly curved back of the humerals in the male. In the female tectiform with a double inflation posteriorly and a single median one. The inflations tan colored with white borders on a gray background. Male tawny with white irrorations, the face and below including the femora black. A tawny red, white-bordered ten pin resting on the two humps with a white dot between. Elytra subhyaline, the nervures broad, dark, the appendix smoky.

Holotype ♀ one paratype female allotype ♂ and six paratype males together with the nymphs taken at Leverton, Texas, May 5, 1934, by the writer. The triangular shape and striking pattern make this species an easy one to recognize.

BRYANTOPSIS Ball, n. gen.

A typical *Polyglyptini* resembling *Publilia* Stal., except that there is a definite anterior horn especially marked in the female, superficially resembling *Metheisa* Fowl, especially in the shape and length of the horn in the male, but differing radically in venation which has warranted Goding in placing this latter genus in the *Smilini*.

As seen from the side with an anterior horn extending obliquely upwards as in *Phyla* for one-third the body length in the female the horn compressed at apex, cut off obliquely and occasionally expanded. There are three lateral carinae. The pronotum covers most of the elytra, is acutely tectiform with four or five lateral carinae, the inner one with branches to the highest part of crest. The face is slightly longer than in *Publilia*, the venation of the elytra similar.

Type of the genus *Bryantopsis ensiger*, n.sp. Named in honor of O. W. Bryant, whose careful and painstaking observations have brought to light this as well as many other rare forms.

Bryantopsis ensiger Ball, n. sp.

Resembling *Polyglyptoides cornigerus* Stal in general size and appearance, but with a much broader horn in the female and different venation which allies it with *Publilia*. Resembling *Publilia modesta* in body shape and venation, larger with a long flattened horn in the female and a shorter pointed one in the male. Length with horn ♀ 7 mm; ♂ 6 mm.

Female with the dorsal line in profile a uniform arch slightly higher than in *P. modesta*. The horn extending upward and forward at an angle of 45° from the line of the costa, strongly compressed, the apex acute and cut off horizontally. The margins are parallel or it is slightly widened at apex. The male horn is about half as long as the female, compressed, but triangular in profile. There are three lateral carinae on the horn and about five on the sides of the pronotum.

Color light brown, the males a little darker, a narrow oblique white band before the apex of pronotum. The tip of horn darker, the dorsal carina broadly light with dark interruptions, the lateral carinae are often light with dark interruptions giving a grizzled appearance.

Holotype ♀ allotype ♂ and 9 pairs of paratypes taken by O. W. Bryant in White House Canyon, Santa Rita Mountains, Arizona, Sept. 25, 1936.

Var. **humerosus** Ball, n. var.

Form and size of the species except that there are large elongated crescentiform ivory or pale yellow areas extending from the humeri half way back on each side. In the male, only the crescentiform margin appears.

Holotype ♀ Huachuca Mountains, July 29, 1935, taken by the writer and allotype ♂ and 6 paratypes taken with the species Sept. 25 and Oct. 5, 1936 by O. W. Bryant.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1105TH MEETING

The 1105th meeting was held in the Cosmos Club Auditorium, October 10, 1936, President SILSBEE presiding.

The program consisted of an invited paper by BRUNO LANGE of the Kaiser Wilhelm Institute, Berlin-Dahlem, and informal communications by Messrs. BRICE and W. J. HUMPHREYS. These were discussed by Messrs. KRACEK, MCNISH, MOHLER, BRICE, and others.

BRUNO LANGE: *The theory and application of photo-electric cells.*—The first part dealt briefly with the photo-electric cell and its physical properties. Tracing photo-electric experiments to Hallwachs, who in 1888 demonstrated the emission of electrons from certain metals when exposed to light, the alkali cells and their limitations were described. The new photo-elements, the development of which was begun in 1884 by Fritts in New York, produce considerably greater currents without booster circuits. In describing the self-generating photo elements in some detail, especial reference was made to their physical and chemical properties by means of actual demonstrations.

The second part dealt with the use of photo-electric cells for radiation measurements, particularly light meters, in conjunction with various filters. With the Multiflex Galvanometer a sensitivity up to 1/100th foot candle per scale division is obtainable. This outfit is of great value in micrometric measurements for microscopes with slit ocular and ocular photo-cell. In describing the recording light meters, it was pointed out that the Multiflex Galvanometer may also be fitted with a photographic recording device to accurately determine the duration of light intensities. A "Sun Motor" the armature of which was rotated by a current generated in a small photo-electric cell, the size of a pocket watch, was demonstrated. It was pointed out that photo-electric measurements can also be made of ultraviolet and x-ray radiation.

The third part dealt with photo-electric elements in optical instruments, particularly in replacing the human eye for accurate measurements of luminosities. The ocular photo-cell on standard microscopes used in evaluating line spectra as well as micro specimens, x-ray films and sound film strips was demonstrated.

The fourth part dealt with special apparatus for testing the permeability of filters. The photo-electric reflexion meter for the rapid and convenient determination of absolute values was demonstrated in detail. Another form, known as the *gloss meter*, is finding applications in many major industries. A colorimeter for turbidity measurements, that will duplicate readings on the same substance, regardless of time elapsed between readings, and unaffected by the visual acuity of the observer, was described. In addition to fluids, solid and powdered substances can be measured, and filters may be employed. It is also suitable for pH measurements. Its application in the determination of iron, manganese, titanium, phosphorous, silicic acid and arsenic, as well as of mercury, of sulphatic ions, of methylene blue, chinolin red, and phenol, aluminum, chlorophyll and vitamin, was stressed, and its industrial applications for the control of signals and switching mechanisms, for water works turbidity control, and smoke alarms aboard ocean liners and for electric power house generators were discussed. A new type of coherer relay as light barrier and as twilight switch was demonstrated. It was pointed out that invisible rays may be employed for the protection of homes, banks and vaults, introducing a new factor of safety. (*Author's Abstract.*)

In an informal communication, Mr. Brice described and demonstrated a photo-electric apparatus built by the American Instrument Company for the Department of Agriculture, for the purpose of measuring the colors of sugar, resins, etc. In a second informal communication Mr. Humphreys, under the title "Tuckerman vindicated" exhibited a slide of an old print showing the scene after a "ball of lightning" had fallen into a barnyard, and by thus presenting photographic evidence, claimed to have demonstrated the truth of a story attributed to Mr. Tuckerman that such an event had occurred.

1106TH MEETING

The 1106th meeting was held in the Cosmos Club Auditorium, October 24, 1936, President **Silsbee** presiding.

The program consisted of an invited paper by **Karl F. Herzfeld** of the Catholic University of America entitled: *Recent investigations on the liquid state.* Discussed by Messrs. **Gibson**, **Kracek**, **Frankland**, **Hawkesworth**, **Humphreys**, **White**, and **Brickwedde**.

1107TH MEETING

The 1107th meeting of the Society was held in the Cosmos Club Auditorium, November 7, 1936, Vice-President **Gibson** presiding.

Program: R. L. **Sanford**: *Magnetic testing of prison bars.*—A brief description of an instrument developed primarily for the purpose of testing prison bars but which can be used for other practical applications of magnetic analysis. It is essentially an alternating-current bridge whose indications depend upon differences in the shapes of the magnetic hystereses loops of the test specimen and a reference specimen of known quality. The instrument is simple to operate, portable, comparatively rugged, and operates from the ordinary alternating-current lighting circuit. (*Author's Abstract.*)

W. H. **Swanger**: *Failures in metals.*—In the examination at the National Bureau of Standards of many metal structural members that failed in service, defective material has seldom been found as the cause of the failure. By far the greatest number of failures resulted because the member, although sound metallurgically, did not have adequate resistance to the imposed service conditions. Resistance to corrosive conditions can be provided by inert coatings. Adequate resistance to service stresses must be provided by the design. Incorrect calculation of stresses or incorrect information on the strength of the material are infrequent causes of failure. Errors in executing the design are frequent sources of failure. Inadequate fillets, sharp re-entrant angles or projecting fins, machine tool marks, constitute points of localized stress concentration which are much more damaging to the resistance of the material to dynamic or cyclic stresses than to static stresses. Fatigue fractures almost invariably originate at a point of localized stress concentration. Corrosion acting simultaneously with cyclic stresses accentuates the localized stress concentration effect, thereby causing a further decrease in resistance to fatigue fracture. Fatigue fractures or fractures resulting from corrosion-fatigue are the most commonly occurring causes of failure in metals used as structural or machine members. (*Author's Abstract.*)

These papers were discussed by Messrs. White, Hawkesworth, Gish, Heyl, Sale, Tuckerman, and Baecher.

1108th meeting

The 1108th meeting was held in the Cosmos Club Auditorium, November 21, 1936, President Silsbee presiding.

The program consisted of reports on the Edinburgh Assembly of the *International Union of Geodesy and Geophysics.*

William Bowie: *General report on meeting.*—The Sixth General Assembly of the International Union of Geodesy and Geophysics was held in Edinburgh, Scotland, in September, 1936. There was a large attendance of delegates and guests from thirty-one countries. The assembly was marked with great friendliness on the part of the delegates and a spirit of cooperation in the attack of geophysical and geodetic problems that extended beyond the areas of any one country.

The International Geodetic and Geophysical Union was organized at Brussels in 1919, when delegates from a number of the allied powers assembled to provide an organization that would care for the international aspects of scientific research. There was created at the Brussels meeting the International Research Council with a number of unions. The Union of Geodesy and Geophysics has as branches seven associations representing geodesy, seismology, terrestrial magnetism and electricity, meteorology, hydrology, vulcanology and oceanography. The statutes of the Council and the Union had provisions that were rather distasteful to the scientific men of the central powers. This was inevitable because war fever had not abated in July 1919, when the scientific meeting was held at Brussels. A few years later, however, the statutes were modified and all references to the war were eliminated. There are now thirty-five countries adhering to the International Union of Geodesy and Geophysics although some of them are not active members since they are delinquent in their dues. Guests from Germany and Austria were present at the Edinburgh meeting. It is expected that those countries will join the Union in the not distant future. The Soviet government has decided to adhere to the Union in 1937.

The Union has as its objective the coordination of the efforts of the workers in the fields of earth sciences of all of the countries of the world. Triennial assemblies are held at which the delegates set forth what work has been accomplished, what problems remain and how those problems may be successfully attacked. During the seventeen years of existence the Union and its associations have been very effective in advancing the several branches of the earth sciences with which they are concerned. Without such an organization there would be little or no opportunity for effective coordination of effort.

The opening meeting of the Assembly was a very interesting one with speeches of welcome made by the Lord Provost of Edinburgh, the Principal of the University of Edinburgh, the President of the Royal Society of London and the President of the Royal Society of Edinburgh. These speeches of welcome were responded to by the President of the Union. Aside from the scientific meetings of the Union, the associations and the committees, there were a number of social events, which were enjoyable in themselves and which enabled the delegates and guests to become better acquainted.

One of the outstanding accomplishments of the Assembly was the creation of a committee on Continental and Oceanic Structures, of which Prof. Richard M. Field of the Department of Geology of Princeton University is chairman. It is expected that a committee in each of the adhering countries will be organized for the purpose of cooperating with the international one. Another event that occurred which is of interest to all American scientific men was the unanimous decision to accept the invitation presented by the chairman of the American delegation to hold the next general assembly of the Union at Washington, D. C. in 1939.

There were 33 delegates and 18 members of their families representing the United States at the meeting in Edinburgh. They were unanimous in their praise of the Assembly and of the friendship and courtesy shown by the officials and citizens of Edinburgh. (*Author's Abstract.*)

W. D. LAMBERT: *Report on geodesy.*—The work of the Association of Geodesy at Edinburgh was done mainly in committee. The speaker reported briefly on those committees the sessions of which he was able to attend. These were: (1) Earth tides; (2) Variation of Latitude; (3) Gravity; (4) the Geoid. Oddly enough, the last-named committee is a new one. A center to further the work of isostatic reduction was established under the direction of Prof. HEISKANEN of Helsingfors. He expects to do the work mainly with the aid of his students; he will receive a small grant from the Association and perhaps a further grant from the Finnish Government.

A Committee on Continental and Oceanic Structure was established by the union. This is an inter-associational committee to promote the application of geophysical methods to the large-scale problems of geological structure. Prof. R. M. FIELD of Princeton is chairman and Dr. J. A. FLEMING is secretary; the membership includes geologists as well as geophysicists of various sorts. (*Author's Abstract.*)

E. W. EICKELBERG: *Report on seismology.*—The history of the International Seismological Association itself merging with the International Association of Geodesy and Geophysics and American participation in the meetings was reviewed. From the contributions of the adhering countries the Secretary maintains the Central Bureau at Strasbourg, France. Normal expenses include the reports of meetings, preliminary determinations of earthquake epicenters, support of the International Seismological Summary and other useful activities. The purpose of the meeting was to report progress, discuss new projects and present papers of broad significance; and to standardize methods. Among the subjects discussed were the significance of the first motions given on the earthquake record and the importance of making this information available. Methods of developing travel time tables and curves received consideration. There were discussions of papers by delegates from the United States covering a wide field of activity and among them a discussion of shaking platform tests at the National Bureau of Standards by WENNER and MCCOMB and the torsion pendulum as an accelerograph analyzer, by NEUMANN. Four members of the PHILOSOPHICAL SOCIETY were on the program.

The national reports show that the United States is well to the fore in seismological investigation. A joint Commission on Ocean Basins was formed to study the application of geophysics in this part of the earth. There were several excursions to regions where known faults are associated with earthquake activity. (*Author's Abstract.*)

J. A. FLEMING and L. V. BERKNER: *Report on Terrestrial Magnetism and Electricity.*—The Edinburgh meeting of the Association was noteworthy because of its distinctly international aspect. Sixty-five delegates and guests represented 17 countries—Austria, Australia, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Holland, Japan, Latvia, Norway, Poland, Portugal, Sweden, Switzerland, and the United States of America. Eight meetings were held. Part of a day was taken in one joint meeting of the Commission on Oceanic and Continental Structure and one full day was given over to a delightful excursion to inspect the Eskdalemuir Observatory. There were 20 reports from national committees and over 60 communications, the majority of which concerned researches requiring international coordination and cooperation.

Good progress in the geophysical sciences during the three years since the Lisbon Assembly was reflected in the address of the President, in the report of the Secretary, and in the reports of the national committees. Of particular significances were the important advances indicated by the presidential address and the suggested directions which future geophysical investigations might advantageously follow. The President noted the full cooperative and harmonious relations maintained by the Association with the Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Organization. These relations make the two bodies of mutual benefit and assure elimination of duplication of effort and expense. The wise use of the Association's resources, both moral and financial, in support of the Polar-Year Commission's Bureau in Copenhagen has greatly advanced the reductions of data obtained during the second Polar Year.

An outstanding announcement at the meeting was that by the Hydrographer of the British Admiralty who informed us that the plans for the nonmagnetic vessel *Research,* to resume the magnetic and electric surveys of the oceans originally carried on by the *Carnegie,* had been completed, and that in this effective assistance had been received from Mr. W. J. PETERS of the Carnegie Institution of Washington as also in the design and plans for the necessary instruments to be used on board. He further advised that just as the meeting was being held the contract for the construction of this vessel, which is but slightly larger than the *Carnegie,* had been let at a cost approximately twice the original estimate. Other outstanding events since the Lisbon meeting include development of magnetic observatories in the world net, more intensive research of observational data, progress in international magnetic standards, and development of methods for recording continuously electric conditions in the ionosphere.

Nineteen resolutions pertaining to international research and cooperation in the fields of our Association were adopted. Emphasis was laid on the necessity of distributing adequately publications of the Association in a resolution adopted also by the Union as a whole. The preparation and publication of a list of magnetic and electric observatories, together with a thesaurus of values, was authorized, this material to be prepared by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the Potsdam Observatory of Germany. The necessity of control of variometers and of examination at regular intervals in the operation of observatories was emphasized. The Association recommended that every observatory provide means to secure registration of extreme values during severe magnetic storms and also that reproductions of magnetograms be supplied the Central Bureau of the Association for photographic reproduction on film, thus permitting economical and widespread distribution of records for purposes of discussion and study. A committee was appointed to consider and report during the next three years upon steps to promote international intercomparisons of magnetic standards. Two resolutions dealt with the effect on magnetic observatories of electrification of railways, and it was requested that information concerning effects be sent to the Central

Bureau of the Association so that material might be available for the use of those organizations whose effectiveness is threatened by proposed electrification of railways.

It was agreed to continue the magnetic character-numbers on the scale of 0, 1, and 2, and also the numerical magnetic activity-figures according to the agreement at the Stockholm Assembly in 1930 but to replace the sum ($HR_H + ZR_Z$) by the daily range of declination expressed in minutes of arc. Arrangements were made for the printing and distribution of activity-figures for the Polar Year 1932–33 and for the extension of magnetic character-numbers to observatory results obtained prior to 1906.

The importance of suitable arrangements by all governments for the complete realization and continuation of the minimum program for international repeat-observations as adopted at the Lisbon Assembly was emphasized. A resolution was passed congratulating the British Admiralty, the Astronomer Royal, and the Chairman of the British National Committee for Geodesy and Geophysics upon the realization of the plans for the non-magnetic ship *Research*, and it was suggested that other maritime nations should consider the construction of such non-magnetic vessels. Already the U.S.S.R. is building a ship for such investigations in the arctic seas and the Japanese Government is making arrangements for magnetic observations at sea.

The reports of frequent records during the International Polar Year of giant pulsations in Iceland led to the adoption of a resolution authorizing the Executive Committee to arrange for the installation of recording variometers in Iceland and to invite collaboration of magnetic observatories. This phenomenon is one which seems to be somewhat local in character.

With regard to investigations in atmospheric electricity, a resolution was adopted recommending continued investigations of the atmospheric-electric elements at observatories now recording their variations and the initiation of such studies at other observatories. It was especially emphasized that observational data about the electrical state of the troposphere and of the stratosphere over land and sea should be augmented.

Emphasis was given in a resolution on the need of more earth-current data and the provision of additional earth-current stations at well-distributed points and especially on islands surrounded by the deep sea. It was recommended that the field-intensity component of the electric current in the Earth be taken as positive when it corresponds to a flow either towards the north or towards the east and, further, that the azimuth of the resultant earth-current intensity-vector be reckoned from north through east to 360°.

The desirability of prompt publication of Polar-Year data was expressed in one resolution. The Association is in favor of having a classification of literature on terrestrial magnetism and electricity drawn up as a part of the international decimal system.

To carry on the activities of the Association until the General Assembly which is to be held in Washington in 1939, existing committees were continued as follows: On the selection of sites of new observatories for terrestrial magnetism and electricity; Auroral committee; Committee on the study of the relationship between solar activity and terrestrial magnetism; Committee on magnetic secular-variation stations; Committee on the study of electrical characterization of days. Three reporters were designated, namely: On numerical characterization of days, on international collaboration for promoting the study of the influence of the moon on geophysical phenomena, and on ion-counters.

One joint committee of the International Commission of Terrestrial Magnetism and Atmospheric Electricity and of the Association was continued, namely: On methods and codes to adequately describe magnetic disturbances and perturbations. A joint committee of the International Scientific Radio Union and of the Association was also formed. New committees were established as follows: On magnetic charts—(1) organization of work, and (2) methodology; on registration of giant pulsations in Iceland; on methods of observatory-publication; on classification of magnetic literature; to promote comparisons of international magnetic standards.

Administrative matters included the adoption of statutes and election of officers. The new officers are as follows: President, FLEMING; Vice-Presidents, MAURAIN, and CHAPMAN; Secretary and Director of Central Bureau, GOLDIE; additional members of the Executive Committee, KERÄNEN and TANAKADATE through 1939, and VAN DIJK, CRICHTON, MITCHELL, and STÖRMER through 1942.

In conclusion, this Assembly of the Association has shown fruitful collaboration and progress during the last three years; it is to be hoped that the ever-widening prospects presented may furnish ample incentive to achieve further understanding and interpretation of the many experimental data nature so generously provides. (*Author's Abstract.*)

Mr. WEIGHTMAN: *Report on meteorology.*—In organizing the program for the meeting it was decided to adopt as the basic theme *The problem of atmospheric disturbances,* which resolves itself quite easily and naturally into six separate divisions covering the different branches of meteorology, as follows: (A) Definition of the disturbances; (B) Origin of disturbances; (C) Structure of cyclones; (D) Interaction of different atmospheric layers; (E) Radiation and its role in atmospheric disturbances; (F) Precipitation, rime and fog. In addition to seventeen papers on the first five of these divisions, there were about a dozen of a nature difficult to classify under the above heads. The papers were mentioned by title and some comments made concerning a few of them.

The meetings were well attended and many interesting discussions followed the reading of the papers. A few of the papers were read by title. In all, it was the feeling of the delegates that the gathering had been an unqualified success. The officers elected were as follows: President: Dr. S. CHAPMAN; Vice-Presidents: P. WEHRLE and W. R. GREGG; Secretary: J. BJERKNES.

1109TH MEETING

The 1109th meeting, constituting the 66th annual meeting, was held in the Cosmos Club Auditorium, December 5, 1936, President SILSBEE presiding.

The treasurer reported that exclusive of liquidation of securities the income of the Society during the past fiscal year was $1400.26, the expenditures, excluding reinvestment of funds, amounted to $1410.71. The fiscal year was entered with $1000 of the investment account in cash. During the year $500 of the invested funds of the Society were liquidated and $1386.29 were invested.

The treasurer's report showed an active membership of 298 of whom 255 were in good standing.

The secretaries reported the following were elected to membership during the year: S. F. ACREE, NORWOOD ADAMS, N. G. ANDERSON, C. E. BENNETT, W. M. BLEAKNEY, HORACE R. BYERS, IRWIN L. COOTER, R. C. DARNELL,

CHARLES E. GAUSS, KARL F. HERZFELD, PETER HIDNERT, D. P. JOHNSON, H. PAUL KAUFMAN, M. FALL KERBEY, R. H. LEE, A. HUGHLETT MASON, G. H. MORSE, OSCAR NORGORDEN, ERNEST J. PARKIN. FRANCIS E. WASHER, ALBERT WERTHEIMER, H. M. WOOLEY.

The following deaths were reported: CHRISTIAN HUFF (a member since 1926), HENRY B. HEDRICK (a member since 1918).

The following officers were declared elected for the year 1937: *President*, F. WENNER; *Vice-Presidents*, F. G. BRICKWEDDE and E. W. WOOLARD; *Recording Secretary*, H. E. McCOMB; *Treasurer*, W. G. BROMBACHER; and Members-at-large of the General Committee, F. E. JOHNSTON and J. A. DUERKSEN.

During the year the sixth Joseph Henry Lecture, in memory of the first president of the Philosophical Society, was given by HERBERT DINGLE, Imperial College of Science and Technology, London.

At the conclusion of the business meeting a humorous talk was presented by G. GAMOW entitled *Cosmos-rays.*

Informal communications were presented by Messrs. A. G. McNISH and E. TELLER.

L. R. HAFSTAD, *Recording Secretary*

1110TH MEETING

The 1110th meeting was held in the Cosmos Club Auditorium, Saturday, December 19, 1936, President WENNER presiding.

Program: T. WAYLAND VAUGHAN: *Notes on Proceedings of the Association of Physical Oceanography, September 17 to 24, 1936, at the Sixth General Assembly of the International Union of Geodesy and Geophysics in Edinburgh. Officers.* The President of the Association was Martin Knudsen, Vice-President, E. Fichot, Secretary, J. Proudman. The members of the Executive Committee who were present were D. J. Matthews, B. Helland-Hansen, and Thomas G. Thompson. Since the meeting in Lisbon in 1933 two members of the Executive Committee, J. Joubin and G. Magrini, had died. T. Witting, Caballero y Lastres, and Odón de Buen were absent.

Attendance. Although I made no attempt to keep a record of the attendance at the different sessions of the Association, I noted that there were representatives from the following countries: Austria, Denmark, Finland, France, Germany, Great Britain, Indo-China, Monaco, Morroco, Netherlands, Norway, and the United States of America, making twelve countries altogether. A few other countries may have been represented. The total attendance at the sessions was about fifty, but, again as no accurate record of those who were present was kept, there may have been a few more. One or more representatives from each of the countries listed presented papers or took part in the scientific discussions. It is to be regretted that several countries that are active in oceanographic research were not represented, for instance the U.S.S.R. and Japan.

Regions covered by Scientific Papers. There were scientific papers on the Norwegian Sea, Atlantic Ocean, Mediterranean Sea, Indian Ocean, and Pacific Ocean including Bering Sea. One paper dealt with the seas surrounding Antarctica. A regrettable gap in the program was that we had no paper on the Arctic Ocean.

Subject covered. Nearly every aspect of physical oceanography received consideration. There were papers on the determination of gravity at sea, bottom configuration, marine bottom deposits, oceanic circulation, tides, submarine solar radiation, the chemical features of sea water, and the interrelations of the sea and the atmosphere. Reports on the result of several important expeditions were presented and accounts were given of the work of leading organizations, such as that of the International Hydrographical Bureau.

Cooperative Projects. A number of projects that require international cooperation were discussed. Among them were: a proposal for an international survey of the Gulf Stream area; the units which should be used in the specification of the different common constituents of sea water and on the necessity of a world-wide uniformity of procedure; the desirability of fixing standard levels for oceanic observations; the new edition of the general bathymetric chart of the oceans; the criteria and nomenclature for the major divisions of the ocean bottom; the study of ocean swell in the proximity of shore and a plan for the international study of marine erosion on the seashore; and the organization of geophysical work in the Mediterranean sea. There were discussions jointly with other associations of the Union. One of these, the interaction between the sea and the atmosphere, was at a joint meeting of the Association for Meteorology and that for Physical Oceanography. Another joint discussion with other Associations was the use and value of geophysical methods in the attack upon the structural problems of oceanic and continental areas. The discussions were very stimulating, even inspiring.

Committees. The old Committees on tides, mean sea level and its variations, and (jointly with other Associations) the study of so-called tidal waves (raz de marée), were continued. Several new Committees were appointed covering several of the subjects that were topics for general discussion. Among these there were committees for an international survey of the Gulf Stream, for the units to be used in the specification of the different chemical constituents of sea water, for the designation of standard levels for oceanic observations, for the criteria and nomenclature of the major division of the ocean bottom, and jointly, with the Association for Meteorology, one on the interaction between the sea and the atmosphere. As I did not take down the names of all those who were appointed as members of the different Committees, it seems inadvisable to give an incomplete list.

New Officers. The following officers of the Association were elected, B. Helland-Hansen, President; Fichot, Vice-President; J. Proudman, Secretary.

During the meeting there was on September 19 an excursion of particular interest to the oceanographers, on the Scottish Fisheries steamer *Explorer*, under the able leadership of J. B. Tait, hydrographer of the Scottish Fisheries Service. It was an all day excursion on the Firth of Forth. The vessel went from Leith docks to the mouth of the Forth. On the excursion Mr. Carruthers gave a demonstration of the use of a current meter designed by him; and D. J. Matthews demonstrated the use of a frameless water bottle recently designed by him. On the same day there was a parallel excursion on the *Armauer Hansen*, the research vessel of the Geophysical Institute in Bergen, under the leadership of Helland-Hansen. Those who took part in the excursion had an opportunity to see both vessels.

Conclusions. From the notes above made it will be seen that great interest was manifested in the proceedings of the Association by the presence of delegates from many countries and the rather large attendance at the different sessions of the Association. Nearly all of the important oceanic areas of the world were considered and there were papers of high quality on almost every aspect of physical oceanography. Many projects requiring international cooperation were discussed and committees were appointed to bring about appropriate international action. The meeting was very successful. (*Author's Abstract.*)

Discussed by Messrs. McNish, Humphreys, Smith and Wenner.

O. E. Meinzer: *Notes on Proceedings of the Association of Hydrology, September 1936, at the Sixth General Assembly of the International Union of Geodesy and Geophysics in Edinburgh.*—The outstanding feature of the hydrology meetings in Edinburgh was the three-day conference on snow, conducted by the Commission on Snow, with the cooperation of the Commission on Glaciers. This conference was arranged through the energetic and cooperative efforts of Dr. J. E. Church, of the University of Nevada, who was the organizer of the Commission on Snow and is still its Chairman. Unfortunately, on account of serious illness in Moscow, he did not reach Edinburgh until after the snow conference, but the conference was nevertheless very successful. The American Section of Hydrology was represented by four eminent authorities on ice and snow, namely, Professors Hobbs and Gould and Messrs. McLaughlin and Elges.

At the regular hydrology meetings about one day each was devoted to the Commissions on Streams, Lakes, Underground Waters, and Practical Applications, and many important problems covering a wide range in the science of hydrology were discussed. The meetings were attended by a small group of able hydrologists, most of whom have a broad scientific interest in hydrology but with less specialization than among the hydrologists in the United States. There was an enthusiastic delegation from France and most of the smaller European countries were represented by one or more able men, among whom I may mention Mr. Smetana, of Czechoslovakia, the genial and energetic President of the Association of Hydrology, Mr. Lutschg, of Switzerland, the President elect, and Mr. Slettenmark of Sweden, the Vice-President elect. Mr. Dienert, of France, continues as the Secretary of the Association.

Action was taken to hold a round table at the Washington meeting in 1939 on the problem of making greater use of the hydraulic laboratories in research in hydrology and other departments of earth physics.

Discussed by Messrs. Vaughan and Heck.

H. E. McComb, *Recording Secretary*

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CHEMISTRY.—*The carotenoid pigments of the sweet potato* (Ipomoea batatas, Poir.).[1] M. B. MATLACK, Food Research Division, Bureau of Chemistry and Soils.

It has been shown (1, 2) that the sweet potato is a good source of vitamin A. This fact and the natural color of the tuber leads one to suspect the presence of at least one of the four known carotenoids which possess the property of acting as a precursor of vitamin A.

For the purpose of identifying the predominant carotenoid pigments from the sweet potato, the deeply colored variety known as "Porto Rico" was obtained from the local market. Twenty pounds of fresh tubers were ground through a meat grinder and allowed to fall into a salt solution. To this mixture was added an equal volume of ninety-two per cent alcohol. The excess solvent was removed in a press and the process repeated with sixty per cent alcohol. The alcoholic ex-extracts were discarded. Alternate extraction with acetone and petroleum ether yielded solutions which were worked up as follows:

In each case the solution was evaporated to dryness in vacuo and taken up in a small amount of carbon disulphide, and absolute alcohol was added. This yielded a crop of large pleochromatic crystals. On concentration of the mother liquor considerable colorless material separated, and, therefore, saponification with sodium methylate was resorted to. The petroleum ether solution from the saponified material was repeatedly shaken with eighty-five per cent alcohol.

The residue remaining after evaporation of the petroleum ether layer was taken up in a small volume of carbon disulphide, and absolute alcohol was added. Crystals of pigment separated on standing and after concentration of the mother liquor.

Attempts to isolate crystalline xanthophylls from the alcohol phase proved futile because of the small amount of pigment and the large amount of colorless impurities. However, a fraction was obtained which gave a blue color with formic acid and with concentrated hydrochloric acid, indicating the presence of violaxanthin. A spectro-

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[1] Food Research Division Contribution No. 340. Received September 20, 1937.

gram was obtained, the absorption maxima of which were very close to that of the mixture known as leaf xanthophyll.

Chromatographic adsorption (3) of the recrystallized pigment on a Tswett column of calcium hydroxide yielded four colored zones ranging from reddish-brown at the top through purple and pale yellow to orange at the bottom. On further treatment of these bands only the lowest one produced sufficient material for actual isolation of crystals. These (Fig. 1) melted at 182° and gave absorption maxima[2] as shown in Table 1. These data indicated the coloring matter to be β-carotene.

Fig. 1.—Sweet Potato Carotene.

TABLE 1.—POSITIONS OF CENTERS OF THE ABSORPTION BANDS, IN ÅNGSTROM UNITS.

Carotene		Sweet Potato Carotene		Leaf Xanthophyll		Xanthophyll Fraction from the Sweet Potato	
Room Temperature	Liquid Air Temperature	Room Temperature	Liquid Air Temperature	Room Temperature	Liquid Air Temperature	Room Temperature	Liquid Air Temperature
4815	5000	4825	5010	4760	4900	4755	4895
4490	4670	4500	4680	4430	4580	4440	4590
4230	4375	4230	4375	4190	4300	4190	4310

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[2] The writer is indebted to G. E. Hilbert and E. F. Jansen for all of the spectrophotographic work presented in this paper.

It is evident from the above results that the predominant pigment of the sweet potato is beta carotene with a small amount of xanthophylls, one of which is violaxanthin.

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BOTANY.—*The grass genus* Cathestecum.[1] Jason R. Swallen, Bureau of Plant Industry.

Cathestecum was described in 1830 by Presl, based on a single species, *C. prostratum.* A second, *C. erectum,* was described by Vasey and Hackel in 1884. Griffiths in 1912 added two more, *C. multifidum* and *C. stoloniferum,* the latter invalid. The genus was placed in Zoysiae by Bentham and Hooker, in Festuceae by Hackel, and in Chlorideae by Griffiths as an ally of *Pentarrhaphis* and *Bouteloua,* the position accepted by Hitchcock and the writer.

Because of insufficient material, the genus has not been well understood. Griffiths noted that the species are variable, but a study of more specimens has made it possible to coordinate specific characters and recognize three additional species, *C. annuum, C. varium,* and *C. brevifolium. Cathestecum stoloniferum* Griffiths was based on *Atheropogon stolonifer* Fourn. The type (*Liebmann* 588) was not examined by Griffiths, but was later found among specimens kindly lent by the Copenhagen Herbarium in 1915. It is a pistillate plant of *Pringleochloa stolonifera* Scribn. as Scribner supposed, although Fournier described the lower florets as hermaphrodite. The species figured as *C. stoloniferum* by Griffiths in his revision is new, *C. varium.* Griffiths included in *C. erectum* and *C. stoloniferum* some specimens which are here referred to three new species.

Presl's description of the florets as hermaphrodite is scarcely correct since they are nearly always unisexual, sometimes sterile, and very rarely perfect. The genus is complicated by the fact that two of the species, *C. erectum* and *C. brevifolium,* have dimorphous spikes. The two forms are sometimes on different parts of the same plant, as on two adjoining tufts connected by a stolon, but usually they are ap-

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[1] Received October 13, 1937.

parently on entirely separate plants. In one form all the florets are staminate, or the upper sterile, whereas in the other the florets of the lateral spikelets are staminate or sterile, and the lower floret of the central spikelet is pistillate, the upper ones staminate, or the uppermost sometimes sterile. The structure of the lemmas is also different in the two forms as described under each species.

A fragment from the type of *C. prostratum* was kindly deposited in the U. S. National Herbarium in 1907 by the Botanischer Garten, Deutsche Universität, Praha, Czechoslovakia. Types of all the other species are in the U. S. National Herbarium.

CATHESTECUM Presl, Rel. Haenk. **1**: 294. *pl. 42*. 1830.

Annual or perennial grasses, frequently stoloniferous, with relatively short flat blades and 3 to 10 V-shaped or rhomboid spreading spikes, evenly arranged on opposite sides of the slender flattened axis; spikes falling entire, consisting of three spikelets, the lateral ones 2-flowered, staminate or sterile, rarely pistillate, the upper floret sometimes much reduced; central spikelet 3-flowered, the lower floret usually pistillate, sometimes staminate, very rarely perfect, the upper florets staminate or sterile; first glume short, that of the central spikelet usually flabellate; second glume about as long as the spikelet, acuminate, sometimes minutely lobed and mucronate; lemmas dissimilar, the lower ones cleft about one fourth their length, the awns from between the lobes equaling or slightly exceeding them, the upper ones deeply cleft, the awns villous in the lower part, extending as much as 3 mm beyond the lobes; in spikes wholly staminate, the lemmas all alike; palea nearly equaling the lemma, the nerves excurrent in short awns.

Type species: Cathestecum prostratum Presl.

Distribution: Endemic to Mexico and Central America, one species extending into southern Texas and Arizona.

KEY TO THE SPECIES

Plants annual.
  Culms slender, not more than 25 cm long (usually less than 15 cm), freely branching from all the nodes, the upper one with two or more slender leafless flowering branches.......................1. *C. prostratum*
  Culms coarse, as much as 50 cm long, if less than 25 cm long the upper node with a single inflorescence or sometimes a second hidden in the sheath...................................2. *C. annuum*
Plants perennial.
  Plants cespitose; third floret reduced to a cluster of 5–7 awns on a naked stipe......................................3. *C. multifidum*
  Plants stoloniferous; third floret glumaceous, 3-awned.
    Lower florets of lateral spikelets pistillate, rarely one of them staminate, the upper usually sterile, rarely pistillate or staminate; lower lemmas usually densely pubescent.................4. *C. varium*
    Lower florets of lateral spikelets staminate or sterile; lower lemmas glabrous or only sparsely pubescent. Spikes dimorphous.
      Lateral spikelets with well developed usually staminate florets; blades, at least some of them, commonly more than 2 cm long, often involute, not becoming curled; stolons comparatively short, conspicuously arching..........................5. *C. erectum*

Lateral spikelets imperfectly developed, the florets mostly sterile, the lemmas reduced; blades flat, mostly 1–2 cm long, rarely longer, becoming curled with age; stolons long, widely spreading, not arching. . . . . 6. *C. brevifolium*

1. **Cathestecum prostratum** Presl

Cathestecum prostratum Presl, Rel. Haenk. **1**: 295. *pl. 42*. 1830. Type collected in Mexico by Haenke, the exact locality not given.

Annual; culms slender in small dense tufts, decumbent-spreading, geniculate at the nodes, freely branching, 4–35 cm long, glabrous; sheaths, except the lowermost, shorter than the internodes, glabrous, or sparsely pilose near the margins and in the mouth, with a pubescent line across the collar; ligule ciliate, about 0.3 mm long; blades flat, acute, glabrous on the lower surface, scabrous and sparsely pilose on the upper, the margins scabrous, 1–5 cm long, 1–2 mm wide, the upper ones and those on the short branches much reduced; inflorescences terminal and axillary from the upper sheaths; spikes ascending or finally spreading, about 4 mm long not including the awns; first glume of lateral spikelets narrow, acuminate, about 2 mm long, that of the central floret broad, scale-like, less than 1 mm long; second glume 3 mm long, hirsute, those of the lateral spikelets acuminate, that of the central spikelet broader, abruptly acute or subobtuse, sometimes lobed, mucronate; florets 3 mm long, dissimilar; lower floret of the lateral spikelets sterile, the lemma glabrous or sparsely pilose, shallowly lobed, the awns equaling or only slightly exceeding them, the upper floret staminate, the lemma cleft to the middle, the awns extending 1 mm beyond the lobes, hispid on the lower part; lower floret of the central spikelet pistillate, the lemma sparsely pilose on the back and on the margins, the lobes about 1 mm long, the awns subequal, 1.5 mm long, scabrous and more or less hispid, the upper florets staminate, the lemmas similar to those of the upper florets of the lateral spikelets, but more deeply lobed, the awns extending 2–3 mm beyond the lobes; stamens 1.5 mm long.

Limestone hills, central Mexico.

Morelos: Jojutla, *Pringle* 8707.

Without locality, *Haenke* (type).

2. **Cathestecum annuum** Swallen, sp. nov.

Annuum; culmi ramosi, geniculati, decumbentes, 15–50 cm alti; vaginae internodiis multo breviores, glabrae, marginibus pilosis; ligula ciliata, 0.5–1 mm longa; laminae planae, firmae, acuminatae, infra glabrae, supra pilosae, marginibus scabris, 3–8 cm longae, 2–3 mm latae, superiores reductae; spicae 5–9, 6 mm longae, rachi producta; gluma prima spicularum lateralium acuminata, 2 mm longa, spiculae centralis flabellata; gluma secunda acuminata, 4–5 mm longa, mucronata, hirsuto-villosa; flosculi spicularum lateralium masculi vel steriles, lemmatibus 3.5–4 mm longis, lobatis, aristis quam lobis paulo longioribus; flosculus inferior spiculae centralis femineus, lemmate 4 mm longo, lobato, aristis quam lobis 0.5–1 mm longioribus; flosculi superiores spiculae centralis masculi, glabri, fissi, aristis quam lobis 2–3 mm longioribus, subtus hispidis, superne scabris.

Annual; culms branching, geniculate, decumbent-spreading, rooting at the lower nodes, 15–50 cm tall, glabrous; sheaths mostly shorter than the internodes, glabrous or more or less pilose in the throat and on the margins; ligule ciliate, 0.5–1 mm long; blades flat, firm, acuminate, glabrous on the lower surface, pilose on the upper, the margins very scabrous, 3–8 cm long, 2–3 mm wide, the upper ones reduced; spikes 5–9, about 6 mm long, the rachis prolonged as a slender hairy bristle; first glume of the lateral spikelets acuminate, 2 mm long, that of the central spikelet minute, flagellate; second glume acuminate, often minutely lobed and mucronate, 4–5 mm long, hirsute-villous at least on the lower half of the keel; florets of the lateral spikelets staminate or sterile, the lemmas 3.5–4 mm long, sparsely pilose on the margins, the lobes 1.5 mm long, the awns equaling or slightly exceeding them, appressed hispid; lower floret of the central spikelet pistillate, the lemma 4 mm long, glabrous or sparsely pilose on the lower part of the back, shallowly lobed, the lateral lobes 1 mm long, the awns strong, extending 0.5–1 mm beyond the lobes, glabrous, the upper florets staminate, the lemmas a little shorter than that of the lower floret, glabrous, deeply cleft, the lateral lobes 2.5 mm long, the awns extending 2–3 mm beyond the lobes, hispid on the lower half, scabrous on the upper; stamens 3 mm long.

Type in the U. S. National Herbarium no. 1720269, collected on open gravelly ground, Balsas, Guerrero, Mexico, altitude 1500 feet, September 9, 1910, by A. S. Hitchcock (no. 6776) (*Amer. Gr. Nat. Herb.* no. 393, distributed as *Cathestecum erectum* Vasey & Hackel).

Prairies and open ground along railroad, Guerrero, Mexico.

GUERRERO: Balsas, *Hitchcock* 6776 (type), 6800. Apipilulco, *Hitchcock* 6697.

3. **Cathestecum multifidum** Griffiths

Cathestecum multifidum Griffiths, Contr. U. S. Nat. Herb. **14**: 360. *f. 24*. 1912.
Type collected at Iguala, Mexico, by Griffiths, September 9, 1909.

Perennial; culms slender, densely tufted, erect or geniculate at the lower nodes, branching, 15–40 cm tall, glabrous, the nodes pubescent; sheaths glabrous, pilose in the throat, the lower crowded, the upper much shorter than the internodes; ligule ciliate, 0.5 mm long; blades flat, acuminate, glabrous or sparsely pilose on the upper surface, the margins very sparsely papillose-pilose, 2.5–8 cm long, 1–1.5 mm wide, the upper culm blades much reduced; spikes, 5–10 mostly secund, 3–4 mm long excluding the awns, the rachis prolonged as a slender bristle; first glume very narrow, acuminate, about 2 mm long, sparsely hirsute; second glume of lateral spikelets acuminate, hirsute, 2.5 mm long, of the central spikelet broader, pilose, notched, with a stout awn nearly 1 mm long from between the teeth; lower floret of the lateral spikelets staminate, the lemma 2.5 mm long, 3-lobed, the lobes mucronate, the upper florets staminate or sterile, 2 mm long, deeply 5-cleft, the divisions aristate; lower floret of the central spikelet pistillate, the lemma 3 mm long, glabrous on the back, the margins sparsely pilose, the tip 3-lobed, the lobes acuminate, sometimes mucronate, the upper florets staminate or sterile, about 2.5 mm long, deeply 5-cleft, sometimes to the base, the lobes narrow, acuminate, the awns 2–3 mm long, the uppermost floret sometimes reduced to awns.

Rocky hills, Oaxaca, Mexico.

OAXACA: Iguala, *Griffiths* without number (type). Oaxaca, *Hitchcock* 6120, 6164. Monte Alban, *C. L. Smith* 950. Ixcotel (Distrito del Centro), *Conzatti* 3607.

4. **Cathestecum varium** Swallen, sp. nov.

Perenne, stoloniferum, stolonibus gracilibus, internodiis 3–15 cm longis; culmi graciles dense caespitosi, ramosi, erecti vel geniculati, 10–15 cm alti;

vaginae glabrae, infirmae basi dense villosae; ligula ciliata, 0.3 mm longa; laminae planae, firmae, acutae, pungentes, infra glabrae, supra scabrae et sparsae pilosae, 1–6 cm longae, 1–2 mm latae, superiores reductae; spicae 3–5, divergentes; gluma prima spiculorum lateralium truncata vel acuminata, 1.5–2.5 mm longa, spiculae centralis flabellata, 1 mm longa; gluma secunda hirsuto-villosa, acuminata, minute lobata, aristis ad 1 mm longis; flosculus inferior spicularum lateralium femineus, lemmate 4 mm longo, dense pubescente, lobato, aristis quam lobis 1–1.5 mm longioribus, flosculus superior neuter, raro masculus vel femineus, fissus, aristis quam lobis 2.5–3 mm longioribus; flosculus inferior spiculae centralis femineus, lemmate eis inferioribus spicularum lateralium simili, flosculi superiores neutri vel masculi, glabri, eis superioribus spicularum lateralium similes.

Perennial, stoloniferous, the stolons slender, wiry, with commonly arched internodes, 3–15 cm long; culms in small dense tufts, slender, branching, erect or geniculate at the nodes, 10–15 cm tall, glabrous; lower sheaths crowded, glabrous, or the lowermost densely villous at the base, pilose in the throat, the upper ones much shorter than the internodes, glabrous; ligule ciliate, about 0.3 mm long; blades flat, firm, acute, pungent, glabrous on the lower surface, scabrous and sparsely pilose on the upper, the margins scabrous, 1–4 cm long (rarely to 6 cm), 1–2 mm wide, the uppermost culm blades much reduced; spikes 3–5, spreading, on a slender flexuous axis 1.5–2 cm long; first glume of lateral spikelets irregular, truncate to acuminate, 1.5–2.5 mm long, that of the central spikelet flabellate, about 1 mm long; second glume hirsute-villous, acuminate or minutely lobed, awned from between the lobes, the awn as much as 1 mm long, that of the central spikelet broader than those of the lateral spikelets; lower floret of the lateral spikelets usually pistillate, sometimes staminate, the lemma 4 mm long, usually densely pubescent but occasionally glabrous, lobed, the lobes about 1 mm long, awned from between the lobes, the lateral awns about equaling them, the central extending 1–1.5 mm beyond them; upper floret usually neuter, rarely staminate or pistillate, sometimes much reduced, the lemma 4 mm long, cleft to below the middle, the awns from between the lobes extending 2.5–3 mm beyond them, villous on the lower part; lower floret of the central spikelet pistillate, sometimes apparently perfect, the lemma similar to the lower lemmas of the lateral spikelets, the upper florets neuter or staminate, glabrous, the lobes and awns as in the upper florets of the lateral spikelets.

Type in the U. S. National Herbarium no. 1720270, collected on dry soil under mesquite, Tehuacán, Puebla, Mexico, August 9, 1910, by A. S. Hitchcock (no. 6072; *Amer. Gr. Nat. Herb.* no. 395, distributed as *Cathestecum stoloniferum*).

Dry rocky hills and in mesquite, Puebla and Oaxaca, Mexico.

PUEBLA: Tehuacán, *Hitchcock* 6072 (type); *Rose & Hay* 5924. San Luis Tultitlanapa, *Purpus* 3569.

OAXACA: Tomellin, *Hitchcock* 6238; *Griffiths* 9764. San Antonio Valley, *C. L. Smith* 958.

5. **Cathestecum erectum** Vasey & Hack.

Cathestecum erectum Vasey & Hack. Bull. Torrey Club **11**: 37. *pl 45.* 1884. Type collected between El Paso and Presidio, Texas, by Havard (no. 2).

Perennial, stoloniferous, the stolons slender, wiry, conspicuously arching, the internodes elongate; culms in small dense tufts, simple or branching, erect or somewhat geniculate-spreading, 15–30 cm tall, glabrous; lower sheaths crowded, pilose in the throat, the lowermost densely villous at the base, the upper ones more distant, glabrous; ligule ciliate, about 0.3 mm long; blades flat or commonly loosely involute, 3–6 mm long, 1–1.5 mm wide, glabrous on the lower surface, scabrous and sparsely pilose on the upper; spikes usually pale, dimorphous, one form entirely staminate, the other with the lower floret of the central spikelet pistillate, the upper floret and those of the lateral spikelets staminate or neuter, the spikes all of the same kind in a single inflorescence, parts of the same plant (joined by stolons) sometimes with both kinds of spikes; staminate spikes: first glume 1 mm long; second glume acuminate, glabrous or nearly so, that of the lateral spikelets 3 mm long, that of the central spikelet about 4 mm long; lemmas similar, 3 mm long, glabrous, irregularly lobed, awnless or mucronate; pistillate spikes: glumes villous, otherwise like those of the staminate spikes; lemmas of the lateral spikelets similar, 3 mm long, glabrous, cleft to the middle, the awns from between the lobes equaling or barely exceeding them, more or less hispid; florets of the central spikelet unlike, the lower lemma glabrous or sparsely pubescent, cleft one third of the length, the awns from between the lobes glabrous, subequal or the central a little longer, somewhat exceeding the lobes; upper florets similar to those of the lateral spikelets, the awns slightly longer, extending 1–2 mm beyond the lobes; anthers 2 mm long.

Dry rocky hills and prairies, southwestern Texas, Arizona, and northern Mexico to Salvador.

TEXAS: Presidio, *Silveus* 734; *Havard* 30. Hot Springs, *Silveus* 649. Bone Spring (Tornillo Cr.), *Havard* 2. Study Butte (Brewster Co.), *Moore & Steyermark* 3300. South of Marathon, *Swallen* 1123. Without locality, *Nealley* in 1890.

ARIZONA: Without locality, *Palmer* in 1869.

SONORA: Alamos, *Palmer* 705 in 1890. Guaymas, *Palmer* 161 and 345 in 1887; *Hitchcock* 3546, 3551. Yaqui River, *Palmer* 17 and 18 in 1869. Imuris to Santa Ana, *Griffiths* 6834. Hermosillo, *Hitchcock* 3535, 3597. Altar, *Wiggins* 5974; *Pringle* in 1884. Llano, *Hitchcock* 3528.

CHIHUAHUA: Batopilas, *Palmer* 66 in 1885.

SINALOA: Imala, *Palmer* 1459, 1460 in 1891. Culiacan, *Brandegee* 1, 2. "La Noria," *Mexia* 295.

COLIMA: Armeria, *Hitchcock* 7024.

GUERRERO: Rio Balsas, *Orcutt* 4166.

OAXACA: San Geronimo, *Mell* 2144.

GUATEMALA: Zacapa, *Kellerman* 7887.

SALVADOR: La Union, *Hitchcock* 8776.

6. **Cathestecum brevifolium** Swallen, sp. nov.

Perenne, stoloniferum, stolonibus gracilibus, late repentibus, internodiis ad 12 cm longis; culmi caespitosi, graciles, ramosi, erecti vel geniculati, 5–10 cm alti; vaginae glabrae vel sparse pilosae, imae basi dense villosae; laminae planae, acutae, cirratae, infra glabrae, supra scabrae et pilosae, 1–2.5 cm longae, 1–2 mm latae; spicae 3–8, purpureae, divergentes, biformes; spica mascula: gluma prima angusta, 1 mm longa; gluma secunda latior, acuta vel acuminata, glabra vel sparse pilosa, 2.5–3 mm longa, minute lobata, mucronata; lemma inferius 3 mm longum, sparse pilosum, lobatum, mucronatum, lemma superius 2.5 mm longum, lemmata inferiori simile sed lobis longioribus; spica feminea: spiculae laterales imperfectae; gluma prima 1 mm longa; gluma secunda acuminata, 2.5 mm longa, pilosa vel hirsuto-villosa; flosculi reducti, steriles, raro masculi; gluma prima spiculae centralis 1 mm longa, secunda 3 mm longa, lobata, mucronata, hirsuto-villosa; flosculus inferior femineus, lemmate 3 mm longo, sparse pubescente, lobato, aristis quam lobis paulo longioribus; flosculi superiores masculi vel neutri, lemmata 2.5 mm longa, fissa, aristis quam lobis 1–3 mm longioribus.

Perennial, soloniferous, the stolons slender, wiry, widely spreading, the internodes as much as 12 cm long (usually less than 10 cm), not conspicuously arched as in *C. erectum;* culms in small dense tufts, slender, usually branching, erect or geniculate at the nodes, 5–10 cm tall (rarely to 15 cm), glabrous; lower sheaths crowded, glabrous or sparsely pilose with a tuft of long hairs at the mouth, the lowermost densely villous at the base; blades firm, flat, acute, becoming conspicuously curled with age, glabrous on the lower surface, scabrous and pilose on the upper, the margins scabrous, 1–2.5 cm long (rarely to 5 cm), 1–2 mm wide; spikes 3–8, usually purple, spreading, dimorphous as in *C. erectum;* staminate spike: first glume narrow, 1 mm long; second glume broader, acute or acuminate, usually glabrous or sometimes sparsely pilose on the keel, those of the lateral spikelets 2.5 mm long, that of the central spikelet 3 mm long, minutely lobed, mucronate; lower lemmas 3 mm long, sparsely pilose, shallowly lobed, mucronate from between the lobes, the upper ones 2.5 mm long, similar to the lower but with somewhat deeper lobes; pistillate spikelets: lateral spikelets imperfectly developed, the first glume 1 mm long, the second glume acuminate, 2.5 mm long, pilose to hirsute-villous on the keel, the florets much reduced, sterile, or the lower one rarely staminate; first glume of central spikelet similar to those of the lateral spikelets, the second 3 mm long, minutely lobed, mucronate, hirsute-villous at least on the keel, the lower floret pistillate, the lemma 3 mm long, sparsely pubescent on the back, the lobes one fourth the length of the lemma, the awns from between the lobes slightly exceeding them, the upper florets staminate or neuter, the lemmas 2.5 mm long, deeply cleft, the awns extending 1–3 mm beyond the lobes; stamens 1.3–1.6 mm long.

Type in the U. S. National Herbarium no. 884043, collected on thin gravelly soil, Tequila, Jalisco, Mexico, October 5, 1893, by C. G. Pringle (no. 4559).

Sterile clay or rocky hills and gravelly soil, Jalisco and Colima, Mexico.

Jalisco: Guadalajara, *Palmer* 270 in 1886; *Hitchcock* 7278, 7300; *Pringle* 4046. San Nicolas, *Hitchcock* 7200, 7202. Tequila, *Pringle* 4559 (type). Valencia, *Hitchcock* 7003.

Guanajuato: Irapuato, *Hitchcock* 7436.

Colima: Colima, *Palmer* 12 in 1897, and 1261 in 1891.

PALEOBOTANY.—Gyrocarpus *and other fossil plants from the Cumarebo field in Venezuela.*[1] Edward W. Berry, The Johns Hopkins University.

Through the friendly interest of Dr. H. G. Kugler, the Trinidad Leaseholds, Limited, forwarded to me in the late summer of 1936, a small collection of fossil plants which had been collected by Dr. Suter of that company near the village of Cuque in the Cumarebo oil

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[1] Received September 20, 1937.

field of Venezuela. This field is on the Caribbean coast of the state of Falcon a few miles east of the base of the Paraguana peninsula.

The horizon is the "Mammonal zone" of the Damsite series, which is considered to be of upper Miocene age. The matrix is a fine, light buff or brownish clay, said to be separated by well developed bedding planes of coarser material. The clay is crowded with plant fragments, mostly leaves, and its texture indicates accumulation in quiet water, so that one would expect perfectly preserved leaves rather than the more or less comminuted fragments such as have been found.

The collection is of special interest from several points of view, notably in that it consists of but 26 small pieces of matrix of which half contain nothing that is determinable and the remaining 13 pieces contain not only four new species but four additional known species that can be positively identified with forms described from the Forest sand of the Island of Trinidad, B.W.I. From the character of the material contained in this small collection from Cuque it would seem that a much more extensive and varied suite of plants could be obtained from this horizon.

The Damsite series, according to Liddle, comprises 3000 feet of shales, limestones and sandstones, with extensive marine faunas of upper and middle Miocene age. It is considered to be of about the same age as the Palmarejo formation and younger than the lower Miocene Betijoque formation, from both of which I have described a few fossil plants. It can not be said that the printed information on the stratigraphy of Venezuela is either complete or precise, despite the brave showing of Liddle's useful account, nor is this the place to discuss it even were the facts available.

The present collection is too limited to afford conclusive evidence as to its precise age or environment, but I see no reason for doubting that it is upper Miocene, since the four previously known species were all described from the Forest sand of Trinidad and three of these, *Anacardites americanus*, *Colubrina miocenica* and *Sideroxylon mastichodendroides*, were definitely from the upper part of that formation. Recent collections of fossil plants from Trinidad, not yet described in print show the *Sideroxylon* in the Forest clay overlying the Forest sand, and both the *Sideroxylon* and *Anacardites* at a locality known as the Mud Plant which is said to lie 1700 feet above the plant horizon in the Forest clay.

As will be seen from the following list of species represented, all of the plants are angiosperms and all but one are dicotyledons. They represent 8 genera in 7 families and 7 orders, and it would seem that the presence of the unique aroid *Caladiosoma* is sufficiently conclusive evidence of a wet tropical climate in a densely forested region, were such evidence thought necessary. Two of the genera, both represented by fruits or seeds—*Melloa* doubtfully, and *Gyrocarpus* more certainly—have not before been found fossil and the latter is of unusual interest.

- Monocotyledonae
  - Arales
    - Araceae
      - *Caladiosoma miocenica*
- Dicotyledonae
  - Rosales
    - Leguminosae
      - *Mimosites suteri*
      - *Leguminosites cuquensis*
  - Sapindales
    - Anacardiaceae
      - *Anacardites americanus*
  - Rhamnales
    - Rhamnaceae
      - *Colubrina miocenica*
  - Laurales
    - Hernandiaceae
      - *Gyrocarpus miocenica*
  - Ebenales
    - Sapotaceae
      - *Sideroxylon mastichodendroides*
  - Personales
    - Bignoniaceae
      - *Melloa* (?) *cuquensis*

Caladiosoma miocenica Berry

Caladiosoma miocenica Berry, Pan. Am. Geol. **44:** 38, pl. 5, 1915; Johns Hopkins Studies in Geology **6:** 83, pl. 10, figs. 1–4, 1925.

A single fragment collected by Dr. Suter in the Cumarebo field shows a two centimeter length of two stout secondaries with the intervening lamina and with the absolutely characteristic tertiary venation of this species. Had it not been for the more complete material known from Trinidad, B.W.I., it would have been impossible to identify the tiny fragment from near Cuque. As it is the identification is as certain as anything can be on this mundane sphere.

The type was described from the Forest sand of Trinidad and a reference to the published figures, particularly of the tertiary venation, will convince the student that my statement of the impossibility of making a mistake has not been exaggerated.

Mimosites suteri Berry, n. sp. Fig. 1

Leaflets small, elongate elliptical, somewhat inequilateral, widest medianly, slightly more narrowed at the rounded tip than at the rounded base, apparently sessile. Margins entire. Texture subcoriaceous. Length about 11 mm. Maximum width about 4.5 mm. Midvein stout, straight, prominent. Secondaries numerous, thin, partially immersed, comptodrome.

The species is represented by a complete leaflet and several fragments. It is a type of leaflet not uncommon in the various families of this extensive alliance and can be compared with existing leaflets in *Cassia*, *Drepanocarpus*, *Platypodium*, *Mimosa*, *Caesalpinia*, and many other genera. It can probably be matched by fossil forms described under a variety of names from other regions and different geological horizons, but such comparisons are lacking in significance. It is referred to the form genus *Mimosites* following tradition, and also because the Mimosaceae probably contains more genera with leaflets of this type than do the other families of Leguminosae. The species is named in honor of the collector, Dr. Suter of Trinidad Leaseholds, Ltd.

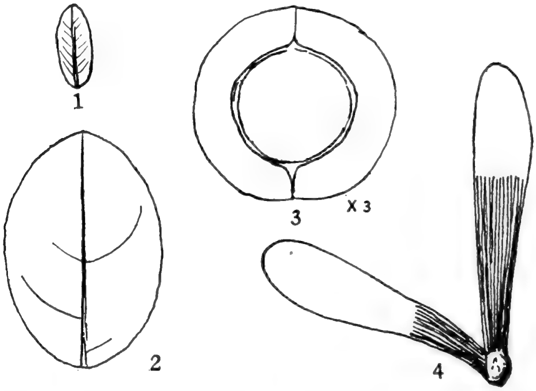

Fig. 1.—*Mimosites suteri* Berry, n. sp. Fig. 2.—*Leguminosites cuquensis* Berry, n. sp. Fig. 3.—*Melloa? cuquensis* Berry, n. sp. Fig. 4.—*Gyrocarpus miocenica* Berry, n. sp.

Leguminosites cuquensis Berry, n. sp. Fig. 2

Leaflets elliptical, nearly symmetrical, widest medianly, with full and rounded entire margins and about equally rounded at the apex and base. No trace of a petiolule. Extremely thick and coriaceous in texture. Midvein very stout, straight and prominent. Secondaries thin, diverging from the midvein at wide angles, regularly curved and camptodrome, almost completely immersed in the leaf substance, as are the tertiaries. Length about 3 cm. Maximum width about 2 cm.

This is a type of leaflet which is frequently referred to *Sophora* and might well represent that genus. It is referred to *Leguminosites* since it might equally represent *Cassia, Dalbergia, Copaifera* or other unrelated genera in this prolific alliance. Lacking generic certainty there is little point in comparisons with either fossil or living species. Description is attempted since it may have stratigraphic value at some future time.

Anacardites americanus Berry

Anacardites americanus Berry, Johns Hopkins University Studies in Geology **6**: 104, pl. 1, fig. 3, 1925.

This species was described from the Forest sand of the Island of Trinidad, B.W.I. A single incomplete specimen is contained in the small collection from near Cuque, Venezuela. It represents a leaflet of some undeterminable member of the Anacardiaceae, *Anacardites* being a form genus proposed especially for material of this sort and the name does not imply any close relationship to the existing genus *Anacardium*. It has recently been found in the Forest clay and at the Mud Plant in Trinidad.

Colubrina miocenica Berry

Colubrina miocenica Berry, Johns Hopkins University Studies in Geology **6**: 106, pl. 13, figs. 1–3, 1925.

The type is not uncommon in the upper part of the forest sand of the Island of Trinidad, B.W.I. A single specimen with the base missing is present in the small collection from near Cuque, Venezuela.

Gyrocarpus miocenica Berry, n. sp. Fig. 4

The present species is based upon a single fairly complete specimen and a few small fragments of the rather coriaceous wings. It does not differ appreciably from the immature fruits of the existing *Gyrocarpus jacquini* Roxburg except that the essential part was apparently spherical instead of being the very prolate spheroid of both the immature and mature fruits of the existing species. The thickened covering of the fruit is continued upward to form two, narrow, thickened, spatulate, mostly longitudinally parallel-veined wings which in the fossil specimen are pressed in a divergent position just as are the majority of recent immature fruits in herbarium material. Carpel about 4 mm in diameter. Wings about 4 cm long (estimated) and about 7 mm in maximum width.

The mature fruits of the existing species may become very large and leathery, with opposite wings up to 10 or more centimeters in length, but they show great variation in size and some are scarcely if any larger than the fossils. There seems slight doubt but that the fossil represents a Miocene ancestor of the existing species.

The supposedly single existing species is a stately tree with large quinque-palmate leaves much like those of *Sterculia platanifolia* Linné fils. It is not uncommon in northern South America and is common in the tropics of both the new and old worlds. The variation in the fruits alone seen in comparing the fossil with the existing forms leads me to doubt the wisdom of referring all of the existing forms to a single botanical species.

The present is the first fossil record of the genus and fulfills the necessary corollary that a genus found in both hemispheres must have had a geological history.

Sideroxylon mastichodendroides Berry

Sideroxylon mastichodendroides Berry, Johns Hopkins University Studies in Geology **6**: p. 124, pl. 13, figs. 4–8, 1925.

This is a common species in the upper part of the Forest sand of the Island of Trinidad, B.W.I. A part of a leaf and its counterpart are contained in the small collection from near Cuque, Venezuela. It has also been found recently in the Forest clay and at the Mud Plant in Trinidad.

Melloa? cuquensis Berry, n. sp. Fig. 3

A single specimen and its counterpart of a small winged seed are doubtfully referred to this genus of the Bignoniaceae on the basis of descriptions and figures as I have been unable to see seeds of the existing species. Seed circular, flatly compressed, about 5 mm in diameter, with a thickened border, surrounded by a narrow fairly thick rim-like wing about 2 mm wide; no venation visible. The hilum and chalaza are at opposite poles of the seed dividing the wing into 2 equal semicircular segments.

The reference to the Bignoniaceae appears to be reasonably certain but the genus is somewhat problematical, for adequate comparisons could not be made because specimens of seeds of the recent genera are seldom preserved in available herbaria. No related fossil forms have heretofore been described. The genus comprises 2 or 3 existing species of lianas ranging from Venezuela to Brazil. Another genus with similar seeds is *Eccremocarpus* with several species of climbing shrubs in the Peruvian region.

PALEOBOTANY.—*Further additions to some fossil floras of the western United States.*[1] ROLAND W. BROWN, U. S. Geological Survey.

During the interval between the writing and publishing of my last paper on this subject[2] new collections have been received, some old collections have been reexamined, and several articles by other students dealing with the fossil floras of the western United States have been published. A survey of this material makes the following additions and changes necessary. Unless otherwise stated, the specimens figured are deposited in the U. S. National Museum.

Populus jenningsi Brown, n. sp. Fig. 3

Description.—A 4-valved, open capsule, 1.8 cm in diameter; valves lance-

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[1] Received September 23, 1937.

[2] BROWN, ROLAND W. *Additions to some fossil floras of the western United States.* U. S. Geol. Survey Prof. Paper **186**: 163–206. 1937.

ovate, showing the broad placental lines with raised scars where the seeds were attached.

The matrix in which this fossil was found is similar to that near Missoula, Mont., from which Jennings[3] in 1920 described a small flora assigned by him to the Oligocene. Although he reported two species of *Populus*—*P. smilacifolia* and *P. zaddachi*—it seems now that neither of these belongs to *Populus* but can be referred to another genus. Fruits generally similar to this fossil have been described under one name or another from foreign countries, but so far as I know none has hitherto been reported as *Populus* from strata in the United States.

I take pleasure in naming this fossil fruit for Dr. O. E. Jennings, of the Carnegie Museum, Pittsburgh, Pa.

Occurrence.—Near O'Keefe Canyon, 11 miles northwest of Missoula, Mont. Collected by Earl Douglass.

Populus lamottei Chaney & Elias Figs. 4, 5

Populus lamottei Chaney & Elias, Carnegie Inst. Washington Pub. **476** (1): 35, pl. 4, figs. 4, 5, 1936.

Cercidiphyllum crenatum (Unger) Brown. Chaney and Elias, idem, p. 40, pl. 7, figs. 4, 5.

A reexamination of both the follicle and leaf considered by Chaney and Elias to be *Cercidiphyllum crenatum* shows that they represent *Populus* instead. The features that more particularly distinguish the typical leaves of *Cercidiphyllum* from those of *Populus*, especially *P. tremuloides*, the leaves of which are most nearly comparable to those of *Cercidiphyllum*, are the presence of 3 pairs of lateral veins arising from the top of the petiole, and the departure of the first prominent secondary vein from the midrib at a point above the middle of the blade. In the leaf (Fig. 5) assigned to *Cercidiphyllum* by Chaney and Elias there are only 2 pairs of lateral primaries, and the first strong secondary emerges from the left side of the midrib well below the middle of the blade. The venation is therefore populoid, and the leaf apparently belongs to *Populus lamottei.*

The follicle (Fig. 4) represents the impression of the interior of two almost separated valves of a *Populus* fruit. On the dark placental line the scars where the seeds were attached can be seen faintly. What appears to be venation on the valves may be folds or cracks developed before or during fossilization. This follicle most likely also belongs with *Populus lamottei,* for it was found at the same locality as the leaves. It compares in size with the fruits of a number of cottonwoods, more particularly those of the Southwestern States.

Occurrence.—Pliocene, locality P-42, sec. 3, T. 3 N., R. 25 E., southwest of Beaver, Beaver County, Okla. (Fig. 5); locality P-44, 3½ miles east of locality P-42, sec. 5, T. 3 N., R. 26 E. (Fig. 4).

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[3] Jennings, O. E. *Fossil plants from the beds of volcanic ash near Missoula, western Montana.* Carnegie Mus. Mem. **8**(2): 385–450. 1920.

Fagus pacifica Chaney Fig. 11

Fagus pacifica Chaney, Carnegie Inst. Washington Pub. **346** (4): 108, pl. 10, figs. 6–9, 1927.

Chaney described the leaves and fruit of this species from the Gray ranch, 11 miles east of Post, in the Crooked River basin, Oreg. The impression of the fruit figured here (Fig. 11) comes from the reddish shales along Bridge Creek, Oreg., and is the first evidence of the presence of *Fagus* in the flora from the shales in that area. The flanges of the nut and the three persistent styles are well preserved.

Occurrence.—Oligocene (according to the usage of the U. S. Geological Survey), 9 miles north of Mitchell, Oreg.

Quercus bretzi Chaney Fig. 7

Quercus bretzi Chaney, Contrib. from Walker Mus. **2** (5): 171, pl. 12, fig. 4; pl. 13, fig. 3, 1920.

These oblong to obovate shallowly lobed leaves with broad undulate apexes exhibit characters that suggest relationship to such living American white oaks as the bur oak, *Quercus macrocarpa*, and the swamp white oak, *Q. bicolor*, of the eastern United States. The type figured by Chaney (his pl. 12, fig. 4) is a well-nigh perfect example as such paleobotanic materials go.

Occurrence.—Latah formation (Miocene), Spokane, Wash. Collected by E. E. Alexander.

Quercus columbiana Chaney Figs. 6, 12

Quercus columbiana Chaney, Contrib. from Walker Mus. **2** (5): 170, pl. 13, figs. 1, 2, 1920.

These elliptic to oblong leaves with relatively acute lobes and apexes of a single lobe only slightly larger than the lateral lobes may be compared to a number of living American white oaks, such as the white oak, *Quercus alba*, the valley oak, *Q. lobata*, the Oregon white oak, *Q. garryana*, and the Rocky Mountain white oak, *Q. utahensis*. To which of these specifically, if any, the fossil species may be related, it seems impossible to determine with the scanty material now at hand.

The only other definite representative of the white oak group so far recorded from the Latah formation is *Quercus mccanni* Berry[4] from Grand Coulee, Wash. These leaves are remarkably like those of the chestnut oak, *Q. prinus*, of the eastern United States. The species, *Q. spokanensis* Knowlton,[5] founded on the upper half of a leaf, appears to be the tip of *Castanea orientalis* Chaney.

The leaves of the white oak group are distinguished, in most species, from those of the black oak group by having rounded, blunt lobes, whereas those

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[4] Berry, E. W. *A Miocene flora from Grand Coulee, Washington.* U. S. Geol. Survey Prof. Paper **170**: 36, pl. 11, figs. 5–7. 1931.

[5] Knowlton, F. H. *Flora of the Latah formation.* U. S. Geol. Survey Prof. Paper **140**: 37, pl. 19, fig. 3. 1926.

of the black oaks are generally acute and bristle-tipped. On this basis the black oaks now recognized in the Latah formation are: *Quercus merriami* and *Q. payettensis*. It is possible that these two should be synonymized. The status of two other species, *Q. simulata* and *Q. consimilis*, has not yet been satisfactorily determined.

Occurrence.—Latah formation (Miocene), on Poorman Creek, 22 miles east of Orofino, Idaho (Fig. 6). Collected by Boyd H. Olson. On Potlatch Creek, between Arrow Junction and Juliaetta, Idaho (Fig. 12). Collected by Roland W. Brown.

Cercidiphyllum crenatum (Unger) Brown Fig. 9

Cercidiphyllum crenatum (Unger) Brown, Jour. Paleont. **9** (7): 575–577, pl. 68, figs. 1, 6, 8–10, 1935.—U. S. Geol. Survey Prof. Paper **186**: 175, 1937.

In my 1935 paper I reported the leaves and capsules, but no seeds, of this species from the reddish shales along Bridge Creek, Oreg. The seeds are small and difficult to detect in the reddish matrix, but recently I succeeded in finding one and its counterpart. These small seeds, averaging 5 mm in length, are generally crescent-shaped, the seed portion being long and slender and about the same length as the wing which is attached laterally to the seed at almost a right angle. Small coniferous seeds (Fig. 8) from the same strata should not be confused with *Cercidiphyllum*, because their wings extend in the direction parallel to the linear axis of the seed.

Occurrence.—Oligocene (according to the usage of the U. S. Geological Survey), 9 miles north of Mitchell, Oreg.

Nymphaeites nevadensis (Knowlton) Brown, n. comb. Fig. 10

Spathyema? *nevadensis* Knowlton, U. S. Geol. Survey Ann. Rept. **21** (2): 211 pl. 30, figs. 17, 18, 1900.

Unknown plant. Idem, 212, pl. 30, figs. 16, 24, 25.

Nymphaea diatoma MacGinitie, Carnegie Inst. Washington Pub. **416** (2): 55, pl. 7, fig. 6; pl. 8, 1933.

Nymphaeites diatoma (MacGinitie) Arnold, Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 85, 1937.

The impressions described by Knowlton from the Esmeralda formation of Nevada as an "unknown plant" are on the same piece of rock as those he called *Spathyema*? *nevadensis*. An examination of the surface of a rhizome of a living water lily shows large single petiole scars flanked by aggregates of small root scars; and it is to these, respectively, that Knowlton's specimens correspond.

It is possible that some of the smaller aggregates showing a gradation in size from large to small may be the impressions of the scars on a stem of *Trapa americana*, the nuts of which are abundant in the same strata.

The seeds called *Castalia*? by Berry[6] also from the Esmeralda formation,

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[6] Berry, E. W. *The flora of the Esmeralda formation.* U. S. Nat. Mus. Proc. **72**(23): 12, pl. 1, fig. 1. 1927.

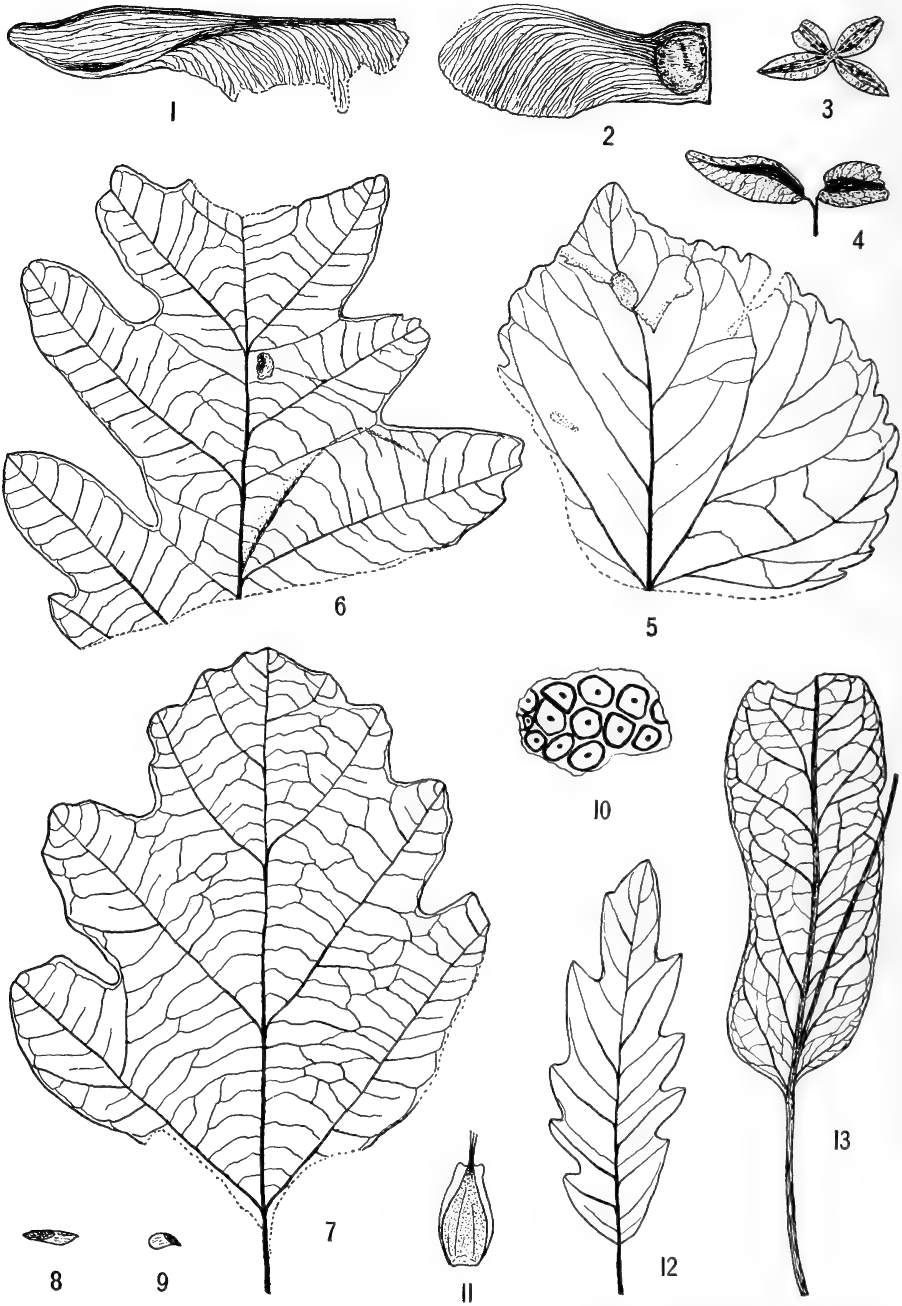

Fig. 1.—*Acer osmonti* Knowlton. Fig. 2.—*Acer scottiae* MacGinitie. Fig. 3.—*Populus jenningsi* Brown, n. sp. Figs. 4, 5.—*Populus lamottei* Chaney & Elias. Figs. 6, 12.—*Quercus columbiana* Chaney. Fig. 7.—*Quercus bretzi* Chaney. Fig. 8.—A coniferous seed. Fig. 9.—Seed of *Cercidiphyllum crenatum* (Unger) Brown. Fig. 10.—Root scars of *Nymphaeites nevadensis* (Knowlton) Brown, n. comb. Fig. 11.—Nut of *Fagus pacifica* Chaney. Fig. 13.—Fruit bract of *Tilia aspera* (Newberry) LaMotte. All figures natural size.

may have been produced by *Nymphaeites nevadensis,* but as their identity is in doubt, they are not now synonymized with the latter species. It is not possible to determine from Arnold's sketch whether his *N. rotundus,* also from Trout Creek, should be synonymized here.

The fossil figured here (Fig. 10) is an aggregate of circular to polygonal root scars showing central pits.

Occurrence.—Miocene. Esmeralda formation, Nev.; Trout Creek, Oreg.; Payette formation, on east side of Snake River, 12 miles west of Weiser, Idaho (Fig. 10). Collected by Roland W. Brown.

Amelanchier dignatus (Knowlton) Brown

Celastrus dignatus Knowlton, U. S. Geol. Survey Bull. **204:** 71, pl. 11, fig. 5, 1902.

Phyllites couleeanus Berry, U. S. Geol. Survey Prof. Paper **170:** 42, pl. 13, fig. 12, 1931.

Amelanchier scudderi Cockerell. Berry, U. S. Geol. Survey Prof. Paper **154:** 252, pl. 55, fig. 4, 1929.

Amelanchier dignatus (Knowlton) Brown, Jour. Paleont. **9:** 577, pl. 69, figs. 5, 6, 1935.—U. S. Geol. Survey Prof. Paper **186:** 176, pl. 53, fig. 11, 1937.

Amelanchier magnifolia Arnold, Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 89, pl. 4, figs. 1, 4, text figs. 2, 3, 1937.

Since my publication of the new combination, *Amelanchier dignatus* (Knowlton) Brown, in 1935, I have compared the specimens there combined with recently acquired new material and have concluded that the types of *A. peritula* Cockerell and *A. scudderi* Cockerell, from Florissant, Colo., and of *A. grayi* Chaney, from Crooked River, Oreg., on both stratigraphic and morphologic grounds, are different from *A. dignatus* and should not be synonymized with it. The three species thus removed from *A. dignatus* may represent a single species, but they at least are uniformily smaller and display sharper apexes than *A. dignatus.* Arnold's *A. magnifolia* is clearly the same as *A. dignatus* as can be seen by comparing his figures with Knowlton's *Celastrus dignatus* and Berry's *Phyllites couleeanus.* The statement that the leaves of the living *A. alnifolia* are *much* smaller than those of *A. magnifolia* is unfortunate. It is true that the average leaf of *A. alnifolia* is smaller, but in my herbarium material of *A. alnifolia* collected in Idaho in 1934 are specimens that easily match Arnold's figures of *A. magnifolia.*

Cedrela merrilli (Chaney) Brown, n. comb.

Rhus merrilli Chaney, Carnegie Inst. Washington Pub. **346** (4): 125, pl. 16, figs. 1, 2, 1927.

Cedrela pteraformis (Berry) Brown, Jour. Paleont. **9** (7): 579, 1935. Referring only to *Acer* sp.? Newberry.— U. S. Geol. Survey Prof. Paper **186:** 179, 1937. Referring only to *Pinus knowltoni* Chaney [Mason].

Although the resemblance between the fossil leaflets called *Rhus merrilli* to those of the living *Rhus sylvestris,* of China, is very striking, as pointed out by Chaney, two considerations cast doubt on their identification as *Rhus.* First, between the secondaries of *R. sylvestris* there are usually two or more very prominent, short, intermediate secondaries, but in the fossil leaflets these intermediates are thin, few, and commonly, none. Second, the winged seeds of *Cedrela* have been found in the same strata as the leaflets. Because these leaflets can be matched easily with those from living species of *Cedrela* and because they are associated with *Cedrela* seeds it seems more probable that they represent *Cedrela* than *Rhus.*

In 1935 when I made the discovery that the winged seeds theretofore identified as *Acer* and *Gordonia* were in reality *Cedrela,* I was unaware that fossils of this genus were of widespread occurrence in the middle Cenozoic floras of the western States. Since then, remains of *Cedrela,* either leaflets, capsules, or seeds, have been identified in the collections from Florissant, Colo.; Crooked River and Bridge Creek, Oreg.; Mascall formation, John Day basin, Oreg.; Tipton, Sumpter quadrangle, Oreg.; Sucker Creek, Oreg.; 49 Camp, Nev.; Hog Creek, Idaho; and Latah formation, Spokane, Wash. These occurrences cover a large area, geographically, and a span of time from upper Oligocene to early Pliocene. It seems probable therefore, that, instead of a single species, *Cedrela pteraformis,* several species were in existence during that interval. Can these postulated species be distinguished in the fossil materials now at hand?

The earliest western species now known, *Cedrela lancifolia* (Lesquereux) Brown[7] from Florissant, has narrowly lanceolate leaflets and small seeds. It can apparently be separated readily from the other species which exhibit great variability in the size and form of their leaflets and seeds.

The leaflets from Crooked River and Bridge Creek, Oreg., are uniformly elongate elliptic. Those from the Latah formation are in general relatively short, elliptic in outline, with rather blunt apexes. Those from the John Day basin, Trout Creek, and Sucker Creek, Oreg., are lanceolate to broadly ovate-lanceolate with rather acute apexes. As regards the seeds from these several localities I have not yet detected in them such morphologic differences as would serve to distinguish them specifically, but I assume that the capsules and seeds found at any given locality belong with the leaves occurring in the same formation.

The fossil species of *Cedrela* from the western United States, on the basis of differences in foliage, therefore, now appear to be: *C. lancifolia* (Lesquereux) Brown, *C. merrilli* (Chaney) Brown, *C. oregoniana* (Lesquereux) Brown, and *C. pteraformis* (Berry) Brown.

Occurrence.—Oligocene (according to the usage of the U. S. Geological Survey), Gray ranch, Crooked River basin; and 9 miles north of Mitchell, Bridge Creek basin, Oreg.

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[7] BROWN, ROLAND W. *Additions to some fossil floras of the western United States.* U. S. Geol. Survey Prof. Paper **186:** 178, pl. 60, figs. 3, 4. 1937.

Cedrela oregoniana (Lesquereux) Brown, n. comb.

Ficus? oregoniana Lesquereux, U. S. Nat. Mus. Proc. **9**: 18, pl. 9, fig. 3, 1888.—Knowlton, U. S. Geol. Survey Bull. **204**: 56, pl. 10, fig. 3, 1902.
Sapindus oregonianus Knowlton. LaMotte, Carnegie Inst. Washington Pub. **455** (2): 37, pl. 1, figs. 2, 3, 5; pl. 2, figs. 1–4; pl. 3, figs. 2, 4, 5, 1935.
Sapindus affinis Newberry? MacGinitie, Carnegie Inst. Washington Pub. **416** (2): 60, 1933.
Cedrela browniana Arnold, Amer. Midland Naturalist **17** (6): 1019, fig. 11, 1936.—Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 95, pl. 7, figs. 1, 2, 1937.
Cedrela trainii Arnold, Amer. Midland Naturalist **17** (6) : 1018, figs. 1, 2, 1936.—Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 95, pl. 6, figs. 1–3, 6, 1937.
Apocynum indiana MacGinitie, Carnegie Inst. Washington Pub. **416** (2):66, pl. 12, fig. 1, 1933.
Cedrela pteraformis (Berry) Brown, U. S. Geol. Survey Prof. Paper **186**: 179, pl. 60, fig. 9, 1937. Including also *Pinus monticolensis* Berry [LaMotte], *Pinus russelli* LaMotte, *Pseudotsuga masoni* MacGinitie [LaMotte], *Libocedrus* sp. Dorf, and *Cedrela pteraformis* (Berry) Brown in Arnold, Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 95, pl. 6, figs. 4. 7–10, 1937.

The leaflets of this species were characterized in the preceding discussion of *Cedrela merrilli*.

Occurrence.—49 Camp, Nev.; Mascall formation (Miocene), John Day basin, Oreg.; Tipton, Oreg.; Trout Creek, Oreg.; Sucker Creek, Oreg.; Hog Creek (according to Dorf, Upper Miocene or lower Pliocene), Idaho.

Cedrela pteraformis (Berry) Brown

Cedrela pteraformis (Berry) Brown, Jour. Paleont. **9** (7): 579, 1935. Referring only to *Carpolithus pteraformis* Berry and *Gordonia pteraformis* Berry. —U. S. Geol. Survey Prof. Paper **186**: 179, pl. 52, fig. 12; pl. 60, figs. 5–8, 10, 1937. Referring only to *Umbellularia dayana* (Knowlton) Berry and *Sapindus armstrongi* Berry.
Cassia spokanensis Berry, U. S. Geol. Survey Prof. Paper **156**: 253, pl. 63, fig. 8, 1929.

The specimen called *Cassia spokanensis* by Berry is the impression of a large capsule that simulates those of *Cedrela*. The seeds of *Cedrela* are abundant in the Latah formation at Spokane, Wash.

The leaflets of this species were characterized in the discussion of *Cedrela merrilli*.

Occurrence.—Latah formation (Miocene), Spokane, Wash.

Acer osmonti Knowlton Fig. 1

Acer osmonti Knowlton, U. S. Geol. Survey Bull. **204**: 72, pl. 13, fig. 3, 1902. —Brown. U. S. Geol. Survey Prof. Paper **186**: 180, pl. 58, figs. 16–18, 1937. (See synonymy and discussion.)
Rhus diluvialis Arnold, Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 93, pl. 5, fig. 4, 1937.

Both the samaras and leaves of this species are clearly of the silver maple (*Acer saccharinum*) type and may be readily identified. The fragment figured by Arnold as *Rhus diluvialis* is the lobe, probably apical, of a leaf of *A. osmonti*. The living *Rhus trilobata* to which this fragment was compared has rounded not sharp marginal teeth as displayed by the fossil. In the Sucker Creek collection of the U. S. National Museum are specimens of *Acer bendirei* Lesquereux, *A. glabroides* Brown, and *A. osmonti* Knowlton.

Occurrence.—Latah formation (Miocene) on Orofino Creek, 20 miles east of Orofino, Idaho. Collected by Boyd H. Olson.

Acer scottiae MacGinitie Fig. 2

Acer scottiae MacGinitie. Carnegie Inst. Washington Pub. **416** (2):62, pl. 11, figs. 4, 8; pl. 12, fig. 4, 1933.

Acer septilobatum Oliver. Dorf, Carnegie Inst. Washington Pub. **476** (2):122, pl. 3, fig. 5, 1936.

The samara figured here (Fig. 2) is almost identical with that figured by Dorf. Both, however, differ somewhat from the type in having the distal end of the wing less prominently upturned. All, having long, squarely truncated, proximal ends (the line of attachment to the twin), seem clearly to belong to the Platanoidea section of *Acer*.

Occurrence.—Diatomite (probably the Idaho formation of Kirkham) in road cut 11 miles south of Horseshoe Bend toward Boise, Idaho. Collected by Roland W. Brown and Don Emigh, Aug. 25, 1934.

Tilia aspera (Newberry) LaMotte Fig. 13

Tilia aspera (Newberry) LaMotte, Carnegie Inst. Washington Pub. **455** (3): 45, pl. 1, figs. 1–3; pl. 2, figs. 1, 2, 1933.

Tilia oregona LaMotte. Idem, 47, pl. 3, fig. 6. [*Platanus aspera* Newberry, U. S. Geol. Survey Mon. **35**: 102, pl. 59, fig. 3. 1898.]

Tilia sp. Arnold, Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 94, pl. 5, fig. 1, 1937.

The fragmentary bract figured here (Fig. 13) is the sole evidence of *Tilia* so far reported from Sucker Creek, Oreg. A portion of the peduncle bearing the fruit is preserved, and that is connate with the midrib of the bract for only a short distance. The peduncle of the bract, it should be noted, is unusually long as compared with those of most living species of *Tilia*.

The leaf originally called *Platanus aspera* Newberry, from Bridge Creek, Oreg., and referred by LaMotte to *Tilia oregona*, is a small leaf of *T. aspera*, because it has the long, coarse teeth and the conspicuously asymmetric base that characterize the latter species.

Occurrence.—Miocene, on Sucker Creek, near the Idaho-Oregon boundary.

Nyssa hesperia Berry

Nyssa knowltoni Berry. Brown, U. S. Geol. Survey Prof. Paper **186**: 184, pl. 62, figs. 1–3, 1937. [Not *Nyssa knowltoni* Berry, U. S. Geol. Survey Prof. Paper **154**: 261, pl. 59, fig. 7, 1929.]

Nyssa hesperia Berry, U. S. Geol. Survey Prof. Paper **170**: 42, pl. 13, figs. 9–11, 1931.

With the acquisition of new material from the Latah formation at Spokane, Wash., it becomes apparent that the specimens figured by me as *Nyssa knowltoni* in 1937 differ so markedly in form and secondary venation from the type described by Berry in 1929 that they should be segregated from the latter and retain the name *N. hesperia.* Whether the type of *N. knowltoni* is in reality a *Nyssa* is problematical. Its form and venation find counterparts in some of the leaves of the living *Magnolia acuminata* and also in the entire, somewhat asymmetric leaflets of *Rhus toxicodendron.*

CHANGES OF NAME AND NEW COMBINATIONS

Acer aquilum Chaney (Contrib. from Walker Mus. **2** (5): 178, pl. 17, figs. 4, 5; pl. 18, fig. 1; pl. 19, fig. 1, 1920)—*Acer negundoides* MacGinitie.

Acer completum Chaney (idem, 179, pl. 18, fig. 2)—*Acer negundoides* MacGinitie.

Acer merriami Knowlton (U. S. Geol. Survey Bull. **204**: 74, pl. 14, fig. 7, 1902) = *Platanus dissecta* Lesquereux.

Acer septilobatum Oliver (Carnegie Inst. Washington Pub. **455** (1): 25, pl. 4, figs. 1, 2, 1934) = *Acer bendirei* Lesquereux. The coarse marginal teeth distinguish this species from the *circinnatum* type to which it was likened, and relate it to the *macrophyllum* type. I can match Oliver's septilobate leaves with specimens of *macrophyllum* I collected near You Bet, Calif., in 1936.

Acer septilobatum Oliver. Dorf (Carnegie Inst. Washington Pub. **476** (2): 122, pl. 3, fig. 5, 1936) = *Acer scottiae* MacGinitie.

Acer sp.? Newberry (U. S. Geol. Survey Mon. **35**: 115, pl. 46, fig. 8, 1898) = *Cedrela merrilli* (Chaney) Brown, n. comb.

Amelanchier magnifolia Arnold (Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 89, pl. 4, figs. 1, 4, text figs. 2, 3, 1937) = *Amelanchier dignatus* (Knowlton) Brown.

Apocynum indiana MacGinitie (Carnegie Inst. Washington Pub. **416** (2): 66, pl. 12, fig. 1, 1933) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Cassia spokanensis Berry (U. S. Geol. Survey Prof. Paper **156**: 253, pl. 63, fig. 8, 1929) = *Cedrela pteraformis* (Berry) Brown.

Cedrela browniana Arnold (Amer. Midland Naturalist **17** (6): 1019, fig. 11, 1936) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Cedrela trainii Arnold (idem, 1018, figs. 1, 2) = *Cedrela oregoniana* (Lesquereux) Brown n. comb.

Cedrela pteraformis (Berry) Brown (part) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Cercidiphyllum crenatum (Unger) Brown. Chaney and Elias (Carnegie Inst. Washington Pub. **476** (1): 35, pl. 4, figs. 4, 5, 1936) = *Populus lamottei* Chaney & Elias.

Diospyros elliptica Knowlton (U. S. Geol. Survey Bull. **204**: 83, pl. 16, figs. 5, 1902) = *Castanopsis convexa* (Lesquereux) Brooks.

Fagus? *bonnevillensis* Chaney (Contrib. from Walker Mus. **2** (5): 167, pl. 11, fig. 1, 1920) = *Fagus washoensis* LaMotte.

Ficus? *oregoniana* Lesquereux. Knowlton (U. S. Geol. Survey Bull. **204**: 56, pl. 10, fig. 3, 1902) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Libocedrus sp. Dorf (Carnegie Inst. Washington Pub. **476** (2): 108, pl. 1, fig. 4, 1936) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Liriodendron trilobatum Chaney (Contrib. from Walker Mus. **2** (5): 173, pl. 14, fig. 4) = *Acer negundoides* MacGinitie.

Nymphaea diatoma MacGinitie (Carnegie Inst. Washington Pub. **416** (2): 55, pl. 7, fig. 1, 1933) = *Nymphaeites nevadensis* (Knowlton) Brown, n. comb.

Nymphaeites diatoma (MacGinitie) Arnold (Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 85, 1937) = *Nymphaeites nevadensis* (Knowlton) Brown, n. comb.

Nyssa knowltoni Berry (part) = *Nyssa hesperia* Berry.

Philadelphus bendirei (Knowlton) Chaney. Arnold (Contrib. Mus. Paleont., Univ. of Mich. **5** (8):88, pl. 3, fig. 4, 1937) = *Sassafras hesperia* Berry. Arnold's leaf figured as *Philadelphus bendirei* is a fragment of an unlobed leaf of *Sassafras hesperia.*

Picea? sp. Chaney (Contrib. from Walker Mus. **2** (5): 159, pl. 5, fig. 2, 1920) = *Betula fairii* Knowlton.

Pinus knowltoni Chaney. Mason (Carnegie Inst. Washington Pub. **346** (5): 148, pl. 2, fig. 3, 1927) = *Cedrela merrilli* (Chaney) Brown, n. comb.

Pinus monticolensis Berry. LaMotte (Carnegie Inst. Washington Pub. **455** (5): 110, pl. 5, figs. 1, 4, 1936) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Pinus russelli LaMotte (Carnegie Inst. Washington Pub. **455** (5): 110, pl. 5, figs. 2, 3, 1936) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Populus lindgreni Knowlton. LaMotte (Carnegie Inst. Washington Pub. **455** (5): 115, pl. 5, fig. 1, 1936) = *Populus washoensis* Brown, new name. The type of *P. lindgreni* Knowlton has numerous, relatively small, somewhat crenate, rounded, marginal teeth, whereas the specimen figured by LaMotte has few, large, dentate, blunt-pointed teeth, and a longer, slenderer petiole.

Pseudotsuga masoni MacGinitie. LaMotte (Carnegie Inst. Washington Pub. **455** (5): 111, pl. 2, figs. 6, 7, 1936) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Quercus duriuscula Knowlton. Dorf (Carnegie Inst. Washington Pub. **476** (2): 114, pl. 2, fig. 8, 1936) = *Quercus columbiana* Chaney.

Quercus spokanensis Knowlton (U. S. Geol. Survey Prof. Paper **140**: 37, pl. 19, fig. 3, 1926) = *Castanea orientalis* Chaney.

Quercus sp., unnamed leaf. Berry (U. S. Geol. Survey Prof. Paper **156**, pl. 50, fig. 15, 1929) = *Salix spokanensis* (Berry) Brown.

Rhus diluvialis Arnold (Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 93, pl. 5, fig. 4, 1937) = *Acer osmonti* Knowlton.

Rhus merrilli Chaney (Carnegie Inst. Washington Pub. **346** (4): 125, pl. 16, figs. 1, 2, 1927) = *Cedrela merrilli* (Chaney) Brown, n. comb.

Rhus payettensis Knowlton (U. S. Geol. Survey Ann. Rept. **18** (3): 733, pl. 101, figs. 6, 7, 1898) = *Fraxinus idahoensis* Brown.

Sapindus affinis Newberry? MacGinitie (Carnegie Inst. Washington Pub. **416** (2): 60, 1933) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Sapindus oregonianus Knowlton (U. S. Geol. Survey Bull. **204**: 79, pl. 15, fig. 3, 1902) = *Castanopsis convexa* (Lesquereux) Brooks.

Sapindus oregonianus Knowlton. LaMotte (Carnegie Inst. Washington Pub. **455** (2): 37, pl. 1, figs. 2, 3, 5; pl. 2, figs. 1–4; pl. 3, figs. 2, 4, 5, 1935) = *Cedrela oregoniana* (Lesquereux) Brown, n. comb.

Scale. Chaney (Contrib. from Walker Mus. **2** (5): 181, pl. 22, fig. 5, 1920) = *Libocedrus praedecurrens* Knowlton.

Spathyema? *nevadensis* Knowlton (U. S. Geol. Survey Ann. Rept. **21** (2):

211, pl. 30, figs. 17, 18, 1900) = *Nymphaeites nevadensis* (Knowlton) Brown, n. comb.

Sterculia aceroides Knowlton (U. S. Geol. Survey Prof. Paper **131**: 191, pl. 43, fig. 12, 1923) = *Mahonia marginata* (Lesquereux) Arnold.

Tilia sp. Arnold (Contrib. Mus. Paleont., Univ. of Mich. **5** (8): 94, pl. 5, fig. 1, 1937) = *Tilia aspera* (Newberry) LaMotte.

Tilia oregona LaMotte (Carnegie Inst. Washington Pub. **455** (3): 45, pl. 1, fig. 6, 1935. [*Platanus aspera* Newberry, U. S. Geol. Survey Mon. **35**: 102, pl. 59, fig. 3, 1898]) = *Tilia aspera* (Newberry) LaMotte.

Unknown plant. Knowlton (U. S. Geol. Survey Ann. Rept. **21** (2): 212, pl. 30, figs. 16, 24, 25, 1900) = *Nymphaeites nevadensis* (Knowlton) Brown, n. comb.

ZOOLOGY.—*The histology of nemic esophagi.* VIII. *The esophagus of representatives of the Enoplida.*[1]

B. G. Chitwood, Bureau of Animal Industry, and M. B. Chitwood.

This paper is the eighth of a series (Chitwood and Chitwood, 1934–1936) describing the esophagi of representatives of various groups of the Nematoda. In previous papers representatives of the suborders Rhabditina, Strongylina, Ascaridina, Chromadorina, and Monhysterina have been studied. The present paper deals with representatives of the three suborders of the Enoplida, namely, Enoplina, Dorylaimina, and Diocotophymatina. Of the free-living representatives of this group only *Enoplus*, *Oncholaimus*, *Thoracostoma*, *Cylicolaimus*, and *Dorylaimus* have received any attention by previous authors and even these were not studied from the standpoint of nuclear distribution and nuclear constancy. Among the parasitic forms *Hexamermis*, *Trichuris*, *Trichinella* and *Capillaria* have been studied, but recent observations (Chitwood, 1935) make it necessary to reinvestigate the esophagi of the trichuroids and mermithoids from the comparative standpoint. References to the results of previous authors will be made in the text wherever closely related forms are treated.

The nomenclature and general approach in this paper is the same as that in previous papers and is explained in Part I of the series. As in the sixth paper of the series, data are presented in tabular form, wherever possible, in order to avoid extended descriptions.

Prionchulus muscorum (Mononchidae)

The esophagus of this species is cylindrical, only slightly larger at the posterior end than at the anterior end, and its proximal end surrounds the basal part of the stoma. Grossly, the anterior part differs from the posterior part in being completely muscular, the posterior part containing lobulations of the esophageal glands. The lumen varies with the region of the esophagus but retains a peculiarly modified triradiate character throughout its length.

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[1] Received August 13, 1937.

This is due to 6 thickenings of the esophageal lining which serve as attachment points for the radial muscles.

The esophagus cannot clearly be subdivided into regions homologous with those of rhabditids, but in general the muscular part is comparable to the corpus and the glandular part to the bulbar region. There are 36 radial muscle nuclei arranged in 6 groups, the first and second groups (r_{1-12}) being anterior to the nerve ring, and the fourth, fifth, and sixth groups (r_{13-36}) posterior to the nerve ring. The nuclei of the first two groups are considerably smaller than those of the remaining groups.

There are 9 marginal nuclei arranged in 3 groups, the first group (m_{1-3}) being immediately anterior to the third group of radial nuclei (r_{13-18}), the second (m_{4-6}) lying between the fourth and fifth groups of radial nuclei (r_{19-24} and r_{25-30}) and the third group (m_{7-9}) near the base of the esophagus and near the level of the sixth group of radial nuclei (r_{31-36}).

There are 44 nerve cell nuclei, 25 being situated anterior and 22 posterior to the fourth group of radial nuclei. The peculiarities of the pattern of distribution of nerve cell nuclei are distinctive and, with modifications, characteristic of the Enoplina and close relatives.

Five esophageal gland nuclei are present, 1 (g_1) in the dorsal sector and 2 (g_{2-4}) in each of the subventral sectors. The dorsal nucleus lies anterior to the others, near the fourth group of radial nuclei (Fig. 2) while the subventral nuclei are arranged in tandem and posterior to the fifth group of radial nuclei. Each esophageal gland possesses a separate opening close to the nucleus.

The esophago-intestinal valve consists of a short internal triradiate layer of tissue outside of which there is a circular layer, the whole containing 22 nuclei.

Tripyla papillata (Tripylidae)

The esophagus of this species is cylindrical throughout, terminating in a complex, lobular, esophago-intestinal valve. The stoma is rudimentary, the stomatal region being entirely surrounded by esophageal tissue; the lumen is simple, triradiate, and the lining without thickened attachment points for the radial muscles which are dispersed throughout the sectors rather than concentrated in special areas.

There are 36 radial nuclei, 12 marginal nuclei, 45 nerve cell nuclei, 5 gland cell nuclei and 1 nucleus (s_1) of undetermined character. The relative position of most of the nuclei is essentially the same as in *Prionchulus* except that there are 4 groups of marginal nuclei instead of 3, the fourth group being situated anterior to the first group of radial nuclei; the dorsal esophageal gland nucleus (g_1) is situated posterior to n_{39} in *Tripyla* whereas in *Prionchulus* it is anterior to n_{28}.

The dorsal gland nucleus is the largest nucleus of the esophagus; the gland in which it lies opens through the small dorsal denticle at the base of the stomatal region; throughout the anterior part of the esophagus the gland is small and occupies only a small part of the dorsal sector, but becomes lobed and extensive in the posterior part of the esophagus. The nuclei of the first pair of subventral glands are but little larger than the radial nuclei, and those of the second pair are intermediate in size between the first pair of subventral gland nuclei and the dorsal gland nucleus. The first pair of subventral glands have orifices near the level of the dorsal gland orifice, while the second pair appears to have separate orifices situated near the nerve ring, a short distance anterior to their nuclei; no subventral gland tissue extends anterior to the fifth group of radial nuclei.

The posterior lobed structure (commonly termed the "pseudobulb,") at the base of the esophagus apparently represents an unusual development of the esophago-intestinal valve and does not correspond to the base of the esophagus as commonly supposed. The external, lobed part of this structure contains 7 large nuclei and the internal part of this structure contains about 96 small nuclei; some of these nuclei lie in a triradiate tissue surrounded by the external lobed layer, while the others lie posterior to this structure; the anterior (internal) portion is continuous posteriorly with the intestine. The above-described formation is homologous with the "pseudobulb" of *Trilobus* and does not correspond to the bulbar region of other nematodes.

Prismatolaimus sp. (Tripylidae)

The prismatolaim esophagus resembles that of *Tripyla* in being cylindrical and terminating in a massive esophago-intestinal valve; here, however, the resemblance ceases. There is a well developed cylindroid stoma surrounded only at its base by esophageal tissue, and there are three inconspicuous teeth projecting from the base of the stoma which are very similar to those of the oncholaims. The lumen is simple, with very faint indications of terminal dilation of the radii; the lining is unmodified but the radial muscles are concentrated rather than dispersed as in *Tripyla.*

The radial nuclei (30 in number) as well as the marginal and nerve cell nuclei are arranged in a pattern somewhat closer to that found in *Eurystomina* than to that occurring in any other form. The five subequal esophageal gland nuclei are located in the posterior part of the esophagus, and a gland duct extends anteriad through the center of each sector to the anterior end where each opens into the stoma through an orifice in the corresponding tooth. Orifices of the second pair of subventral glands, if separate from the first pair, are probably situated near the nerve ring.

The esophago-intestinal valve is triradiate, massive and apparently contains 13 nuclei.

Aliamus sp. (Alaimidae)

The esophagus of this form consists of a rather elongate anterior part and a moderately short, wide, glandular posterior part. Since the stoma is rudimentary, the stomatal region is surrounded by esophageal tissue. A complete enumeration of the nuclei was not possible. There are 5 subequal esophageal gland nuclei, the nucleus of the dorsal gland being slightly larger than the nuclei of the subventral glands; the orifice of the dorsal gland is situated at the base of the stomatal region while those of the subventral glands are in the posterior part of the esophagus. The radial muscles are concentrated but no attachment points are present. The esophago-intestinal valve is short, triradiate, and appears to contain 9 nuclei.

Metoncholaimus pristiurus (Oncholaimidae)

The esophagus of *Metoncholaimus pristiurus* is cylindrical, and esophageal tissue surrounds only the base of the stoma. Grossly, the anterior and posterior parts of the esophagus are very similar; the part of the esophagus anterior to the nerve ring is uniformly muscular while in the part posterior to the nerve ring the muscle tissue is broken up to a slight extent by lobulations of the esophageal glands. The lumen is simple, closed and triradiate throughout, and the cuticular lining is thin and without modified regions for the attachment of muscles.

There are 12 marginal nuclei arranged in 4 groups of 3 nuclei each, this distribution being similar to that in *Tripyla* except that the third group of marginals is between the third and fourth groups of radial nuclei instead of between the fourth and fifth groups of radials as in *Tripyla*. The radial nuclei are only 27 in number; they are arranged in 4 groups of 6, and 1 group of 3 radial nuclei each. The first three groups undoubtedly correspond to the first 3 groups of radial nuclei in other forms; the fourth group corresponds to the fifth group in other forms. The last group (r_{25-27}) is composed obviously of giant nuclei resulting from the failure of one nuclear division (Fig. 2). There are 43 nerve cell nuclei which correspond in general to the nerve cell nuclei described in previous forms; the chief differences from forms such as *Tripyla* is that there is 1 additional nucleus (n_{43}) in the mid-dorsal row an-

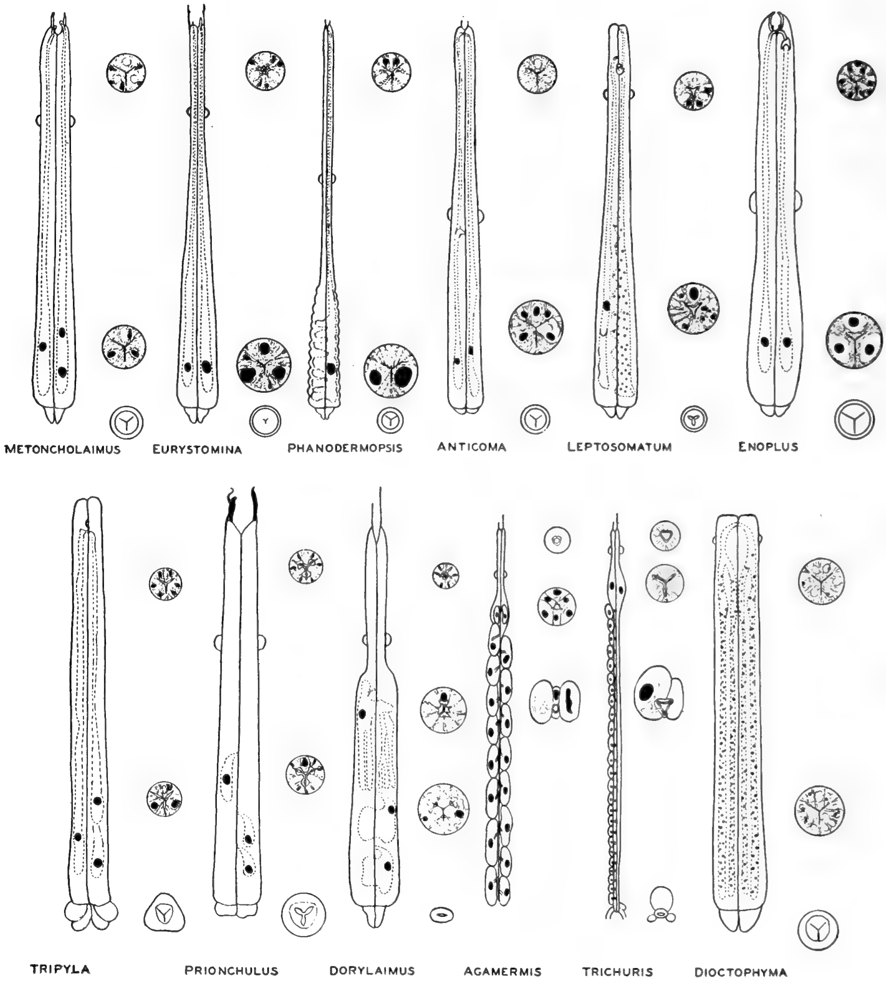

Fig. 1.—Diagrams of esophagi in the Enoplida.

terior to the peculiar dorsal group (n_{29-32}) and there are 2 less subdorsal nerve cell nuclei at the posterior end of the esophagus (n_{43-44} of *Tripyla*).

Three esophageal glands open into the stoma through the 3 teeth. From their orifices posteriorly, each gland is represented by a small strand of tissue containing the duct in the center of each sector extending approximately to the level of n_{30-31}; posterior to this level they become branched and enter other intermuscular regions of the sectors. Rauther (1907) described *Oncholaimus* sp. (?*vulgaris*) as having 5 esophageal glands, 1 dorsal, 2 lateral, and 2 ventral. The lateral glands according to Rauther, open into the lumen some distance from the anterior end of the esophagus. In *Metoncholaimus pristiurus*, however, the present writers observed 1 dorsal and 4 subventral glands, all 5 nuclei being approximately the same size. In so far as the writers have been able to observe, the 2 subventral glands of each sector have but 1 orifice and their cytoplasm is continuous. If additional orifices are present, they are probably situated near the subdorsal margins of the subventral sectors near n_{30-31}.

The esophago-intestinal valve is elongated, triradiate and consists of an internal trilobed layer containing radial fibers, and a double external layer of circular fibers; the whole is inclosed in a trilobed mass of tissue. The nuclei are numerous (number not determined). A single large nucleus, similar to those of the radial muscle tissue of the esophagus, is situated at the junction of the esophagus and the esophago-intestinal valve.

Eurystomina americana (Oncholaimidae)

The esophagus of this species is of the type generally termed "conoid"; the anterior end is narrow and muscular, gradually increasing in diameter posterior to the nerve ring, the posterior third being wide, glandular, and cylindrical. The lumen is simple, triradiate, but the esophageal lining carries paired cuticular thickenings in the form of attachment points for the radial muscles; these thickenings, similar to those of *Prionchulus*, *Dorylaimus*, *Ironus* and *Cryptonchus*, extend from the anterior end of the esophagus to a short distance posterior to the nerve ring or approximately to the beginning of the glandular part of the esophagus.

The number (12) and arrangement of marginal nuclei is like that in *Tripyla* and *Oncholaimus*. There are 44 nerve-cell nuclei as in *Tripyla* and *Prionchulus*, the first 28 of which are arranged as in those forms, while the remainder differ in many respects in their distribution. Only 30 radial nuclei are present, these being arranged in 5 groups of 6 each. Only 3 nuclei have been identified with certainty as belonging to the esophageal glands; all three of these nuclei are gigantic, the right subventral being considerably larger than the other two. All three glands open through teeth into the cavity of the stoma, the right subventral tooth, like the right subventral gland, being much larger than the other two. In some series there appear to be 2 additional small subventral gland nuclei situated anterior to the large ones.

The esophago-intestinal valve contains only 8 nuclei; the anterior part is triradiate in cross section while posterior part is dorso-ventrally flattened.

Enoplus communis v. *meridionalis* (Enoplidae)

The esophagus of *Enoplus* is cylindrical, slightly enlarged posteriorly, and shows moderate "vesiculation" in the glandular region. Since the stoma is reduced—the stomatal region being indicated by the large bifurcate teeth—this region is entirely surrounded by esophageal tissue. The lumen is simple and the esophageal lining unmodified (i.e., without cuticular thickenings) throughout the length of the esophagus.

There are 12 marginal nuclei, arranged approximately as in *Tripyla.* Only 33 radial muscle nuclei are present and of these the first 30 comprise the first 5 groups of radial nuclei which correspond to the first 5 groups of *Tripyla,* while the last group of 3 nuclei (r_{31-33}) apparently represents the 6 nuclei (r_{31-36}) composing the sixth group of radial nuclei in that form. The nerve cell nuclei, 44 in number, correspond to the 44 nerve cell nuclei of *Prionculus* and *Tripyla,* but their arrangement differs considerably. There are 3 large similar esophageal-gland nuclei (gl_{4-5}) and 2 smaller subventral gland nuclei (g_{2-3}). Just posterior to the latter an additional pair of ventrolateral nerve cell nuclei (s_{1-2}) are present.

The three large esophageal glands have their orifices at the base of the teeth as Rauther (1907) has already shown in *Enoplus* sp. The vesiculate appearance of the esophagus when viewed in toto is due to the separation of radial muscle fibers by gland tissue. The cytoplasm of the glands is relatively greater in proportion to the muscular tissue than in any of the forms previously described.

The esophago-intestinal valve is short, consisting of an internally trilobed and an externally circular part; the entire valve contains 12 or 13 nuclei (actual number not ascertainable).

Anticoma litoris (Enoplidae)

The esophagus of *Anticoma* is cylindrical and similar to that of *Enoplus;* the anterior part surrounds the stomatal region. Since all of the nuclei have their homologues in *Enoplus,* they are arranged in a practically identical pattern (Fig. 2) and further description seems unnecessary. The gland orifices all appear to be situated at the anterior end of the esophagus, the 2 small subventral glands ending in the marginal regions of the dorsal sector. The esophago-intestinal valve is like that of *Enoplus.*

Rhabdodemania minima (Enoplidae)

The esophagus of *Rhabdodemania* is also like that of *Enoplus,* except that the orifice of the dorsal gland is some distance from the anterior end of the esophagus; the small subventral glands (g_{2-3}) extend nearly to the anterior end as in *Anticoma,* and the large subventral glands (g_{4-5}) have swollen ampulla near the level of their orifices.

Leptosomatum elongatus v. *acephalatum* (Enoplidae)

The esophagus of *Leptosomatum* is grossly conoid, of smooth contour and internally vesiculate. The lumen is simple, triradiate, and the lining thick but unmodified. The relative proportions of muscular and glandular tissue give to the esophagus a consistency somewhat like that observed in *Eurystomina* or *Enoplus.*

There are 2 groups of 3 marginal nuclei, 3 groups of 6 radial nuclei and 18 nerve cell nuclei anterior to the nerve ring as in *Eurystomina* and *Enoplus.* Posterior to the nerve ring nuclear identification becomes extremely difficult due to a great increase in the number of these structures, there being approximately 105 nuclei in the remainder of the esophagus. The ventral gland nuclei have apparently undergone multiple division, since nuclei lie in all possible positions and have little or no definite arrangement. The numerous small nuclei extend into the dorsal as well as the subventral sectors, although the dorsal gland nucleus has retained its individuality. There is no evidence of atypical division such as nuclear budding, for the small nuclei are all of about equal size. The subventral esophageal gland orifices are near the anterior end of the esophagus while that of the dorsal gland is situated somewhat posterior.

Leptosomatum is provided with pigment spots or "ocelli" which are generally considered to be situated dorsal to the esophagus; the spots are acorn-shaped and contain a distinct lens. Schulz (1931) described such ocelli in *Parasymplocostoma formosum*, stating that the lens is a continuation of the external cuticular covering of the body and that the presence of a special cell lying outside of the esophagus is responsible for this formation. In the present form, such is not the case. The pigment spot and lens form a swelling in the wall of the esophagus and are clearly of esophageal derivation. This is a peculiar situation in the origin of photoreceptors, if such they be, and supplies definite evidence of the homology of this type of ocellus with the pigment spots of forms such as *Enoplus*.

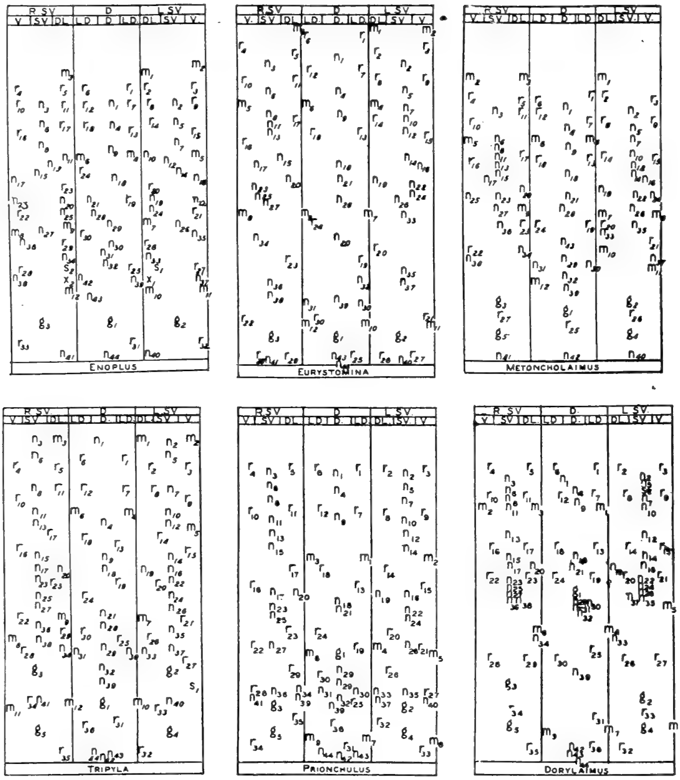

Fig. 2.—Tables of nuclear distribution in the Enoplida.

Cryptonchus nudus (Ironidae)

The esophagus of *Cryptonchus* grossly resembles that of *Dorylaimus* since it is clearly divisible into a narrow anterior muscular part and a wide posterior glandular part. The long cylindrical stoma is surrounded by esophageal tissue throughout its length and the esophageal lining has marked attachment points for the concentrated radial muscles except in the basal region. The esophageal nuclei seem to follow the pattern seen in *Prionchulus* more closely than to any of the other enoploids, but the dorsal gland nucleus is situated near the level of g_{4-5} instead of being far anterior as in *Prionchulus* and *Dorylaimus.* Apparently the glands have orifices in the posterior part of the esophagus since no tubes extending anteriorly were observed. The rather thick esophago-intestinal valve is very well developed, triradiate, and consists of an anterior part which contains at least five nuclei of obvious esophageal origin followed by a posterior part (cardiac column) containing about 35 nuclei and apparently represents a differentiated region of the intestine.

Ironella prismatolaima (Ironidae)

The esophagus and stoma of *Ironella* are both cylindroid, the latter being surrounded by esophageal tissue and the stomatal region set off from the remainder of the esophagus as a distinct enlargement. The esophageal lining has large thickened attachment points for the radial muscles. The nuclear arrangement is apparently like that of *Cryptonchus,* and the 5 esophageal gland nuclei are subequal but the glands extend anteriorly through the stomatal region nearly to the base of the three bifurcate teeth.

Ironus ignavus (Ironidae)

This form appears to be somewhat intermediate between *Cryptonchus* and *Ironella,* having the gross morphology of *Cryptonchus* but the teeth of *Ironella;* the esophageal glands have orifices anterior to the base of the stomatal region, the subventrals opening near the teeth and the dorsal about midway between the teeth and base of the stoma.

Phanodermopsis longisetae (Enoplidae)

The general outline of the esophagus of *Phanodermopsis,* like that of *Eurystomina,* is of the type described as "conoid," but unlike the latter the margin of the posterior part of the esophagus is "crenate." The crenate appearance is due to development of the esophageal glands and reduction in the relative amount of muscular tissue, the strands of which are set off in relief causing the illusion of cells. The lumen is usually open toward the margins; the esophageal lining is simple.

The nuclear arrangement anterior to the nerve ring in this form appears to agree with that of *Enoplus,* except that the fourth group of radial nuclei is anterior to n_{12-13} instead of posterior to n_{26-27} as in *Enoplus.* Posterior to the nerve ring the number and distribution of nerve cell nuclei and marginal nuclei appear to be as in *Enoplus,* while there is a fifth group of 6 radial nuclei near the level of n_{37-38} (not far from the position of the fourth group of radial nuclei in *Enoplus*), and there appears to be 2 groups of 3 radial nuclei, or a complete sixth group, instead of 1 group of 3 radial nuclei (the diminished sixth group in *Enoplus*) near the posterior end of the esophagus. There are 2 extremely large subventral gland cell nuclei situated not far from the posterior end of the esophagus. Near the anterior end of the glandular region in the dorsal sector there are three bands of tissue each containing a nucleus; these probably are the dorsal and small subventral (g_{2-3}) gland nuclei which in this case have moved to the dorsal sector.

The subventral esophageal glands extend to the anterior end of the esophagus where they open directly into the lumen. The glandular tissue of the dorsal sector stains very intensely with hematoxylin, and near the level of m_{7-9} the tissue is distinctly subdivided into a dorsal and 2 subdorsal marginal lobes, each of which may represent a separate gland. While no orifice has been observed, it is certain that no glandular material extends anterior to n_{30} in the dorsal sector.

The esophago-intestinal valve is short, internally triradiate and externally circular, the whole containing 8 nuclei.

Soboliphyme baturini (Soboliphymatidae)

The esophagus of *Soboliphyme* is cylindrical and without subdivisions. Since there is no stoma, the anterior end of the esophagus projects slightly into the muscular oral sucker. The esophageal lumen is simple and triradiate throughout its length. The orifices of the three esophageal glands are situated at the extreme anterior end of the esophagus. From each of these orifices a short terminal cuticle-lined duct extends to a short distance posterior to the nerve ring where it bifurcates. Each branch is thick-walled and lined by a peculiar fibrillar layer which is apparently composed of "cilia." Still further posteriad the "cilia" disappear and the branches further subdivide until there may be as many as six parallel tubes in each sector of the esophagus. At times some of the tubules end blindly, while others divide. As a rule, the outer or most marginal tubules in each sector are the ones which terminate blindly while the others continue. There is little difference in the appearance of the glands except near the base of the esophagus. At this point the protoplasm of the dorsal gland tubules is reticulate and the lumen may contain a reticulated mass; the subventral gland tubules appear to have acidophilic granules imbedded in the tubule wall and the protoplasm is more dense than that of the dorsal gland tubes.

Exact information cannot be given regarding the nuclei of the esophagus since only one complete series of sections was available for study, and in places these sections may not have been correctly placed. However, the esophageal glands are multinucleate, each gland containing several hundred nuclei scattered throughout the length of the esophagus. The radial nuclei are in groups of 3, there being 2 groups anterior to the nerve ring and 5 or more groups posterior to that region. The marginal nuclei are likewise arranged in groups of 3. Between the second radial group and the first marginal group of nuclei 11 nerve cells were observed. The determination of other nuclei was difficult because of the great number of esophageal gland nuclei which obscured the picture. The esophago-intestinal valve is triradiate.

Other dioctophymatids

Dioctophyma renale, Eustrongylides ignotus and *E. perpapillatus*, none of which has an oral sucker, were all studied in comparison with *Soboliphyme*. The esophagus of *Dioctophyma* is similar to that of *Soboliphyme* except that no "cilia" were observed in the esophageal gland ducts. The dorsal gland ducts, after their primary bifurcation, were never seen to subdivide though every section in an incomplete series of 2000 sections was studied. The esophagi of *Eustrongylides ignotus* and *E. perpapillatus* were also studied in incomplete series, the findings agreeing with those in *Soboliphyme* except that no cilia or granules were observed in the gland tubules. The tubule branching occurs in all three glands and only the outer or marginal tubules in each sector terminate blindly. Slides of these forms always show a marked differential staining of the glands, the dorsal being acidophilic and the subventrals basophilic. This is particularly marked when stained in a Mallory triple stain, the subventrals being orange or red, the dorsal blue. Subventral gland tubules entering the dorsal sector were only observed in *Dioctophyma* but whether or not this occurs in *Soboliphyme* or *Eustrongylides* is not known; no such case has been observed.

Unfortunately our observations of the esophagi of this particular group, the Dioctophymatina, are not so complete as might be desired. Nevertheless it does serve further to indicate the possible relationships of the forms. In this connection, it may be noted that the dorsolateral mesenteries of the intestinal region begin anteriorly as a single ventral mesentery from the esophagus, which splits before reaching the body wall subventrally. Gradually as one traces the mesentery posteriad the split becomes wider, the single mesentery ultimately forming two subventral mesenteries, two ventrolateral, two lateral, and finally, two subdorsal.

Dorylaimus obtusicaudatus (Dorylaimidae)

The esophagus of this species consists of a short narrow anterior muscular part and a long wide posterior glandular part. There is no distinct stoma in the sense that this structure is present in *Prionchulus*, it having been replaced by a well developed stylet. The stylet is joined at its base with the cuticular lining of the anterior end of the esophagus. The lumen of the esophagus is at first open, wide, and subtriangular (see Chitwood, 1931, fig. 22, No. 5), gradually becoming smaller, the esophageal lining thicker (Chitwood, loc. cit. Nos. 6–7) and with radial thickenings similar to those present in *Prionchulus*. These thickenings are largest in the posterior part of the narrow muscular region but continue throughout the remainder of the esophagus.

There are 36 radial muscle nuclei arranged in 6 groups as in *Prionchulus;* there are 9 marginal nuclei, also arranged as in *Prionchulus;* comparison with the latter form indicates that in *Dorylaimus* n_{28}, $_{30}$, and $_{41}$ are absent, but it may be that they are merely obscured by glandular tissue. It may also be noted that the group n_{29-32} is more compact than in other forms. A nucleus (st) not present in other forms, is characteristic of the Dorylaimidae. This nucleus, situated in the anterior muscular part of the esophagus is that of the formative or generative cell of the stylet.

Four well developed esophageal gland nuclei, 1 in the dorsal sector (g_1), 2 in the left subventral sector (g_2 and g_4) and 1 in the right subventral sector (g_5), are present. The other esophageal gland nucleus (g_3) is much smaller than the former and easily overlooked. The dorsal gland nucleus lies relatively much farther forward than in *Prionchulus*. Each gland has a separate orifice situated near the level of its nucleus. The dorsal gland is very much lobed and branches of it enter into all sectors of the esophagus. The subventral glands, on the contrary, remain within their sectors and their tubules are relatively smaller.

The esophago-intestinal valve is elongate, dorso-ventrally flattened and contains about 27 nuclei.

Other dorylaimoids

The esophagi of such forms as *Actinolaimus*, *Leptonchus* and other close relatives of *Dorylaimus* appear to be histologically identical to that of the latter form, while that of *Triplonchium* differs considerably. The short bulbar region in *Triplonchium* is literally packed with nuclei, presumably because all of the nuclei of the more elongated glandular region of *Dorylaimus* are concentrated in less space. The dorsal gland nucleus and those of the first pair of subventrals are subequal in size and smaller than those of the second pair of subventrals. The esophageal lining appears to be simple, unmodified, but this may be due to its extreme minuteness.

Agamermis decaudata (Mermithidae)

The esophagus of *Agamermis decaudata* undergoes considerable transformation during its development. In order to understand satisfactorily the esophagus of the later parasitic stages and adults a brief résumé of the earlier stages is necessary.

Christie (1936) described the morphology of the various larval stages of *A. decaudata* and the essentials of this description are as follows: In the preparasitic larva the digestive tract consists of a stylet followed by the esophagus and intestine. The anterior part of the esophagus is narrow, muscular, surrounded near the middle of its length by the nerve ring; the narrow anterior part is followed by a short elongated muscular swelling posterior to which there is a long glandular region. In the latter region the esophagus proper is very narrow and surrounding it are three large elongated esophageal glands and 2 rows of 8 smaller cells, the stichocytes. The largest gland is unicellular, right subdorsal in position, and extends from the esophageal swelling to the base of the esophagus; the two unicellular subventral esophageal glands are left subventral in position and extend posteriorly from the esophageal swelling to about $\frac{1}{4}$ the length of the glandular part of the esophagus; the stichocytes extend from slightly anterior to the base of the subventral glands to the posterior end of the esophagus. At this time the intestine does not extend anterior to the base of the esophagus.

Shortly after entrance into the host the three esophageal glands become atrophied while the stichocytes become larger and the intestine begins growing anterior to the base of the esophagus.

The present study was based on partially grown parasitic larvae about 5 mm long (approximately 1 to 2 days in host) at which stage the external cuticle is still thin, though otherwise the larvae is in much the same condition as it is at the time of its emergence from the host.

At this stage the esophagus is no longer distinctly muscular in any region, the elongated swelling posterior to the nerve ring has disappeared, and the trophosome extends anteriorly nearly to the level of the anterior esophageal glands. The stichocytes are large, forming a double row of elongated cells with their ends touching one another.

Anterior to the nerve ring the lumen is internally hexagonal, the lining thick and externally rounded to subtriangular in cross section. There is a group of 9 small nuclei near the oral opening, which appear to be radial or marginal in character. The surrounding esophageal tissue is spongy, without apparent symmetry. Posterior to these nuclei, there are 12 large rather irregularly arranged nuclei (r_{1-12}) anterior to the nerve ring. Between the nerve ring and the orifice of the dorsal esophageal gland the esophageal nuclei, lining, and general structure are like that part anterior to the nerve ring. In this region 15 large nuclei (r_{13-37}) and at least 5 nerve cell nuclei (n_{1-5}) are present. The region of the esophageal glands contains 4 nerve cells (n_{6-9}) and 3 large nuclei (r_{28-30}) in addition to the 3 gland nuclei (g_{1-3}). Each gland has at least 1 distinct orifice, sometimes several.

Posterior to the gland nuclei (g_{1-3}), the chief part of the esophageal tissue containing the esophageal lumen is flattened between the two large rows of stichocytes. The tissue surrounding the lumen (which corresponds to the ordinary muscular and fibrous parts of the esophagus) contains 18 large nuclei (r_{31-48}) and 2 nerve cell nuclei (n_{11-12}) between the beginning of the stichosome and the posterior end of the esophagus. The esophageal lumen in this region varies in shape but is for the most part rounded; the esophageal lining is thin and without evidence of triradiate or hexaradiate structure.

Each stichocyte is a large unicellular gland having 1 distinct orifice from which a wide irregular tubule extends into the cell where it branches into many smaller tubules. Posteriorly the esophageal lumen ends blindly in a mass of fibrous esophageal tissue and apparently is without direct connection with the intestine or trophosome. Several minute nuclei present in this region may correspond to the nuclei of the esophago-intestinal valve of other nematodes.

Discussion.—The fact that the 3 primary esophageal glands are highly developed in the preparasitic larva and undergo atrophy after entrance into the host indicates that they probably function during penetration into the host. The hypertrophy, during larval development, coincides with the time in parasitic life at which most rapid development takes place and, these glands are considered as being the chief digestive glands during this stage of of life. When the larva reaches maturity the stichocytes undergo reduction in size, and in the adult stage, when no nourishment is taken in, their pores are no longer apparent.

Regarding the number and arrangement of non-glandular nuclei, it may be pointed out that the number of large nuclei (r_{1-48}) corresponds with the total number of radial and marginal nuclei in *Dorylaimus* but the observed number of nerve cells (n_{1-12}) and nuclei of unknown nature (the possible nerve cell nuclei (s_{1-9})) is much smaller. Perhaps some of the nuclei were overlooked, or perhaps the decreased number may have been due to degeneration. Since radial and muscular fibers are only represented by a spongy network in the parasitic stage studied, normal function of the esophagus as a sucking organ is impossible; hence, nerve cells would be of little benefit in coordinating muscular activity.

Trichuris ovis (Trichuridae)

The esophagus of *Trichuris* consists of an anterior part (corpus) and a greatly elongated posterior part (bulbar region) embedded in a series of gland cells, the stichosome. The anterior part is divisible into sections, the first part being entirely muscular, narrow, slightly constricted at the nerve ring and the second part glandular and rather wide. The lumen of the entire corpus is definitely triradiate, without special modifications. A group of 3 minute nuclei (s_{1-3}) and a group of somewhat larger nuclei (c_{1-3}) are situated anterior to the nerve ring. The esophagus gradually becomes larger in diameter posterior to the nerve ring and a group of 3 marginal nuclei (m_{1-3}) is followed by a group of 6 radial nuclei (r_{1-6}). The first glandular substance makes its appearance in the esophagus just posterior to the radial nuclei. Between this level and the beginning of the stichosome 2 additional groups of 3 radial nuclei (r_{7-9}) (r_{10-12}), 6 smaller nuclei (s_{4-9}), and 3 large gland cell nuclei (g_{1-3}) are situated. In one of the 6 series studied a fourth gland cell nucleus, slightly smaller than the others, appeared to be present. The esophageal gland nuclei (g_{1-3}) extend anteriorly to within about 50μ of the beginning of the enlarged portion of the corpus. Sometimes what appeared to be orifices were observed near this level but it cannot be definitely stated that what was observed were actually orifices of the esophageal glands. There was no evidence that any ducts extend anteriorly beyond this level.

In the posterior or stichosome region the esophagus is embedded in a single row of large subcylindrical cells or stichocytes. The lumen varies from subtriangular to triradiate to hexaradiate. The wall and external covering of the esophagus both retain their identity throughout the stichosome region. Large and small nuclei are present within the wall, the large nuclei corresponding to the radial nuclei of the anterior part of the esophagus and the small nuclei possibly corresponding to the s or c types or nuclei of the esophagus of other forms. Contrary to the general opinion, the esophagus is muscular and capable of dilation and contraction throughout its length. In areas close to the large radial nuclei only sarcoplasm is present but further distant, where the nucleus would not interfere with muscular activity, well developed radial fibers may be demonstrated by proper staining.

The numerous large stichocytes forming the stichosome or "cell body" are actually esophageal glands. Each cell has a duct through the wall of the esophagus to the lumen and this duct branches into many tubules within the cell. The orifices of the stichocytes alternate, one entering from the left subventral side, the other from the right subventral side, etc. The stichocytes are more numerous in *Trichuris* than in *Agamermis,* and apparently their number may vary within a limited range.

Posteriorly the esophagus joins the intestine through a dorsoventrally elongated esophago-intestinal valve. The most distal stichocyte often protrudes posteriorly past the beginning of the intestine, and at the same level 2 large cells (cc.) are attached to the esophagus and intestine. The nature of these cells is not known; they do not appear to be in intimate protoplasmic connection with the intestine, esophagus, or stichosome, and stain differently from all three of these structures; it is suggested, without great conviction, that these cells may be coelomocytes.

Discussion.—Ward (1917) divided the Nematoda into two groups, Myosyringata and Trichosyringata, assuming for the latter group, which included *Trichuris* and *Mermis,* a fundamentally peculiar esophagus formed as an intracellular tube. However, Chitwood (1930) has pointed out that the esophagi of *Trichuris* and *Trichinella* are triradiate and not intracellular tubes as stated by previous writers.

Concerning the nature of the stichosome or cell body, Rauther (1918) considered the stichocytes as gland cells and observed orifices of the first 2 or 3, but no orifices thereafter. Chitwood (1930) overlooked the orifices of these glands and considered the stichosome as an outgrowth of the intestine. G. W. Müller (1929) and Christenson (1935) considered the stichocytes as intimately connected with the hypodermis. Later Chitwood (1935) corrected these errors, finding the stichocytes to be esophageal glands. Additional intraesophageal glands are described here for the first time.

As regards the nature of feeding trichurids, the following are several points of interest:

(1) Fülleborn (1923) described a stylet in the larvae of *Trichuris* and Li (1933) observed this structure in adult *Trichuris.* This point has been verified by the present writers. Stylet bearing nematodes usually feed by pressing the head against a membrane, protruding the stylet through the membrane and sucking the material through the stylet into the esophagus.

(2) The esophagus in trichuroids always has a well developed anterior muscular part and in this paper it has been shown that muscles capable of the dilation necessary for sucking are present in the posterior part.

(3) Both Müller and Christenson regarded the stichosome a hypodermal development, which is contrary to our observations. Müller considered the bacillary bands as regions of "feeding pores," while the present writers agree with Jägerskiöld (1901) in classifying them as hypodermal glands.

Christenson is of the opinion that the stichosome is a hypodermal development since he states: "The writer . . . is of the opinion that they (the stichocytes) originate from the hypodermis since in *Capillaria aerophila* they are intimately connected with that layer. It seems possible that during the development the alimentary canal first forms and specializes into its component parts. As the epithelogenous muscles develop the muscle fibers arise in the subcuticular portion of the hypodermal cells, and the nucleus and cell body are 'pushed' toward the center of the worm where they enlarge and surround the esophagus, all the while maintaining their relationship with the hypodermis through anastomising processes. In this fashion their origin would be somewhat similar to that of the esophageal glands which are formed in many nematodes." The supposed connection between the stichosome and bacillary band, namely the mesenterial tissue is *isolation tissue* and belongs to neither the esophagus nor the body wall, but is mesenchymatous in origin (see Chitwood & Chitwood, 1937) and contains its own nuclei; furthermore, as shown by Martini (1903–1910) the musculature is not epithelogenous but *mesodermal* and finally, the esophageal glands of nematodes are formed from the stem cell and may in development leave the esophageal wall, but they are always in the esophagus at the time the esophageal primordium is laid down.

(4) Several investigators, including Guiart (1908) found blood engorged specimens of *Trichuris*, while G. W. Müller (1929) considered the esophagus as non-functional; apparently Müller was unaware of previous reports. G. G. Smirnov (1936) after a comprehensive survey of the literature concluded that there was no convincing evidence that trichuroids feed on blood; he was also unable to obtain such evidence from sectioned material. In one series of sections studied by the present writer red corpuscles were numerous in the esophageal lumen, a total estimated at about 700; this observation confirms the findings of Guiart.

These above facts together with the extreme minuteness of the esophageal lumen indicate that *Trichuris* is possibly an obligatory hematophagous animal; this is supported by the reports of Whipple (1909) and of Garin (1913) of the occurrence of *Trichuris* of hemolytic enzymes.

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ENTOMOLOGY.—*The beetles of the subfamily Chasmatopterinae in the New World (Coleoptera: Scarabaeidae).*[1] Lawrence W. Saylor, Bureau of Biological Survey. (Communicated by E. A. Chapin.)

According to the Junk and Leng Catalogues the tribe Chasmatopterini includes seven genera, four of which are listed from the United States. Present studies, however, indicate that of these four genera, one (*Oncerus*) belongs near the subfamily Aclopinae because of the presence of the exposed labrum, which is foreign to the rest of the Melolonthinae; a second (*Podolasia*) is very different in general habitus and does not belong here, as is explained more fully below; the third (*Pseudacratus*) is a synonym of the fourth (*Chnaunanthus*) and

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[1] Received October 5, 1937.

the latter then is the only representative of this group in the New World.

I have seen but three examples of *Podolasia*, one in Mr. E. G. Linsley's collection from Brownsville, Texas, and two in the United States National Museum from "Ft. Ringgold (May and June)," and from "near Hansville, base of Henry Mts., Utah, June, E. Bowles collector." Although the mouthparts and connate abdominal segments appear to place this genus with the Chasmatopterinae the general habitus and the remaining morphological features are radically different and prevent its inclusion in this subfamily. Until specimens can be dissected, the exact place of the genus in the scheme of classification must remain in doubt. It is quite probable, however, that *Acoma* will be its nearest relative.

Oncerus belongs near the Aclopinae, and a paper on the species of this and a related new genus is about ready for publication.

While the Chasmatopterinae is listed in our catalogues as a tribe under the subfamily Melolonthinae, a careful examination of the characters forbids its placement with that group. All species of the Melolonthinae proper have at least the last two or three spiracles in the chitinous abdominal plates while the present genera, *Chnaunanthus* and *Chasmatopterus* (as well as *Oncerus*) have the spiracles entirely in the membrane, and therefore are more closely related to the Glaphyrinae, Pleocominae and others. These cannot be placed with *Acoma* of the Pleocominae which also has the spiracles in the membrane because of many differences: the labrum is small but near the clypeal apex in the Chasmatopterinae, but very small and far back from the apex in *Acoma;* the antennae are of entirely different conformation in the former, being very short and with the small, oval club composed of segments capable of fitting one into another, and the club is much shorter than the funicle, while the latter (*Acoma*) has the antennae quite long, much longer than the funicle and the segments are not capable of folding one into the other; also, the abdominal segments in the Chasmatopterinae are connate with the sutures nearly or entirely effaced, while *Acoma* has entirely free ventral abdominal segments and the sutures are quite obvious. Other characters of less importance but much supplementary value are the cleft tarsal claws, small eyes, and diurnal habits of *Chnaunanthus* as opposed to the entirely simple claws and the very large eyes, fitted for nocturnal life, of *Acoma.*

Many characters, such as the position of the spiracles, and especially the absence of the large exposed mandibles and labrum prevent the placement of the Chasmatopterinae with either the *Glaphyridae spuriae* of Burmeister or the Aclopinae, so that a separate subfamily is necessary for its reception. This new subfamily may be called the Chasmatopterinae, and is characterized by the position of all the spiracles in the abdominal membrane, the hidden labrum and small concealed mandibles, the cleft tarsal claws, the small oval antennal club and the semiconnate or connate ventral abdominal segments.

The genus *Chnaunanthus*, our sole representative of the subfamily, is represented by three species, one of which is here described as new. In contrast to the published statements of authors that in this group there is no front tibial spur I wish to point out that such is almost always present in the female, and *may* be absent in the male. It is more likely that it is so fragile as to be readily lost through wear. In *Chasmatopterus* the front tibial spurs are usually present and conspicuous.

The two common genera of the subfamily may be more completely separated as follows (I have not seen specimens of the remaining two genera in the subfamily, the African *Microdoris* Burm., and the Chinese *Diphycerus* Fairm.):

Front inner tarsal claw of male deformed, the outer as in the remaining claws on the other legs; front femora bidentate; labrum in lateral view very conspicuous, especially in ♀; front tibial spur always large and conspicuous. (European.) .... *Chasmatopterus*

Front inner claw of male not deformed, of the same size and shape as the remaining claws; front femora tridentate; labrum in lateral view very small and hardly noticeable; front tibial spur usually lacking. (American.) .... *Chnaunanthus*

Dr. E. A. Chapin of the National Museum has made helpful suggestions in the present studies, and the author also wishes to thank him for the loan of material.

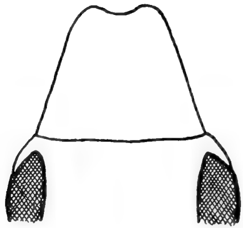
CHNAUNANTHUS

Chnaunanthus Burmeister, Hand. Ent. **4**: 31, 1844.—Lacordaire, Gen. Col. **3**: 221, 1856.—Bates, Biol. Cent. Amer., Col. **2**(2): 130, t. 8, f. 2.—Dalla Torre, Coleop. Cat. **45**: 7, 1912.

Acratus Horn, Trans. Amer. Ent. Soc. **1**: 165, f. 1, 1867.—Dalla Torre, Coleop. Cat. **45**: 7, 1912.

Pseudacratus Dalla Torre, Coleop. Cat. **45**: 7, 1912.

Oblong-oval, little wider behind, polished, pilose above. Ligula separate from mentum. Antennae 9-segmented; club 3-segmented, short and oval. Front coxae conical. Front femora tridentate. Tarsi with all claws cleft, the upper tooth noticeably shorter; tarsi noticeably longer than the tibiae, the latter usually strongly spinose. Head slightly longer than thorax; clypeus convergent anteriorly. Thorax slightly subangulately rounded at sides, margins ciliate. Elytra not quite twice as long as thorax. Pygidium usually hidden from above. Abdominal segments closely connate, sutures barely visible in the male and apparently absent in the female. Male abdomen in lateral view concave, that of female convex.



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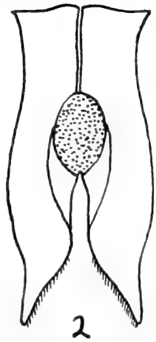

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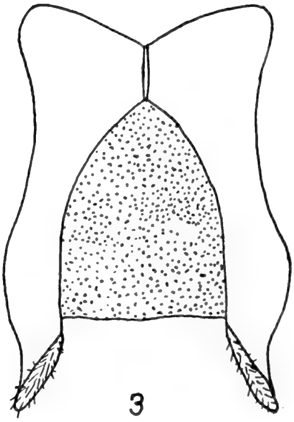

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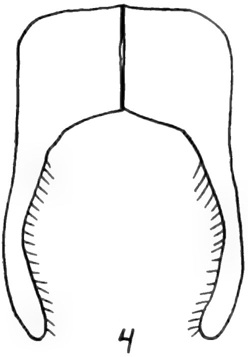

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Fig. 1.—Head of *Chnaunanthus flavipennis*, showing clypeal shape. Fig. 2.—Male genitalia of *Chnaunanthus chapini*. Fig. 3.—Male genitalia of *Chnaunanthus discolor*. Fig. 4.—Male genitalia of *Chnaunanthus flavipennis*.

KEY TO THE SPECIES

1. Hind angles of the thorax broadly rounded, not at all subangulate; clypeus wider than long but not distinctly so, the apex always deeply emarginate; female pygidium with two longitudinally-impressed subapical foveate areas before apex and these often converging, forming a U-shaped sulcus. (Utah and Arizona.) . . . . *flavipennis*

   Hind angles of thorax rounded but subangular; clypeus usually noticeably wider than long; apex of clypeus often but little emarginate; female pygidium not as above *2*

2. Pygidium of male longer than wide, very densely hairy all over; female pygidium usually noticeably concave at apical fourth, always densely hairy all over. (Mexico.) . . . . *discolor*

   Pygidium of male wider than long, moderately hairy at base, subglabrous apically; female pygidium flattened, with no trace of any apical sulci, moderately densely hairy near base, subglabrous apically. (Calif. and Oreg.) . . . . *chapini*

Chnaunanthus flavipennis (Horn)

Acratus flavipennis Horn, Trans. Amer. Ent. Soc. **I:** 165, 1867.
Pseudacratus flavipennis Dalla Torre, Coleop. Cat. **45:** 7, 1912 (new combination).
Chnaunanthus palmeri Horn, Proc. Calif. Acad. **4:** 393, 1894.—Dalla Torre, Coleop. Cat. **45:** 7, 1912. (New synonymy).

This species may be quickly placed by the key characters and the male genitalia. The elytra vary from testaceous to piceotestaceous, and the thorax from rufous to rufopiceous.

I have seen 11 specimens, including a pair of Horn's paratypes; of these all but 2 Arizona specimens are from Utah. I have been able to examine the types of *Pseudacratus flavipennis* through the courtesy of Mark Robinson and the authorities of the Philadelphia Academy of Natural Sciences, and was able to confirm the suspicion I have had for some time that both genus and species are synonomous with the above, the specific name *flavipennis* having priority.

Chnaunanthus discolor Burm.

Chnaunanthus discolor Burmeister, Hand. Ent. **4:** 32, 1844.—Bates, Biol. Cent. Amer., Col. **2**(2): 130, 1887.—Dalla Torre, Coleop. Cat. **45:** 7, 1912.

The main specific characters are given in the key and the male genitalia are shown on the plate. This species varies considerably in color, the elytra ranging from entirely testaceous, through testaceous with black cloudings on the disc, to almost entirely piceocastaneous; the thorax may be piceorufous, rufous with testaceous marks on the lateral margins, or may (rarely) be almost entirely testaceous.

Apparently confined to Mexico and Lower California; I have examined 65 specimens from Mexico, all taken in the late fall. I have also seen two specimens from San Jose del Cabo in Lower California (Fuchs collection) in the United States National Museum.

Chnaunanthus chapini Saylor, n. sp.

Male.—Size, shape and many characters exactly the same as in *Ch. discolor*. Head with front smooth at base, coarsely densely punctured apically; clypeus coarsely punctured, apex reflexed, emarginate. Thorax finely moderately densely punctured, disc glabrous (due to wear?); hind angles subangulate but hardly obvious, side margins ciliate. Elytra with sparse erect hairs. Pygidium convex, polished, densely hairy in basal half, smooth at apical half. Abdominal segments connate, with the sutures hardly obvious, sixth segment free.

Female.—Head with front entirely punctured; pygidium flattened, polished, sparsely hairy in apical two-thirds, subglabrous apically; otherwise similar to male. Length 3.5–4 mm.

Holotype and allotype (U.S.N.M. no. 5227) are from Panamint Valley, Death Valley, California, and were collected in April 1891 by A. Koebele. A single paratype male, in the author's collection, is from Oregon, collected in July, and probably came from the arid parts of that state.

I take pleasure in naming this species in honor of Dr. E. A. Chapin of the National Museum as a slight token of my appreciation for many favors.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

RECENTLY ELECTED TO RESIDENT MEMBERSHIP IN THE ACADEMY

Lloyd Viel Berkner, physicist, Department of Terrestrial Magnetism, Carnegie Institute of Washington, in recognition of his contributions to the physics of the earth's outer atmosphere, particularly the development of methods and measurement of outer atmospheric ionization, and the study of the relation of this ionization to solar and geophysical effects and to radio wave propagation.

A. Harold Blatt, associate professor, Howard University, in recognition of his achievements in organic chemistry.

Wilbur S. Burbank, geologist, Section of Metalliferous Deposits, U. S. Geological Survey, in recognition of his contributions to petrology and economic geology, in particular, his researches on the structural geology of Colorado.

Edward A. Chapin, curator of insects, U. S. National Museum, in recognition of his contributions to systematic entomology, especially the taxonomy of the Scarabaeidae.

William Ridgely Chapline, principal inspector of grazing, U. S. Forest Service, in recognition of his contributions to forestry research, especially range research and erosion control.

Jesse Roy Christie, associate nematologist, Bureau of Plant Industry, in recognition of his work in zoology, parasitology, and phytopathology.

Mayne Reid Coe, associate chemist, Bureau of Chemistry and Soils, in recognition of his researches on the effect of the various wave lengths of light upon the development of rancidity of oil-bearing foods.

Harry Diamond, principal physicist, National Bureau of Standards, in recognition of his contributions to safety in aerial navigation, in particular, the development of aids in blind flying and blind landing.

Paul F. Dickens, associate in medicine in George Washington University Medical School and Chief of Medical Service, Gallinger Hospital, in recognition of his researches in circulatory and respiratory diseases.

Rolla Eugene Dyer, assistant director and chief of the Division of Infectious Diseases, National Institute of Health, in recognition of his contributions to medical science, in particular, his researches on typhus fever.

Walter Freeman, professor of neurology, George Washington University Medical School, in recognition of his researches in neurology and neuropathology.

Karl F. Herzfeld, professor of physics and head of department, Catholic University, in recognition of his outstanding contributions in physics and physical chemistry.

Walter C. Hess, assistant research professor of chemistry, Georgetown

University, in recognition of his contributions to the field of biological chemistry, especially the chemistry of the biologically important sulfur compounds.

Anna I. Jonas, associate geologist, U. S. Geological Survey, in recognition of her work in the geology of the crystalline schists.

Myrna Frances Jones, zoologist, Division of Zoology, National Institute of Health, in recognition of her contributions to parasitology, especially the life histories of bird tapeworms and their invertebrate hosts.

Annie M. Hurd-Karrer, associate physiologist, Bureau of Plant Industry, in recognition of her work on plant physiology, especially on disease resistance of plants, seed disinfection, properties and buffer systems of plant sap, absorption of selenium by wheat, and the protection from selenium injury given by sulfur.

Theodore Koppanyi, professor of pharmacology and chairman of the department, Georgetown University, in recognition of his researches in pharmacology.

Samuel Henry McCrory, chief, Bureau of Agricultural Engineering, in recognition of his contributions to agricultural engineering.

Albert R. Merz, chemist, Bureau of Chemistry and Soils, in recognition of his achievements in the field of agricultural and fertilizer chemistry.

Howard E. Middleton, senior soil conservationist, U. S. Department of Agriculture, in recognition of his contributions in soil physics and chemistry.

Ben Harry Nicolet, senior chemist, Bureau of Dairy Industry, in recognition of his contributions to organic chemistry.

Paul Wilson Oman, assistant entomologist, Bureau of Entomology and Plant Quarantine, in recognition of his work on leaf hoppers.

John W. Roberts, principal pathologist, Bureau of Plant Industry, in recognition of his researches on the diseases of apples, peaches, plums, and cherries.

Roscoe Roy Spencer, senior surgeon, U. S. Public Health Service, in recognition of work in bacteriology and especially for his discovery of the vaccine for Rocky Mountain spotted fever.

Lloyd A. Spindler, associate zoologist, Bureau of Animal Industry, in recognition of his contributions to parasitology.

Alan Stone, associate entomologist, Bureau of Entomology and Plant Quarantine, in recognition of his contributions to the biology and taxonomy of Diptera.

James Steele Williams, associate geologist, U. S. Geological Survey, in recognition of his work on the carboniferous faunas and formations of the central and western United States.

Willard Hull Wright, senior parasitologist, National Institute of Health, in recognition of his contributions in the field of therapeutics of diseases caused by internal parasites.

PHILOSOPHICAL SOCIETY

1110TH MEETING (continued)

F. G. Brickwedde: *Some recent investigations of ortho- and para-hydrogen at low temperatures.*—Hydrogen, of atomic weight one, is a mixture of ortho- and para-hydrogen (o-H_2 and p-H_2) in varying concentrations. Since the properties of o- and p-H_2 differ, the properties of hydrogen are variable. The hydrogen vapor pressure thermometer which is used to measure temperatures in the range of liquid hydrogen temperatures, 13.9 to 20.4°K, is therefore, subject to variation, and the experiments which formed the subject of this report were undertaken by R. B. Scott and the speaker in the Cryogenic Section of the National Bureau of Standards for the purpose of finding ways to improve the reliability of this instrument. The results were reported, however, from the point of view of the information they reveal concerning the fundamental differences between the condensed phases of o- and p-H_2 responsible for the observed differences in properties.

The change with temperature of the difference between the vapor pressures of p-H_2 and n-H_2 (normal hydrogen whose composition is 75 percent o-H_2), dP/dT reveals a difference between the *lattice* energies of p- and n-H_2 in a condensed phase, the energy of liquid p-H_2 being 2.4 cal mol^{-1} greater than the energy of liquid n-H , and the energy of solid p-H_2 5 cal mol^{-1} greater than that of solid n-H_2.

The change of the *lattice* energies of liquid solutions of o- and p-H_2 with the composition reveals a large deviation from the law of ideal solutions which states that differences in the properties of solutions are proportional to the differences in the composition. The vapor pressure data lead to the following equation which represents the dependence of the internal or lattice energy of solutions of o- and p-H_2 upon the concentration:

$$dE_s/dx_1=E_1+(1+a_{1,2}x_2)$$

where E_s is the energy per mol of solution whose composition is given by the mol fraction $x_1=1-x_2$, E_1 is the energy per mol of pure variety 1, and $a_{1,2}$ is an empirical constant different in value from $a_{2,1}$.

The densities of liquid p-H_2 and n-H_2 differ by 0.5 percent. Orthohydrogen, the freely rotating variety, has a smaller molecular volume and internal energy than p-H_2, the non-rotating variety. The direction of these differences is opposite to the direction of the changes observed in other substances in passing through the transition from the state in which the molecules are oriented to the state in which they rotate freely. The application of the Heisenberg Uncertainty Principle to the problem shows that the p-H_2 molecules are not aligned in any preferred direction but rather that the orientation of the axes of p-H_2 molecules are randomly distributed over all possible directions. The state of molecular orientation in liquid and solid p-H_2 corresponds, therefore, with that of free rotation in other substances. The rotating o-H_2 molecules are oriented, their state corresponding more nearly with that of oriented non-rotating molecules in other substances.

The difference in the intermolecular forces in liquid or solid p-H_2 and o-H_2 arises, because of the difference in the distribution of the electron density of p-H_2 and o-H_2 molecules. The electron distribution of a p-H_2 molecule at liquid hydrogen temperatures ($j=0$) is spherically symmetrical. For o-H_2 molecules ($j=1$) the electron density is greatest either along an axis ($m=0$) or over a plane ($m=\pm 1$).

The ortho-para vapor pressure difference of deuterium was compared with that of hydrogen. The ratio of the difference in the vapor pressures of the non-rotating variety and the normal mixture to the product of the change in the ortho-para composition and the vapor pressure of the normal variety,

$$\left[\frac{\Delta P(p\cdot H_2 - n\cdot H_2)}{0.75p(n\cdot H_2)} \text{ for } H_2, \text{ and } \frac{\Delta P(o\text{-}D_2 - n\cdot D_2)}{0.33P(n\cdot D_2)} \text{ for } D_2\right],$$

is about the same for H_2 and D_2. If, however, the differences in vapor pressures are compared subject to the condition that the change in the composition of the rotating and non-rotating varieties is the same for H_2 and D_2, it is found that $\Delta P/P$ is larger for D_2 than for H_2. The difference in the lattice energies of a condensed phase of ortho and para varieties depends upon d/dT of $(\Delta P/P)$. The vapor pressure data lead to a smaller ortho-para lattice energy difference for D_2 than for H_2.

The vapor pressure of freshly condensed normal hydrogen increases with time because of the conversion of o-H_2 to p-H_2, the rate being 0.2 mm per hour. The rate of increase of the vapor pressure decreases as the concentration of o-H_2 decreases in accordance with a bimolecular reaction of o-H_2 molecules. The rate of change of the vapor pressure of n-D_2 is so small that it was beyond the accuracy of our experiments to detect it, the experiments setting as an upper limit for the change 10^{-2} times the rate of change of the vapor pressure of n-H_2. Conversion in the condensed phases of hydrogen and deuterium results from the *collision* of rotating molecules with paramagnetic molecules. The o-H_2 molecules, and the p-D_2 and 5/6 th of the o-D_2 molecules are paramagnetic, whereas the p-H_2 and 1/6 th of o-D_2 molecules are diamagnetic and hence are ineffective in bringing about conversion. The probability of conversion upon *collision* of two molecules is proportional to the square of the force of interaction of their magnetic moments, and thus approximately proportional to the 4th power of the magnetic moments of the nuclei. The magnetic moment of the proton is about 2.9 Bohr nuclear magnetons, whereas the magnetic moment of the deuteron is about 0.75. Taking into account the difference in the ortho-para composition of n-H_2 and n-D_2 a calculation shows that the rate of change of the vapor pressure of n-D_2 may be expected to be of the order of 10^{-3} times the rate of change of the vapor pressure of n-H_2, which is in accord with the experiments. The average magnetic moment of o-D_2 is greater than that of p-D_2 and, hence, it is to be expected that the order of the conversion reaction p-D_2 to o-D_2 is more nearly first order than second order. (*Author's Abstract.*)

H. E. MCCOMB, *Recording Secretary*

Obituary

LORD ERNEST RUTHERFORD, noted British physicist, died October 19, 1937, at Cambridge, England.

He was born at Nelson, New Zealand, August 30, 1871. Educated at Nelson College, Canterbury College, New Zealand University, and Cambridge University, he received in succession the M.A., B.Sc., and B.A. degrees. New Zealand University conferred upon him the D.Sc. degree in 1901, and many domestic and foreign universities honored him during his subsequent career.

Lord Rutherford lectured at McGill University, the University of Manchester, and Trinity College, of which he was a Fellow. Since 1919 he was Cavendish Professor of Experimental Physics and Director of the Cavendish Laboratory, University of Cambridge. He was also Professor of Natural Philosophy, Royal Institution, and Chairman of the Advisory Council of the Department of Scientific and Industrial Research since 1930. His life's work and many publications dealt chiefly with the problems of radio-activity. He was the pioneer of the modern school concerned with the splitting of the atom and the transmutation of the elements. For his great achievements he received the Rumford, Copley, Barnard, Franklin, Albert, and Faraday medals; the Bressa Prize from the Turin Academy of Science; and the Nobel Prize for Chemistry, 1908.

Lord Rutherford was President of the British Association for the Advancement of Science, 1923; and President of the Royal Society, 1925–1930. He was knighted in 1914 and raised to a barony in 1931. He was an honorary member of the Washington Academy of Sciences.

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An asterisk * denotes the abstract of a paper presented before the Academy or an affiliated society.

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