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Page 102, line 47: take out "G" before "formations."

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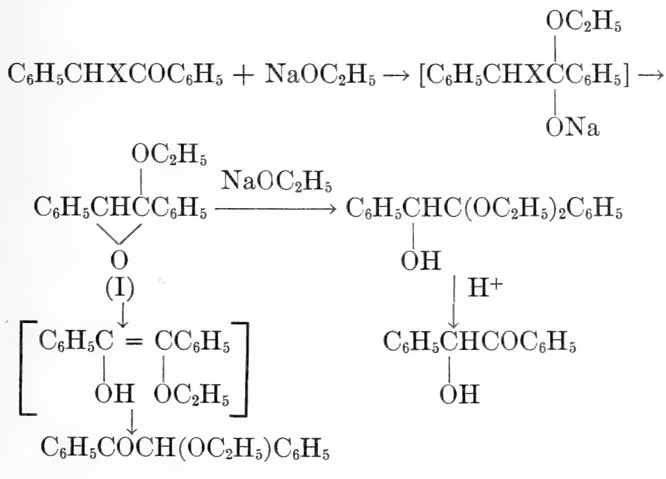
CHEMISTRY.—*The formation of hydroxy β-diketone acetates from bromo α-diketones.*[1] A. H. BLATT, Howard University.

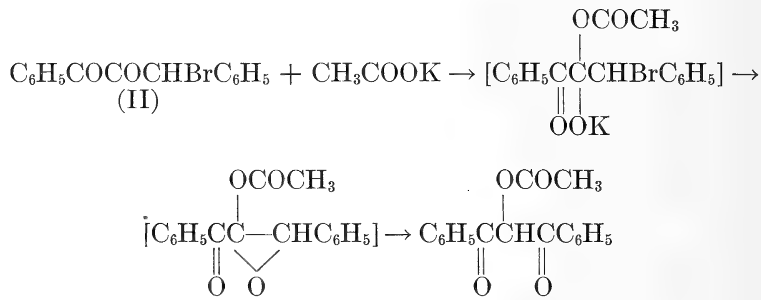
In recent years there has been accumulated a considerable amount of evidence which indicates that many of the replacement reactions of α-haloketones proceed through addition to the carbonyl group and subsequent ethylene oxide formation, followed by ring opening to furnish the final replacement product.[2] To cite a specific illustration, desyl halides react with alcoholates to form epoxides, such as (I), which can then undergo ring opening either by addition of a molecule of alcoholate or by rearrangement which takes place on heating or in the presence of acids. These possibilities are shown in the following equations:



It is, it will be noticed, a consequence of this mechanism of replacement that, when ring opening occurs by rearrangement, the entering group is found attached to what was, in the α-haloketone, the carbonyl carbon atom, while the carbonyl oxygen atom shifts

[1] Received November 19, 1937.
[2] (a) Ward, J. Chem. Soc., **1929**: 1541.
(b) Kohler and Brown, J. Am. Chem. Soc., **55**: 4299. 1933.
(c) Madelung and Oberwegner, Ann., **490**: 201. 1931; **526**: 195. 1936.

from its original location to an adjacent carbon atom. In the desyl halides such a shift, because of the symmetry of the molecule, would not reveal itself, and to the best of our information no one has sought to verify this consequence of the replacement mechanism just described by an examination of the products obtained from a substituted desyl halide. However, an extremely simple experimental test of the mechanism in question is possible if one starts not with a simple α-haloketone but instead with a halo α-diketone, for in this latter case the shift of the carbonyl oxygen atom will result in the formation of a derivative of a β-diketone. Thus, if phenyl bromobenzyl diketone (II) is subjected to a replacement reaction with, say, potassium acetate, the product should be the acetate of dibenzoylcarbinol (III).

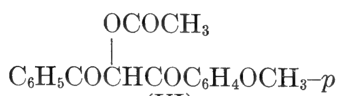


(III)

We have verified this by examining the reaction between phenyl bromobenzoyl diketone and potassium acetate and have found that the product is the hydroxy β-diketone acetate (III). In addition we have found that the two isomeric bromo α-diketones, phenyl p-methoxybromobenzyl diketone (IV) and anisyl bromobenzyl diketone (V), react with potassium acetate to furnish the same hydroxy β-diketone (VI).

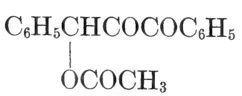
$C_6H_5COCOCHBrC_6H_4OCH_3$–*p*
(IV)

$C_6H_5CHBrCOCOC_6H_4OCH_3$–*p*
(V)



(VI)

$C_6H_5COCHBrCOC_6H_5$
(VII)

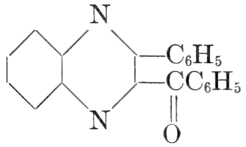


(VIII)

$C_6H_5COCHBrCOC_6H_9OCH_3$–*p*
(IX)

$C_6H_5COCOCHC_6H_9OCH_3$-p
|
$OCOCH_3$
(X)

$C_6H_5CHCOCOC_6H_4OCH_3$-p
|
$OCOCH_3$
(XI)



(XII)

In view of the foregoing discussion and facts it may appear surprising at first glance that bromodibenzoylmethane (VII) reacts with potassium acetate to yield the acetate (III) and not (VIII), and that p-methoxybromodibenzoylmethane (IX) with the same reagent furnishes the acetate (VI) and not (X) or (XI). In neither case does a shift of the carbonyl oxygen atom take place. In our opinion, however, there is no inconsistency in these results. Rather, they indicate that the replacement of a halogen atom in an α-haloketone need not of necessity proceed by way of addition and ethylene oxide formation. Instead, the reaction may follow a course comparable to that of the replacement of the halogen atom in an alkyl halide. Such a suggestion is in harmony with all the available facts for, with two competing reaction paths available, the course of the replacement process with a given reagent would be determined by the relative reactivities of the carbonyl group and the halogen atom. In the bromo α-diketones discussed in this paper there is present an extremely reactive carbonyl group activated by the adjacence of a second carbonyl group,[3] while in the bromo β-diketones under consideration there is present an unusually reactive halogen atom activated by adjacence to two carbonyl groups.

We have examined a number of other reactions of phenyl bromobenzyl diketone (II) in order to see whether they follow a course parallel to that with potassium acetate, but unfortunately in only two cases were the products sufficiently tractable to furnish definite information. With o-phenylene diamine, phenyl bromobenzyl diketone furnishes the halogen free quinoxaline (XII). The same quinoxaline is also obtained when bromodibenzoylmethane is treated with this reagent. The quinoxaline (XII) is derived, it will be noticed, from neither of the bromoketones but, instead, from diphenyl trike-

[3] Fuson, Matuszeski and Gray, J. Am. Chem. Soc., **56**: 2099. 1934 and earlier articles.

tone. With hydriodic acid, phenyl bromobenzyl diketone is reduced to phenyl benzyl diketone. The same reagent reduces bromodibenzoylmethane to dibenzoylmethane. Up to the present time, reduction with hydriodic acid is the only reaction we have found which, applied to isomeric bromo α- and β-diketones, leads to products whose structures correspond with those of the starting materials.

Experimental

The reactions between the bromoketones and potassium acetate were run in acetic acid using 10 cc. of solvent per gram of bromoketone. To the bromoketone dissolved in the solvent at its boiling point, was added 2.5 equivalents of fused potassium acetate. The acetate dissolved rapidly and within five minutes a heavy precipitate of potassium bromide separated. After thirty minutes the reaction mixture was cooled, diluted with water, and extracted with ether. The ether, on evaporation after appropriate washing and drying, furnished the hydroxy β-diketone acetate in a yield varying between 70 and 80 per cent. Dibenzoylcarbinol acetate (III) obtained from phenyl bromobenzyl diketone[4] was identified by comparison with an authentic specimen.[5] Benzoyl *p*-methoxybenzoylcarbinol acetate (VI) obtained from phenyl *p*-methoxybromobenzoyl diketone (IV),[6] from anisyl bromobenzyl diketone (V),[7] and from benzoyl anisoylbromomethane (IX)[8] is a colorless solid melting at 70° which is moderately soluble in the ordinary solvents. It can be distilled in high vacuum. For analysis it was crystallized from methanol. Anal. Calcd. for $C_{18}H_{17}O_5$: OCH_3, 9.91. Found: OCH_3, 10.13.

When bromodibenzoylmethane in alcohol containing acetic acid was boiled for a half hour with a molar equivalent of *o*-phenylene diamine the blood-red solution furnished, after the usual treatment, 2-phenyl-3-benzoylquinoxaline (XII) which was identified by comparison with a sample prepared according to Gastaldi and Cherchi.[9] The same quinoxaline was obtained from phenyl bromobenzyl diketone but only after vacuum distillation of the first oily reaction product.

Bromodibenzoylmethane dissolved in alcohol acidified with hydrochloric acid was reduced by the addition of potassium iodide. After

[4] Jörlander, Ber., **50**: 417. 1917.
[5] Neufville and Pechmann, Ber., **23**: 3375. 1890.
[6] Moureu, Ann. Chim., (10), **14**: 364. 1930.
[7] Jörlander, Ber., **50**: 410. 1917.
[8] Pond and Shoffstall, J. Am. Chem. Soc., **22**: 684. 1900.
[9] Gastaldi and Cherchi, Gazz. chim. ital., **43**: 1, 299. 1913.

removing the liberated iodine with thiosulfate, dilution of the alcohol with water precipitated dibenzoylmethane. Phenyl bromobenzyldiketone on similar treatment was reduced to phenyl benzyl diketone which was isolated as the antimony derivative.[10]

In order to test the possibility that the formation of the acetate (III) from the bromo α-diketone (II) might have been due to the rearrangement of a positive fragment, such as $C_6H_5C^+HCOCOC_6H_5$, after elimination of a bromide ion, we treated the bromo α-diketone (II) with pyridine, for the formation of a pyridinium salt would involve just such a process. The product of the reaction was an oily pyridinium salt which could not be purified and which was not identical with the product obtained from bromodibenzoylmethane and pyridine.[11]

On treatment with alcoholates, with phenylmagnesium bromide, with hydroxylamine hydrochloride and with ammonia, phenyl bromobenzyl diketone gave only intractable products.

Summary

Indirect replacement of the halogen atom in an α-haloketone should result, in certain cases, in a shift of the carbonyl oxygen atom from its original position to an adjacent carbon atom. This shift could easily be detected by employing halo α-diketones for with these ketones it would lead to derivatives of hydroxy β-diketones, and an examination of the reaction between some bromo α-diketones and potassium acetate shows that acetates of hydroxy β-diketones are formed. The structural factors which determine the course of replacement reactions of α-haloketones are briefly discussed and the conclusions from this discussion are shown to be consistent with the observed facts.

[10] Dufraisse and Moureu, Bull. soc. chim., (4) **41**: 1611. 1927.
[11] Kröhnke. Ber. **68**: 1180. 1936.

BOTANY.—*Additions to the grass flora of British Honduras.*[1] JASON R. SWALLEN, Bureau of Plant Industry.

Since the publication of "The Grasses of British Honduras and the Petén, Guatemala,"[2] two collections have been made in British Honduras which add many grasses to the flora. One of these was made by Rev. Dr. Hugh O'Neill in the Belize District, and the other by C. L. Lundell in the El Cayo District.

Several of the species in these collections were found for the first time outside of the United States, some are South American not before known from North America, others are Eastern United States and West Indian species found for the first time in Central America, while the rest were to be expected in British Honduras but have not previously been reported. There are also six species new to science.

Arthrostylidium spinosum Swallen, sp. nov.

Culmi scandentes, 5–15 m longi, ramis spinosis; vaginae (ramulorum) internodiis longiores, glabrae, fimbriatae, marginibus ciliatis; ligula firma, 0.2 mm longa; laminae lineares, 10–25 cm longae, 5–8 mm latae, infra glabrae, supra pubescentes, marginibus hispidis; paniculae rami curtissimi densi, axe curto pubescente; spiculae 3–10 cm longae, cylindricae, patentes vel adscendentes; glumae curtissimae; lemmata inferiora reducta; lemma flosculorum fertilium amplexans 15–18 mm longum, ad 7 mm latum, multinervium, acutum, aristatum; palea 10 mm longa, inter carinas ciliata, 1.5–2 mm lata, pubescens, marginibus latissimis 3-nerviis; stamina 3, 5–7 mm longa.

Culms clambering, 5–15 m long, hollow, thick walled, branching, the branches as much as 8 mm thick, with a solitary conspicuous spine (rarely two) and a dense fascicle of slender, stiff, leafy branchlets at each node; sheaths (of the branchlets) overlapping, the margins densely short ciliate, otherwise glabrous, with slender erect to flexuous fimbriae 2–3 mm long on the truncate shoulder; ligule firm, about 2 mm long; blades deciduous, linear, 10–25 cm long, 5–8 mm wide, firm, pungent, abruptly rounded at the base into a minute pedicel, scaberulous on both surfaces, often pubescent on the upper, the margins appressed hispid; panicles at the ends of leafy or nearly leafless branchlets, the branches very short, crowded on the short, pubescent axis; spikelets 3–10 cm long, about 2.5 mm thick, cylindric; glumes very small, scale like; rachilla joints striate, about half as long as the lemmas; lower lemmas much reduced, many-nerved, mucronate; fertile lemmas 15–18 mm long, as much as 7 mm wide clasping the base of the one above, many nerved, acute, aristate, the slender awns 3–5 mm long; palea 10 mm long, 1.5–2 mm wide between the ciliate keels, pubescent, the margins 3-nerved, glabrous, overlapping enclosing the flower; stamens 3, 5 mm long.

Type in the U. S. National Herbarium no. 1649171 collected along the Belize River at El Cayo, El Cayo District, British Honduras, June-August, 1936, by C. L. Lundell (no. 6939).

[1] Received November 16, 1937.

[2] SWALLEN, JASON R. Carnegie Inst. Washington Publ. **461**: 143–189. 1936.

This species of *Arthrostylidium* differs from all others in having prominent spines at nearly all the nodes. In this respect it resembles *Guadua*, but in that genus the florets have six stamens and the palea is winged, while in *Arthrostylidium* there are only three stamens and the palea is wingless.

Fournier[3] described *Chusquea spinosa* from sterile material collected in Oaxaca by Liebmann (no. 130). This appears to be the same species as the one described above, but since there were no flowering specimens, it can not definitely be determined.

ERAGROSTIS HIRSUTA (Michx.) Nees. Locally abundant in sandy pine-oak uplands, San Agustin, Mountain Pine Ridge (*Lundell* 6738). First record outside of the United States. Dry fields and open woods, southeastern United States and British Honduras.

TRIPLASIS PURPUREA (Walt.) Chapm. On the strand, Puerto Cortez, Honduras (*O'Neill* 8423). First record outside of the United States. Open sandy ground, eastern United States and Honduras. Although not properly belonging to the flora of our region, this species is noted here because of the great extension of range which the above collection records.

ARISTIDA IMPLEXA Trin. Locally abundant in sandy pine uplands, San Agustin, Mountain Pine Ridge (*Lundell* 6904). Plains, rocky slopes and pine woods, British Honduras, Salvador, and Panama; Brazil to Paraguay.

ARISTIDA PURPURASCENS Poir. In tropical pineland, Old Hector Creek (*O'Neill* 8438). First record outside of the United States. Dry sandy soil, eastern United States and British Honduras.

ARISTIDA LONGIFOLIA Trin. Rare in wet sand at edge of stream, Rio On, Mountain Pine Ridge (*Lundell* 6801). First record from North America. Sandy, open or brushy ground, British Honduras; eastern Brazil.

ARISTIDA TENUISPICA Hitchc. Common in sandy pine uplands. San Agustin, Mountain Pine Ridge (*Lundell* 6815). First record outside of Florida. Pine woods, southern Florida and British Honduras.

Digitaria multiflora Swallen, sp. nov.

Annua; culmi graciles, erecti, simplices vel ramosi, glabri; vaginae internodiis longiores, carinatae, glabrae, basi in marginibus sparse pilosae; ligula membranacea, 2–3 mm longa; laminae planae, acuminatae, 10–28 cm longae, 4–8 mm latae, glabrae vel scaberulae, supra sparse papilloso-hirsutae, marginibus scabris; racemi 8–25, 6–15 cm longi, graciles, adscendentes; pedicelli teretes glabri vel sparse scabri 1–4 mm longi; spiculae 1.2 mm longae ternatae; gluma prima obsoleta; gluma secunda 1 mm longa, acuta, 3-nervia, inter nervos et in marginibus dense pubescens; lemma sterile quam lemma fertile paulo brevius, acutum, 3-nervium, inter nervos et in marginibus sparse vel dense pubescens; lemma fertile 1.1 mm longum, acutum, fuscum, striatum.

Annual; culms slender, erect, simple or sparingly branched, 50–115 cm tall, glabrous; sheaths longer than the internodes, keeled, glabrous, the margins more or less pilose or ciliate toward the base; ligule membranaceous, brownish, 2–3 mm long; blades flat, acuminate, 10–28 cm long, 4–8 mm wide, smooth or scaberulous on both surfaces, sparsely papillose-hirsute on the upper at least toward the base, the margins scabrous; axis of the inflorescence 8–15 cm long; racemes 8–25, 6–15, cm long, slender, ascending or

[3] FOURNIER in Hemsl. Biol. Centr. Amer. Bot. **3**: 587. 1885.

sometimes spreading, rather evenly scattered along the axis, the rachis wingless, 0.3 mm wide, the margins scabrous; spikelets 1.2 mm long, in groups of 3 or 4, the unequal pedicels terete, glabrous or sparsely scabrous, 1–4 mm long, somewhat spreading; first glume obsolete or nearly so; second glume 1 mm long, acute, narrower than the fruit, 3-nerved, with dense lines of white pubescence on the internerves; sterile lemma a little shorter than the fruit, acute, 3-nerved, pubescent like the second glume but the hairs shorter, sometimes nearly wanting on the internerves; fruit 1.1 mm long, extending slightly beyond the second glume and sterile lemma, acute, dark brown, striate.

Type in the U. S. National Herbarium no. 1647576 collected in sandy pine-oak uplands, San Agustin, Mountain Pine Ridge, El Cayo District, British Honduras, July-August, 1936, by C. L. Lundell (no. 6730).

The usually numerous spreading racemes with many minute spikelets are characteristic.

Digitaria cayoensis Swallen, sp. nov.

Annua; culmi erecti vel adscendentes, ramosi, 80 cm alti, glabri; vaginae internodiis longiores, dense hirsutae; laminae planae, acuminatae, ad 16 cm longae, 3–5 mm latae, scabrae, supra sparse pilosae; racemi 6–8, graciles, adscendentes, 8–12 cm longae; spiculae 1.5–1.6 mm longae, ternatae, pedicellis subplanis, scabris, 1–3 mm longis; gluma prima obsoleta; gluma secunda 1.3 mm longa, acuta, 3-nervia, inter nervos et in marginibus dense pubescens, pilis apice glumae paulo longioribus; lemma sterile quam lemma fertile paulo longius, 3-nervium, inter nervos et in marginibus pubescens, pilis quam pilis glumae secundae brevioribus; lemma fertile 1.4–4.5. mm longum, fuscum, acutum, striatum.

Annual; culms erect or ascending, sometimes geniculate and rooting at the lower nodes, freely branching, as much as 80 cm tall, glabrous; sheaths longer than the internodes, rounded, or keeled only toward the summit, densely hirsute, or the uppermost nearly glabrous, the hairs ascending or spreading; blades flat, acuminate, as much a 16 cm long, 3–5 mm wide, scabrous, the upper surface very sparsely pilose; axis of inflorescence 5–8 cm long; racemes slender, ascending, 8–12 cm long, pilose in the axils, the rachis 0.3 mm wide, the very narrow margins scabrous; spikelets 1.5–1.6 mm long, in groups of three, the unequal pedicels flattened, scabrous, 1–3 mm long; first glume nearly obsolete; second glume about 1.3 mm long, acute, 3-nerved, with dense lines of white hairs on the internerves and margins, the hairs near the tip somewhat longer than the others, extending slightly beyond the glume; sterile lemma a little longer than the fruit, 3-nerved, densely pubescent in lines on the internerves and margins, the hairs shorter than those on the second glume; fruit 1.4–1.5 mm long, dark brown, striate.

Type in the U. S. National Herbarium no. 1647578, collected in soil pockets in granite in stream-bed, San Agustin, Mountain Pine Ridge, El Cayo District, British Honduras, July-August, 1936, by C. L. Lundell (no. 6670).

This species is closely allied to the preceding but differs in having fewer racemes and larger spikelets, the pedicels of which are flattened and scabrous instead of terete and nearly glabrous.

Known also from Pocoboch, Yucatan (*Gaumer* 2494). This specimen was previously referred to *Digitaria filiformis*.

PASPALUM BLODGETTII Chapm. Locally abundant, San Agustin, Mountain Pine Ridge (*Lundell* 6714). Open or brushy places, southern Florida, the West Indies, Yucatan, Honduras and British Honduras.

PASPALUM CLAVULIFERUM Wright. On pine ridge. Maskall (*O'Neill*, 8451). Moist open ground and waste places, southern Mexico and the West Indies to Brazil.

PASPALUM CORCOVADENSE Raddi. Occasional at San Agustin, Mountain Pine Ridge (*Lundell* 6640). Native of Brazil; new to North America.

PASPALUM CORYPHAEUM Trin. Rare in wet sand of stream bed, Rio On, Mountain Pine Ridge (*Lundell* 6784). First record north of Panama. Savannas, brushy slopes, and river banks, British Honduras and Trinidad to Brazil.

PASPALUM NUTANS Lam. Rare, Cohune Ridge (*Lundell* 6525). Shady slopes, Central America and the West Indies to Brazil.

PASPALUM PILOSUM Lam. Locally abundant, Vaquero, Mountain Pine Ridge, (*Lundell* 6877). Occasional, San Agustin, Mountain Pine Ridge (*Lundell* 6659). Wooded slopes and brushy savannas, British Honduras to Bolivia and Brazil.

PASPALUM REPENS Berg. Deep water, Mussell Creek, 5 miles west of Boomtown, (*O'Neill* 8461A.). Floating in streams and ponds, southern United States to Paraguay.

PANICUM AGROSTOIDES Spreng. New River at Orange Walk, (*O'Neill* 8505). First record outside of the United States. Wet ground, eastern United States and British Honduras.

Panicum lundellii Swallen, sp. nov.

Perenne, glaucum; culmi erecti, crassi, rhizomatosi 2.5 m alti, glabri; vaginae purpurascentes, glabrae, marginibus ciliatus; ligula ciliata, 2 mm longa; laminae planae, attenuatae, 40–70 cm longae, 15–20 cm latae, glabrae, marginibus hispido-serratis; panicula 35 cm longa, ramis adscendentibus ad 15 cm longis, in parte inferiore nudis; spiculae 4–4.5 mm longae, glabrae; gluma prima acuta vel acuminata, 2.5–3 mm longa, 3-nervia; gluma secunda acuminata, 4–4.5 mm longa; lemma sterile acutum, 3–3.5 mm longum, obscure 5–7 nervium; fructus ellipticus, 2.5 mm longus, 0.9 mm latus, albescens.

Perennial, glaucous. Culms coarse, erect, 2.5–3 m tall, as much as 9 mm thick at the base, producing short rhizomes, glabrous; sheaths glabrous, or the margins ciliate, mostly a little shorter than the long internodes, deeply tinged with purple especially near the nodes; ligule ciliate, about 2 mm long; blades firm, flat, narrowed toward the base, attenuate-pointed, 40–70 cm long, 15–20 mm wide, glabrous, the margins hispid-serrate; panicle about 35 cm long, the branches narrowly ascending, naked in the lower half, the lower as much as 15 cm long; pedicels terete, glabrous, 1–5 mm long; spikelets 4–4.5 mm long, glabrous, usually tinged with purple; first glume rather abruptly acute or acuminate, 2.5–3 mm long, 3-nerved; second glume abruptly acuminate, 4–4.5 mm long, 5-nerved; sterile lemma 3–3.5 mm long, acute, 5–7 nerved, the nerves rather obscure especially toward the base; fruit (immature) 2.5 mm long, 0.9 mm wide, elliptic, blunt, whitish.

Type in the U. S. National Herbarium nos. 1647561 and 1647562, collected in wet alluvial lowland, along Mahogany Creek, Mountain Pine Ridge, El Cayo District, British Honduras, July-August, 1936, by C. L. Lundell (no. 6903).

Panicum lundellii is closely related to *Panicum virgatum* L., but differs in having much stouter culms, which root at the lower nodes, and usually broader blades. The base of the type specimen is incomplete, there being only an extravaginal bud, which would indicate the plant produces rhizomes, but it is impossible to determine whether they are long or short. It seems probable, however, that they are much shorter than those of *P. virgatum*.

Panicum neuranthum Griseb. Edge of creek near Salt Creek (*O'Neill* 8454). Open ground, southeastern United States, the West Indies, and British Honduras.

Panicum parviglume Hack. Occasional in patches, open places at top of limestone hill, San Agustin, Mountain Pine Ridge (*Lundell* 6809). This specimen differs from the typical form in having blades densely pubescent beneath. Along banks and ditches, Mexico to Costa Rica.

Panicum patulum (Scribn. & Merr.) Hitchc. In tropical pineland, Boomtown (*O'Neill* 8430). Low woods, southeastern United States, Hispaniola, and British Honduras.

Panicum polycaulon Nash. In tropical pineland, Boomtown (*O'Neill* 8480). Sandy pine woods, southeastern United States, the West Indies, and British Honduras.

Panicum sellowii Nees. Occasional at San Agustin, Mountain Pine Ridge, (*Lundell* 6734). Rocky places, the West Indies, British Honduras, Venezuela and Brazil.

Ichnanthus lagotis (Trin.) Swallen, comb. nov.

Panicum lagotis Trin. Mem. Acad. St. Pétersb. VI. Sci. Nat. **1**: 326. 1834.

Rare along roadside in limestone valley, San Antonio (*Lundell* 6941). First record in North America. Open woods and brushy borders, British Honduras; eastern Brazil.

Ichnanthus villosus Swallen, sp. nov.

Perennis; culmi erecti vel decumbentes, 90–110 cm longi, ramosi; vaginae internodiis breviores, dense villosae; ligula truncata, 0.5 mm longa; laminae lanceolatae, 8–13 cm longae, 12–20 mm latae, infra pubescentes, supra scabrae et pilosae; panicula 25 cm longa, ramis gracilibus divergentibus, ad 11 cm longis, sparsifloris; spiculae 4–4.5 mm longae, appressae; gluma prima acuta, 3-nervia, scabra; gluma secunda et lemma sterile subequalia, 5-nervia, acuta; lemma fertile 3.3 mm longum, glabrum, lucidum, appendicibus 0.7–0.8 mm longis, subhyalinis.

Perennial; culms erect or decumbent at the base and rooting at the lower nodes, 90–110 cm long, sparingly branched; sheaths shorter than the internodes, rather densely villous, ligule membranaceous, truncate, more or less ciliate, 0.5 mm long; blades lanceolate, acuminate, asymmetric, 8–13 cm long, 12–20 mm wide, softly pubescent on the lower surface, scabrous and pilose on the upper; panicle about 25 cm long, the slender branches stiffly spreading, the middle ones longest, as much as 11 cm long, with one to few branchlets at the very base; spikelets 4–4.5 mm long, appressed, usually in pairs, one on a pedicel 8–20 mm long, the other on a much shorter pedicel; first glume acute or subacuminate, 3-nerved, scabrous; second glume and sterile lemma nearly equal, acute or blunt, 5-nerved, more or less scabrous, extending well beyond the fruit; fruit 3.3 mm long, narrowly elliptic, blunt, smooth, shining, the wings subhyaline, 0.7–0.8 mm long, rather broad.

Type in the U. S. National Herbarium no. 1647573, collected in sand along creek at Vaquero, Mountain Pine Ridge, El Cayo District, British Honduras, July-August, 1936, by C. L. Lundell (no. 6852). Also collected along the Rio On, El Cayo District (*Lundell* 6785).

Ichnanthus villosus resembles *I. leiocarpus* (Spreng.) Kunth, but in that species the first glume and the fruit are as long as the second glume and sterile lemma, and the wings of the fertile lemma are more conspicuous, 1.2–1.3 mm long.

SETARIA TENAX (L. Rich.) Desv. Occasional in sandy pine-oak uplands, San Agustin, Mountain Pine Ridge (*Lundell* 6731). Open or brushy places, Mexico and the West Indies to Brazil.

ERIOCHRYSIS CAYENNENSIS Beauv. Locally abundant, San Agustin, Mountain Pine Ridge (*Lundell* 6628). Wet ground, southern Mexico and the West Indies to Paraguay.

ANDROPOGON ELLIOTTII Chapm. Common in sandy pine uplands, San Agustin, Mountain Pine Ridge (*Lundell* 6727). Occasional in wet sand in stream bed, Rio On, Mountain Pine Ridge (*Lundell* 6785). Open ground, eastern United States, Cuba, and British Honduras.

ANDROPOGON LATERALIS Nees. On granite along stream, Rio On, Mountain Pine Ridge (*Lundell* 6791). Grassy places, Cuba and British Honduras; Colombia and Brazil to Argentina.

SORGHASTRUM SETOSUM (Griseb.) Hitchc. Occasional in sandy pine uplands, San Agustin, Mountain Pine Ridge (*Lundell* 6865). In tropical pineland, Boomtown (*O'Neill* 8481). Grassy hillsides and pinelands, southern Mexico and the West Indies to Argentina.

ZOOLOGY.—*Stored nutritive materials in the Trophosome of the nematode,* Agamermis decaudata (*Mermithidae*).[1] B. G. CHITWOOD and LEON JACOBS, Bureau of Plant Industry.

During parasitic development, colorless globules accumulate in the intestine of *Agamermis decaudata*, Cobb, Steiner and Christie, 1923, and during adult free-living life these globules gradually disappear. Since the greater part of the globules are insoluble in alcohol-xylol, Rauther[2] pointed out that they are not fat. In the present note the results of our observations on the globules of this *Agamermis* are presented.

Strong Flemming's mixture or osmic vapor blackens only a small proportion (about 10 per cent) of the globules; alcohol, xylol, ether, and chloroform remove about the same proportion of globules, and after such treatment osmication is without effect. Nile blue sulphate, prepared by the method of Smith,[3] stains the majority of the globules blue (indicating a fatty acid according to Smith) but a small proportion red (indicating a neutral fat according to Smith); only blue-coloration is observed after alcohol extraction. Scharlach R stains all globules. From these results it appears that a small proportion of the globules are neutral fat and that the majority contain some fatty acid but do not behave as do normal fatty acids.

Material previously extracted with alcohol contains most of the original globules. These give positive xanthoproteic and ninhydrin reactions and stain with gentian violet or haematoxylin, indicating their protein nature. When hydrolized in 10 per cent KOH the surface tension of the solution is reduced about 10 per cent as indicated by capillary tests with 10 per cent KOH as a control, the readings of the tests being 48 and 53 mm and the controls 52 and 59 mm respectively. This reduction in surface tension indicates the presence of a fatty acid.

Artificial gastric juice removes the majority of the globules from untreated material, supporting the conception that they are a protein. Hydrolysis with 10 per cent HCl produces the same effect. The residual globules after such treatment are stained red by Nile blue sulphate, and black with osmic acid, confirming the conclusion that they are a neutral fat.

The above observations show that the stored nutritive materials

[1] Received October 19, 1937.

[2] Zool. Jahrb., Abt. Anat. **23** (1). 1–76. 1906.

[3] Jour. Path. and Bact. **12**: 1. 1907.

of *Agamermis decaudata* are of two types; namely, a protein with reactions of a conjugated fatty-acid-protein, and a neutral fat. It is also indicated that Scharlach R and Nile blue sulphate are not specific tests for uncombined fat or fatty acid but may indicate the presence of a fatty-acid-protein complex. Substances which are stained by Scharlach R or Nile blue sulphate must be shown to be extractable in fat solvents, to be non-digestible in artificial gastric juice, and to give negative xanthroproteic and ninhydrin reactions, before it can be concluded that they are free fatty acids or neutral fats.

Preliminary observations indicate the presence of protein (?-fatty-acid-protein) globules in *Rhabditis strongyloides* Schneider (Rhabditidae), and *Ditylenchus dipsaci* (Kühn) Filipjev (Tylenchidae).

The writers are indebted to Mr. Jacob M. Schaffer, Mr. Robert R. Henley and Mr. Howard R. McMillin of the U. S. Bureau of Animal Industry for valuable suggestions.

ZOOLOGY.—*Nomenclatorial changes involving types of polychaetous annelids of the family Nereidae in the United States National Museum.*[1] OLGA HARTMAN. (Communicated by MARY J. RATHBUN.)

An examination of the types of polychaetous annelids deposited in the U. S. National Museum indicates a necessity for several changes of names in the family Nereidae. The following alphabetical list gives the original name, reference, type locality, museum catalog number, and revised name. Synonyms are enclosed in brackets.

[*Ceratonereis alaskensis* Treadwell] (Proc. U. S. Nat. Mus. **60**: 1–3, figs. 1–5, 1921) from Alaska, U.S.N.M. no. 19029, is *C. paucidentata* (Moore).

Ceratonereis bartletti Treadwell (Jour. Wash. Acad. Sci. **27**: 30–31, figs. 8–13, 1937) from western Greenland, U.S.N.M. no. 20224, is close to, if not identical with, *C. hircinicola* (Eisig). Area I of the proboscis lacks teeth, area III has a circular patch of 7 teeth; the jaw has 5 oblique teeth.

Ceratonereis gracilis n. comb., for *Nereis gracilis* Webster.

Ceratonereis irritabilis, n. comb., for *Nereis irritabilis* Webster.

Ceratonereis paucidentata, n. comb., for *Nereis paucidentata* Moore, includes *Ceratonereis alaskensis* Treadwell.

Ceratonereis pusilla, n. comb., for *Nereis pusilla* Moore.

[*Heteronereis caeruleis* Hoagland] (Bull. U. S. Nat. Mus. **100**: 608, pl. 47, figs. 13–16, pl. 48, figs. 1–4, 1920) from the Philippine Islands, U.S.N.M no. 18948, is a *Perinereis*. It is close to *P. camiguina* Grube, but differs in that the areas V and VI of the proboscis have numerous small flat plaques in addition to the single series of transverse plates characteristic of the genus *Perinereis*, also, areas I and II lack paragnaths. *P.*

[1] Received November 1, 1937.

neo-caledonia Pruvot (Arch. zool. éxp. Paris, **70**: 50–54, pl. 3, figs. 77–79) from New Caledonia, seems to be identical with *P. caeruleis*. This has already been suggested by Pruvot.

[*Leptonereis acuta* Treadwell] (Rev. Mus. Paulista São Paulo **13**: 3–5, figs. 1–7, 1923) from Brazil, U.S.N.M. no. 19030, is identical with *Leptonereis culveri* (Webster).

Leptonereis culveri, n. comb., for *Nereis culveri* Webster, includes *Leptonereis acuta* Treadwell.

[*Neanthes palpata* Treadwell] (Rev. Mus. Paulista São Paulo **13**: 5–9, figs. 6–15, 1923) from Brazil, paratype U.S.N.M. no. 19031, is a *Pseudonereis*. Transverse teeth are present on area VI, pointed cones are present on areas V, VII and VIII and rows of pectinae are on the maxillary ring.

[*Nereis brevicirrata* Treadwell] (Proc. U. S. Nat. Mus. **58**: 467–468, figs. 1–4, 1920) from Brazil, U.S.N.M. no. 18934, is a *Perinereis*. Area V of the proboscis has 2 conical teeth, side by side, area VI has 2 transverse teeth in similar arrangement but nearer the maxillary ring, areas VII and VIII have about 12 larger flattened cones on the oral side and an irregular row of smaller cones on the maxillary side; area I has 2 teeth in tandem.

[*Nereis culveri* Webster] (Ann. Rep. New York Mus. **32**: 111–113, pl. 3, figs. 23–30; pl. 4, figs. 31, 32, 1879) from New Jersey, U.S.N.M. no. 541, is a *Leptonereis*. Paragnaths are absent from both rings. Jaws are delicate, amber, with 9–12 closely set teeth; parapodia have greatly shortened dorsal and ventral cirri. The types of *N. culveri* and *Leptonereis acuta* agree favorably.

[*Nereis decora* Treadwell] (Rev. Mus. Paulista São Paulo **17**: 15–17, figs. 6–11, 1932) from Brazil, U.S.N.M. no. 19639, is identical with *Nereis riisei* Grube.

[*Nereis disparsetosa* Treadwell] (Rev. Mus. Paulista São Paulo **17**: 15–17, figs. 6–11, 1932) from Brazil, U.S.N.M. no. 19638, is a *Pseudonereis*, identical with *Ps. palpata*. Area VI of the proboscis has a transverse chitinous plate, area V a pointed cone, areas VII–VIII have 21 cones in a single continuous row. Posterior dorsal lobes are elongate, flattened, foliaceous, convex along the dorsal edge, the dorsal cirrus is inserted terminally. Jaws are dark brown, each with 6 indistinct crenulate teeth. Dorsal, middle and ventral parapodial lobes are pigmented.

[*Nereis eucapitis* Hartman] (Proc. U. S. Nat. Mus. **83**: 468–469, fig. 46, 1936) from California, U.S.N.M. no. 20198, is identical with *Nereis heterocirrata* Treadwell.

[*Nereis gracilis* Webster] (Bull. U. S. Nat. Mus. **25**: 313–314, pl. 9, figs. 29–35, 1884) from Bermuda, U.S.N.M. no. 4787, is a *Ceratonereis*. Paragnaths are absent from the oral ring. Paragnaths on the maxillary ring are arranged as follows: areas I and II none, areas II and IV each with about 9 to 12 tall, slender cones in a crescent. Jaws are light horny brown, each with 4 or 5 teeth. The name, *N. gracilis* is preoccupied by Hansen (Mém. cour. Belg. **44**: 10, 1882). Since, Webster's type is a *Ceratonereis*, no change seems necessary.

Nereis heterocirrata Treadwell (Proc. U. S. Nat. Mus. **80**: 1–2, figs. 1a–e, 1931) from Japan, U.S.N.M. 19323, includes *N. eucapitis* Hartman.

[*Nereis irritabilis* Webster] (Trans. Albany Inst. **9**: 231–234, pl. 5, figs. 56–64; pl. 6, figs. 65–69, 1879) from Virginia, U.S.N.M. no. 531–534, is a *Ceratonereis*. It differs from the widely known *C. hircinicola* (Eisig) which it resembles in some respects, in having area III of the proboscis provided with a broad band of 3 or 4 irregular rows of teeth, which almost meet those of area IV, instead of having a subcircular patch. Transformation of parapodia in epitokous females is at the 31st parapodium.

[*Nereis* (*Neanthes*) *linea* Treadwell] (Proc. U. S. Nat. Mus. **83**: 268–270, fig. 19, 1936) from China, U.S.N.M. no. 20115, is a *Perinereis*, identical with *P. aibuhitensis* (Grube).

[*Nereis* (*Neanthes*) *orientalis* Treadwell] (Proc. U. S. Nat. Mus. **83**: 270–272, fig. 19, 1937) from China, U.S.N.M. no. 20116, is identical with *Perinereis aibuhitensis* Grube. The type is a male heteronereid.

[*Nereis paucidentata* Moore] (Proc. Acad. Nat. Sci. Philadelphia, pp. 430–431, pl. 24, figs. 28–30, 1903) from Alaska, U.S.N.M. no. 15709, is a *Ceratonereis.*

[*Nereis pusilla* Moore] (Proc. Acad. Nat. Sci. Philadelphia, pp. 428–429, pl. 24, figs. 25–27, 1903) from Japan, U.S.N.M. no. 15734, is a *Ceratonereis.* The specific name has been previously used by Bosc in 1802, and by Langerhans in 1879. Neither of these, belongs to the genus *Ceratonereis,* thus a change of name is unnecessary.

Perinereis aibuhitensis Grube (Mem. Acad. Sci. St. Petersburg **25**: 89–90, pl. 5, fig. 3, 1878) from the Philippine Islands, includes *Nereis linea* and *Nereis orientalis,* both from China.

Perinereis caeruleis, n. comb., for *Heteronereis caeruleis* Hoagland.

[*Platynereis integer* Treadwell] (Bull. Mus. Nat. Hist. **100**: 595–597, figs. 1–4, 1920) from the Philippine Islands, U.S.N.M. no. 18939, is identical with *Pl. polyscalma* Chamberlin (*vide* Monro, in Scientific Reports, **4**: 18, 1931, and Fauvel, in Voy. Indes orient. Neérlandaises, p. 23, 1931).

Platynereis polyscalma Chamberlin (Mem. Mus. Harvard **48**: 219) from the Gilbert Islands, U.S.N.M. no. 19449, includes *Pl. integer.*

[*Pseudonereis atopodon* Chamberlin] (Mem. Mus. Harvard **48**: 228, pl. 35, figs. 3–5, 1919) from the Tonga Islands, U.S.N.M. no. 19467, is identical with *P. palpata.*

Pseudonereis palpata, n. comb., for *Neanthes palpata* Treadwell, includes *Nereis disparsetosa* Treadwell and *Pseudonereis atopodon* Chamberlin.

Uncinereis agassizi (Ehlers) (Die Borstenwürmer, pp. 542–546, p. 23, fig. 1) from the Gulf of Georgia, British Columbia and Mendocino, California, includes *U. subita* Chamberlin.

[*Uncinereis subita* Chamberlin] (Mem. Mus. Harvard, 48: 215–219, pl. 30, figs. 1–4, 1919) from California, U.S.N.M. no. 19495, is identical with *U. agassizi* (Ehlers).

ZOOLOGY.—*Three new species of the amphipod genus* Ampithoe *from the west coast of America.*[1] CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by WALDO L. SCHMITT.)

When examining collections of Amphipoda from the west coast of America from time to time, I have noted several specimens of *Am-*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 4, 1937.

pithoe which did not appear to belong to any of the species with which I was familiar. After studying the literature of this genus, I have concluded that at least three new species are represented in the material. These new species, the descriptions of which follow, are *Ampithoe plumulosa* represented from Ecuador, Lower California, California, and British Columbia; *Ampithoe dalli* from Alaska, Bering Island, British Columbia, and Puget Sound; and *Ampithoe rubricatoides* from the Aleutian Islands and the Pribilof Islands, Alaska.

Family AMPITHOIDAE

Ampithoe plumulosa, n. sp. Fig. 1

Description of male.—Head with lateral lobes prominent, rectangular, corners evenly rounding. Eye rather small, oval, black. Antenna 1 longer than antenna 2, and over two-thirds the length of the body; first peduncular joint equal in length to the second, which is over three times the length of the third; flagellum over twice as long as the peduncle and composed of about forty-eight joints. Antenna 2 much stouter than antenna 1; fifth joint a little shorter than fourth; flagellum a little longer than fourth joint and composed of about twenty-eight joints; the anterior two-thirds of the lower margin of the fifth joint and the flagellum densely clothed with long plumose setae. Right mandible with six spines in spine-row; palp well developed, third joint shorter than second and very little, if at all, expanded distally, the obliquely rounding distal end bearing long curved setae. Maxilla 1, inner plate very short, conical, and bearing four setae on the outer margin, outer plate armed with ten spine-teeth. Maxilla 2 normal and as figured by Sars for *A. rubicata.* Maxillipeds, inner plate reaching beyond the base of the first joint of the palp, outer plate reaching to the end of the second joint of the palp. Lower lip very much as figured by Sars for *A. rubicata.*

Gnathopod 1 with side-plate produced far forward; second joint bearing a forward-pointing lobe on the outside distal corner; third joint with lobe on the inside front margin; fifth joint about four-fifths as long as the sixth with the hind margin produced into a shallow lobe; sixth joint with margins parallel, palm oblique, broadly and evenly rounding and defined by a spine; seventh joint greatly overlapping palm and finely serrate on inner margin. Gnathopod 2, second joint with outside distal corner produced into a forward-pointing lobe; third joint with inside front margin produced into a lobe; fifth joint about half the length of the sixth joint; sixth joint large and powerful, palm slightly oblique, central portion in old males occupied by a long, flat tooth, but in younger males evenly convex; seventh joint strongly curved so that when closed the apex meets the rather blunt defining angle of the palm. Peraeopods 1 and 2 alike except that 1 is slightly the longer; second joint somewhat expanded; fourth joint slightly expanded and slightly produced distally. Third peraeopod as represented by Fig. 1 m. Peraeopods 4 and 5 alike, but 5 a little the longer; second joint moderately expanded with hind margin produced below into a short, downward-pointing lobe; sixth joint with three or four stout spines on the lower hind margin, and a pair of smaller spines nearer the seventh joint. The seventh thoracic segment bears ventrally a median, forward-directed, translucent, lamellar, oval keel armed with marginal teeth, those on the anterior half pointing

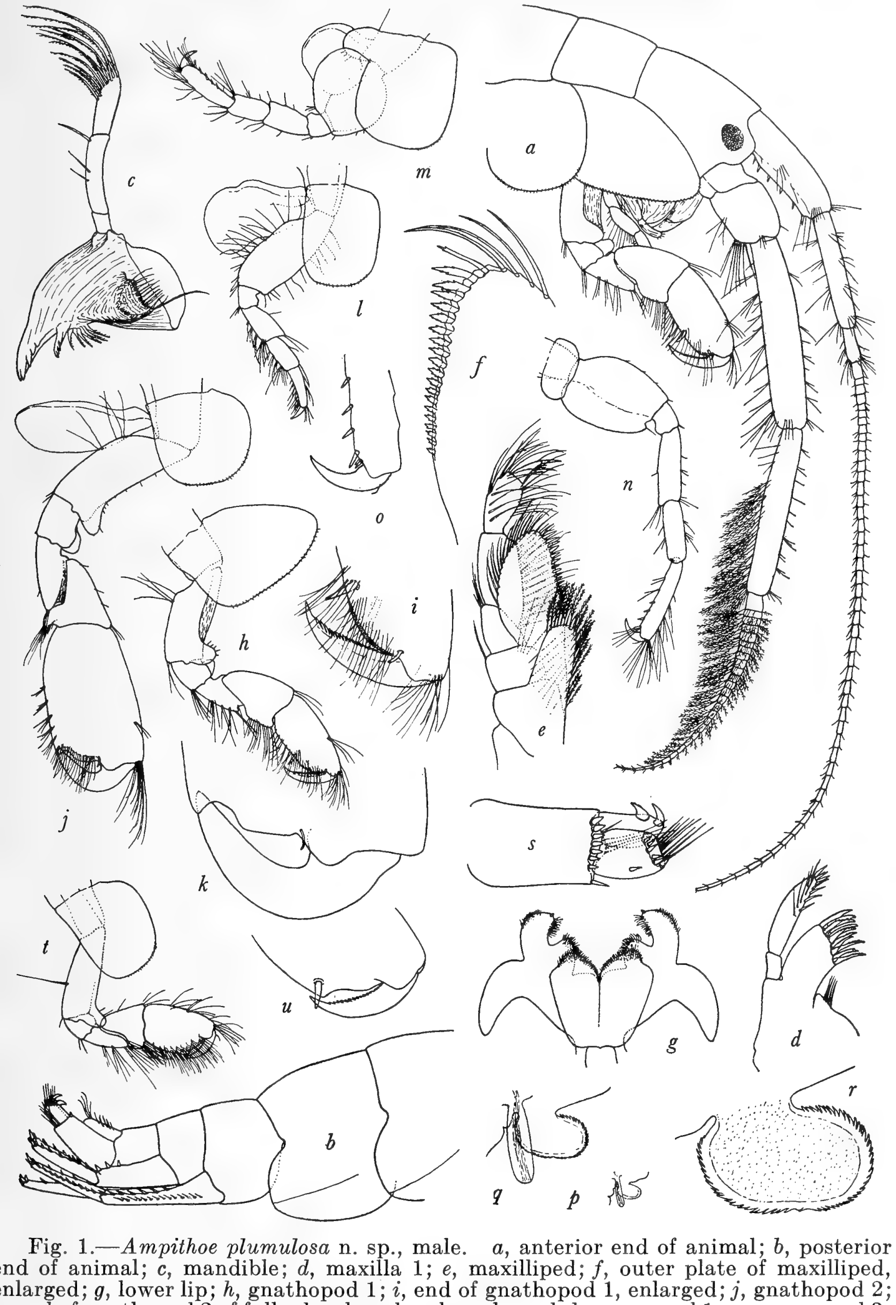


Fig. 1.—*Ampithoe plumulosa* n. sp., male. *a*, anterior end of animal; *b*, posterior end of animal; *c*, mandible; *d*, maxilla 1; *e*, maxilliped; *f*, outer plate of maxilliped, enlarged; *g*, lower lip; *h*, gnathopod 1; *i*, end of gnathopod 1, enlarged; *j*, gnathopod 2; *k*, end of gnathopod 2 of fully developed male, enlarged; *l*, peraeopod 1; *m*, peraeopod 3; *n*, peraeopod 4; *o*, end of peraeopod 4, enlarged; *p*, ventral, oval keel of seventh thoracic segment, drawn on the same scale as the peraeopods; *q*, keel on larger scale showing its situation in reference to the male genital organ; *r*, keel greatly enlarged showing the marginal teeth; *s*, uropod 3; *t*, gnathopod 2, ♀; *u*, end of same, enlarged.

forward and those on the posterior half pointing backward. The penes are prominent and are situated on either side of this keel.

Third abdominal segment with lower postero-lateral margin broadly and evenly rounding and lower postero-lateral angle scarcely perceptible. Uropods 1 and 2 extending back the same distance, but not as far as uropod 3. Uropod 1, distil half of upper margin of peduncle armed with spines, and a row of fine spines or setae on outer surface; outer margin of outer ramus closely set with spines. Uropod 2, distal half of outer margin of peduncle armed with three spines. Uropod 3, peduncle extending farther back than telson and without marginal spines, but bearing a row of short spines at the upper distal edge. Telson a little broader than long, sides converging to the rather narrow, slightly excavate apex. Length of animal about 16 mm.

Type.—A mature male taken from a tide pool at La Jolla, California, by Dr. Waldo L. Schmitt, Sept. 20, 1918, U. S. Nat. Mus. cat. no. 71443.

The female is much like the male except in the following characters. Side-plate 1 is not produced so far forward. Gnathopod 1 is like that of the male except there is no lobe on the third joint. Gnathopod 2 very slightly larger than gnathopod 1; third joint without lobe; sixth joint one-third longer than fifth, palm formed by an oblique compound curve which ends in a blunt defining angle below which is a stout spine; seventh joint slightly overlapping palm and bearing fine serrations on inner margin. The keel on the ventral surface of the seventh thoracic segment is not so prominently developed as in the male, and in some specimens is reduced to a low ridge.

The first specimens of this species were taken by Dr. Wm. H. Dall at Catalina Harbor, Catalina Island, California, in 1874.

The specific name *plumulosa* is given in reference to the prominent plumose setae on the distal portion of the second antennae.

Specimens from the following localities are in the national collection:

Salinas, Ecuador, September 12, 1926, Dr. Waldo L. Schmitt, collector, 4 specimens.

La Libertad, Ecuador, January 19, 1933, Dr. Waldo L. Schmitt, collector, 1 specimen.

La Ensenada, Lower California, November 28, 1936, low tide, Steve A. Glassell, collector, 7 specimens.

**Velero III* Sta. 639, San Lorenzo Channel, Espiritu Santo Island, Lower California, March 7, 1937, 3–5 fathoms, sandy coralline algae, Hancock Pacific Expeditions 1937, 4 specimens.

**Velero III* Sta. 683, outside Concepcion Bay, Lower California, March 15, 1937, 12 fathoms, corallines, Hancock Pacific Expeditions, 1937. 1 specimen.

**Velero III* Sta. 706, Puerto Refugio, Angel de la Guardia, Lower California, March 20, 1937, 8–10 fathoms, *Ulva*, Hancock Pacific Expeditions, 1937, 1 specimen.

**Velero III* Sta. 731. Tiburon Island, Gulf of California, March 28, 1937, 12 fathoms, Hancock Pacific Expeditions, 1937, 7 specimens.

San Diego, California, May 29, 1927, Wilbur Reed and Leroy Arnold, collectors, 1 specimen.

La Jolla, California, tide pools, September 1918, Dr. Waldo L. Schmitt, collector, 15 specimens, and 25 specimens received from the Scripps Institution.

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Corona Del Mar, California, January 31 to March 3, 1933, Mr. G. E. MacGinitie, collector, 1 specimen.

Newport Bay, California, November 15, 1933, Mr. G. E. MacGinitie, collector, 2 specimens, and July 14, 1935, 35 specimens.

Off Balboa, California, November 25, 1932, Mr. G. E. MacGinitie, collector, 1 specimen.

Long Beach, California, September 26, 1925, University of Southern California, 16 fathoms, 1 specimen.

Catalina Island, California, 1874, Dr. Wm. H. Dall, collector, 3 specimens, and 5 specimens collected by W. A. Hilton, Aug. 24, 1918.

Patos Island, Strait of Georgia, British Columbia, April 23, 1921. 3 specimens.

Ampithoe dalli n. sp. Fig. 2

Description of male.—Head with lateral lobes prominent and rectangular, corners evenly rounding. Eyes rather small, circular, black. Antenna 1 shorter than antenna 2, which is about one-half the length of the body; peduncle extending very nearly to the end of the fourth joint of antenna 2; second joint a little shorter than the first and a little over twice the length of the third; flagellum composed of about thirty joints. Antenna 2 rather robust; fourth and fifth joints about equal in length; flagellum composed of about eighteen joints and equal in length to the fourth and fifth peduncular joints combined. Mandible with rather stout palp; second joint shorter than the third; third expanding distally and with the obliquely truncate upper margin bearing the usual long curved spines. Maxilla 1 with small conical inner plate bearing one lateral seta; outer plate bearing ten serrate spine-teeth; palp with distal end rounding and bearing five straight spines below which are two slender setae. Maxilla 2, inner plate much narrower than outer. Maxilliped with inner plate rather short, bearing distally and on the inner margin long, slender setae, and at the inner distal corner a stout spine; outer plate reaching perhaps a little beyond the second joint of the palp and broadest a little beyond the middle, upper third of outer margin with curved spines, inner margin bearing the usual serrate spine-teeth; palp rather short and strong, first and second joints about equal in length, the third joint is a little shorter than first or second.

Side-plate 1 produced forward, but not so much so as in *A. plumulosa*. Gnathopod 1, second joint rather short and robust and with distal anterior corner produced into a lobe; third joint short, without anterior lobe; fourth joint with lower distal margin somewhat produced; fifth joint shorter than sixth, lower margin extended downward into a shallow lobe which is not at all produced forward; sixth joint with the oblique, slightly convex palm merging into the hind margin by an evenly rounding curve, palm defined by a stout spine; seventh joint fitting palm, but the apex extending beyond the defining spine. The inside surface and lower margin of all the joints, except the sixth and seventh, of gnathopod 1 are densely clothed in long plumose setae. Side-plate 2 about as deep as side-plate 1 and much longer than deep. Gnathopod 2, second joint shorter than sixth and with lower anterior corner produced downward into a prominent lobe; fourth joint rectangular; fifth joint short, lower part narrowly produced between fourth and sixth, a low protuberance on upper proximal margin; sixth joint strong and robust, front and hind margins divergent, front margin slightly convex and twice the length of the hind margin which is continued distally into a

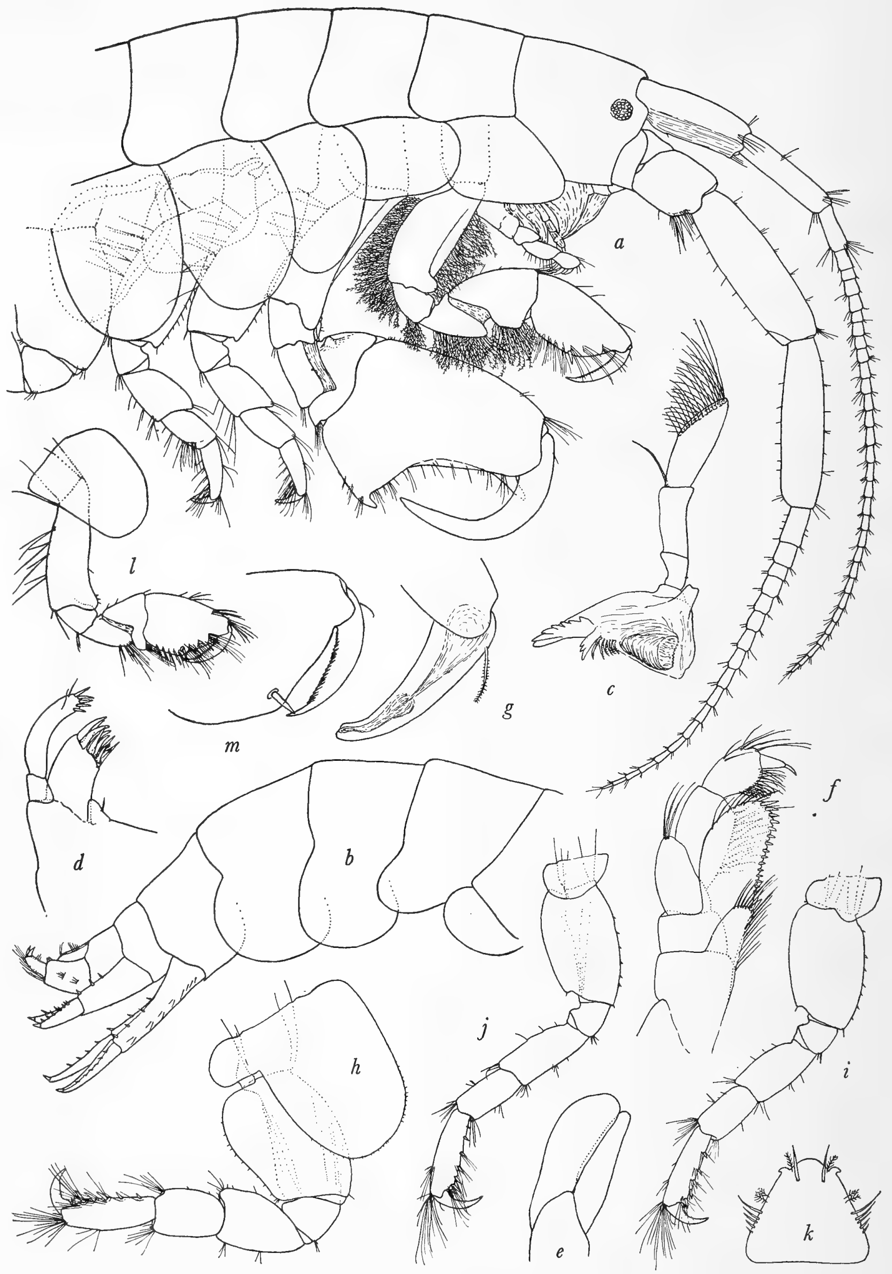

Fig. 2.—*Ampithoe dalli* n. sp., male. *a*, anterior half of animal; *b*, posterior half of animal; *c*, mandible; *d*, maxilla 1, *e*, maxilla 2; *f*, maxilliped; *g*, end of peraeopod 1, enlarged; *h*, peraeopod 3; *i*, *j*, peraeopods 4 and 5, drawn on a smaller scale than peraeopod 3; *k*, telson; *l*, gnathopod 2, ♀; *m*, end of same, enlarged.

forward-pointing tooth; palm very oblique and passing by an uneven concave curve from a prominent tooth near the dactyl hinge to the distal tooth of the hind margin. Seventh joint strong and very much curved, the apex meeting the palm some distance short of the tooth of the hind margin. Side-plates 3 to 5 much deeper than the two preceding and increasing slightly in depth from the third to the fifth, lower margins evenly rounding. Peraeopods 1 and 2 subequal in length; second and fourth joints only moderately expanded. Peraeopod 3, second joint longer than broad with hind margin produced into a rather flat lobe whose margin is slightly concave on the lower half; sixth joint bearing on the hind margin five stout spines which increase in length toward the seventh joint, which is strong and much curved. Peraeopods 4 and 5 much alike, rather short, but 5 slightly the longer; second joint very moderately expanded; sixth joint bearing five or six stout spines on front margin; seventh joint strong and much curved.

Pleon segments 1 to 3 with lower margins evenly rounding and no apparent lower postero-lateral angle on the third. Uropods rather short and stout. Uropod 1 reaching back only very slightly farther than 2; peduncle with very few spines on the upper inner and outer margins, and a few groups of fine spines or setae on the lower outer margin; rami with a few short spines on upper edges. Uropod 2 with rami much shorter than peduncle; upper outer edge of peduncle bearing three spines; rami bearing a few short spines on their upper edges. Uropod 3 extending back a little farther than 2; peduncle nearly twice as long as the rami and bearing no spines on the upper surface except the transverse distal row; the outer ramus bearing, besides the two terminal upward-pointing spines a group of slender spines on the central area of the upper surface. Telson about two-thirds the length of the peduncle of uropod 3, broadly triangular, with the sides, each of which bears a row of upward-pointing spines and two plumose setae, converging to a narrowly rounded apex bordered on either side by a hooked spine and a long slender spine. Length of male 15 mm.

Type.—A mature male taken by the steamer *Albatross*, June 24, 1914, at Yakutat Bay, Alaska, U. S. Nat. Mus. cat. no. 73274.

The species is named in honor of Dr. Wm. H. Dall, who collected the first specimens in 1873 in Kyska Harbor, Kyska Island, Alaska.

The female is like the male except in the first few side-plates and the gnathopods. Side-plates 1 and 2 are not longer than deep, as they are in the male, and side-plate 1 is not produced forward as much as in the opposite sex. Gnathopod 2 is very slightly larger and stronger than gnathopod 1, which is like that of the male, but without the plumose setae; sixth joint like that of gnathopod 1 except the palm is not evenly convex and does not merge into the hind margin by an evenly rounding curve, but is defined by a blunt rounding angle. Length of female 15 mm.

Specimens from the following localities are in the national collection:

Kyska Harbor, Kyska Island, Aleutian Islands, Alaska, 1873, beach, Wm. H. Dall, collector, 2 female specimens.

Lissonkovaya Bay, Bering Island, August 22, 1882, L. Stejneger, no. 1491, 1 female specimen.

Unalaska Island, Aleutian Islands, Alaska, May 26, 1906, taken by the steamer *Albatross*, 4 female specimens.

Attu Island, Aleutian Islands, Alaska, shore, June 10–11, 1906, taken by the steamer *Albatross*, 2 male specimens.

Adakh Island, Aleutian Islands, 1 male and 1 female specimen.

Ucluclet, British Columbia, May 19, 1909, John Macoun, collector, no. 9, 4 specimens, male and female; and no. 10, 1 male specimen.

Observation Island, Alaska, June 27, 1914, taken by the steamer *Albatross*, 3 specimens.

Neah Bay, Puget Sound, April 27, 1914, taken by the steamer *Albatross*, 1 male specimen.

Yakutat Bay, Alaska, June 24, 1914, taken by the steamer *Albatross*, 1 male specimen.

Friday Harbor, Puget Sound, in eel grass. August 5, 1928, Mr. K. L. Hobbs, collector, 25 specimens, male and female.

False Bay, Puget Sound, August 12, 1928, Mr. K. L. Hobbs, collector, 1 female specimen.

Ampithoe rubricatoides n. sp. Figs. 3, 4

Description of male.—Head, lateral angle with upper front corner broadly rounding, lower corner scarcely perceptible, front of lobe passing by an almost straight line into the lower front margin of head; eye small, round, very pale in alcohol, and about the same color as the rest of the head. Antenna 1 apparently a little shorter than antenna 2; second peduncular joint a little shorter than first and a little over twice as long as third; flagellum a little shorter than peduncle and composed of about twenty joints. Antenna 2, fourth joint a little longer than fifth; flagellum equal to or a little longer than the fourth and fifth joints combined and composed of about fourteen joints; the lower margin of the fifth peduncular joint and the lower margin of the flagellum bearing conspicuous groups of setae. Mandible with small tooth on anterior edge of triturating surface of molar and a racket-like spine and a simple spine on the upper corner, a very conspicuous grooved prominence near the base of the palp; six spines in spine-row; palp rather short and stout, second joint about half the length of the third, the upper edge of which is very obliquely truncate. Maxilla 1, inner plate with one marginal seta; outer plate with ten simple, curved spine-teeth; rounding apex of palp bearing five slender spines and upper inside margin with five or six longer spines, Maxilla 2, outer plate not much wider than inner; apex and upper half of inner margin of outer plate with long spines; apex and entire inner edge of inner plate with long spines. Maxilliped very much like that of *A. dalli*, inner plate extending a little beyond the base of the first palp joint, apex rounding, with no apical teeth, but apex and inner margin bearing long spines; outer plate extending a little beyond the end of the second palp joint, upper half of outside margin and rounding apex armed with long curved spines, inner margin with the usual spine-teeth, which do not appear to be serrate; palp short and stout.

Side-plate 1 produced moderately forward. Gnathopod 1, second joint bearing forward-pointing lobe on the lower front corner; fifth joint over half the length of the sixth; sixth joint widest through the middle; palm very oblique, defined by a spine and passing by a scarcely perceptible angle into the hind margin, both palm and hind margin of sixth joint bearing conspicuous setae; seventh joint fitting palm, but slightly overlapping it. Gnathopod 2 much resembling gnathopod 1 but larger and stronger, and the lower front lobe of the second joint is less produced; sixth joint stout and strong, widest through the middle, palm oblique, concave, and forming a blunt angle with the hind margin, a submarginal palmar spine on inside surface of joint just before the defining angle; seventh joint strong, moder-

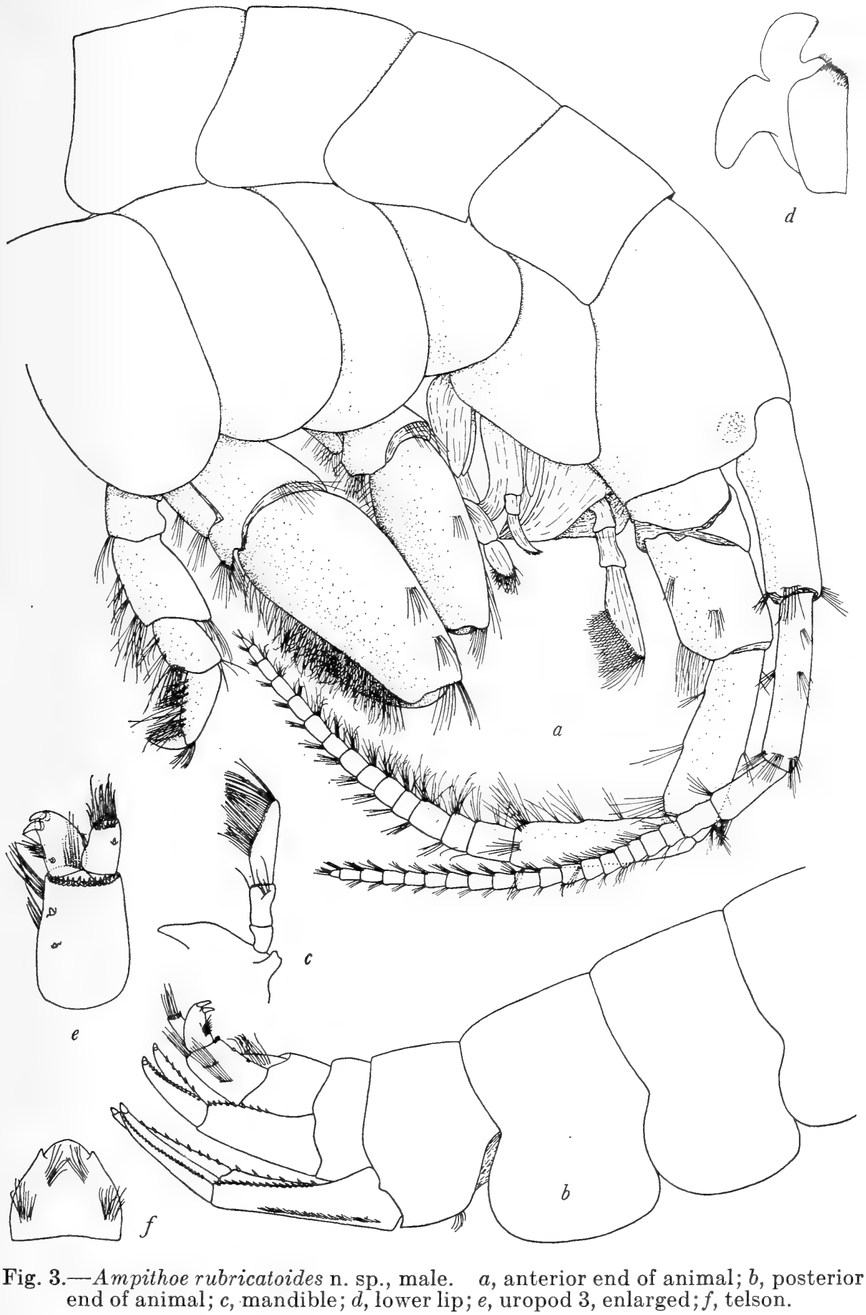

Fig. 3.—*Ampithoe rubricatoides* n. sp., male. *a*, anterior end of animal; *b*, posterior end of animal; *c*, mandible; *d*, lower lip; *e*, uropod 3, enlarged; *f*, telson.

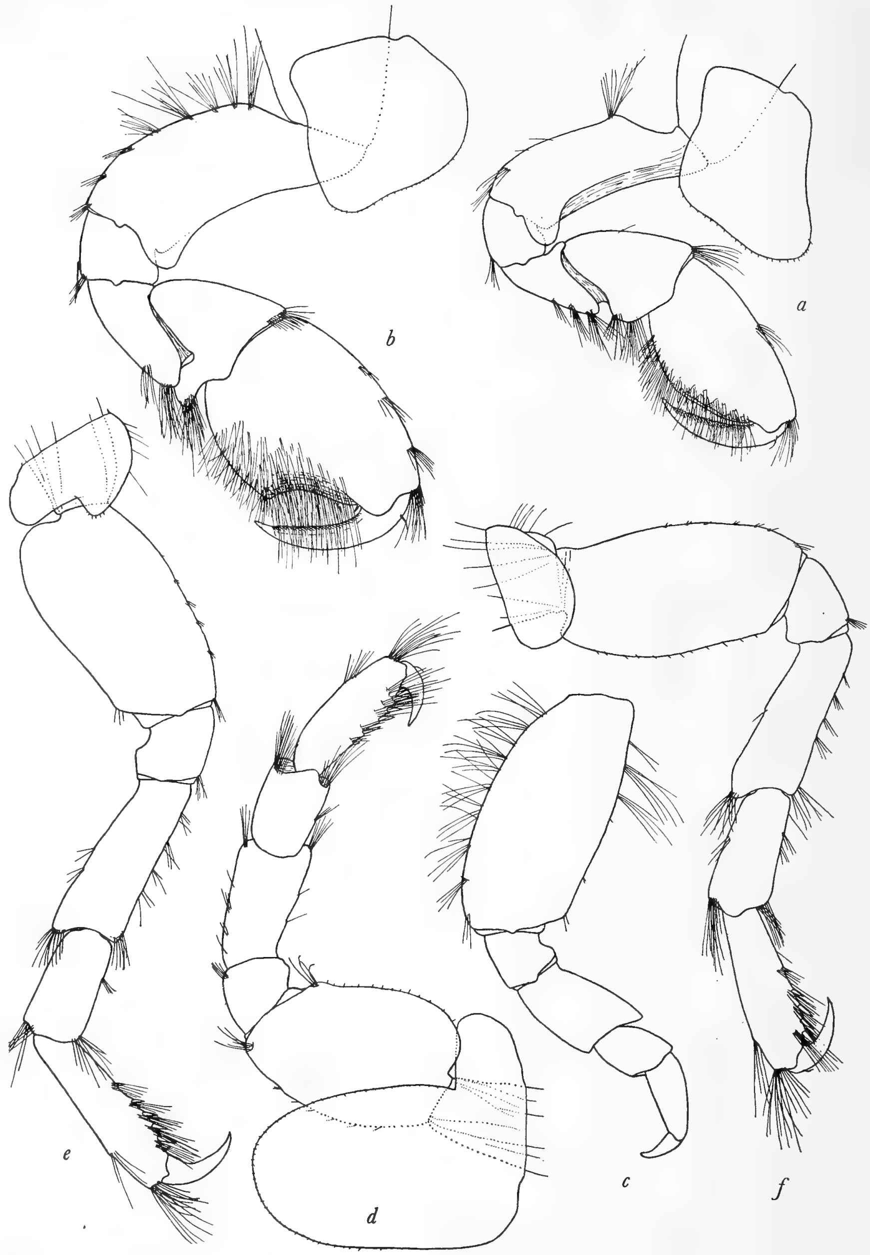

Fig. 4.—*Ampithoe rubricatoides* n. sp., male. *a*, gnathopod 1; *b*, gnathopod 2; *c*, peraeopod 1; *d*, peraeopod 3; *e*, peraeopod 4; *f*, peraeopod 5.

ately curved, not fitting palm when closed, but apex resting on the inside of sixth joint against the submarginal spine; the palm and lower surface of sixth joint conspicuously setose. Peraeopods 1 and 2 subequal in length, second joint moderately expanded; fourth joint moderately expanded with lower front corner produced slightly downward. Peraeopod 3, second joint longer than wide and widest across upper third; sixth joint armed on hind margin with about five stout spines. Peraeopods 4 and 5 very much alike, but 4 a little the longer, second joint moderately expanded; sixth slightly expanded distally and armed on hind margin with five stout spines; seventh joint strong and much curved.

Pleon segments 1 to 3, lower postero-lateral margins merging into lower margins by a broad evenly rounding curve. Uropod 1 reaching back a little farther than 2, rami about two-thirds the length of the peduncle, peduncle with the distal two-thirds of the upper outer edge furnished with a row of short closely-set spines, while the spines on the upper inner edge are set farther apart, lower outer edge provided with a row of fine setae; outer edge of outer ramus with fine closely-set spines throughout, inner edge apparently without spines; inner edge of inner ramus with spines set farther apart than those of outer ramus, the opposite edge apparently without spines. Uropod 2, rami about three-fourths the length of the peduncle; the distal half of upper, outer edge furnished with short closely-set spines; armature of rami the same as in uropod 1. Uropod 3 extending back very little beyond 2, rami a little over half the length of the peduncle, which bears two very short spines on the upper surface, and a row of very short closely-set spines on the upper distal margin, outer side of peduncle with two groups of slender setae; outer ramus with the usual uncinate distal spines, a very short spine near the proximal margin of upper surface, and a group of setae on the outer surface; inner ramus bearing apically a transverse row of very short spines and a row of long slender setae. Telson as broad as long, and about reaching the end of uropod 3, sides converging by a convex curve to a narrowly rounding apex which is bordered on either side by a short blunt tooth or spine, upper surface with a group of setae proximally on either side and a group of setae distally nearer the center. Length of male 24 mm.

Type.—A mature male from Kyska Harbor, Kyska Island, Aleutian, Islands, taken in 1873 by Dr. Wm. H. Dall, 10 fathoms, U. S. Nat. Mus. cat. no. 74661.

The female is very much like the male in general appearance. Gnathopod 1 like that of the male. Gnathopod 2 very little larger than 1 and closely resembling it in form, but the palm is obliquely straight and not concave. The armature of uropods is the same as in the male. The females which I have seen are considerably smaller than the largest males, but these specimens may not have attained their greatest development.

There are in the collection of the U. S. National Museum the following specimens:

Kyska Harbor, Kyska Island, Aleutian Islands, Alaska, 1873, 9–12 fathoms, sandy, mud, collected by Dr. Wm. H. Dall, no. 164 (1001), 3 specimens.

Kyska Harbor, Kyska Island, Aleutian Islands, Alaska, in pass, 1873, 10 fathoms, collected by Dr. Wm. H. Dall, nos. 234 (1035), 235 (1036), and 236 (1037), 4 specimens.

Saint Paul, Pribilof Islands, Alaska, July 24, 1874, 6–9 fathoms, sand, collected by Dr. Wm. H. Dall, no. 721 (1163), 4 specimens.

ENTOMOLOGY.—*A new anobiid beetle from Alaska.*[1] W. S. Fisher, Bureau of Entomology and Plant Quarantine. (Communicated by E. A. Chapin.)

The beetles described in this paper were submitted for identification by James H. Condit from the Sheldon Jackson Museum at Sitka, Alaska, who reported them as doing considerable damage to the wooden articles in the museum, as well as to the surfaces of the supporting columns of the building.

Hadrobregmus destructor, n. sp.

Elongate, subcylindrical, brownish black (tarsi and antennae slightly paler), subopaque, rather densely pubescent.

Head deeply sunk within the prothorax, strongly carinate around the antennal bases, with a round, smooth, median spot beneath; front uneven; surface broadly, transversely depressed behind the eyes; finely, densely granulose, sparsely clothed with recumbent, brownish yellow hairs; maxillary palpus with the last segment elongate oval, pointed at apex, slightly wider than preceding segment; labial palpus with the last segment subtriangular, rounded on inner side, much wider than preceding segment. Eyes moderately large, strongly convex. Antenna 11-segmented; first and second segments robust, oblong; third to eighth segments narrow, not serrate, subequal in length; ninth, tenth, and eleventh segments slightly flattened, subequal in length, and together longer than the preceding segments united.

Prothorax distinctly narrower than the elytra, deeply excavated beneath for the reception of the head, which is received in repose upon the anterior coxae. Pronotum as wide as long; sides parallel anteriorly, acurately narrowed posteriorly; lateral margin irregular, distinct, strongly elevated at posterior angle; anterior margin strongly sinuate; disk strongly gibbose posteriorly; surface finely, densely granulose, rather densely clothed with moderately long, recumbent, brownish yellow hairs.

Elytra twice as long as wide, slightly wider behind the middles; sides nearly parallel from bases to apical fifths, then arcuately narrowed to the tips, which are conjointly broadly rounded; disk strongly convex; each elytron with about ten longitudinal rows of deep, coarse punctures; intervals from two to three times as wide as the punctures, feebly elevated basally, strongly, irregularly elevated apically; surface rather densely clothed with moderately long, recumbent, brownish yellow pubescence, which forms more or less distinct vittae between the alternate rows of punctures.

Body beneath finely, densely granulose, rather densely clothed with moderately long, recumbent, brownish white pubescence. Front and middle coxae widely separated, the antennae received between them. Metasternum not at all or only vaguely excavated in front, but with a broad, deep, median depression near the posterior margin. Abdominal sternites free, with the sutures straight; second sternite slightly longer than the fifth.

Length, 3.25–5.25 mm; width, 1.25–1.75 mm.

Type locality.—Sitka, Alaska.

Type and paratypes.—No. 52232, United States National Museum.

Described from 25 specimens (one type) collected in the Sheldon Jackson

[1] Received November 6, 1937. Paper No. 4250 of the Bureau of Entomology and Plant Quarantine.

Museum during July 1937 by James H. Condit. The work of this beetle is similar to that of the "European death-watch" beetle (*Anobium punctatum* De Geer). Mr. Condit reports this species as working in a dugout Thlinget canoe, an old deadfall trap, a birch canoe, and in the unpainted surfaces of the supporting columns of the building. The articles affected have been in the concrete building for some 45 years, but some ten years ago new wooden cases were installed and it is Mr. Condit's belief that the insects were brought in at that time.

This species resembles *Anobium punctatum* De Geer, but it differs from that species in being larger, in the pubescence on the elytra forming more or less distinct vittae between the alternate rows of punctures, and in not having the metasternum deeply excavated in front. It differs from the other known species of *Hadrobregmus* in having the pubescence on the elytra forming more or less distinct vittae.

ENTOMOLOGY.—*A new European species of* Epiurus, *parasitic on a leafmining sawfly* (*Hymenoptera: Ichneumonidae*).[1]

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

The new species described below was originally reared in Europe by agents of the Bureau of Entomology and Plant Quarantine, from mines of the sawfly leaf-miner of birch, *Phyllotoma nemorata* (Fallén). Living individuals brought to the United States were bred at the Melrose Highlands, Mass., laboratory of this Bureau. Some of the specimens on which the description is based are first-generation progeny of imported parents. Many were released in areas in New England infested by the host species, but at this writing no specimens of the parasite have been recovered.

The figure was drawn by Mary Foley Benson.

Epiurus foliae, n. sp. Fig. 1

Female.—Length 8.5 mm; antennae 5 mm; ovipositor sheath 4.5 mm.

In Schmiedeknecht's key to the European species of *Pimpla*, *sens. lat.* (Opuscula Ichneumonologica, Suppl., Bd. 18–19, 1933–1934) this species runs to *Epiurus inquisitor* (Scopoli), and agrees very closely with the description of that species except that the hind tarsus is pale, with only narrow apices of the joints dark, and that the propodeum is not striate posteriorly. Comparison of specimens shows the most striking difference between the two species to be in the form of the apical portion of the ovipositor, which in profile is strongly, concavely curved on the dorsal margin from the high point to the apex in *foliae* and is nearly straight in *inquisitor;* this is adequately shown in the accompanying figure. The epipleura are narrower in *foliae* than in *inquisitor* and the sclerotized portions of the abdominal sternites broader, broadly oval in *foliae* and elongately oval in *inquisitor*. Otherwise like *inquisitor* in structure, sculpture, and color.

[1] Received November 10, 1937. Paper No. 4269 of the Bureau of Entomology and Plant Quarantine.

Male.—Differs from male of *inquisitor* principally in the much smaller extent of dark color on hind tarsal joints, more than half of the basal joint being white.

Host.—*Phyllotoma nemorata* (Fallén).

Type locality.—Freistadt, Austria.

Type, allotype, and *paratypes.*—No. 52251, U. S. National Museum.

Paratypes.—British Museum; Paris Museum.

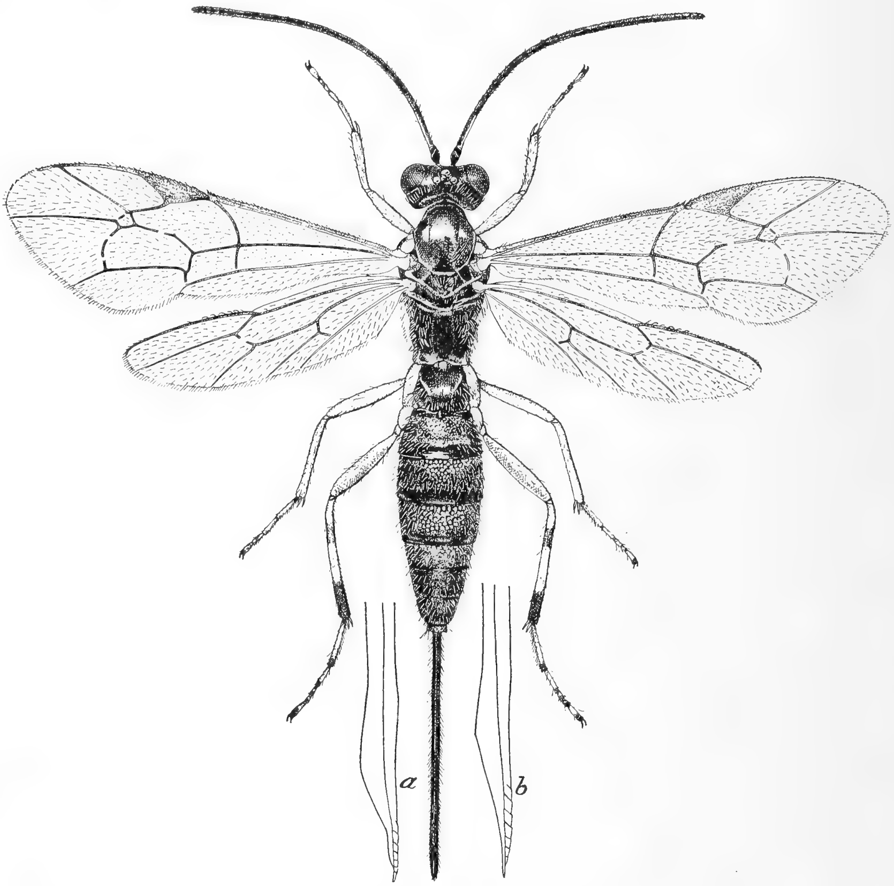

Fig. 1.—*Epiurus foliae* Cushman. *a*, apex of ovipositor; *b*, same of *Epiurus inquisitor* (Scopoli).

Three females (including holotype) and one male from the type locality, reared under Gipsy Moth Laboratory No. 13610 B, June 3, 1933 (holotype), October 8. 1932 and May 16, 1933; 10 females from the type locality, under No. 13610 B1, reared May 28, 1935; also 11 females and six males (including allotype) reared May 10, 1934, at Melrose Highlands, under No. 13613A, progeny of European specimens; and one male from Austria, reared in May 1934, under No. 13618, as a secondary parasite through *Phanomeris phyllotomae* Muesebeck.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1111TH MEETING

The 1111th meeting was held in the Cosmos Club Auditorium, January 16, 1937, President WENNER presiding.

An address entitled *Explorations in the superconducting state,* illustrated by slides, was delivered by the retiring President, F. B. SILSBEE. This address was published in this JOURNAL **27**: 225–244. 1937.

1112TH MEETING

The 1112th meeting was held in the Cosmos Club Auditorium, January 30, 1937, Vice-President WOOLARD presiding.

Program: RICHARD M. FIELD, Princeton University: *Structure of continents and ocean basins.*—This address, which was published in this JOURNAL **27**: 181–195. 1937, was discussed by Messrs. MCNISH, FLEMING and GISH.

ROSS GUNN: *On the origin of the continents and their motions.*—An approximate quantitative study has been made of the relation of the observed symmetry of the earth to certain aspects of geological evolution and to the problem of the origin of the solar system.

Geophysical data from several sources emphasize the unusual nature of the Pacific basin with its encircling mountain chains and suggests that the sub-Pacific layers of appreciable strength are slightly denser (1 or 2 per cent) than elsewhere. It is shown, as a result of this asymmetry and the isostatic adjustment of the continents, that the mass per unit area of the earth's outer shell in Pacific regions is about 3/100 per cent greater than in the continents. This relatively slight mass asymmetry is found to produce geologically important tangential forces on the continents of gravitational origin which frequently compress their boundaries playing an important part in mountain building and may actually produce continental motions. The force of North America urging it to the south and west, for example, approximates 10^{25} dynes and is adequate, or at least nearly adequate, to crush or produce over thrusting in the resisting Pacific basin, permitting continental motion with a velocity of the order of an inch per year. The author's earlier theory of the earth's origin, which was based upon purely astronomical facts (Phys. Rev., **39**: 130 and 311. 1932), is found to be particularly adapted to describe the origin of the continents and the observed asymmetry of their distribution. (*Author's abstract.*)

This was discussed by Messrs. GISH, BOWIE, FIELDS, PIGOT and WRIGHT.

1113TH MEETING

The 1113th meeting was held in the Cosmos Club Auditorium, February 13, 1937, President WENNER presiding.

Program: M. A. TUVE and L. R. HAFSTAD, Department of Terrestrial Magnetism of the Carnegie Institution of Washington: *Structural forces within the atomic nucleus.*—An important new physical force, in its way as fundamental and significant as the force of gravitation or that of electric attraction and repulsion, was directly observed and measured for the first time in the laboratory of the DTM, CIW, during the past year. This force is an attraction between the component primary particles, protons and neutrons, causing them to aggregate and form the central nuclei of all atoms; thus, it underlies the existence and form of all larger things in the material universe. It has hitherto been inferred to exist, because atoms heavier than hydrogen are known. The truly basic physical forces are exceedingly few in number, and the initial observation and measurement of such a force is a correspondingly unusual event. It is worthy of emphasis that these measurements represent the attainment of one of the original objectives in a program of fundamental investigations begun ten years ago.

Two rather similar heavy units, protons and neutrons, form the massive nuclei of all atoms, the protons being electrically charged (positively). There exist as well two other units of small intrinsic mass, again similar to each other but both electrically charged, positive electrons, and the negative electrons which form the outer "shells" of all atoms; these latter units act as the chief connecting links between matter and energy in the form of electromagnetic radiation. The basic forces which bind together matter and energy to form atoms and then all larger material bodies are necessarily very few. They comprise the mutual interactions between protons and neutrons, the interactions between these units and electrons (positive and negative), and lastly the interactions of these several types of particles with energy in the form of radiation.

By experimentally measuring at different voltages the frequency with which high-speed protons from a well-defined beam are scattered through various angles as a result of single collisions with other relatively stationary protons in a given volume of hydrogen, a basis becomes available for important deductions as to the forces of interaction which protons exert on each other when separated by various specific small distances. The scattering to be expected on the basis of the familiar $(1/r^2)$—law of repulsion between like charges, assumed to hold even for minutely close distances of approach, was worked out by Rutherford and Darwin (1911–14) with the minor numerical modifications resulting from the quantum-mechanical identity of the two protons added later by Mott (1930).

Using the Department's 1200-kilovolt electrostatic generator, with the new high-resistance voltmeter and properly aligned tube to produce a highly homogeneous proton-beam of the desired adjustable energy, counts were made (using a linear amplifier) of the number of protons scattered through various angles when passing through a path, about 2 mm long, of hydrogen at a pressure of 12 mm. For angles in the range measured (15° to 50°) plural scattering is negligible for this case, both experimentally and theoretically, and the observed particles are primary and recoil-particles which enter the particular angular region under observation as a result of single collisions. The measurements, carried out for voltages of 600, 700, 800, and 900 kilovolts, were made on an absolute basis, with an accurately defined scattering-volume and with an angular definition of about 2°. For angles of 15° and 20° the observed scattering at each voltage was about two-thirds of that predicted by Mott's formula, whereas at 45° the scattering varied progressively with voltage from somewhat under Mott's value at 600 kilovolts to four times Mott's value at 900 kilovolts. Intermediate angles show correspondingly progressive changes.

Interpreted in terms of proton-proton interaction, these results show that at small distances, of the order of 5×10^{-13} cm or less, the ordinary inverse-square repulsion between like charges is overwhelmed by another proton-

proton force, which is shown to be an attraction, according to the careful quantum-mechanical analysis of our measurements by Breit, assisted by Professor Condon of Princeton and Professor Present of Purdue. As mentioned above, these new attractive forces explain the aggregation of protons and neutrons into groups to form the nuclei of the various elements of the atomic table, thereby accounting for their existence. A satisfying feature of these results is the fact that the observed variation of the anomalous scattering with angle and with voltage permits of a simple and direct interpretation on the basis of the "wave-mechanics" which has so successfully met all previous requirements as a description of atomic phenomena. In terms of this theory the observed proton-scattering is accounted for as a simple scattering (phase-shift) of the spherically symmetrical wave-component by a "potential-well" (superposed on the Coulombian potential) which has almost exactly the depth and width previously assumed for the proton-neutron interaction. Furthermore, no appreciable effect on the higher wave-components appears to be required.

Immediately after the announcement that these proton-scattering results led to a proton-proton interaction very similar to that hitherto assumed by theoretical physicists for the proton-neutron interaction, serious doubts were cast on the latter interaction by Goldhaber of the Cavendish Laboratory, who announced measurements on the scattering of neutrons by protons widely different from the expected values. We were just then undertaking similar measurements of nearly the same kind under well-defined conditions—possible through the use of artificial neutron-sources of high intensity. Because of the doubt arising from Goldhaber's measurements, however, a repetition of his neutron-scattering experiment was made, using the (carbon+deuteron)−neutrons instead of his photo-neutrons from deuterium. Our measurements agreed astonishingly well with the value predicted by theory. The observed cross-section for scattering was 4.2×10^{-24} cm^2, whereas the values predicted by Wigner's theory of the deuteron lie between 5.4 and 3.2×10^{-24} cm^2 depending on the values taken for the excited level of the deuteron and for the exact energy of the carbon neutrons used (600 to 1200 kilovolts, probably about 900). These measurements are being refined and extended.

It thus appears that the earlier conclusions by Breit on the basis of our proton-scattering results that the proton-neutron, proton-proton, and neutron-neutron interactions are identical is probably valid, and a real step has been made toward the final understanding of the forces underlying the structure and behavior of all matter. (*Author's Abstract.*)

These addresses were discussed by Messrs. WHITE and STEPHENS.

An informal communication on ball lightning was presented by L. B. TUCKERMAN. It was discussed by W. J. HUMPHREYS.

WALTER P. WHITE presented an informal communication on some unusual formation of ice crystals. This was discussed by Messrs. WENNER and HUMPHREYS.

1114TH MEETING

The 1114th meeting was held in the Cosmos Club Auditorium, February 27, 1937, President WENNER presiding.

Program: FRED L. MOHLER, National Bureau of Standards: *The vertical distribution of ozone from the sky spectrum.*—This was a report of results obtained in cooperation with Dr. Brian O'Brien and Mr. H. S. Stewart, Jr. of

Rochester University from the 1935 Stratosphere Flight of Major Stevens and Captain Anderson. Two spectrographs were carried for the purpose of measuring the vertical distribution of ozone in the atmosphere. One recorded the ultraviolet spectrum of sunlight while the second instrument photographed the sky spectrum at an angle of 9° above the horizontal. The amount of ozone above the balloon was computed from the sun spectrum by the conventional method. The ultraviolet intensity of the sky spectrum depends on the distribution of ozone in a layer extending 4 to 6 Km above the balloon. Previously published results from the sun spectrum indicate very little ozone below 15 Km and a rapidly increasing amount up to the ceiling of the flight at 22 Km. The sky spectra show that the amount of ozone is a maximum near 22 Km and drops rapidly to less than half the maximum amount at 25 Km. Half of the ozone in the atmosphere is below 27 Km. Results are published in full in National Geographic Society Contributed Technical Papers 2, 1936. (*Author's Abstract.*)

This address was discussed by Messrs. GISH, TUCKERMAN, DRYDEN, HAWKESWORTH and HUMPHREYS.

O. R. WULF, Bureau of Chemistry and Soils: *The atmospheric ozone equilibrium and its rate of maintenance.*—The hypothesis that the ozone of the atmosphere exists as a consequence of the photochemical action of solar radiation can be tested by computing the distribution with height which the ozone existing in the photochemical steady state should possess on this assumption. The results of such a treatment yield a distribution sufficiently in accord with observation to indicate that photochemical action can account for the major aspects of atmospheric ozone. (O. R. Wulf and L. S. Deming, Terr. Mag. Washington, **41**: 299. 1936; **41**: 375. 1936.) Critical for the calculations are the absorption coefficient of ozone and oxygen as a function of wave-length, and these are not as well known as might be desired. Atmospheric circulation can lead to disturbances in the photochemical steady state, and can cause the transportation of ozone into lower regions where it is stable, protected in large measure from photochemical action, thereby leading to high apparent vertical ozone paths. These effects can be illustrated rather simply in the laboratory under conditions analogous to the atmospheric case. Variations which have been observed under conditions where the change in the character of the air over the observer was fairly well known, suggest that such effects are probably of considerable importance in the well established changes which the vertical ozone path exhibits from day to day. (*Author's Abstract.*)

This was discussed by Messrs. MOHLER, HUMPHREYS and GISH.

1115TH MEETING

The 1115th meeting was held in the Cosmos Club Auditorium, March 13, 1937, President WENNER presiding.

The seventh Joseph Henry Lecture entitled *Fundamentals of photosynthesis* was delivered by JAMES FRANCK of Johns Hopkins University. It was published in this JOURNAL **27**: 317–329. 1937.

1116TH MEETING

The 1116th meeting was held in the Cosmos Club Auditorium, March 18, 1937, as a joint meeting with the Washington Academy of Sciences, President Thom presiding. ROBERT R. MCMATH of the University of Michigan gave an address on *Solar phenomena in motion pictures* and *A motion picture journey to the moon.*

1117TH MEETING

The 1117th meeting was held in the Cosmos Club Auditorium, March 27, 1937, President WENNER presiding.

Program: EDGAR W. WOOLARD, U. S. Weather Bureau: *The physical basis of air mass analysis.*—This paper drew attention to the fact that meteorology, considered as the scientific investigation of weather phenomena, is essentially a branch of physics; and outlined the nature of the physical analyses of weather phenomena that are now being used to aid in weather forecasting, with particular attention to air mass analysis. (*Author's Abstract.*)

H. R. BEYERS, U. S. Weather Bureau: *The practical analysis of synoptic data.*—While theoretical studies in meteorology for many years had pointed toward, and even had arrived at, the "counter-currents" theory, which was the basic form of the Norwegian concepts, the application of these ideas to the synoptic chart represented a more nearly revolutionary step; it was in practical synoptic meteorology that the Norwegians made their greatest contribution.

Air mass analysis on the synoptic chart involves delineating the air masses by locating the discontinuities or fronts which separate them. The rules for finding the fronts may be stated rather simply, but in practice the task often becomes difficult.

The proper analysis does not carry with it necessarily a correct prognosis. Neither do kinematic calculations alone, even if correct, produce an exact forecast of the weather. Thermodynamic processes and new developments in the moving systems themselves must be considered. Examples of these prognostic factors are provided by the maps of September 15 and 16, 1936. (*Author's Abstract.*)

H. WEXLER, U. S. Weather Bureau: *Some dynamical problems of air mass analysis.*—By considering the radiation exchange between a snow surface and a clear, calm, sunless atmosphere, it is possible to determine a relation between the temperature of the snow surface and the maximum free-air temperature. For the snow surface temperature to fall below the value given by this relation, the maximum free-air temperature must decrease; and the cooling process will be one whereby the atmosphere loses energy to space mostly through the spectral band of the black-body radiation emanating from the snow surface to which water vapor is transparent. As the cooling continues, the steep temperature lapse-rate characteristic of polar maritime or tropical air decreases until, finally, the atmosphere becomes practically isothermal from above the shallow surface layer of cold air to a certain height dependent on the initial lapse-rate. The cooled air mass is what may properly be called polar continental air, and is found covering extensive land and frozen maritime areas during winter.

When cooling of air over a certain region occurs, the air contracts, the isobaric surfaces are lowered, and the consequent inflow of air aloft raises the surface pressure, giving rise to a surface anticyclone. An explanation of the mechanics of the compensating inflow was attempted on the basis of the Brunt-Douglas isallobaric velocity component, which is directed into the deepening cyclone (polar cyclone) aloft. The vertical distribution of this inflow was studied and it was found that in going through the front from the polar continental air to the air above, a twenty-fold discontinuity in isallobaric velocity occurs, showing that almost all the increase in surface pressure results from convergence in the air above the lower cooled air.

At any given time in the life-history of the growing polar anti-cyclone it is possible to construct surface pressure tendency profiles, and the magnitude of these increases seems to be in satisfactory agreement with those observed on weather maps.

It was pointed out that the next step in the problem is to explain the release of these large masses of cold air, which occurs in a discontinuous manner, sometimes with no apparent clue from the shape of surface insobars. A few suggestions regarding this problem were made from the standpoint of the stability of the westerly winds above the polar wedge. (*Author's Abstract.*)

The first two papers were discussed by Messrs. GISH, HUMPHREYS, MCNISH, HAWKESWORTH, WULF and TUCKERMAN.

1118TH MEETING

The 1118th meeting was held in the Cosmos Club Auditorium, April 10, 1937, President WENNER presiding.

Program: I. C. GARDNER, National Bureau of Standards: *The 1936 solar eclipse in Russia.*—A nine-inch photographic objective was specially designed and constructed for eclipse photography. The design comprises two doublets and the relative aperture and field of view are $f/25$ and 4.5 degrees, respectively. If f denotes the focal length of the combination, $f/2$ and $-f/2$ are the focal lengths of the first and second doublets, respectively, and $f/4$ is the separation. With this design, if the same pairs of glasses are used in the two doublets and if each is separately achromatized, one has an achromatic system that also satisfies the Petzval condition. By "bending" the second doublet a flat field free from distortion is obtained, after which correction for spherical aberration and coma is obtained by "bending" the first doublet. An objective of this construction is of the telephoto type, an important advantage, as the total length of the camera is only three-quarters of the equivalent focal length. The lens was ground and polished by Mr. Robinson from glass produced in the optical glass plant of the National Bureau of Standards.

The camera proper was constructed of fabricated aluminum tubing with a plate-holder that moves on ways to compensate for the motion of the sun during an eclipse. The packing boxes were designed to serve as a base for the camera when set up at the eclipse station. With this construction one has an eclipse camera that can be focussed in the laboratory, rather than at the eclipse site. It is easily transported and can be erected in a few hours. The image of the sun is approximately two inches in diameter. The equivalent focal length and aperture of the lens have been selected so that the image is sufficiently large to enable the photographic plate to record all detail that is resolved by the lens. Consequently, it is considered that a photograph taken with this objective will show as much detail as if a lens of the same diameter had the much longer focal length such as is frequently characteristic of eclipse cameras.

Under the sponsorship of the National Geographic Society and the National Bureau of Standards, this lens was taken to Ak Bulak, in Asiatic Russia, to photograph the total solar eclipse of June 19, 1936. At the time of the eclipse the quality of seeing was excellent and eight exposures were made, six on Dufay color films and two on panchromatic process plates. A one-second exposure on the process plate showed the coma extending nearly a diameter from the sun's limb. With a ten-second exposure the longer coronal streamers extended beyond the limits of the 8×10 plate or more than two solar diameters from the limb. The black-and-white photographs and one of the color pictures are reproduced in the February (1937) issue of the National Geographic Magazine. (*Author's Abstract.*)

This was discussed by Messrs. BRIGGS, BITTINGER, BRODE and HAWKESWORTH.

1119TH MEETING

The 1119th meeting was held in the Cosmos Club Auditorium, April 24, 1937, President WENNER presiding.

Program: W. J. MOXOM, U. S. Weather Bureau: *Ohio river flood of January–February 1937.*—The Ohio River flood of 1937 will long rank as one of the greatest floods, not only on account of the record-breaking stages, but for the unusual conditions that produced it and the numerous interesting features connected with it. Practically all the precipitation occurred from January 1st to January 24th with an exceedingly heavy rainfall during the the second half of this period. The total loss by flood damage will never be known. Mud was happily absent from most of the flooded areas. Another characteristic of the flood was the long duration of high stages. The long soaking received by Paducah, Ky., intensified the damage from submergence. Relatively, more of Paducah was affected than any other large community. Louisville suffered the greatest total loss of any city in the valley.

MERRILL BERNARD, U. S. Weather Bureau: *Plans for the development of river forecasting methods.*—One of Webster's definitions of the word philosophy is: Practical wisdom; calmness of temper and judgment; equanimity, as to meet misfortune with philosophy. The word can hardly be applied to human conduct at congested centers along our principal rivers during periods of major floods. One does not have to take part to visualize the disorder, panic and lawlessness accompanying such a catastrophe, for no more graphic story has ever been broadcast than that heard over the radio during the recent flood, in which the actual direction of flood rescue work at Louisville, Kentucky, was heard in millions of homes throughout the country. The news reel, too, has made the flood scene commonplace, so that all here have some conception of the misery and stark tragedy that follows in the wake of a calamitous flood.

Into a situation like this it is difficult to believe that such a thing as order can be injected. However, it is the hope of the Weather Bureau and other interested agencies, that, through careful coordination of effort, and the issuance of dependable and timely warnings all loss of life, much of the misery, and an appreciable part of the property damage may be prevented.

The undertaking requires not only the support of the meteorologist and the engineer, but the aid of those experienced in human relationships. I have seen children playing around a home that stood literally in the shadow of a levee whose top was being hastily raised a matter of 6 inches to prevent overtopping. In assisting in the evacuation of backwater areas of the Mississippi during the flood of 1927 I spent precious minutes in the effort to convince an old man that the approaching flood would exceed the depth of the famous flood of 1884, which he assured me could not be possible, returning the following day to pick him out of the branches of a tree. Highlights along the route of evacuation—the tragedy of an abandoned sow and litter; an expensive car with two exhausted calves draped over the hood; a lost child, an hysterical mother. And in the concentration camps—the comedy of a negro baby, bath, unexpected reunions, family feuds over clothes-line space, an improvised maternity ward. In short, the philosophy of floods and flood relief should make interesting reading.

A philosophic acceptance of the situation can be carried a bit too far, as in the case of the mother who, in her ordinary circumstances, worried but little over the uncertainty and irregularity with which food reached her table. She, with others from her neighborhood, found herself and family in one of the many concentration camps distributed along the border of the flooded area during the recent flood. For the first time she and her family were enjoying clean beds and good food. On the first morning, in her zeal to take full advantage of her opportunity, she hastened back to her tent, after having passed through the food line three times, to round up her flock and for once in their short lives to fill them up. Her instructions to the children were to get into the line and stay there until they were filled up or caught. In due time she strolled back to the center of camp and coming upon a crowd worked her way to the center to find her children spread out on the ground, all but unconscious. They had, in following her hurried directions, gotten into the line for typhoid inoculation.

It is the authorized function of the Weather Bureau to observe meteorological conditions throughout the country, measure river stages, forecast weather, issue storm and flood warnings, and carry on climatological research. The river forecasting work of the Bureau is carried on at some 50 odd river forecasting centers throughout the country. On the lower reaches of the principal rivers the Bureau has for many years accurately forecast and published, days and even weeks in advance, the approach of flood crests. A flood crest on a large river like the Mississippi or the Ohio travels rather slowly—about 40 miles per day—so that there is usually ample time to correct and refine a forecast at a lower river point before its arrival.

As the headwaters are approached, however, river stage prediction becomes increasingly complicated. The amount and rate of the rainfall, the slope of the land and the stream channel, the character of the watershed and its cover, and the influence of antecedent rainfall, factors which have been integrated into terms of stage on the lower river, now become variables which must be dealt with separately and quantitatively.

Our Nation is rapidly becoming flood conscious with the result that the Weather Bureau has been forced to extend its river forecasting service into the headwater areas of nearly all the principal streams. There has been neither time, nor opportunity, to prepare for basic changes which involve method and procedure wholly without precedent. Where the flood forecaster on the lower river has days to refine an estimate as the flood crest approaches, he has, at many of the important up-river stations, only a comparatively few hours to foretell the approach of a flood and that under the conditions of "flashy" streamflow typical of headwater tributaries. Pittsburgh is perhaps the best example of such a situation. Here the Allegheny and Monongahela Rivers combine to form the Ohio at the triangle so famous for its industrial wealth. The time of concentration at Pittsburgh for a large part of the contributing area is a matter of hours, and not days, and therefore any plan to meet this situation must be prepared to predict flood stage practically as the rain falls and snow melts. The City itself must be organized to evacuate certain areas with the precision of a fire department. Industry and business occupying danger zones must plan to waterproof against the rising water or be prepared with minimum notice to remove perishable and damageable goods to higher levels. This city, and other municipalities so situated, must maintain stand-by emergency water supplies and lighting facilities. Permanent concentration centers must be selected in advance and emergency housing provided. These and other plans in considerable detail are being formulated by the agencies charged with responsibility of dealing with the great floods.

It is the plan of the Weather Bureau to establish ultimately over the watersheds of the headwater tributaries rain gages which record not only the total depth of rainfall, but the rate at which the rain is falling. In cooperation with the United States Geological Survey, run-off from many of the smaller watersheds will be measured. Certain of these watersheds will prove to be accurate indices of surface conditions over much larger areas and will indicate the extent to which the rain, as it falls, will appear as stream flow in the principal channel. The record of both rainfall and run-off being continuously recorded, will be transmitted immediately, either through arrangements with amateur broadcasters or automatic radio transmitters, to a central routing office, where the rainfall data will be quickly analyzed and converted into terms of streamflow. Thus, almost as quickly as rain falls, can its effect on river stage at points downstream be ascertained.

The first step in the expansion of the flood forecasting service has been made possible under a project in which the Weather Bureau, the Geological Survey, and the State of Pennsylvania are cooperating. Approximately 130 recording rain gages will be established in the watersheds of the Allegheny, Monongahela, Susquehanna and Delaware Rivers. These rain gages will be established on 3 circuits over which experienced hydrologic engineers will travel on schedule, attending and servicing the gages and, in season, conducting snow surveys. It is hoped that such cooperation may be established in other states.

Great floods have occurred periodically throughout the years and will continue to occur with painful regularity. Plans for flood control promise to reduce their magnitude and protect favorably situated areas, but as long as communities and industries find it profitable to occupy that portion of the stream channel intended by Nature for the passage of flood waters, accurate and timely flood forecasting and the methodical evacuation of stricken areas must be integrated into the National plan of river regulation and control. (*Author's Abstract.*)

The second paper was discussed by Messrs. TUCKERMAN and CURTIS.

L. B. TUCKERMAN presented an informal communication on *A curious Edison patent.* This was discussed by Messrs. MCNISH, HAWKESWORTH and SILSBEE.

1120TH MEETING

The 1120th meeting was held in the Cosmos Club Auditorium, May 8, 1937, President WENNER presiding.

Program: WILLIAM M. BLEAKNEY, National Bureau of Standards: *Dynamic strain gages.*—The recent demand for information on vibratory stresses developed in structures under service conditions has stimulated interest in dynamic strain gages, particularly of the recording type. One of the difficulties encountered in trying to apply existing strain gages to the measurement of dynamic strain has arisen from deformation within the gage caused by the inertia of the gage itself when subjected to high accelerations. These deformations in general affect the reading of the gage and may cause serious errors. It has been customary in the past to decrease the mass and increase the rigidity of the gage in an effort to minimize these deformations. The Tuckerman optical strain gage, modified for dynamic work, is the most precise instrument available at present. It is an example of the practical limit in the construction of rigid strain gages, but even it is subject to error under severe vibratory accelerations.

The new method (See N. B. S. JOURNAL of RESEARCH **18**: 1005. 1937.) consists in so adjusting the ratio of stiffness to inertia of the parts of the gage that these deformations are compensating. The indications of the instrument may thus be made independent of any acceleration of the gage as a whole. Methods of applying the compensation principle to various general types of gages were discussed with the aid of slides. The speaker also described a particular electromagnetic strain pick-up unit embodying this principle. It was designed by him in collaboration with the Massachusetts Institute of Technology and the Sperry Gyroscope Company for the Navy Department, for the purpose of recording strains in airplanes during flight.

A third method, developed by DeForest (See AERONAUTICAL SCIENCES **4**: 227. 1937.), makes use of a light flexible resistance unit which is glued directly to the specimen in which the strain is to be measured. (*Author's Abstract.*)

L. B. TUCKERMAN, National Bureau of Standards: *What hardness is or what hardness is not.*—Much effort has been expended in an attempt to give an all inclusive definition of "hardness" which would receive universal scientific and technical acceptance. Frequently such phrases as "true hardness," "absolute hardness," "real hearness," etc., appear in the literature. Even as keen a thinker as Heinrich Herz could say "Now as I went on working it became clear to me what hardness really was."

All attempts to formulate a definition of an inclusive concept which would cover all the current technical implications of hardness and thus warrant the designation of "true" or "absolute" or "real" hardness, have so far failed, and in the nature of the case must fail. "Hardness" in common parlance and even in technical usage represents a hazily conceived conglomeration or aggregate or properties of a material more or less related to each other.

A study of the very diverse properties included under the one term "hardness" shows that they are all in their essence negative properties. A material is called hard if it is not easily scratched; is not easily worn down; is not easily deformed, either elastically or plastically; is not easily broken; is not easily melted; is not easily demagnetized; etc. etc. All that is common to these properties is that the physical state of the material is not easily changed in one or more particulars by outside mechanical, thermal or other physical influences.

A better understanding of their diversity is obtained by thinking rather of the different implications of softness, i.e., of the different ways in which the physical state of a material may be changed, rather than of their negation "hardness."

The softness of a feather pillow is obviously something wholly different from the softness of putty. The softness of annealed steel is different from either, and the softness of soft glass is something different from any of these.

Not only may the "softness" of different materials represent wholly different kinds of behavior, but even the same material may exhibit different kinds of softness. The softness of a piece of copper in plastic yielding under load is something entirely different from its softness when scratched or abraded.

This is easily shown by comparison of a copper alloy with an annealed mild steel. Pairs of such materials may easily be found in which the steel scratches the copper but the copper indents the steel. In such a case there is no answer to the question, "Which is the harder of the two?" unless the whole complex of procedure involved in the determination of the particular "not softness" is specified in detail. (This was illustrated by numerous experiments with a wide variety of materials.)

The fact that it is impossible to formulate any acceptable definition of hardness to include all the current implications, in no way lessens the practical value of the common indentation and scratch tests. They are among the most useful tests in the control of the uniformity of a product. (*Author's Abstract.*)

These papers were discussed by Messrs. WENNER, MCNISH, HAWKESWORTH and MCCOMB.

H. H. HOWE presented an informal communication on *Errors in the theoretical determination of the velocity of light.* This was discussed by Mr. BUCKINGHAM.

1121ST MEETING

The 1121st meeting was held in the Cosmos Club Auditorium, May 22, 1937, President WENNER presiding.

Program: F. C. BRECKENRIDGE and W. R. SCHAUB, National Bureau of Standards: *An orthogonal color coordinate system having uniform chromaticity scales.*—The advantages and limitations of the I. C. I. coordinate system (See J. OPTICAL SOC. AM. **23**: 359. 1933.) and the trilinear coordinate system yielding uniform chromaticity scales as proposed by Judd (See J. OPTICAL SOC. AM. **25**: 24. 1935.) were compared. The advantages for engineering applications of a system combining the rectangular coordinates with the uniform chromaticity scale (UCS) was pointed out. The UCS triangle has been transformed to give such a system. A slight modification of the constants and a simple translation gives a system of coordinates in which the first quadrant contains only greens, the second reds and yellows, the third purples and the fourth blues. A diagram containing small areas illuminated with the appropriate colors was exhibited. (*Author's Abstract.*)

WILLIAM F. FRIEDMAN, Signal Reserve: *Cryptography.*—Beginning with a brief history of cryptography, including examples of the use of cryptography in Biblical and ancient times, the speaker illustrated the various types of codes and ciphers employed by the Federal Army and the Confederate Army in the Civil War, and by the various belligerents in the World War, 1914–18. These examples included instances of the employment of sympathetic or invisible inks, code books, cipher systems, and cipher devices, the last named opening the way for a discussion of modern cryptographic machinery constructed for the purpose of facilitating the enciphering and deciphering of messages with great rapidity and with a high degree of cryptographic security. The speaker concluded this part of his paper with the comment that the development of such machinery was today engaging the attention of many large governments and that the hope of reaching a satisfactory solution would no doubt be fulfilled. Question was raised as to the possibility of devising a system which could be regarded as being absolutely indecipherable. The speaker stated that while theoretically such a system is possible, despite the famous dictum established by Poe to the contrary, the actual embodiment of this theoretical possibility in a practical machine or system remains yet to be accomplished. The speaker then directed attention to one of the interesting side lights of his subject, namely, the attempts on the part of various persons to prove, by means of cryptography, that the authorship of certain works, principally those of Shakespeare, is spurious and that these works should be credited to others. (*Author's Abstract.*)

The first paper was discussed by Messrs. TUCKERMAN, HAWKESWORTH, WENNER, HUMPHREYS, BROMBACHER and DRYDEN.

An informal communication on *Radio fade outs* was presented by A. G. McNISH.

H. S. McCOMB, *Recording Secretary.*

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PALEONTOLOGY.—*Fossil peccary remains from the upper Pliocene of Idaho.*[1] C. LEWIS GAZIN, U. S. National Museum.

In 1934 the Smithsonian Institution expedition to southern Idaho was fortunate in securing unusually good material of the extinct peccary, *Platygonus.* These remains, together with those of a variety of other mammalian forms, were found in deposits considered to be of late Pliocene age, exposed along the west side of the Snake River near the town of Hagerman, Idaho.

Many fragmentary specimens were found at various localities in the deposits, but the most nearly complete specimens were obtained at a small quarry about 3 miles south of the *Plesippus shoshonensis* quarry (see fig. 9, p. 11, Explorations and field work of the Smithsonian Institution in 1934). The material from this locality includes an articulated skeleton of an adult animal, complete except for the left fore limb, and articulated portions of two young individuals, one of which includes the skull and lower jaws (Fig. 1).

The occurrence of *Platygonus* in the Pleistocene of North America is not rare, but remains of this form are not well known from upper Pliocene deposits and only the material from the Blanco formation (Gidley, 1903) of Texas and the Coso Mountains locality in California (Schultz, 1937) has been certainly referred to this genus. Peccary remains from the Benson locality in the San Pedro Valley of Arizona are also recognized as belonging to this genus, and certain fragmentary specimens from the Eden beds (Frick, 1921) and the upper Etchegoin deposits (Merriam, 1915) in California may possibly be *Platygonus.*

Platygonus pearcei, n. sp.

Type.—A nearly complete adult skeleton, U.S.N.M. no. 13800. Named for Mr. George B. Pearce who found the specimen designated as the type.

Locality.—T. 7 S., R. 13 E., about 3 miles south of Plesippus quarry, near Hagerman, Idaho.

Horizon.—Hagerman lake beds.

[1] Published by permission of the Secretary, Smithsonian Institution. Received November 11, 1937.

Specific characters.—Size of skull slightly less than that of *Platygonus cumberlandensis.* Rostrum of skull elongate and slender. Cranium short.

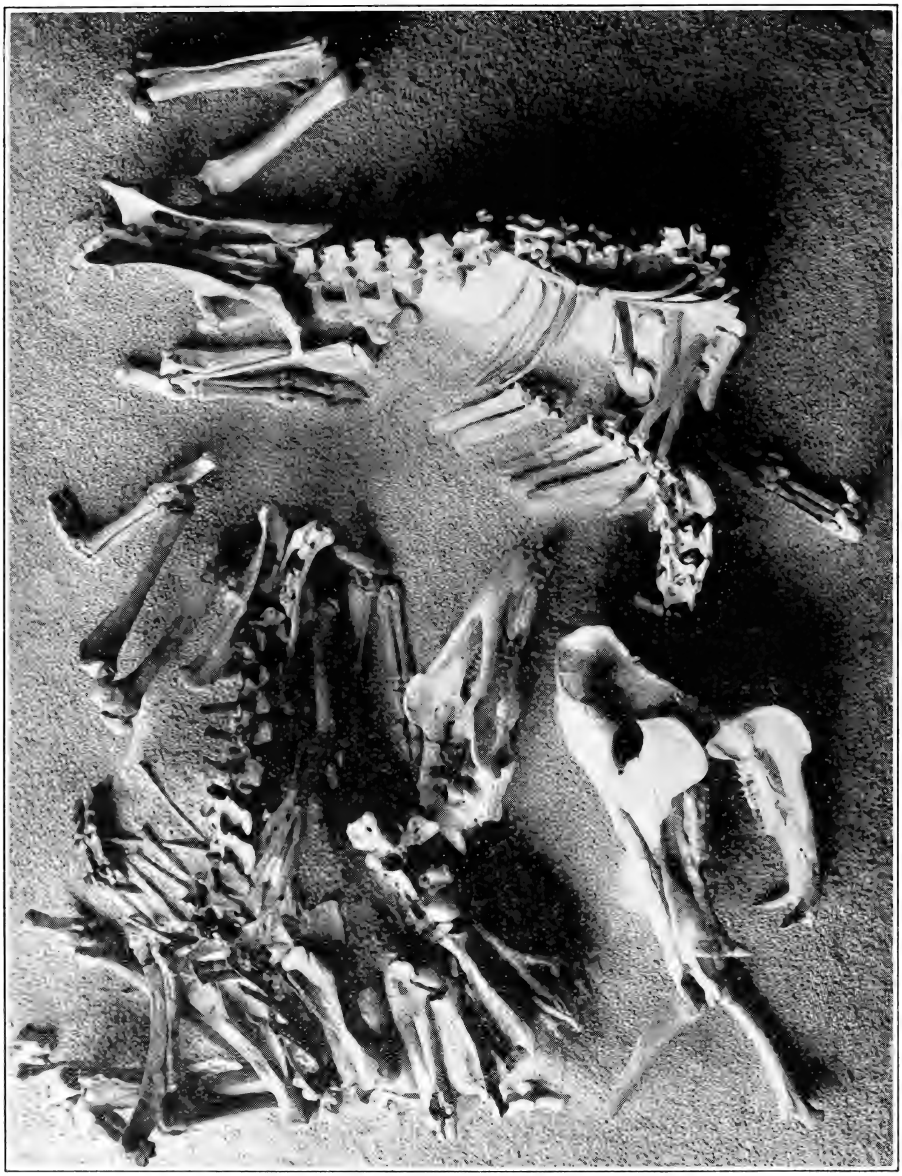

FIG. 1.—*Platygonus pearcei,* n. sp. Articulated skeletons prepared for exhibition as they occurred in the matrix. The adult skeleton, U.S.N.M. no. 13800, is the type of the species. About 13/100 natural size.

Articulation with lower jaw very low with respect to basicranium. No anteroventral projection or keel along symphysis of lower jaws. I_3 present.

Upper and lower canines slender. Cingula and accessory cuspules not strongly developed on cheek teeth. Inner and outer cusps of transverse lophs on molars more distinct than in *Platygonus cumberlandensis*. Heel or third lobe on M^3 and M_3 strong and simple. Third and fourth metacarpals not fused. Third and fourth metatarsals generally fused but not to the extent seen in *Platygonus cumberlandensis*.

Description of skull.—Species of *Platygonus* show considerable variation between individuals in proportions and characters of the skull, as observed in the material of *Platygonus cumberlandensis* from Maryland (Gidley, 1920; Gidley and Gazin, 1938) and as noted by Williston (1894, p. 23) in the *Platygonus leptorhinus* material. The skull of *Platygonus pearcei* is distinctly larger than those of *Platygonus leptorhinus* or *P. compressus* (LeConte, 1848 and Leidy, 1853), and is only slightly smaller though noticeably less robust than in *P. cumberlandensis*.

The skull of *P. pearcei*, U.S.N.M. no. 13800 (Figs. 2a and 2b) is of an advanced adult with well worn teeth and a slender, elongate rostrum, resembling specimens of *P. cumberlandensis* that have been regarded as female. The palatal surface is narrow and elongate though noticeably distorted by crushing. It is more distinctly concave between the canines than in *P. cumberlandensis* and extends considerably behind the last molar. The latter character is probably not significant, however, as the extent of the palate behind the dentition varies greatly in *P. cumberlandensis*.

The cranial portion appears relatively short by comparison with *P. cumberlandensis* and the temporal ridges converge more abruptly to the sagittal crest. The occiput is almost as high above the condyles as in *P. cumberlandensis* but the glenoid surfaces are placed below the orbits a distance equal to that in the more robust skulls of *P. cumberlandensis*. The development of the jugal below the orbit is comparable to that in fully mature female skulls of the Maryland form.

As compared with a skull (Am. Mus. no. 10388) of *Platygonus leptorhinus*, that of *P. pearcei* is considerably more elongate with a much deeper zygoma and a deeper occiput and cranium. The elongate rostrum may be shallower and perhaps narrower, although the width has been much reduced through crushing. The frontal area appears more convex and the glenoid surface is placed noticeably lower with respect to the condyles or basicranium. Also, the ridge or expansion along the lower margin of the jugal is carried farther forward on the rostrum than in *P. leptorhinus*, but not so markedly as in male specimens of *P. cumberlandensis*. Moreover, the occipital area is not so widely expanded dorsally with the lateral margins more nearly parallel.

The basicranial region is not well preserved in the skull of *P. pearcei*. The cancellous bullae are nearly obliterated and the basisphenoid and basioccipital are damaged. The basisphenoid in skulls of *Platygonus* are directed abruptly upward from the basioccipital in a nearly vertical direction as contrasted with the gentler slope of this element in the living peccaries. The external audital tube extends posterodorsally and slightly outward in a groove in the ascending wing of the squamosal. The posterior process of the tympanic overlaps to a marked extent the posterior surface of the squamosal and is firmly fused medially and posteriorly with the exoccipital.

As in recent peccaries, *Platygonus* possesses a foramen that opens ventrally in a position corresponding to that normally occupied by the postglenoid foramen. Dorsally the foramen opens anteroexternal and adjacent to the external auditory meatus. According to Van Kampen (1905), Pearson (1923), and others this foramen is not the postglenoid, although Rusconi

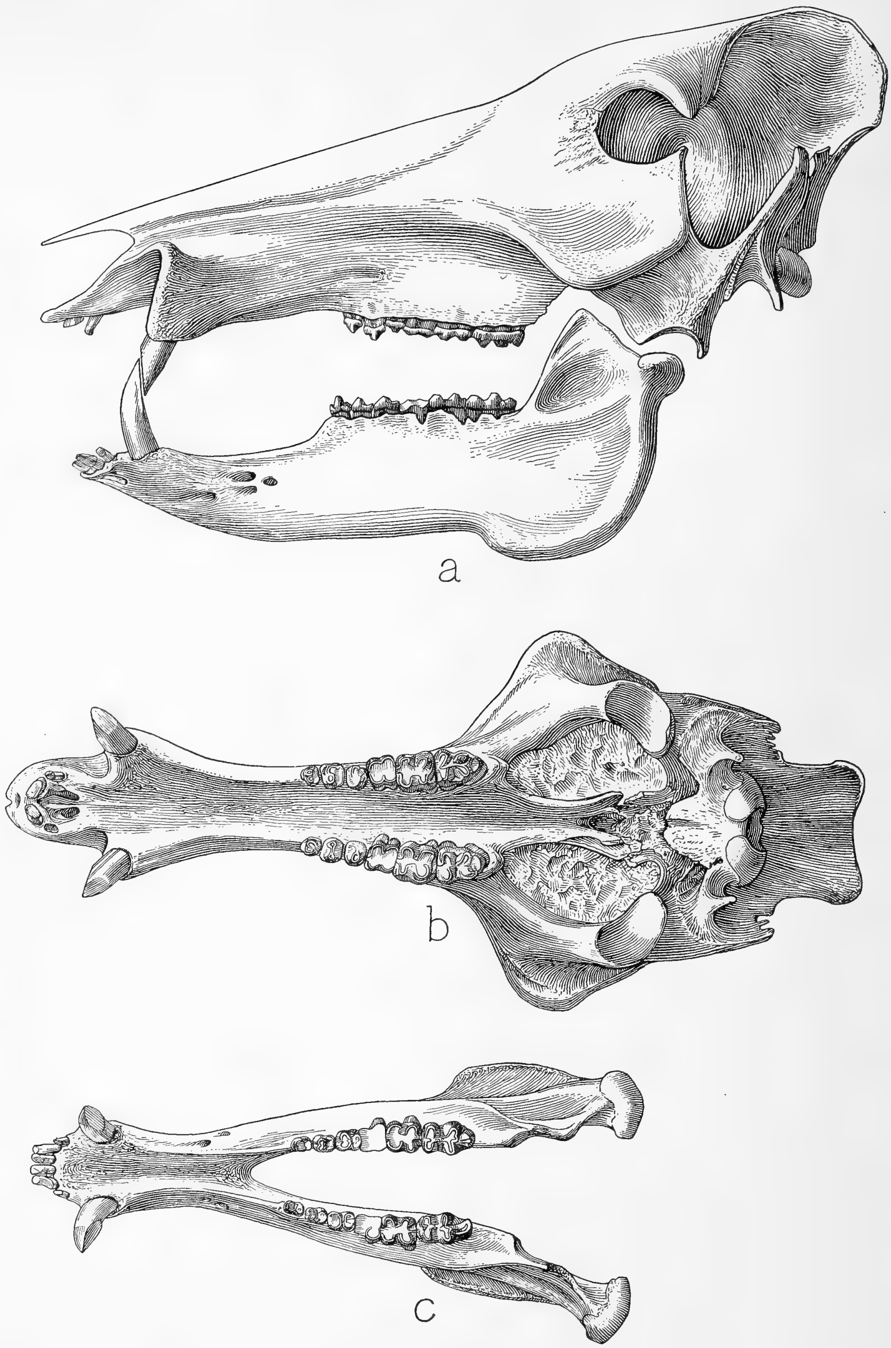

Fig. 2.—*Platygonus pearcei*, n. sp. Skull and mandible, type specimen, U.S.N.M. no. 13800; a, lateral view of skull and mandible; b, ventral view of skull; c, dorsal view of mandible. 3/10 natural size. Upper Pliocene, Hagerman, Idaho. Drawing by Sydney Prentice.

(1929) so regards it. The venous sytem communicating with the inner and outer portion of the cranium along the base of the tentorial plate drains ventrally through a small foramen or fissure between the margins of the alisphenoid and squamosal, lateral to the foramen ovale and adjacent to the bulla. This opening is conspicuous on the skull of *Platygonus pearcei* and its position is equivalent to that in *Pecari angulatus*. Functionally it more nearly corresponds to the postglenoid foramen.

The petrosal, which was found in position in the right side of the cranium, is noticeably larger than in living forms. When viewed from above and medially the most conspicuous feature is the prominent anterodorsal projection which joins the tentorial plate, although it does not fuse with it. In *Pecari* and *Tayassu* this process is much less developed. The hiatus facialis lies in the deep angular excavation formed between this process and the anteroventral apex. The floccular fossa, posterodorsal to the internal auditory meatus is also larger and much better defined. The prominence (eminentia arcuata) just below the floccular fossa, covering medially the aqueductus vestibuli, is well developed and is connected by a broad ridge with the process joining the tentorial plate. The slit-like aperture of the aqueductus cochleae is directly below the internal auditory meatus, on the lower margin of the petrosal.

In ventrolateral view of the petrosal the promontorium is no larger than in recent peccaries, and the fenestrae are similar in form and position. The fossa tensoris tympani is larger and the facial sulcus is larger and relatively deeper. Directly above the fenestra ovalis on the crista facialis is a clearly defined impression occupied by the crus breve of the incus. The incus was preserved although the other auditory ossicles were not found. This element is about one half larger than in *Pecari angulatus*, but is otherwise similar. A particularly noticeable feature in a lateral view of the petrosal is a conical prominence projecting nearly vertical from the dorsolateral portion of the bone, separate from the remaining slight mastoid portion. It rises from above the fossa for the tensor tympani, about over the ampula for the lateral and dorsal semicircular canals, and projects into an impression apparently in the squamosal. In *Pecari* the low ridge representing the mastoid portion does not exhibit the conical projection. In *Tayassu* this portion of the periodic is even less developed.

Mandible.—The mandible, no. 13800 (Figs. 2a and 2c) of *P. pearcei* shows the elongate anterior portion characterizing the skull. The length of the diastema between the canine and cheek teeth is nearly as great as in the longest of the *P. cumberlandensis* jaws. However, a second mandible, no. 13798 (Fig. 3), of a young adult *P. pearcei* exhibits a somewhat shorter diastema than in any of the *P. cumberlandensis* jaws with an adult dentition. The difference is probably not greater than might be attributed to the difference between an advanced adult female and a young male, as suggested by the *P. cumberlandensis* material. The elongate symphysial portion appears more procumbent than in *P. cumberlandensis* or *P. leptorhinus*, due in a large measure to the absence of the pronounced anteroventral projection or keel along the symphysis in this species. The lower surface of the symphysial portion is evenly rounded transversely. The depth of the mandible below the cheek teeth is noticeably great in no. 13800; this is variable in the Cumberland form. The lower portion of the angle does not flare outward so markedly as in either *P. cumberlandensis* or the specimen of *P. leptorhinus* (Amer. Mus. no. 10388). The margin of the angle is evenly curved and does not extend posteriorly with reference to the condyle as much as in *P.*

cumberlandensis. The anterior surface of the coronoid process is distinctly broader than in *P. cumberlandensis* and the apex is more acute. In *P. cumberlandensis* the apex of the coronoid is broad anteroposteriorly with a more pronounced dorsoposterior projection. The distance between the third molar and the condyle is greater in *P. pearcei* than in *P. leptorhinus*.

Dentition.—An important character in the dentition is seen in the persistence of the third lower incisor, characteristically absent in the Pleistocene species, although a small vestige of an alveolus for it was seen in one side of one of the lower jaws of *P. cumberlandensis*. Six lower jaws of *P. pearcei* have this portion preserved and show this tooth to be present and moderately developed. Its presence was also noted in the Coso Mountains material.

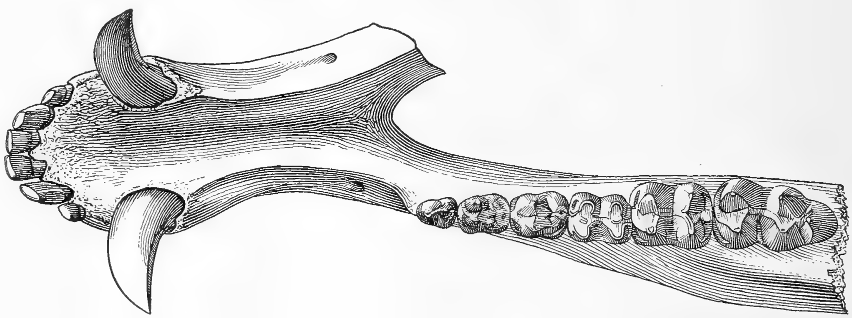

Fig. 3.—*Platygonus pearcei*, n. sp. Mandible, U.S.N.M. no. 13798, occlusal view showing cheek teeth of left ramus. 3/5 natural size. Upper Pliocene, Hagerman, Idaho. Drawing by Sydney Prentice.

The remaining incisors, upper and lower, show no important differences from those in the Pleistocene form. The canines are slenderer than in either *P. cumberlandensis* or *P. leptorhinus*. The upper and lower cheek teeth are somewhat smaller than the average in *P. cumberlandensis*, though larger than in *P. leptorhinus*, and are similar to those in *P. cumberlandensis* in the development of the transverse lophs, but with a slightly greater separation of the inner and outer cusps, more noticeable in the third molars. The cheek teeth exhibit fewer accessory cuspules than in the Cumberland form and the cingula are less prominent, particularly in the upper teeth. The third lobe of M_3 is a large but simple cusp, not showing the incipient cusps on either side usually present in *P. cumberlandensis*.

The cheek teeth in no. 13800 from Hagerman are smaller than those in the isolated jaws, no. 13798. A similar difference in size of the teeth, particularly in the robustness of the premolars was noted between specimens of *P. cumberlandensis*, sorted according to sex as presumed from the development of the zygomae. The larger premolars are generally associated with a shorter diastema and a more rugged, flaring development of jugal.

The heel of M_3 in *P. pearcei* is quite unlike that figured by Cope (1893, pl. 13, fig. 5) for *Platygonus bicalcaratus* of the Blanco formation of Texas. The tooth fragment described by Cope is much smaller, and relatively narrower through the portion considered as the second or posterior crest, moreover, the heel is made up of several relatively small cusps. The anterior portion of the Texas tooth is missing, this fact together with the character of the preserved portion strongly suggests that the fragment represents an incomplete P_3 or P_4 rather than M_3. The heel portion of lower premolars in *Platygonus* is highly variable in character, and may be represented by a prominent portion of the cingulum to a heel fully as developed as that in the above tooth.

TABLE 1.—MEASUREMENTS OF SKULL AND MANDIBLE OF *Platygonus pearcei*

	U.S.N.M. no. 13800	U.S.N.M. no. 13798
Skull:		
Length of skull from premaxillae to top of occipital crest	396 mm	
Length of skull from premaxillae to occipital condyles	350*	
Distance from anterior extremity of premaxilla to postglenoid process	300*	
Distance from anterior extremity of premaxilla to postorbital process of frontal (oblique)	320*	
Width across postorbital processes	125*	
Greatest extent of jugal below orbit	68	
Distance from lower margin of orbit to glenoid surface	77	
Distance from middle of occipital crest to center of glenoid fossa	165	
Distance from occipital crest to lower margin of condyles	128*	
Greatest width across dorsal portion of occiput	63	
Mandible:		
Length from anterior extremity of symphysis to posterior margin of condyle	277*	
Length of symphysis	103	85 mm
Distance between M_3 and posterior margin of condyle	79	
Depth of jaw below M_1 (outside)	55*	45
Greatest distance between top of coronoid process and lower margin of angle	120*	
Height of mandible from condyle to base (table top)	100*	
Distance between inner margins of canine alveoli	25	19
Dentition:		
I^1–M^3, incl.	209*	
Diastema between C and P^2	76	
P^2–M^3, incl.	82	
P^2–P^4, incl.	29.3	
M^1–M^3, incl.	54.2	
P^4, anteroposterior diameter: transverse diameter	10.2:12.8	
M^3, anteroposterior diameter: transverse diameter	23:17	21.8:17
I_1–M_3, incl.	203*	187
Diastema between C and P_2	78	54
P_2–M_3, incl.	84.5	93.6
P_2–P_4, incl.	31.2	34.2
M_1–M_3, incl.	54	59.8
P_4, anteroposterior diameter: transverse diameter	11.4: 9.9	13.1:10.3
M_3, anteroposterior diameter: transverse diameter	25.2:14.5	27.3:15.5

* Approximate.

The upper dentition which Gidley (1903, pp. 477–478, fig. 1) referred to *P. bicalcaratus* includes much larger teeth than would be associated with an M_3 of the size figured by Cope. Considering this tooth as a lower premolar no disparity in size is apparent, but the specimen as a type has little diagnostic value.

The upper teeth of *P. pearcei* do not show the well isolated cross lophs seen in the upper dentition referred to *P. bicalcaratus*. Also M^3 has a moderately developed heel not seen in the tooth which Gidley considered to be the third upper molar of *P. bicalcaratus*. The upper dentition in the type of *P. texanus* Gidley (1903, pp. 478–481, figs. 2, 5) has somewhat larger and relatively much wider molars than *P. pearcei*. Also, the cingula are better developed than in the Idaho teeth.

Limbs.—The bones of the fore and hind limbs are for the most part about the same length as in *P. cumberlandensis*, but slenderer, with smaller, distinctly narrower articular surfaces. The trochlea of the humerus is narrower and not as deep. The distance across the condyles on the femur is less and the ridges bounding the anterior portion of the trochlear articular surface are distinctly closer together. The head of the tibia is of less diameter and the cnemial crest is less outstanding.

The metacarpals and metatarsals, in keeping with their earlier geologic age, show a less advanced stage in the fusion between the third and fourth than do those of the Cumberland Cave form. None of the metacarpals in the Idaho material were found to be co-ossified, but several pairs in the Pleistocene material are fused. In the pes the third and fourth metatarsals are united in most cases but the co-ossification does not extend so far down the shafts as in *P. cumberlandensis*.

In a few instances the second metacarpals and metatarsals were found. In the articulated skeletons these splints are seen to be about two-thirds the length of the adjacent element in the manus and, though incomplete, at least one-half the length of the third metatarsal in the pes.

Remarks.—The record of *Platygonus* prior to upper Pliocene time is very incomplete. Fragmentary specimens from the Miocene and earlier Pliocene that have been referred to this genus in most cases were found later to represent *Prosthennops*. A tooth from the middle or upper Miocene which I (1932, p. 81) referred to *Platygonus* doubtless belongs to some form of *Thinohyus* or *Desmathyus*. As pointed out by Matthew (1924, pp. 177–178) *Desmathyus* in the Miocene probably stands in a relation intermediate between *Perchoerus* and *Platygonus*, but an appreciable hiatus still remains between the known forms of *Desmathyus* and *Platygonus*.

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PALEONTOLOGY.—*An alcyonarian from the Eocene of Mississippi.*[1]

Sidney J. Hickson, Cambridge, England. (Communicated by Waldo L. Schmitt.)

Prof. J. Magruder Sullivan, of Millsaps College, Jackson, Mississippi, found in the Moody marl of the Eocene Jackson group on Town Creek in the city of Jackson a very interesting specimen representing part of the axis of an alcyonarian. As the Alcyonaria are not frequently found in fossil state it is deemed worth-while to record this occurrence.

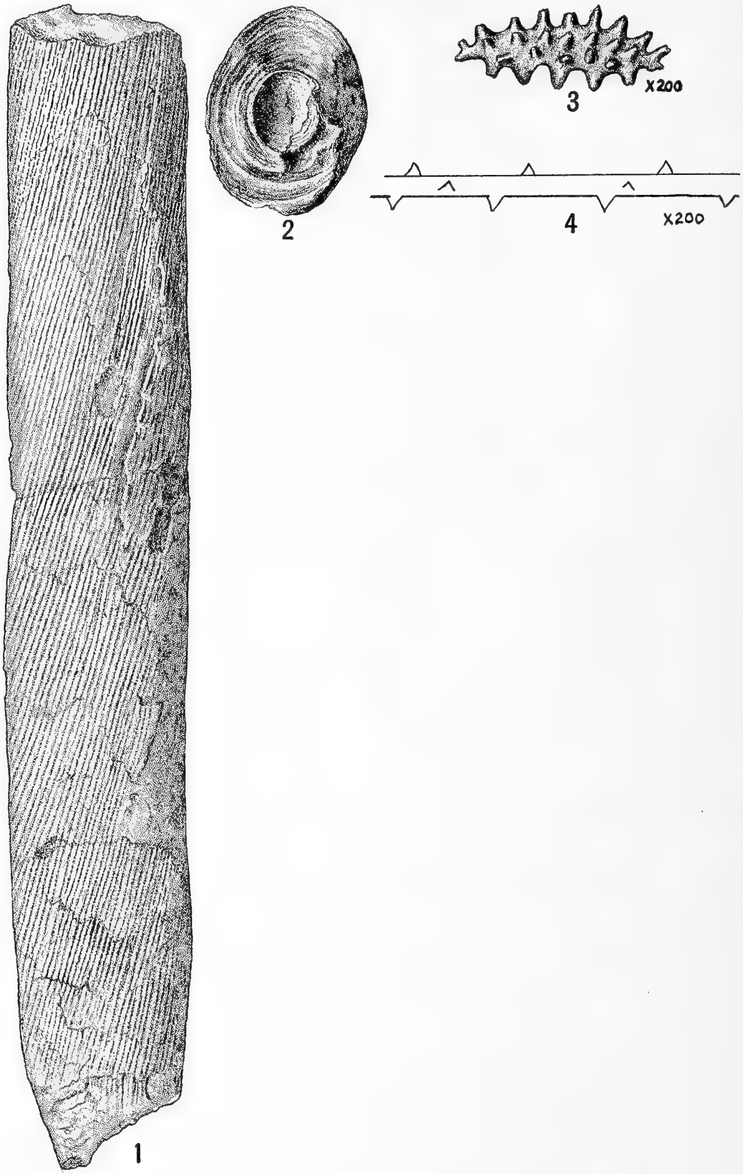
Eogorgia sullivani Hickson, n. gen. and sp.

Figs. 1–4

Description.—This specimen is about 170 mm in length by 25 mm in diameter and is cylindrical in shape. It consists of a series of concentric laminae of a calcareous substance mixed with grit and intercalated with an irregularly disposed black substance that is insoluble in acid. The surface is scored by a number of parallel grooves, with a slight spiral twist as regards

[1] Received December 7, 1937.

the axis of the specimen. The calcareous substance is mainly amorphous, but by an examination of fragments chipped off from and between the



Figs. 1–4.—*Eogorgia sullivani* Hickson, n. gen. and sp. 1, side view of holotype ×1. 2, cross-fracture surface, ×1. 3, spindle-shaped spicule, ×200. 4, spicular needle, ×200.

laminae two kinds of spicules have been found—*a*, long slender needles of unknown length but about 0.015 mm diameter, provided with a few short conical tubercles; *b*, thick spindles about 0.14 mm in length by 0.07 mm in diameter, provided with numerous prominent tubercles. These spicules are not easy to find among the amorphous calcareous debris, but I have found them in several preparations.

Remarks.—I am of the opinion that there are sufficient reasons for believing that this fossil was a part of the axis of an alcyonarian belonging to the Scleraxonia division of the Order Gorgonacea. The surface grooves probably correspond with the positions in which the main nutritive canals were situated, such grooves being occasionally found on the axis of Recent Gorgonacea. The black substance probably corresponds with the horny matter (usually called "keratin") which is commonly found in the axis of Gorgonacea. The amorphous calcareous matter may have been formed in the course of time by the solution of calcareous spicules and redeposition in an amorphous form. Some of the spicules remain in an unaltered condition. The long needle-shaped spicules (*a*) agree very closely with the spicules found in the sheath of the axis of the species of the Recent genus *Iciligorgia*, belonging to the Scleraxonia. The spindle-shaped spicules are similar to some of the spicules found in the axis of *Iciligorgia orientalis* of Australian waters.

The fossil has a diameter much greater than that of the main stem of any species of *Iciligorgia* I have seen, indicating that the whole colony must have been originally of great size; but specimens of another genus of Scleraxonia, *Paragorgia* of the Norwegian fjords, have been dredged with a diameter of the stem much greater than that of this fossil.

I do not consider that we are justified in referring this fossil to the genus *Iciligorgia* or to any other genus of Recent Gorgonacea, and as a new generic name must be found I would suggest that it be called *Eogorgia sullivani*, genotype and holotype, U.S.N.M. No. 510859.

BOTANY.—*New grasses from Oregon.*[1] AGNES CHASE, Bureau of Plant Industry.

Among grasses recently received from Professor Morton E. Peck, collected by him in little known regions of Oregon, are two undescribed species. One, a species of *Pleuropogon* is of especial interest, since it has paleas awned from near the base of the keels as in the type species of the genus, *P. Sabinii* R. Br. of Arctic America, which suggested the generic name. The only other species hitherto known, *P. californicus* (Nees) Benth. and *P. refractus* (A. Gray) Benth., of the Pacific Coast of the United States, have paleas toothed only. The new species is not closely related to *P. Sabinii*, which is a low plant, with small spikelets with awnless lemmas and paleas with short dorsal

[1] Received December 8, 1937.

awns, but resembles *P. refractus*, except that the spikelets are ascending, not reflexed or drooping. Two specimens of this undescribed species were in the National Herbarium in the cover of *P. refractus*, the well-developed though inconspicuous dorsal awns of the palea having been overlooked. One of these is chosen as the type, since it shows well developed rhizomes and has longer spikelets than has Professor Peck's specimen.

The other undescribed grass is a tall, rather coarse species of *Poa* from the region of Metolius River, which forms the southern boundary of Warm Springs Indian Reservation. Professor Peck writes, in answer to my inquiries, "The *Poa*, no. 19804, is from a point remote from any Erosion Control project. It seems quite certain to me that the plant is native. I find no indications of rhizomes and feel sure there were none." In the last two years a number of Old World grasses have appeared in the United States, hence it was necessary to study the whole genus before venturing to propose a new species in so large and variable a genus as *Poa*. But careful search of species of America, North and South, and of the Old World, fails to find any showing the combination of characters found in Professor Peck's specimen.

Pleuropogon oregonus, sp. nov.

Perennis; culmi 55–90 cm alti, e rhizomatibus tenuibus, erecti; vaginae internodiis longiores, scaberulae; ligula 4–5 mm longa, subhyalina, laciniata; laminae erectae, planae, 8–18 cm longae, 4–7 mm latae, acuto-mucronatae, subscaberulae; racemus suberectus, 6–16 cm longus; pedicelli 2–12 mm longi; spiculae 6–8, adscendentes, 7–13-florae, 1.5–4 cm longae; glumae pallidae, subhyalinae, 2–4 mm longae, enerves; lemmata 5.5–7 mm longa, 3 mm lata, 7-nervia, purpurea, scabra, apice lato, hyalino; arista 6–10 mm longa, scabra; palea lemmata aequans, dorso infra medium biaristato.

Perennial with slender rhizomes with purplish-red scales and long soft internodes; culms erect, 55 to 90 cm tall, rather soft and spongy; sheaths overlapping, the lower rather loose, purplish red, nearly smooth, the others scaberulous, striate; ligule 4 to 5 mm long, white, subhyaline, lacerate; blades erect, flat, 8 to 18 cm long, 4 to 7 mm wide (the uppermost reduced), abruptly narrowed into an acute, mucronate-tipped apex, slightly scaberulous on the upper or on both surfaces; raceme suberect, the slender slightly flexuous axis 6 to 16 cm long with 6 to 8 ascending spikelets on slender pedicels 2 to 12 mm long; spikelets loosely 7- to 13-flowered, 1.5 to 4 cm long (excluding the awns); glumes pale, subhyaline, 2 to 4 mm long, nerveless, often erose; rachilla joints 2 to 3 mm long; lemmas 5.5 to 7 mm long, about 3 mm wide, strongly 7-nerved, purplish and scabrous, except at the broad hyaline pale erose summit, the midnerve extending into an erect scabrous awn 6 to 10 mm long; palea as long as the lemma subhyaline, each of the keels bearing, about one-third from the base, a slender, scabrous, erect to spreading awn, from 2 to 7 mm long, the pair of a single palea often unequal, the summit of the palea hyaline the nerves extending into delicate teeth.

Type in the U. S. National Herbarium, no. 913360, collected at Union, Oregon, June 8, 1901, by A. B. Leckenby.

FIG. 1.—*Pleuropogon oregonus.* Raceme, ×1; floret, ×5.

Only known from Oregon, two additional collections being *Peck* 19568, wet meadow, 16 miles east of Adel, Lake County, and *Cusick*, in 1886, without locality, probably Union.

Poa Peckii, sp. nov.

Perennis; culmi caespitosi, erecti, circa 100 cm alti foliosi; vaginae internodiis longiores, carinatae, scabrae; ligula firma, 0.3–0.4 mm longa; laminae firmae, planae vel conduplicatae, acuminatae, 30–45 cm longae, 3–5 mm latae, utrinque scabrae, supra sparse pilosae; panicula 17 cm longa, ramis fasciculatis, scaberrimis; spiculae subcrebrae, compressae, 3–5-florae, 5–5.5 mm longae; gluma prima lanceolata, acuminata, 2.5–2.8 mm longa; gluma secunda latior, 3–3.5 mm longa; lemmata 3.5–4 mm longa, acuminata, sub lente minutissime papillosa, basi arachnoidea, nervis mediis marginalibusque infra medium villosis, inter nervos glabra.

Fig. 2.—*Poa Peckii.* Floret and spikelet, ×20.

Perennial, without rhizomes, rather pale; culms tufted, erect, about 100 cm tall, leafy; sheaths overlapping, carinate, scabrous, the lowermost papery becoming shredded; ligule firm, 0.3 to 0.4 mm long; blades firm, flat or folded or subinvolute toward the acuminate boat-shaped tip, 30 to 45 cm long, 3 to 5 mm wide, scabrous on both surfaces and sparsely pilose, the hairs appressed, some retrorsely so toward the summit; panicle long-exserted, rhomboid-pyramidal, open, 17 cm long, the branches in distant fascicles of 3 or 4, very scabrous, naked and simple below, those of the lowest whorl 3.5 to 9.5 cm long; spikelets rather crowded on short scabrous pedicels on the short branchlets of the upper half to two-thirds of the main branches, strongly compressed, tawny, 3- to 5-flowered, 5 to 5.5 mm long; glumes acuminate, the first lanceolate, 2.5 to 2.8 mm long, the second broader, 3 to 3.5 mm long; lemmas 3.5 to 4 mm long, acuminate, under a lens very minutely papillose, copiously webbed at base, silky-villous on the lower third to half of the keel and marginal nerves, glabrous between the nerves.

Type in the U. S. National Herbarium no. 1,720,372, collected in dry woods, along Metolius River near Camp Sherman, Jefferson County, Oregon, July 11, 1937, by Morton E. Peck (no. 19804).

This species is most nearly related to *Poa occidentalis* Vasey of Colorado and New Mexico, from which it differs in the more scabrous foliage, the minute firm ligule, the longer, firmer blades, appressed-pilose on the upper surface, the shorter, less open, more densely flowered panicle, and in the shorter lemmas, minutely papillose under a lens.

BOTANY.—*Some new snow algae from North America.*[1] Erzsébet Kol,[2] Szeged, Hungary. (Communicated by H. H. Bartlett.)

During my sojourn in America in 1936 I had the opportunity to work in the laboratory of the Department of Botany of the University of Michigan, for which I am very thankful. Professor William Randolph Taylor was so kind as to give me his algal collections from British Columbia to look over. I found in these collections some interesting snow samples, but I could not study the whole collection in the short time available. The snow samples No. 38 and No. 60 contained some *Raphidonema* specimens which, to my knowledge have not previously been described from the snow fields of North America.

The snow samples which form the subject of this report were collected in 1923 and 1925. A full account of the type of country in which the collections were made will be found in Taylor's account (1928).

Sample number 38 was collected at an elevation of about 7000 feet in Eagle Pass Mountains, British Columbia, September 3, 1923, and contained the following kryobionts: *Raphidonema brevirostre* var. *canadense,* var. nov., *R. nivale* var. *taylori,* var. nov., *R. sabaudum* f. *minus,* f. nov., *Chlamydomonas nivalis* Wille?, and *Chionaster nivalis* (Bohl.) Wille. With the exception of *R. sabaudum* f. *minus* the same forms were found in sample number 60, collected at Lakes of S. Grizzly group, British Columbia, August 31, 1925.

Raphidonema brevirostre Scherffel var. *canadense,* var. nov. Figs. 1–2

Filaments short, consisting of 4–8–16–32, straight or curved with slightly pointed ends. Cells usually not as long as broad, or cylindrical, 1–1.5μ diam. and 0.8–1.5μ long. Cell wall thin. Chromatophore yellowish-green, single, a parietal plate without pyrenoid or starch.

Vegetative reproduction by cell division and by separation of the filament into two parts. The filament breaks transversely into two portions, the newly fractured ends of which eventually develop the taper characteristic of this species.

Nearly related to *R. brevirostre,* differing in the slightly smaller average dimensions.

[1] Paper No. 620 from the Herbarium and the Department of Botany of the University of Michigan. Received November 9, 1937.

[2] Holder of the International Fellowship Crusade of the American Association of University Women fellowship for the academic year 1935–36; for which the writer is deeply grateful.

In red snow; North America: British Columbia, Eagle Pass Mountains and Lakes of the S. Grizzly group, collected by Professor William Randolph Taylor.

Filamentis liberis brevibus, 4–8–16–32 cellularibus, rectis, vel leniter curvatis; apicibus breviter acuminatis. Cellulis in media parte filamenti brevibus, cylindraceis, 1–1.5μ latis et 0.8–1.5μ longis. Membranis cellularum tenuibus. Flavoviridibus chromatophoris singulis; pyrenoïdo et amylo nullo. *Multiplicatio:* filamenta in duas partes aequales fragmentant, deinde genicule flectunt et vitae sempiternae in geniculiformis ultimoque cellulae apicibus tangentibus acuminant.

Differt ab *Raphidonemato brevirostri* Scherffel dimensione cellulae.

Habit: in nivibus rubris, in America: "British Columbia: Eagle Pass Mts. et Lakes S Grizzly group."

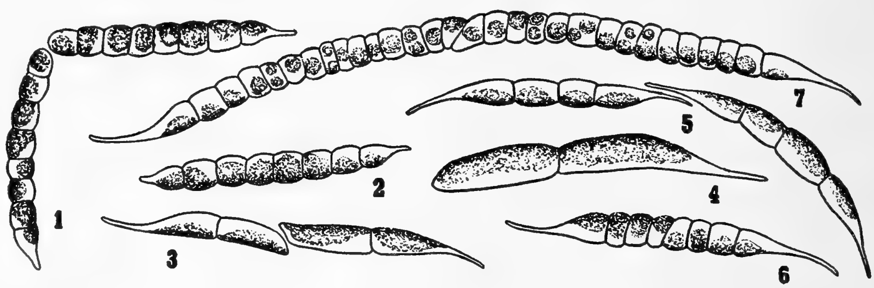


FIG. 1, 2.—*Raphidonema brevirostre* var. *canadense.* Figs. 3–5.—*Raphidonema nivale* Lagerh. var. *taylori,* separation of the filament. Figs. 6, 7.—*Raphidonema sabaudum* f. *minus.* (×3000)

R. brevirostre was collected for the first time by Professor István Györffy in Hungary in the year 1910 and was described by Professor Aladár Scherffel (1910). I found it also in Switzerland in the year 1930.

Raphidonema nivale Lagerh. var. *taylori,* var. nov. Figs. 3–5

Filaments short, consisting of 2–4 cells, straight or slightly curved, with pointed ends. Cells long cylindrical, 1–1.5μ diam. and 2–7μ long. Membrane thin, chromatophore a parietal plate without pyrenoid or starch.

Vegetative reproduction by cell division and separation of the filament. In this species the wall developed before separation is always a little oblique, and each half of the filament then develops the attenuate end characteristic of the species, these ends overlapping until separation occurs, when they slip apart.

In red snow; North America: British Columbia, Eagle Pass Mts. and Lakes of the S. Grizzly group.

Filamentis liberis brevibus, 2–4 cellularibus, rectis vel leniter curvatis, apicibus longe acuminatis. Cellulis 1–1.5μ latis et 2–7μ longis. Membranis cellularum tenuibus, achrois. Chromatophoris planis, rare marginibus lobatis; pyrenoïdo et amylo nullo.

Multiplicatio: filamentum inter 4–4 (2–2) cellules membranis oblique dispositis fragmentatum apicibusque novis filia filamenta acutiusculunt, et ad extremum ea separant.

Differt ab *Raphidonemato nivali* Lagerh.: 1. dimensione cellulae, 2. forma cellularum.

Habit: in nivibus rubris, in America: "British Columbia: Eagle Pass Mts. et Lakes S. Grizzly group."

Nominata in honorem ill. ac clarissimi Domini omnibus noti ord. botan. professoris Michiganensis: William Randolph Taylor.

This microorganism differs from *Raphidonema nivale* Lagerh. in the smaller size and in the form of the cells.

Raphidonema sabaudum Kol f. *minus*, f. nov. Figs. 6, 7

Filaments short, consisting of 8–16–32 cells, straight or variously curved, with pointed ends. Cells not as long as broad. 1–1.5μ diam. and 0.6–1.2μ long. Membrane thin, chromatophores either one or two plates, without pyrenoid.

Vegetative reproduction by cell division and by separation of the filament in two parts, the ends overlapping and developing the characteristic tapered form before separation.

Nearly related to *Raphidonema sabaudum*, differing in the slightly smaller average dimensions.

In red snow; North America: British Columbia: Eagle Pass Mts.

Filamentis liberis brevibus, tenuiter articulatis, 8–16–32 cellularibus, rectis vel curvatis; apicibus longe acuminatis respective setigeris. Cellulis in media parte filamenti: brevibus cylindraceis, 1–1.5μ latis et 0.6–1.2μ longis. Membranis cellularum tenuibus, chromatophoris in centro cellularum sedentibus, planis; pyrenoïdo et amylo nullo.

Multiplicatio: filamentum inter 4–4 cellulas membranis oblique dispositis fragmentatum apicibusque novis filia filamenti acutiusculunt, et ad extremum ea separant.

Differt ab *R. sabaudo* Kol dimensione cellulae.

Habit: in nivibus rubris, in America: "British Columbia: Eagle Pass Mts."

I found *R. sabaudum* for the first time in France on the snow-fields of Mont Blanc in 1933.

This investigation was initiated in the Department of Botany of the University of Michigan, Ann Arbor, under the direction of Professor William Randolph Taylor, for whose advice the writer is deeply grateful.

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PALEOBOTANY.—*Pleistocene fossils from Westmoreland County, Virginia.*[1] Edward W. Berry, The Johns Hopkins University.

In a short article published in 1909 the writer recorded the acorns of an unidentified species of *Quercus* and burs of *Fagus americana* from the Pleistocene (Talbot) near Nomini bluffs on the right (south) bank of the Potomac in Westmoreland County, Virginia.[2] During the past summer this outcrop was visited by my son, Charles T. Berry, and it is the purpose of the present note to discuss the material collected by him.

The locality is about 600 yards below the mouth of Popes Creek and the deposits represent what Wentworth[3] calls in Virginia the Princess Anne terrace and formation, which he regards as of essentially marine origin and extending along the shores of tidewater Virginia, where preserved, inland to the Fall-line. The Princess Anne he regards as the equivalent of the youngest Talbot of Maryland and the youngest Pamlico of North Carolina.

The material is a fine sandy or silty, bluish, ferruginous-stained, somewhat carbonaceous clay, with more or less pyritized sticks or branches up to several inches in diameter that suggest *Pinus*, but which have not been determined; and a few disseminated and angular quartz pea gravels. The deposit is interpreted as a Pleistocene bench of reworked Miocene material that abuts on the cliff section of true Miocene. The reasons for this interpretation are (1) the somewhat more silty texture noticeable in weathering and in the much more friable nature of the Pleistocene material; (2) in the fact that the latter is packed with the casts of *Rangia* to the almost total exclusion of other forms; and (3) to the uncompressed nature of the contained twigs and branches. In the Miocene, similar stem fragments are greatly compressed and molluscan remains are relatively uncommon. Finally the presence of a variety of Pleistocene plants confirms the field relations. I may say that my identification of *Rangia* has been checked by Dr. Julia A. Gardner of the U. S. Geological Survey.

[1] Received December 20, 1937.

[2] Berry, E. W. Amer. Nat. **43**: 432–436. 1909.

[3] Wentworth, C. K. Va. Geol. Survey Bull. **32**. 1930.

The variety of identifiable fossils is not large and the chief interest is the association of brackish water mollusks with the aquatic plants, *Naias* and *Zannichellia*, also frequently found in brackish water, the last being the most abundant fossil and hitherto unknown from the North American Pleistocene. This locality is about 30 miles west (upstream) from the Talbot locality at Wailes Bluff, St. Mary's County, Maryland, where a very considerable marine fauna has been recorded, but is perhaps in no way remarkable since *Rangia cuneata* has been recorded[4] from Charles County, Maryland, at a locality on Nanjemoy Creek over 20 miles farther to the northwest.

The species identified are too few for purposes of correlation or ecological discussion, but are entirely similar to those found in the late Pleistocene at many localities in the Coastal Plain of the Middle and South Atlantic states, all of which is rather consistent in indicating somewhat milder climatic conditions than obtain at the present time.

Naias sp.

Fruits of *Naias* are very common and widespread at various late geological horizons, especially during the Pleistocene. They are present in the Wicomico and very abundant in the Pamlico of the District of Columbia. Pericarps are infrequent at the present locality.

Zannichellia palustris Linnaeus

This interesting aquatic monocotyledon, which in existing floras is found on all the continents except Australia, is widely distributed in ponds and streams in fresh and brackish waters. It is said to be monotypic by Ascherson although other authors (Morong) suggest that more than a single species may be represented.

The nutlets of this species are much the most abundant forms at the present locality. The majority are rather heavily spined, although some are less so, and a single example is smooth. This is the more interesting as the living specimens I have seen have fruits that are practically smooth in the eastern and spinose in the western States, but I have made no attempt to determine whether this difference extends beyond the insignificant amount of material I have examined. In any case the fossil fruits are rather more spinose than any Recent material seen.

So far as I know the present is the first record of this species from the Pleistocene of North America and I have found no fossil records from other continents except one by Holmboe[5] from Norway cited under the name *Zannichellia polycarpa* Nolte. The Virginia fossils are well shown in the accompanying illustration.

[4] CLARK, W. B. Maryland Geol. Survey. Pliocene and Pleistocene, p. 196, 1906.
[5] HOLMBOE, J. *Planterester Norske Toromyrer*, p. 150, pl. 1, fig. 7, 1903.

Carex sp.

A single specimen of the same size and other features as those figured from the Wicomico of the District of Columbia compared with the existing *Carex collinsii* Nuttall[6] except that the style is much shorter in the Virginia specimen, a feature which might well be due to breakage since only the single specimen was found.

FIG. 1.—*Zanichellia palustris* Linnaeus. ×3, ×6, ×7½.

Quercus sp.

The acorns and cupules of some species of oak are rather common in the deposits and were noted in 1909. As there is no certainty that they are mature and as some are obviously aborted, no attempt has been made to identify them specifically.

Phytolacca decandra Linnaeus

A characteristic seed of this species. Previously recorded by the writer from both the Wicomico and Pamlico formations of the District of Columbia and from the lower terrace of the Chattahoochee River in Alabama, and more recently by Brown[7] from Northwest Branch of the Anacostia River in Prince George's County, Maryland.

? *Vitis* sp.

No grape seeds have been discovered in the deposits, but there are several stout coiled tendrils such as have been found elsewhere associated with grape seeds and tentatively referred to this genus, e.g. from the Chowan

[6] BERRY, E. W. This JOURNAL **14**: 17, pl. 1, figs. 4–8, 1924.
[7] BROWN, R. W. This JOURNAL **25**: 443, 1935.

formation of North Carolina[8] and from the Pamlico formation of the District of Columbia.[9]

MOLLUSCA

Rangia cuneata (Gray) Dall

This well known species, which is said to range from the Pliocene to the Recent, is found at the present time in shallow water along the coast of the Gulf of Mexico from Alabama westward and southward to Mexico. Although occurring in both normal sea water and brackish water, it is said to find its optimum conditions in the latter. Its range reaches northward as far as Maryland in the late Pleistocene where it has been recorded not only from the lower beds on both sides of Point Lookout, but from Sparrows Point and Middle River in Baltimore County, as well as Nanjemoy Creek in Charles County.

Some of the foregoing occurrences, as well as additional localities in North Carolina are discussed by Mansfield.[10]

This species appears to be common in the silty clay below Popes Creek in Westmoreland County, Virginia, but is in a very bad state of preservation.

? *Macoma balthica* Linnaeus

This is essentially a northern form although it is said to range southward to the Mediterranean in Europe and to Georgia along our Atlantic coast. It was recorded from the Talbot formation of Wailes Bluff in Maryland, and more recently from Yonges Island, S. C., by Mansfield. The present record is based upon poorly preserved material and is therefore tentative. It is somewhat smaller than the figured specimen from Wailes Bluff. Linnaeus' type was the thin shell of the brackish waters of the Baltic.

Galls

Gall scales similar to those figured from the Pamlico formation of the District of Columbia[11] are not uncommon at the present locality.

ZOOLOGY.—*A new crawfish from Florida.*[1] HORTON H. HOBBS, JR., University of Florida. (Communicated by MARY J. RATHBUN.)

The first specimens of this crawfish, a male (Form I) and three females, were collected by Professor J. S. Rogers and myself in April, 1935, from a pine flatwoods four miles northwest of Blountstown, Calhoun Co., Florida. Dr. Waldo L. Schmitt, of the U. S. National

[8] BERRY, E. W. U. S. Geol. Survey Prof. Paper **140**: 115, pl. 57, fig. 6, 1926.
[9] BERRY, E. W. This JOURNAL **23**: 20, figs. 53, 54, 1933.
[10] MANSFIELD, W. C. U. S. Geol. Survey Prof. Paper **150**-F, 1928.
[11] BERRY, E. W. This JOURNAL **23**: 24, figs. 72–77, 1933.
[1] Received November 16, 1937.

Museum, examined these specimens for me and stated that they are closely related to the members of the first section of Ortmann's first group,[2] Faxon's Group II,[3] although differing in one or another point from all known species.

In April, 1937, I collected two males (Form I), two males (Form II) and one female from the same locality. One of the Form I males is the holotype (U.S.N.M. cat. no. 75120) and the female the allotype (U.S.N.M. cat. no. 75121). From two miles further north I succeeded in taking five males (Form I), one male (Form II), and three females from the same habitat.

Because of Professor Rogers' interest in crawfishes and the aid and encouragement he has given my work on these animals, I take pleasure in naming this species for him.

Cambarus rogersi, n. sp.

Holotypic male (*Form I*).—Body stocky, thickened dorso-ventrally, compressed laterally. Abdomen much narrower than cephalothorax.

Carapace subovate. Width of carapace slightly greater than depth in region of caudo-dorsal margin of cervical groove. Greatest width of carapace about midway between cervical groove and caudal margin of cephalothorax. (Fig. 4)

Areola linear, almost obliterated, depressed, more than half as long as cephalic section of carapace; a single row of punctations present along fusion line of branchiostegites; sides parallel for a short distance in middle.

Rostrum somewhat broad-lanceolate; apex not reaching distal end of second joint of antennule peduncle; upper surface punctate, excavate, with margins elevated, gradually tapering off towards the apex; no lateral spines present. Apex of rostrum directed ventrad, the extreme apex abruptly bent upward. Cephalic region, in lateral aspect, evenly rounded. Postorbital ridges extending caudad more than half the distance between apex and cervical groove.

Surface of carapace punctate; granulate laterally anterior to cervical groove. No lateral spines present. Cephalo-lateral margins each with one spine near anterior extremity of cervical groove.

Abdomen shorter and narrower than carapace. Anterior section of telson with one spine in each of the postero-lateral angles.

Anterior margin of epistoma irregularly semi-circular; without median anterior projecting spine or point; almost as long as wide.

Antennules of the usual form—a spine present on ventral side of basal segment of the right.

Antennae extending slightly beyond caudal margin of carapace when bent backward.

Antennal scale small; extending almost to tip of second joint of peduncle of antennule. Spine on outer margin strong.

First pereiopod very broad and thin, triangulate, with sharp apex. Inner margin of palm with eight regular tubercles in a single row. Both surfaces

[2] Proc. Amer. Philos. Soc. **44**: 98–101. 1905.
[3] Mem. Mus. Comp. Zool. **40** (8): 411. 1914.

of hand partially punctate; both fingers setose. Both fingers with two distinct ridges. Palm with a prominent ridge along articulation with moveable finger. (Fig. 2)

Moveable finger: inner margin excavated near base; dorsal surface with a prominent sub-median ridge extending from base almost to apex. Outer edge studded with four tubercles along proximal third; remaining distal two-thirds with about eight setiferous punctations. Inner margin broken by two major tubercles; one about midway of the proximal third; the other just distad to middle. The excavated region between the major tubercles with one or two smaller tubercles; distad of the distal major tubercle, the margins with minute denticles. Apex sharply pointed and curved laterad toward the tip of immoveable finger; when the fingers are brought together the moveable finger passing beneath the immoveable finger extends slightly laterad of its lateral margin.

Immoveable finger: outer edge trough-like or punctate, studded with hairs; a few tubercles present along outer margin of base. Inner margin broken by one major tubercle which, when the fingers are closed, is about half-way between the major tubercles of moveable finger. Three or four smaller tubercles present along proximal half; distal half, as in other finger.

Carpus longer than wide; longer than inner margin of palm of chelae, with a deep longitudinal groove above; punctate, three tubercles on distad border of inner surface directed forward terminating in sharp spines. Also smaller proximal spines on inner margin.

Merus smooth except on lower side which has a row of very small tubercles (about eleven) on outer margin; a row of larger ones on inner margin (nine on left, ten on right).

Ischiopodite of third pereiopods hooked; hooks strong, long; caudo-ventral surface rounded; cephalo-dorsal surface excavate. (Fig. 6)

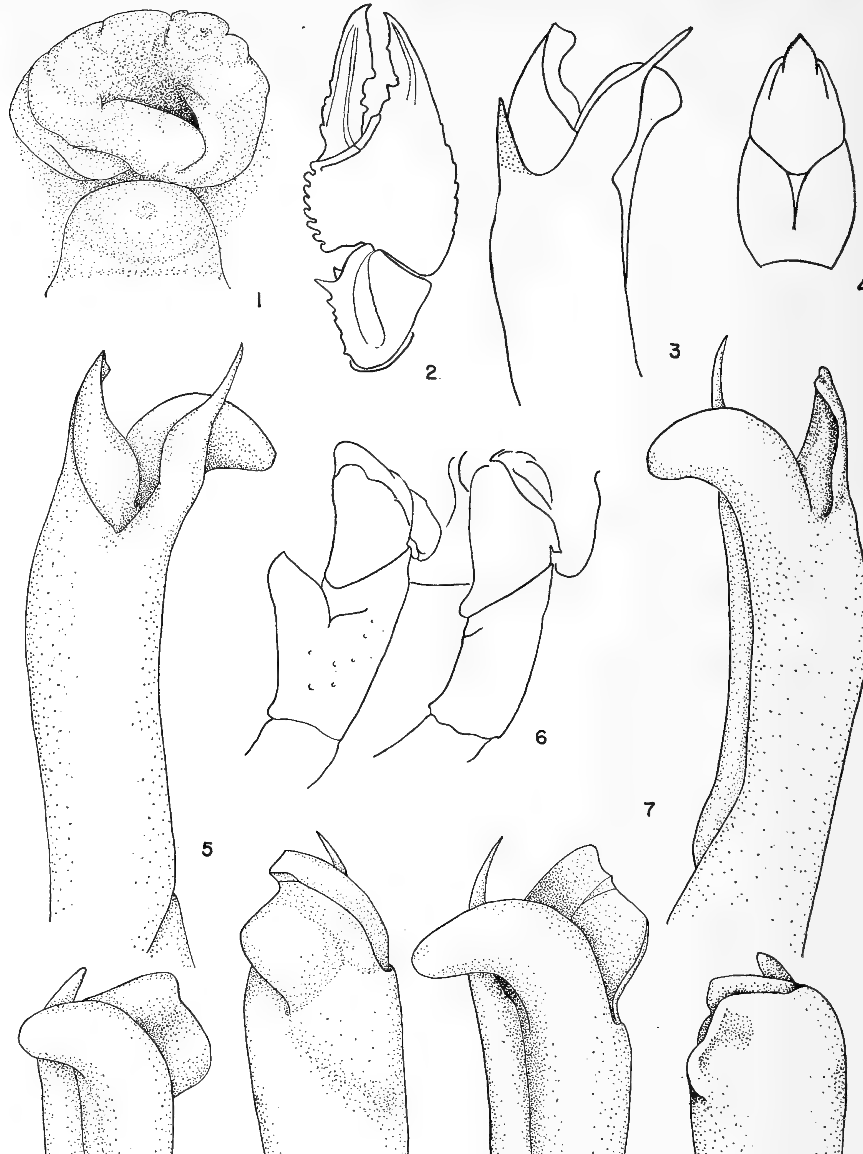
First pleopods of male extending to base of second pereiopods; distinctly separated at the tips; tips ending in three distinct parts. The outer, recurved at right angles with the main shaft, is also turned inward to form the posterior part of the organ. It is the heaviest and most rounded of the three. The inner one extends forward and terminates in a sharp spine. The third terminal consists of a flat, thin plate-like structure on the anterior side of the appendage extending ventrally to the tip of the inner spine and bent laterally at about a forty-five degree angle and extending beyond the main shaft. (Figs. 5, 7, 9, 10) A fourth process is sometimes present as a small spine meso-cephalad of the plate-like structure. (Fig. 3)

Male (*Form II*).—Differs from the male of the first form in the following respects: (1) hooks on ischiopodite of third walking legs greatly reduced, (2) first pleopod with no horny tips, three processes present but all rounded and reduced. (Figs. 8 and 11)

Allotypic female.—Annulus ventralis moveable; fossa sinking beneath the right caudal margin (observer's right with crawfish lying on dorsal surface and anterior end away); cephalad and left lateral walls gently sloping toward the fossa; the caudal, overhanging it; right wall sloping more abruptly. Just posterior to the annulus, a large rounded tubercle bearing punctations or ridges. (Fig. 1)

Besides the sexual characters the female shows the following distinctive structures differing from those described in the male: (1) chelae not quite as heavy, (2) cephalic section of telson with three spines in right and one in left postero-lateral corners.

Measurements given below indicate other differences.



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Measurements.—The holotype: carapace, height 1.3, width 1.4, length 2.79; areola, linear, length. 1.11; rostrum, length 0.44, width 0.41; abdomen, length 2.69; left chela, inner margin of palm 0.6, width of palm 1.06 length of outer margin of hand 1.93, moveable finger 1.14; carpopodite of 1st pereiopod, length 0.75, width 0.63 mm. The allotype: carapace, height 1.24, width 1.32, length 2.58; areola, linear, length 1.02; rostrum, length 0.4, width 0.4; abdomen, length 2.31; left chela, inner margin of palm 0.52, width of palm 0.94, length of outer margin of hand 1.62, moveable finger 0.99; carpopodite of 1st pereiopod, length 0.78, width 0.57 mm.

Type Locality.—Low pine flat-woods four miles north of Blountstown on State Highway no. 6. Pitcher plants (*Sarracenia psittacina* Michx. and *Sarracenia drummondi* Croom) and grasses made up the dominant flora. The soil was a sandy clay mixture. All the crawfish were taken from complex burrows ranging from one to three feet deep and with several passages. The water table was about one foot below the surface and the crawfish were always below it—usually at the end of one of the several tunnels. The burrows were numerous and easily located as each was marked by a neat mound of carefully piled pellets. These so-called chimneys were usually four to six inches high. Living in the burrows with the crawfish were other crustaceans: a few white isopods, *Asellus* species; several amphipods, *Eucrangonyx gracilis* (Smith), determined by Mr. Joel Martin; and quite a number of copepods.

The male holotype (Form I), the female allotype and a male paratype (Form II) are deposited in the collections of the United States National Museum. The paratypes: A male (Form I) and a female have been deposited in the Michigan Museum of Zoology; a male (Form I) and a female in the Museum of Comparative Zoology; a male (Form I) and a female in the Carnegie Museum; four males (Form I), two males (Form II) and three females I have retained in my personal collection.

Relationships.—*Cambarus rogersi* probably is more closely allied to the species of Faxon's Group III, namely: *Cambarus bouvieri, simulans, gracilis, hagenianus,* and *advena.* Structurally, *C. rogersi* has its closest affinities with *C. advena;* the chelae of the two forms are strikingly similar. On the other hand, *C. hagenianus* is the only species of this group in which the areola is obliterated. The first pleopods of *Cambarus rogersi* are distinct from all known species and suggest no very close affinities to any of the species mentioned.

FIG. 1.—Annulus ventralis of female (Allotype). Fig. 2.—Dorsal view of right chela (Holotype). Fig. 3.—Diagram of tip of 1st pleopod (male) showing the fourth process which is sometimes present (Fourth process stippled). Fig. 4.—Dorsal view of carapace. Fig. 5.—Mesal view of the 1st pleopod (Holotype). Fig. 6.—Ischiopodites of the 3rd and 4th pereiopods showing heavy hook on the 3rd (Holotype). Fig. 7.—Lateral view of the 1st pleopod (Holotype). Fig. 8.—Caudal view of the 1st pleopod of male (Form II). Fig. 9.—Cephalic view of the 1st pleopod (Holotype). Fig. 10.—Caudal view of the 1st pleopod (Holotype). Fig. 11.—Cephalic view of the 1st pleopod of male (Form II). The pubescence has been removed from all 1st pleopods.

ENTOMOLOGY.—*Three Japanese beetles of the genus* Serica *Macleay.*[1] EDWARD A. CHAPIN, U. S. National Museum.

In 1927, a few specimens of a *Serica,* obviously not a described American species, were taken by Mr. H. C. Hallock at Westbury, L. I. In succeeding years additional specimens were found at the same locality. The species was erroneously determined in 1928 as *Serica similis* Lewis and has appeared in the recent literature under that name. It was later also erroneously determined as *Serica brunnea* Linn. and has been so recorded in print. Doubt was cast on the specific determination of the form in 1936 and specimens of two related species were sent to the British Museum for comparison with Lewis' type. Word came from Mr. G. J. Arrow that neither of the two species sent agreed with the type of *S. similis.* Two specimens from the type series of *similis* were kindly loaned the writer for study; one of these was believed by Mr. Arrow to be the same as the type, the other apparently different and perhaps the Long Island form. Mr. Arrow also supplied a pencil sketch of the aedeagus of the type for further assistance.

The dissection of the two specimens from the British Museum type series shows that they belong to two species, one of which is *S. similis* Lewis, and the other a species different from both *similis* and the Long Island form. Further search of the National Museum collection yielded a single male collected at Yokohama by Kobayashi that is undoubtedly the same as the Long Island species, which fact tends to establish the original habitat of the Long Island species as Japan. There are, therefore, at least three Japanese species which have been confused under the name *Serica similis* Lewis.

Serica similis Lewis

Serica similis Lewis, 1895, Ann. Mag. Nat. Hist., Ser. 6, vol. 16, p. 391.

Male: Elongate subparallel, not strongly convex above. Color medium dark brown with frons and vertex nearly black. Clypeus strongly shining, sides straight and convergent anteriorly. Notches between clypeus and labrum not evident. Labrum bilobed with median angulation broad and moderately deep. Surface of head moderately coarsely and rather sparsely punctured. Antennae 9-segmented, the three segmented club more than three times as long as the five preceding segments combined. Eyes relatively large and convex. Pronotum a little more than twice as wide as its length along median line, posterior angles rounded, anterior produced and acute, lateral margins evenly curved. Surface slightly more densely and coarsely punctured than frons. Scutellum elongate triangular with punctation similar to that of pronotum. Elytra each with nine well impressed grooves which are

[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 22, 1937.

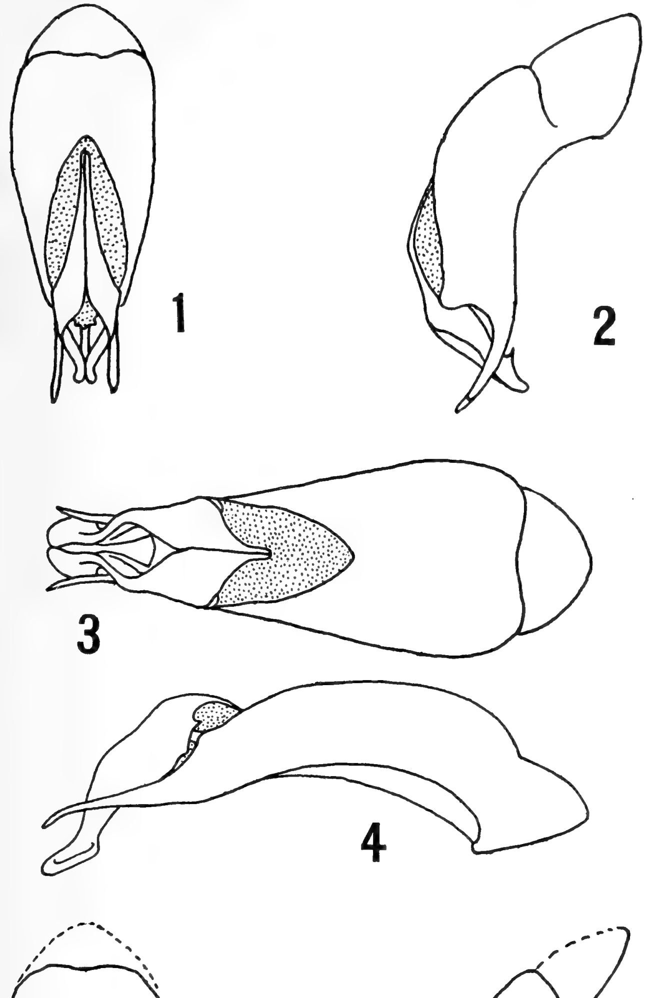

FIG. 1.—*Serica similis* Lewis. Aedeagus, dorsal view. Fig. 2.—*S. similis* Lewis, idem, lateral view. Fig. 3.—*S. peregrina*, n. sp., idem, dorsal view. Fig. 4.—*S. peregrina*, n. sp., idem, lateral view. Fig. 5.—*S. lewisi*, n. sp., idem, dorsal view. Fig. 6.—*S. lewisi*, n. sp., idem, lateral view.

finely and densely punctured, intervals convex without punctures, epipleura narrow, abruptly terminated at apical truncation, with a single row of short setae. Pygidium subtriangular, slightly convex, coarsely and moderately densely punctured. Under parts of thorax and posterior coxae with punctation similar to that of pronotum. First and second visible sternites with transverse, median patches of setae, third with a few setae at middle. In addition to the dense patches, each sternite has a single row of setae extending to lateral margins. Aedeagus, figures 1, 2. Length: male 8.5 mm.

Type: in the British Museum.

Type locality: Japan, "Nagasaki, Hitoyoshi, Nikko and on the Wada-togé."

Material examined: A male from the type series loaned for study by the British Museum. The specimen bears the locality label "S. Japan" only.

The Hitoyoshi specimen has been withdrawn from this species and is made the type of a new species described below. The Nikko specimen is probably also different from *similis* as it comes from the mountainous part of Nippon Island.

Serica peregrina, n. sp.

Serica brunnea Waterhouse, 1875, Trans. Ent. Soc. London, p. 101 in part (synonomy according to G. J. Arrow in letter to writer); Schaeffer, 1931, Bull. Brooklyn Ent. Soc., vol. 26, p. 176 (not *S. brunnea* L. 1758).

Serica similis Hallock, 1929, Journ. Econ. Ent., vol. 22, p. 299; Sim, 1932, Journ. N.Y. Ent. Soc., vol. 40, p. 381, Pl. 15; Schaeffer, 1932, Bull. Brooklyn Ent. Soc., vol. 27, p. 50 (not *S. similis* Lewis 1895).

Male: externally essentially the same as *S. similis* Lewis. Coloration pale yellowish brown, sides of pronotum less curved and with anterior angles usually perceptibly more abrupt. Aedeagus, figs. 3, 4.

Female: more robust than male. Eyes proportionately smaller, antennal club shorter, not twice as long as preceding five segments combined. First visible sternite alone with patch of dense setae. Anterior tibia less slender.

Length: male 8–8.5 mm, female 9 mm.

Type and paratypes: U. S. National Museum Cat. No. 52294, paratypes in the British Museum.

Type locality: Long Island, N. Y. (type from Westbury, paratypes from Westbury and Douglaston).

Material examined: 40 male and 5 female specimens from the above locality, collected by Mr. H. C. Hallock during June and July. Also a single male from Yokohama, Island of Nippon, Japan, collected by Kobayashi.

Serica lewisi, n. sp.

Male: externally essentially the same as *S. similis* Lewis. Coloration paler, yellowish brown with frons and vertex only slightly darker than rest of body. Punctation of pronotum less deeply impressed than in *similis*. Aedeagus, figs. 5, 6.

Length: male 8.5 mm.

Type: in the British Museum.

Type locality: Japan Hitoyoshi, Island of Kyushu, May 15–17, 1881.

Material examined: A male from the G. Lewis collection, loaned for study by the British Museum (withdrawn from the type series of *S. similis* Lewis).

While externally similar to the two preceding species, the aedeagus of this species is asymmetrical and in this respect quite different from either.

ENTOMOLOGY.—Specularius erythrinae, *a new bruchid affecting seeds of* Erythrina (*Coleoptera*).[1] JOHN C. BRIDWELL, U. S. National Museum. (Communicated by C. F. W. MUESEBECK).

When some future philosopher assembles data for the psychology of the color red he may well consider the brilliant red flowers and beans of *Erythrina* which have attracted the attention of men of all races. Few plants encountered by visitors in the tropics are so admired and the literature of botanical exploration is full of tributes to these glorified bean plants grown large, often of tree size, the leafless branches adorned with masses of red or near-red flowers. Aztecs, Negroes, Hindoos, Hawaiians, and Australian blacks have had a lively interest in the species in their own countries and, finding many uses for these plants and their products, have distributed some of them in cultivation far from their original homes. The botanists distinguish some thirty species of *Erythrina.* Three of these occur in the warmer parts of the United States. One, *Erythrina herbacea* Linnaeus, is a perennial herb found from North Carolina to Texas, bearing long racemes of scarlet flowers, each itself two inches long, succeeded by pods containing brilliant scarlet beans, in form not unlike kidney beans. Torrey and Gray report, on the authority of Dr. Boykin, that its irregular branched rootstock is esculent and it is reported that the roots of some tropical American species are eaten. The flowers and tender leaves of some species are used as salad or as cooked vegetables. The flower buds of one species are boiled and eaten with meat. Wilson Poponoe[2] found that the large seeds of *Erythrina edulis* Triana form an important article of food for the Indians of certain mountainous regions of Colombia and praised the flavor of the dish prepared in their manner. Most species, however, are reputed to contain dangerously poisonous substances in seeds and bark. The seeds of some are used to poison rodent pests and the bark serves as a fish poison. Poisonous substances have been isolated from some species and named but this work needs to be repeated with modern methods and their reputed medicinal properties require investigation for acceptance. The flowers and bark are said to yield dyes and the bark a useful fiber. The light, soft, easily-worked wood serves many uses, for temporary posts and firewood, and in making corks, toys, images of saints, light boxes, lacquer ware, scabbards, shields, wooden dishes, water troughs and canoes. The Australian blacks dragged the light

[1] Received January 5, 1937.
[2] WILSON POPONOE, 1923, in Bur. Plant. Ind. Inventory of Seeds and Plants Imported **64**: 89–90, no. 51357.

unworked logs into the water to use in crossing creeks and rivers. The branches are usually armed with stout sharp prickles and readily strike root when thrust into the ground. Hence they are often used for hedges to protect garden plots. Being legumes with root nodules supporting nitrogen-fixing bacteria they have soil-improving properties, discovered long before the reason became apparent. Hence, in spite of the brittle nature of the branches, which lessens their value, they have come to be used to a considerable extent for shade for coffee, tea, cacao, and the *Areca* palm and as support for the vines of the true pepper. Although generally considered poisonous the seeds are widely used for necklaces and other ornamental purposes and in children's games and in games of chance by their elders. But, perhaps more generally than for any other reason, they are grown as ornamental trees because most of the human race is fond of the color red.

While working on the biology of Bruchidae in Hawaii I encountered two species of *Erythrina*. One is a native species not found elsewhere, the wili-wili tree, *Erythrina monosperma* Gaudichaud. This tree is often frequented by *Caryedon fuscus* (Goeze), formerly called *Caryoborus gonagra* (Fabricius), many adult beetles hiding by day in the partially opened pods. I have seen hundreds of eggs laid upon the seeds but not one larva was able to develop within them. The Indian coral-tree, *Erythrina variegata* Stickman, formerly known as *E. indica* Lamarck, is a common ornamental tree and its seeds were obtained in quantity for experiment. Most of the species of Bruchidae available deposited their eggs upon the seeds in confinement but none could develop within them, as was anticipated in both cases because of the reputed poisonous nature of the seeds.

In September 1920, W. S. Fisher, our well known specialist in Buprestidae and Cerambycidae, was serving temporarily as inspector for the Federal Horticultural Board and intercepted the first examples of a bruchid affecting the seeds of an *Erythrina*. This was an undetermined species collected by Dr. H. L. Shantz, of the Bureau of Plant Industry with the Smithsonian Expedition at Chuka, Kenia Province, under the equator far in the interior of British East Africa. This insect could not then (or now) be referred to any described genus or species and is described here as *Specularius erythrinae*, in allusion to the mirror-like area on the pygidium and to the host-plant in the seeds of which it develops.

While in India I was surprised to find the same species in December 1924 affecting the seeds of *Erythrina variegata* in the suburbs of Bombay on the island of Salsette and learned something of its habits. It was also found in Savantvadi State, some fifteen miles inland from the port of Vengurla in British India along the heavily traveled highway leading up to Belgaum in the interior; and at Mormugao Harbor in Goa, Portuguese India, a few miles away; and again down the coast at Mangalore, a port of British India. Upon returning to America in 1927 I found in the National Museum one lot of the species intercepted in the seeds of *E. abyssinica* Lamarck (*E. tomentosa* R. Brown) from Amani, Tanga, Tanganyika Territory, and another taken from the seeds of an undetermined *Erythrina* at Sabang, Pulu We Island, on the north coast of Sumatra, by David Fairchild and P. H. Dorsett of the Bureau of Plant Industry, while accompanying the Allison V. Armour expedition into that region. Subsequently the species has been intercepted by inspectors of the Bureau of Entomology and Plant Quarantine, mostly in the seeds of *Erythrina abyssinica* from various east and south African localities. I know of no records of the seeds of *Erythrina* being attacked by other Bruchidae or by this species in Australasia or America, nor has this species been known to attack other legumes.[2a]

Specularius, n. gen.

The most conspicuous character of *Specularius* is the dark brown, glabrous, highly polished, mirror-like, circular area, occupying the greater part of the plane, sub-vertical pygidium in both sexes, elsewhere found only in the Brazilian *Gibbobruchus speculifer* (Gyllenhal), another member of the Bruchidae, Bruchinae, believed to be not closely allied to *Specularius*.

Type of the genus, *Specularius erythrinae*, n. sp.

Specularius erythrinae, n. sp.

Brownish-red with suffused darker, or piceous-black, areas on the head antennae, pronotum, elytra, breast, hind coxae, femora beneath, some of the sternites, and pygidium; densely pubescent with coarse appressed hairs (often abraded) concealing the sculpture except for naked or partly naked areas on elytra, hind coxae, and pygidium; this pubescence is tawny, varying to whitish in maculate areas, and darker (blackish) on the darker elevated areas of pronotum and elytra; with large coarse punctures and coarse micro-sculpture, very irregularly disposed.

Head short with short malar space; eyes moderately granulate, strongly convex and strongly projecting, emarginate for about two thirds of their length; front strongly carinate, separating the eyes at the clypeus by a little more than the width of their upper lobe; temples abruptly declivous to the contraction; antennae about half as long as the body, a little stouter and more expanded in the male, pubescent, compressed, expanded and serrate,

[2a] Note added in proof: Since this paper was written a brief note has appeared in Proc. Hawaiian Ent. Soc. 9: 368, 1937, saying: "Mr. D. T. Fullaway mentioned having reared . . . *Bruchus pruininus* from *Erythrina* seeds from the Waianae Mts." It may be that these beetles were hidden in the pods. My experience with *B. pruininus* would lead me to doubt its being able to develop in *Erythrina* seeds.

beginning with the 5th joint; 1st and 4th joints subequal in length and breadth; 2nd and 3rd joints shorter, similar to each other, about as long as broad; 5th broader than 4th, its apical angle a little produced; 6th–10th similar to each other, narrowed to base, the inner angle strongly produced, these joints about as long as broad; 11th narrowly ovate, subacute at apex.

Pronotum conical, its sides nearly straight, converging anteriorly to a little more than one third of basal width, with very uneven surface, with a median longitudinal elevation obsolescent in the middle and not strong anteriorly, divided by a median longitudinal sulcus strong on the basal lobe, obsolete in the middle, visible anteriorly, together forming four elevations of which the basal pair are much stronger, outside these in the middle separated from the basal pair by a depression is another similar elevation on either side; lateral lobes strongly depressed; flanks narrow, vertical, not separated from the dorsum; lateral margin represented by a feeble vestigial carina above the coxa, seen with difficulty when denuded of pubescence; cephalic foramen of prothorax strongly inclined backward below; prosternum a little less inclined, triangular, separating the coxae for two thirds their length; mesosternum truncate at apex, descending below prosternum about as far as its length, overlapping the metasternum obliquely; mesepimeron subtriangular, somewhat acuminate along the meso-metapleural suture, ending remote from the coxal cavity; scutellum small, longer than broad, emarginate and bidentate at apex; elytra broader than pronotum basally, broader in the middle, together somewhat longer than broad, separately broadly rounded at apex and serrulate near the suture, depressed along the suture, striae 2, 4, 6, and 8 slightly interruptedly elevated, the elevations accentuated by the pubescence which is blackish on the elevations, an area on the 2nd, 3rd, and 4th intervals[3] within and behind the humeral calli is most strongly elevated (3rd interval depressed between the strong elevations of 2nd and 4th intervals); striae strongly impressed with strongly impressed punctures; intervals without punctures, more or less transversely rugulose and flat except for the elevations of the alternate intervals (which with the humeral calli are evenly transversely finely ridged); sutural margin in the middle some distance behind the scutellum dark with dark pubescence; denuded elytron irregularly checkered with reddish and blackish, all intervals, margins and the apex bearing some dark markings; 10th stria abbreviate at about the apical third; 4th and 5th striae abbreviate at apex; 2nd, 5th, 6th and 10th striae extending nearer the base than the others; base without tubercles or denticles.

Front and middle legs without special structures of note; hind coxa about as broad as the two sternites next behind it, slightly broader than the femur, with rather coarse piliferous punctures denser in the middle, lateral fourth more densely pubescent, hind margin naked, a narrow densely punctate and pubescent band just before the hind margin extending far toward the insertion of trochanter; hind femur compressed nearly straight beneath for most of its length, gradually arcuately widened above to beyond the middle, then more suddenly narrowed to apex; ventral edge flattened, inner and outer margins of ventral surface subcarinate apically, inner ventral margin emarginate and armed before the emargination with a strong acute suberect tooth and beyond it with one or two small denticles, and before it with one or two feeble serrulations, outer ventral margin with a small rounded con-

[3] The intervals are numbered here from the striae outside which they lie beginning with the stria nearest the suture as stria 1, hence there are nine intervals and sutural and lateral margins on each elytron.

dylar lamina, emarginate before the lamina and subangulate before the emargination; flexed tibia resting between this subangulate process and the great tooth of the inner margin; tibia nearly straight, dorsoventrally widened at apex to about three times its basal width, bearing at apex a strong porrect acute mucro, nearly as long as breadth of tibia, a shorter triangular lateral tooth, and three small subequal subdorsal teeth; outer face with a ventral longitudinal carina, a less elevated intermediate carina obsolescent at apex where it approaches the base of the mucro and a strong lateral longitudinal carina ending in the lateral tooth; basitarsus more than half as long as tibia, gently arched in the middle, produced into a tooth at apex beneath, with a longitudinal carina on outer and inner faces and a single ventral longitudinal carina; second tarsal joint longer than broad, not expanded apically, feebly longitudinally carinate and produced at apex beneath; lobes of third joint feeble, not expanded; ungues appendiculate.

Abdomen shorter than the breast, not attaining the apex of elytra or of hind femora, three intermediate sternites subequal, each shorter than the first sternite behind the coxa and longer than the fifth in the male, shorter in female; pygidium flat nearly vertical, broadly triangular, bearing on the disc a large polished, reflecting area surrounded by a border of whitish pubescence concealing the surface; this area is dark brown with some irregularly disposed, strongly impressed punctures arranged in a marginal series with others scattered within; male pygidium slightly reflexed at apex and subtruncate, with another tergite visible between pygidium and narrowed fifth sternite.

Length from anterior margin of pronotum to apex of elytron 2.6–4 mm; width 1.75–2.8 mm.

Described from a type series in the United States National Museum of 52 ♀s and 33 ♂s, with accompanying material showing eggs, pupae, work in host seeds, and dissections. Type no. 52331 U.S.N.M.

Type locality: Amani, Tanga, Tanganyika Territory, East Africa, type male, allotype female and two female paratypes labelled "Amani, Tanga, East Africa on *Erythrina tomentosa* F.H.B. 89143 March 31, '25."

Additional localities and material as follows:

AFRICA: Chuka, Kenia Province, Kenia, 3 ♀s, 1 ♂, and 3 seeds of host plant labelled as from Nairobi intercepted by W. S. Fisher F.H.B. 37623 (Cf. Inventory **65**: 33, 34 no. 51637. From seeds of *Erythrina* sp. collected by H. L. Shantz, June 16, 1920). Amani, (2nd lot), 3 ♀s, 2 ♂s, 3 seeds of host plant labelled "Seed of *Erythrina tomentosa*, 12.X. '28, H. Y. Gouldman, P. Q. & C. A. 7581." South Africa, 5 ♀s, 3 ♂s, 3 seeds of host plant labelled "Ex *Erythrina* from So. Africa, San Francisco, Cal. Jul. 1, '29 G. Wilson." Natal, 2 ♀s, 1 ♂ labelled "Natal, South Africa Sept. '36 coll. R. H. Smith host *Erythrina abys*[*s*]*yni*[*c*]*a*." Rhodesia, 3 ♀s, 2 seeds of host plant [*Erythrina sp.*] labelled "Wilmore Kentucky Nov. 12, 1937 ex beans from Rhodesia, S. Africa." (One additional female paratype and one seed of host plat were returned to the sender, Lee H. Townsend, University of Kentucky.)

INDIA: Goregaum, Bombay Salsette, 12 ♀s, 9 ♂s, 10 fragmentary adults and dissections from them, 5 cocoons containing adults, 2 empty cocoons, 4 pupae, 9 seeds of host plant (*Erythrina variegata*, labelled *E. indica*, Dec. 1924). Borivli, Bombay Salsette, 12 ♀s, 8 ♂s Jan. 1925. Savantvadi State, 5 ♀s, 5 ♂s, bred from *Erythrina variegata*, labelled *E. indica* April, 1926. Mormugao Harbor, Goa, Portuguese India, 1 ♂ coll. Sept. '25. Mangalore, 1 ♀ coll. Jan. '27. All these bred or collected by J. C. Bridwell.

SUMATRA; Sabang, Pulu We Island, 2 ♀s, 1 ♂ labelled "Sumatra D. Fairchild D.F. 431 (Cf. Inventory **87**: 22. Obtained by David Fairchild and P. H. Dorsett. S.P.I. no. 67182. *Erythrina* sp. No. 431. February 17,1926)."

Dark pubescent spots on the pygidium are not unusual in Bruchidae and glabrous polished areas occur in groups of the Bruchinae otherwise unlike. Such an area occurs upon the pygidium of the female of *Bruchidius stierlini* (Allard), (affecting *Scorpiurus compressus* Linnaeus in the Mediterranean Region), which has been absurdly considered a variety of *Bruchidius seminarius* (Linnaeus). But in this species the area is convex and the pygidium oblique and the insect is otherwise quite unlike *Specularius*. In some American Bruchinae affecting seeds of *Bauhinia* and *Cercis* perhaps referable to *Gibbobruchus* Pic, polished glabrous areas are found on the female pygidium. Our *Gibbobruchus mimus* (Say) breeding in the seeds of *Cercis canadensis* Linnaeus has a cordate glabrous polished area on the female pygidium but this is convex and oblique and femoral characters forbid association with *Specularius*. These femoral characters are found also in *Gibbobruchus speculifer* (Gyllenhal) in which the pygidium is much more like that of *Specularius* and the mirror-like area is present in both sexes. The similarity of structure of hind legs, scutellum and antennae leads me to place these American forms in *Gibbobruchus*. The strongly elevated pronotum which Pic used as the principal character for his group does not run through the genus and in two undescribed species which certainly belong with *mimus*, and probably with *speculifer*, the median longitudinal elevation is so reduced as to be almost imperceptible. In all the species which I should place in *Gibbobruchus* the scutellum is transverse (emarginate and bidentate at apex) and thus unlike the oblong scutellum of *Specularius*. The hind femur expands above and below in similar even opposed curves to the middle and similarly narrows to apex. The flexed tibia is received in a groove on the ventral edge of the femur. The outer margin of this groove is armed with a long series of denticulations or serrulations and the inner margin bears near apex a stout tooth and a series of three or more strong acute denticles beyond it, quite unlike the one or two feeble denticles in the same position in *Specularius*. The tibia is more slender and arcuate and lacks the lateral tooth at appex; the intermediate longitudinal carina is more strongly developed so that the tibia is distinctly sulcate beneath with the inner or ventral carina somewhat more elevated than the outer or intermediate. The basitarsus is not produced into a tooth at apex beneath. In none of them can the antennae be said to resemble those of *Specularius*.

I have thus particularly compared *Specularius* with *Gibbobruchus* since the differences found seem to remove any probability of an American origin for this genus of uncertain nativity. I believe the genus originated in the interior of Africa and was taken to India and Sumatra by inhabitants of India who were employed in Africa and carried back with them the brilliant scarlet seeds of *Erythrina abyssinica* or other species containing the larvae of *Specularius*.

If *Specularius* is of African origin and not closely allied to *Gibbobruchus*, its kin must be sought among Old World Bruchidae without the peculiar pygidial mirror. Pic has established a genus *Callosobruchus* of which *Curculio chinensis* Linnaeus 1758 (=*Bruchus scutellaris* Fabricius 1792=*Bruchus pecti[ni]cornis* Linnaeus 1767) is the genotype. The callus of the basal lobe of the pronotum was considered by Pic as its distinguishing character but this is found in other genera and is not found in some species which must be placed near *chinensis* because of other characters. As understood by me the genus is represented by many species in the Old World tropics, Africa, southern Asia, and Malaysia. Three of these have been widely distributed in commerce and established in many countries where their favored host plants are grown. These are *C. chinensis*, *C. maculatus* (Fabricius 1775) (=*quadrimaculatus* Fabricius 1792) and *C. phaseoli* (Gyllenhal 1833), all affecting food legumes of Old World origin. Also affecting Old World food legumes but not yet, apparently, established in the Americas are the important economic species *C. analis* (Fabricius 1781), *C. theobromae* (Linnaeus 1767), *C. subinnotatus* (Pic 1914) and other species of still undetermined status. One somewhat aberrant species, *C. ademptus* (Sharp 1886) extends out of the tropics into temperate northeastern Asia affecting the kudzu, *Pueraria thunbergiana* Bentham. Another extra-tropical species, *C. spiniger* (Baudi 1886) is found in Asia Minor and the Eastern Mediterranean Islands, its food plant still unknown. Besides these, numerous species attached to non-economic leguminous host plants are found in tropical Africa, Asia and Malaysia. All these agree in having the hind femur armed beneath near apex within and without with a strong tooth. In *ademptus* only is the outer tooth so reduced as to suggest comparison with the slight subangulate process in the same position in *Specularius*. None of them have any trace of denticles beyond the tooth on the inner margin. In all the basitarsus resembles that of *Specularius* but the ventral carina is double with a narrow sulcus separating the carinae. The mesepimeron is more acuminate along the pleural suture, reaching nearly or quite to the trochantin extension of the mesocoxal cavity and in none of them are the irregularities of the pronotum so fully developed. The elytra lack the irregularities of surface in *Specularius*, the tenth stria is less abbreviate and striae 2, 3, 4, 5, and 6 extend evenly to the base of the elytron. All the species have stronger sex dimorphism than found in *Specularius*, the sexes differing in coloration of elytra and pygidium, in antennal structure, and in form and inclination of pygidium and fifth sternite. Hence it seems to me that *Specularius* must be considered closely allied to *Callosobruchus* but sufficiently unlike to be excluded from the genus.

The pods of the species of *Erythrina* remain for a long time attached to the trees and are only very tardily dehiscent. Being very brittle they become broken by the whipping of the branches in the wind and the seeds become exposed and fall to the ground as the pods open partially or are broken. It is not until the seeds are exposed that oviposition by *Specularius* takes place and the eggs are laid scattered on the seeds. The eggs resemble those of *Callosobruchus maculatus* being long ellipsoidal and firmly cemented to the seed. The contraction of the cement substance in hardening flattens the egg to an ovate outline with one pole elevated into a peak near one end. The larva enters the seed directly from the egg and develops within the cotyledon, preparing, when full grown, a strong cocoon attached to a window of the seed coat ready to be cut by the adult and pushed loose as a perfect disc when the adult emerges. In the smaller seed of *E. abyssinica* from one to three adults can develop while in the larger seed of *E. variegata* more than a dozen exit holes have been found. The seeds may be reinfested until the entire contents is destroyed. The tardy attack of *Specularius* upon the seeds of *Erythrina* makes it a simple matter to secure uninfested seeds for propagation if the pods are gathered promptly when they become ripe before the seeds are exposed.

However poisonous the seeds of *Erythrina* may be shown to be on further investigation there is nothing surprising in finding a bruchid adapting itself to feeding in poisonous seeds. *Bruchidius villosus* (Fabricius) is not deterred from destroying the seeds of *Cytisus scoparius* by the toxic alkaloid contained in them; the toxalbumen in the seeds of *Abrus precatorius* does not render them unsuitable for food for the larvae of *Caryopemon cruciger* (Stephens) in Africa and *C. lhostei* Pic in Ceylon. The rotenone in seeds of *Cracca virginiana* has no ill effect upon the larva of *Acanthoscelides obsoletus* (Say) and Trelease and Trelease[4] have recently shown that concentrations of selenium in the seeds of *Astragalus* lethal to vertebrate animals may be endured by *Acanthoscelides fraterculus* (Horn).

[4] Sam F. and Helen M. Trelease, 1937, Science **85**: 590; and Amer. Jour. Bot. **24**: 448–451, f. 1–4.

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PHYSICS.—*The skeptical physicist.*[1] Paul R. Heyl, National Bureau of Standards.

Those of you who are acquainted with the history of science will recognize the source whence I have plagiarized the title of this address. In the middle of the 17th century the young science of chemistry was in a state which troubled the conscience of the Honorable Robert Boyle, whose interest in this science was life-long. There was a theory widely held at that time that all substances were composed of three primary principles—salt, sulphur and mercury. In "The Sceptical Chymist," published in 1661, Boyle combated this idea, criticizing the experiments upon which it was based, and pointing out among other things the difference between mixtures and compounds. Modern chemistry owes much to the pioneer work of Boyle, and his merits were not unappreciated by his contemporaries, who dubbed him "the father of chemistry and the brother of the Earl of Cork."

The term "skeptical" has an etymology from which its present-day meaning has widely departed. The Greeks applied the adjective σκεπτικός to a person who gave thoughtful consideration to matters which called for action or decision. The antithesis of such a skeptic was the person who acted on impulse or emotion. Perhaps because the judgment of the skeptic was so often adverse, he gradually became recognized as a chronic doubter or even as an iconoclast. It is possible, however, that these adverse opinions may have been due in many cases not to original sin in the skeptic, but to essential unsoundness in the subjects that he was called on to consider.

I like to think that Boyle used the term "skeptical" in its original sense, and in that sense I may be permitted to use it in the present discussion. It is as true now as when Victor Cousin said it, nearly a century ago, that "la critique est la vie de la science," and the history of science shows that situations arise at frequent intervals where the application of this principle is called for. When criticism is stifled, science is dead.

[1] Address before the Philosophical Society of Washington on December 18, 1937. Received January 12, 1938.

One of these situations confronts us at the present time, and has called forth a protest from a skeptical physicist to which scientific men of all households of faith may well give attention, for though it is the science of physics that is immediately concerned, the situation involves the fundamental question of the attitude of the scientific man toward Nature.

I refer to Dr. Herbert Dingle and his article on "Modern Aristotelianism" which appears in *Nature*, May 8, 1937. The replies, pro and con, to this article were so numerous and extensive that it was necessary to devote an entire supplement of *Nature* to them (June 12, 1937). It will, I think, be interesting and profitable to give a resumé of Dingle's article and of some of the replies to it.

Dingle's article may appear to have been inspired by published statements by Eddington and Milne, but between the lines there are some of us who can read sympathetically the story of a slowly growing skepticism which has finally burst all bounds.

The term "Aristotelianism," as Dingle uses it, does not refer so much to the doings and thinkings of Aristotle himself as to the habit of mind and the outlook upon Nature of the medieval scholars who acknowledged the great Stagirite as their master. Orthodox science since Galileo's day has held that the first step in the study of Nature is the observation of phenomena, from which we may pass by induction to the derivation of general principles. The "Aristotelianism" to which Dingle refers, and which dominated the scholastic thought of the western world up to the 17th century, was the doctrine that there are general principles known *a priori* to the human mind apart from observation or sense perception.

For instance, Aristotle reasoned that a heavy body must fall more rapidly than a lighter one, and this *a priori* principle was accepted and believed by the Aristotelians for 2000 years, until it was shown by experiment and observation that such was not the fact. As Emerson says, "Things are in the saddle, and ride mankind."

For three centuries this Aristotelian view of Nature has been regarded, at least by scientific men, as dead. It is therefore, as Dingle says, no light matter when we find in our own day a revival of Aristotelianism in the front ranks of science itself. As ground for this serious charge Dingle quotes statements by Eddington and by Milne.

Eddington[2] says, "There is nothing in the whole system of laws of physics that cannot be deduced unambiguously from epistemological

[2] "Relativity Theory of Protons and Electrons," p. 327.

considerations. An intelligence unacquainted with our universe, but acquainted with the system of thought by which the human mind interprets to itself the content of its sensory experience, should be able to attain all the knowledge of physics that we have attained by experiment."

Milne[3] is somewhat more restrained and conservative when he says, "It is, in fact, possible to derive the laws of dynamics rationally . . . without recourse to experience."

Statements like these, coming from leaders in science, are indeed serious, and it will be interesting to see what their authors have to say in their own defense.

Eddington stands by his guns, remarking that the passage cited by Dingle has been likewise quoted "without its safeguards" by almost all the reviewers of his book. And what are these safeguards? Eddington makes it clear that the quoted passage must not be interpreted as the *a priori* basis of his philosophy, but is the unexpected conclusion at which he has arrived as the result of his investigations.

And what are these investigations?

Some years ago Eddington, by an abstruse mathematical discussion which he states did not involve any observational measurements, arrived at a figure for the mass-ratio of the proton and electron which was quite close to the accepted experimental results. Still later he calculated by relativistic-wave-mechanics method that the total number of elementary particles in the universe is $2 \times 136 \times 2^{256}$. This result still awaits experimental check.

"After a rather extensive series of researches," says Eddington in his reply to Dingle, "I have found that a great part of the current scheme of physics is deducible by *a priori* argument." But he goes on to admit that "since we can have no *a priori* knowledge of an objective universe such results do not constitute knowledge of an objective universe." Just what they do constitute he does not make clear.

Milne, in his defense, takes much the same position as Eddington. Dingle's criticism of Milne was directed in part against his doctrine of "kinematical relativity," which is a study of the consequences of the assumption that the universe is, on the average, homogeneous both in distribution and motion. In developing the consequences of this assumption Milne endeavored to avoid any empirical appeal, and to develop the physics of the universe after the manner of a logical geometry based upon axioms or space-definitions. In carrying out

[3] Proc. Roy. Soc., A, **158**, 329; 1937.

this development Milne appears to have made the same discovery as Eddington. Milne remarks that it is an astonishing thing to find that the elimination of empirical appeal, including all appeals to quantitative laws of physics, can be carried as far as it can; and that with the elimination of such empirical appeals regularities emerge which play the part of the very laws of Nature which are observed to hold good.

Milne admits that his resulting logical structure may not correspond to Nature any more than do the various hypergeometries that have been invented, but says that just as results of value have followed from the development of such non-realizable abstractions as a four-dimensional cube, so it may be valuable to construct an abstract physics for its own sake.

This is a reasonable defense. As long as the limits of such investigations are clearly recognized, and they are held strictly within these limits, they may be as valuable and stimulating as any other scientific speculations. But the essence of Dingle's criticism is that this line of action can be carried to such excess and be given such a color as to deceive the very elect. When those to whom we look for scientific leadership can say, in effect, "Don't experiment; calculate! It is easier, cheaper, more exciting and productive of results," then science is on its way back to the Aristotelianism of the Middle Ages.

The ability of a theory to calculate and predict phenomena is an asset of undoubted importance, but it is not enough, and must not be over-rated. A modern instance of this is Bohr's theory of atomic structure. The flexibility and accuracy with which the Bohr atom adjusted itself to the manifold conditions required by the periodic law of the elements were remarkable. The Bohr theory moved along with regular steps, dropping the right element into each empty compartment provided by the periodic law. When it came to the rare earths the theory halted for a moment, dropped exactly the right number of elements all into the same compartment, and then resumed its measured tread, dropping one element at each step until all were put in their proper places. No wonder that Whetham characterized this behavior as "satanic." Yet with all this to its credit the Bohr atom, because of its failure to meet three requirements, had to give place to a still more adaptable theory as soon as one could be found.

The theory of relativity is in a similar position today. It has done much; it has explained one astronomical puzzle for which the Newtonian law of gravitation was inadequate; it has predicted two other physical phenomena whose existence has been experimentally verified; but when it comes to such a simple matter as centrifugal force, then, as Eddington himself says, the theory stops explaining phenomena and begins explaining them away. The theory of relativity holds its own today only because no one has as yet been able to devise a better.

The failure of a theory for reasons of this character need reflect no discredit upon its author. We can still admire a theory which has marked a step in progress, which has been able to cut a little more closely to the line than any which preceded it, even though it be soon superseded by a better. But some theoretical researches in modern physics fall into a different category, and tend to make the skeptical physicist a little more skeptical.

These researches are for most of us difficult reading. Perhaps this is unavoidable, considering the nature of the subject. We of the rank and file must frequently take the results of our leaders on faith; and unfortunately we sometimes find in those portions which we can understand that which seriously shakes our confidence in the parts that we cannot follow. When, for example, Eddington[4] says that the mass of the sun is 1.47 kilometers, and repeats this in the second edition of his book, and when Minkowski[5] points with pride to what he calls "the mystic formula"

$$3\times 10^5 \text{ km} = \sqrt{-1} \text{ sec},$$

and when it requires no knowledge of the calculus of tensors to see what the trouble is, the only conclusion possible is that the fundamental principles of mathematics and physics are like the laws of whist—for beginners to observe and for masters to disregard.

Minkowski's memoir on "Space and Time," in which this "mystic formula" occurs, has long enjoyed the reputation of a classic. It antedates Einstein's general theory of relativity by seven years, and in his paper of 1915 Einstein acknowledges his debt to Minkowski. Minkowski's memoir contains the concepts of the four-dimensional space-time continuum, of world lines and of space-like and time-like vectors upon which basis has been erected a vast structure of relativistic cosmology. With this "mystic formula" staring us in the face it will be interesting to examine the philosophical basis of Minkowski's theory.

The fundamental idea of the memoir is that time in some way bears

[4] Report on the Relativity Theory of Gravitation, second edition, 1920, p. 50.

[5] "Raum und Zeit," an address before the German Convention of Natural Scientists and Physicians, Cologne, Sept. 21, 1908. Phys. Zeitschrift, Vol. X, p. 104, 1900. English translation in "The Principle of Relativity; memoirs by Lorentz, Einstein, Minkowski and Weyl," New York, Dodd, Mead and Co., 1923.

a fourth-dimensional relation to our solid space. Now, of course, time has not the dimensions of a length, but if we multiply it by a velocity that defect disappears. Minkowski multiples the time t by the velocity of light c, thus obtaining the length ct which may be used as a fourth dimension. Unfortunately, it happens that an important equation resulting from this hypothesis is not symmetrical.

Now every mathematician has in him something of the artist; an eye for symmetry, for beauty of results and for elegance in the methods used in obtaining them. An unsymmetrical equation offends the artistic sense; in addition, it is scientifically undesirable, as results cannot be obtained from it as readily as from a symmetrical form. And here Minkowski had a brilliant idea. If we multiply the fourth dimension ct by $\sqrt{-1}$ the unsymmetrical equation becomes symmetrical.

Of course this gives us a set of four axes, three of which are real and one imaginary, but any difficulty attaching to this detail is soon forgotten in the dazzling light of the brilliant results that begin to appear. For example, referred to our new coordinates, the complicated Lorentz transformation appears as a mere rotation of the axes—which, however, involves the turning of the imaginary axis through an imaginary angle.[6] Whether this makes the Lorentz transformation any more comprehensible is a question—which the artist-mathematician answers in the affirmative.

$\sqrt{-1}$ has a legitimate application in pure mathematics, where it forms a part of various ingenious devices for handling otherwise intractable situations. It has also a limited value in mathematical physics, as in the theory of fluid motion, but here also only as an essential cog in a mathematical device. In these legitimate cases, having done its work it retires gracefully from the scene; but to make an imaginary quantity a permanent foundation stone for a physical hypothesis is, as they say in Ireland, a white horse of another color.

There is no denying the potency of $\sqrt{-1}$ as a useful tool. As an illustration, I may point out how it helps us to an interesting little theory of gravitation. Einstein, in discussing the resemblance between inertia and gravitation, considers the case of a revolving circular platform. Suppose such a disk large enough to hold an observer, and let it be covered by a dome so that the observer within cannot tell by direct observation of outside bodies whether the disk is in motion. Let the disk be at rest. The observer, in moving from one place to

[6] Minkowski discusses this point very briefly. The complete methematical treatment is given by Eddington in his "Report on the Relativity Theory of Gravitation," second edition, 1920, page 14.

another in his little world would notice no difference between one point and any other. Let the disk be now set in rotation. The observer, unless he stood at the center of the disk, would experience a force urging him radially outward, and the farther he was from the center the greater would be this force. He would, in fact, be living in a sort of turned-inside-out gravitational field.

As a theory of gravitation there are two defects in this. The force increases with the distance from the center; and it is in the wrong direction, outward instead of inward. The first of these defects is quite easy to remedy. We may suppose the speed of rotation of the disk to be variable, governed either by a mechanical device or by a watchful engineer so that the speed will increase as the observer approaches the center, and will diminish as he nears the circumference.

The other defect is not so easy to dispose of. It is obviously useless to give the disk a negative velocity of rotation, as the centrifugal force depends on the square of the velocity. But if we multiply the velocity not by -1 but by $\sqrt{-1}$, the trick is done.

Everybody laughs at this; nobody laughs at Minkowski. Yet I have done nothing but what Minkowski has done. I have turned my disk through an imaginary angle; Minkowski turned his axes of coordinates through an imaginary angle. The trouble is that I have made my illustration so simple that anyone can see through it. Had I made it as abstruse as Minkowski's memoir it might have been received with equal seriousness. Truly, as Dingle says, the criterion for distinguishing sense from nonsense has been lost; our minds are ready to tolerate anything, if it comes from a man of repute and is accompanied by an array of symbols in Clarendon type.

And yet we must not be too hard on $\sqrt{-1}$; it may stand us in good stead on occasion, as is instanced by a tradition of the National Bureau of Standards.

In the early days of the Bureau, when the staff was smaller, and there were no official guides, the staff-members took turns in conducting parties of visitors through the laboratories. On one such occasion the visitors were shown some liquid air, and they asked, "What is this used for?" In those days liquid air had not yet found any practical application, and was merely a scientific curiosity. The guide, who tradition says was one of the lady-members of the staff, was rather non-plussed for the moment, but quickly recovered her presence of mind, and replied, "It is used to lubricate the square root of minus one."

I sometimes think Minkowski must have heard that story.

CHEMISTRY.—*Biochemistry by analogy: the sulfur of cystine.*[1]
BEN H. NICOLET, Bureau of Dairy Industry.

We are, I think, all agreed on the proper way to attack a chemical problem. One should set up a crucial experiment with the substances supposed to be concerned, carry the experiment to completion, and see what happens. But often, particularly in biochemistry, this is hard to do. It may be necessary to carry out an analogous reaction, under supposedly more or less analogous conditions. This is known as a "model" experiment, though it is very far from being a model of what one might wish to do. It frequently amounts to thinking what certain molecules *should* do, and trying to establish, a bit indirectly, whether such a reaction is really plausible. I shall talk to you this evening of "model" experiments, and I intend to see whether I can convince you of the value of the conclusions, as yet incompletely confirmed, which I shall draw from them.

Cystine (I) and methionine (II) are the two best known amino acids containing sulfur which go to make up proteins. Both are readily synthesized by plants, but with regard to animals (including outselves) both are essential amino acids—or nearly so.

An "essential" amino acid is one which must be supplied in the diet if an animal is to live and grow normally. In other words, the animal body cannot synthesize essential amino acids, or cannot do so in sufficient quantity. According to the latest data,[2] animals can not synthesize methionine under any known conditions. On the other hand, a cystine deficiency can be corrected either by cystine, methionine, or homocystine (III). It is, accordingly, at least very probable that animals *can* synthesize cystine, although only, so far as we yet know, when methionine or homocystine is fed. The problem tonight is, how cystine and methionine get their sulfur, and, in part, how they lose it again.

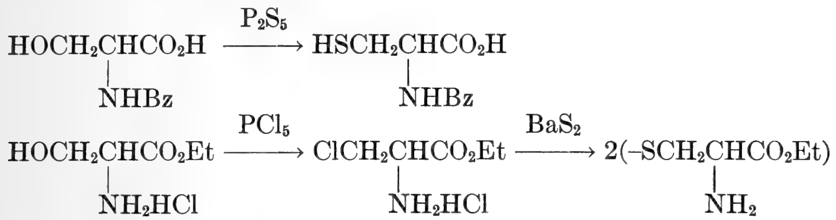
$$2(-SCH_2CH(NH_2)CO_2H) \quad \text{I} \qquad CH_3SCH_2CH_2CH(NH_2)CO_2H \quad \text{II}$$

$$2(-SCH_2CH_2CH(NH_2)CO_2H) \quad \text{III}$$

There are two syntheses of cystine on record. Erlenmeyer treated benzoylserine with phosphorus pentasulfide. Emil Fischer converted serine ester hydrochloride to β-chloroalanyl ester hydrochloride, and

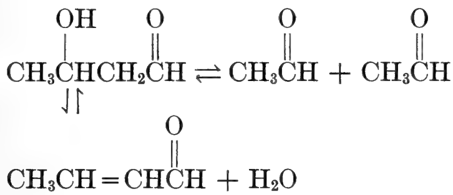
[1] Address of retiring president, Chemical Society of Washington, January 13, 1938. Received January 28, 1938.
[2] Rose, Science **86**: 298. 1937.

then allowed this to react with barium disulfide. Hydrolysis gave cysteine and cystine, respectively.

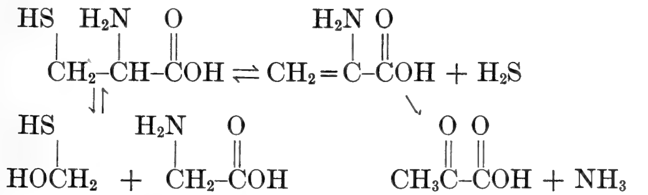


Surely neither of these syntheses approaches the possibility of being a biological synthesis.

A few years ago I talked to you once before[3,4] about cystine. I asked you then to recall the reactions of aldol formation and dehydration, and their reversals. It is particularly necessary to remember that *all* these reactions are reversible.



I presented to you at that time the idea that the desulfurization of cystine by alkali was essentially analogous to the dehydration of an aldol, and should obey the same rules, including reversibility. The work of Dr. H. T. Clarke[5] and his students on the hydrolysis of cystine was entirely in accord with the first part of this notion. It showed very clearly that the chief direction of cystine decomposition by alkali led to hydrogen sulfides, ammonia, and pyruvic acid. In the following equations cysteine is used, for simplicity of presentation, in place of cystine to show the formal analogy to the aldol reactions shown above. Under suitable conditions, reactions analogous to most of these types can be demonstrated.



[3] Nicolet, J. Am. Chem. Soc. **53**: 3066. 1931.
[4] Nicolet, J. Biol. Chem. **95**: 389. 1932.
[5] Clarke and others, J. Biol. Chem. **94**: 541. 1931. **102**: 171. 1933. **106**: 667. 1934.

At the same time, attention was called to the fact that modification of the cystine molecule in the direction of peptide formation, or, to put it more simply, in the direction of combining the carboxyl group with an amide grouping (as in peptide formation) and the amino group with an acyl group (which *could* be an aminoacyl group) *facilitated* the *removal* of hydrogen sulfide (or disulfide) and *should* facilitate its addition.

It might be argued that the dehydration of an aldol is a very easily occurring reaction, and is due to the activating influence of the aldehyde group. Cystine, on the other hand, offers considerable resistance to alkali; and it is well known that the –CO– grouping present in carboxyl, retains very little of the typical "carbonyl" properties. It was, however, shown quite definitely at that time that mercaptans add very readily to α,β-unsaturated ketones, such as benzalacetone.

$$PhCH=CHCOCH_3 + RSH \rightleftharpoons PhCH(SR)CH_2COCH_3$$

These products lose mercaptans with extreme ease. A quite small fraction of the full "carbonyl" activity would therefore be sufficient to account for the results obtained.

You will perhaps not ask me to repeat my earlier talk further. Let us assume that the reactions eliminating sulfur occur as suggested, and that they are reversible. The simplest reaction by which cystine (or cysteine) could be formed, would be the addition of hydrogen disulfide (or hydrogen sulfide) to α-aminoacrylic acid (IV), which we may also call dehydroalanine, since it represents the removal of two hydrogen atoms from alanine.

But we shall not expect to be able to demonstrate this reaction, as such, for two reasons. Aminoacrylic acid itself is so unstable that it has never been isolated. And, secondly, we should have much better hope of success if the carboxyl or amino group, or both, were suitably modified. What we should prefer would evidently be a peptide (V) (at least a tripeptide) in which the dehydroalanyl group was not at either end.

$$\underset{\text{IV}}{CH_2=C(NH_2)CO_2H} \qquad \underset{\text{V}}{NH_2CHR'CO\text{–}NH\text{–}\overset{\overset{\displaystyle CH_2}{\|}}{C}\text{–}CO\text{–}NHCHRCO_2H}$$

Such a compound was not itself available. For the tentative test, a compromise had to be made. The simplest known derivative of aminoacrylic acid is Bergmann's acetylaminoacrylic acid (VI). It should not be expected to work very well, but it does work. Heated for ten hours at 100° with benzyl mercaptan and a little piperidine as catalyst, it gave a small but definite yield of N-acetyl-S-benzylcysteine (VII). This was hydrolyzed to S-benzylcysteine (VIII).

$$\underset{\text{VI}}{\begin{array}{l}CH_2{=}CCO_2H\\ \quad\;|\\ \quad NHAc\end{array}} + PhCH_2SH \rightarrow \underset{\text{VII}}{\begin{array}{r}PhCH_2SCH_2CHCO_2H\\ |\quad\;\;\;\\ NHAc\;\;\end{array}}$$

$$\underset{\text{VIII}}{PhCH_2SCH_2CH(NH_2)CO_2H} \qquad HSCH_2CH(NH_2)CO_2H$$

Dr. Loring was kind enough to apply to this Dr. du Vigneaud's process of reduction by means of sodium in liquid ammonia, for the removal of the benzyl group from sulfur, and obtained a 93 per cent yield of cysteine, as shown by the specific Sullivan method.

This is a new synthesis of cysteine, and therefore of cystine. But certain other requirements must be met if it is to be considered as even a possible model for a biochemical synthesis of these amino acids.

Since a dehydroalanyl tripeptide such as V was not available, benzyl mercaptan was next added to benzoyldehydrophenylalanylglycine ester (IX). The resulting mercapto derivative (X) was formed some 50 or 100 times more readily, as estimated by the much better yield obtained in a much shorter time.

$$\underset{\text{IX}}{\begin{array}{c}PhCH\\ \|\\ PhCONHCCONHCH_2CO_2Et\end{array}} \qquad \underset{\text{X}}{\begin{array}{c}PhCHSCH_2Ph\\ |\\ PhCONHCHCONHCH_2CO_2Et\end{array}}$$

Now peptides containing alanine are very common. It is extremely probable that, in their metabolism, they pass, in the presence of suitable enzymes and of suitable hydrogen acceptors (or oxidizing agents), through the stage of dehydroalanine derivatives. I have tried to show elsewhere[6] that this dehydrogenation should take place more readily when the alanine was a component of a peptide chain, and particularly when it was not terminally located. Thus the most commonly formed dehydroalanyl derivatives should be just of the type most suitable for sulfide addition. We have thus acquired, through model experiments, the basis for a picture of the biological synthesis of cystine which is at least somewhat credible.

As a sort of parenthesis, it might well be remarked here that a

[6] Nicolet, Science **81**: 181. 1935.

natural synthesis of serine should be based on just the same organic intermediates as the cystine synthesis. It is here merely a case of adding water, instead of sulfide.

Silk proteins contain much more serine than any others. They are also conspicuously richer in alanine than most other proteins, and therefore should offer a richer source of dehydroalanyl derivatives. This is not, I think an accident

I should now like to extend the ideas already advanced to the consideration of the biochemical synthesis of methionine. Only plants can make methionine, for Rose has found it an essential amino acid for animals.

The logical intermediate for its synthesis appears to be methylenepyruvic acid (XI). It is a well known fact that plants have at their disposal for synthetic purposes formaldehyde and pyruvic acid. The condensation of these to form methylenepyruvic acid would be most orthodox. Here again we meet a substance which has never been isolated, presumably on account of its considerable lability.

This is a hindrance to its use by a chemist, but not to its use by a plant. Formaldehyde has been condensed with pyruvic acid by various investigators, and under various conditions. The process has always gone too far, but in such a way as to indicate that methylenepyruvic acid, or possibly hydroxymethylpyruvic acid, which would perhaps serve equally well, has been an intermediate.

$$CH_2O + CH_3COCO_2H \rightleftharpoons \underset{\text{XI}}{CH_2{=}CHCOCO_2H} \rightleftharpoons$$

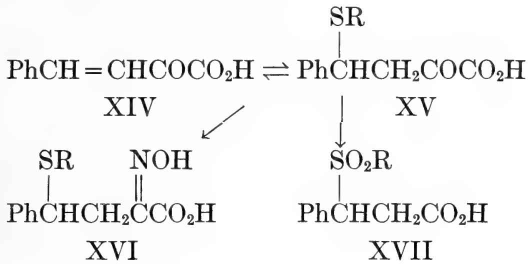
$$\underset{\text{XII}}{\overset{\displaystyle SH}{\overset{|}{C}}H_2CH_2COCO_2H} \rightarrow \underset{\text{XIII}}{\overset{\displaystyle SCH_3}{\overset{|}{C}}H_2CH_2COCO_2H} \rightarrow \overset{\displaystyle SCH_3}{\overset{|}{C}}H_2CH_2\overset{\displaystyle NH_2}{\overset{|}{C}}HCO_2H$$

Whether the addition reaction involves methylmercaptan, or hydrogen sulfide with subsequent methylation, is not at present considered. Plants, in contrast to animals, have a conspicuous capacity for such methylations.

Since the desired substance was not available, recourse was had to another model experiment. Benzalpyruvic acid (XIV) was found to add mercaptans[7] with the greatest ease, under the simplest conditions possible. With no added catalyst whatever, fairly quantitative addition was obtained in five minutes at 100°. It is considered that this is an obviously adequate rate of reaction to justify this stage of the

[7] Nicolet, J. Am. Chem. Soc. 57: 1098. 1935.

synthesis. It was further shown that the products had the structure indicated, since on oxidation they yielded the known β-sulfones of β-phenylpropionic acid (XVII).



This was the only really doubtful reaction in the series postulated. Methylenepyruvic acid is an entirely reasonable product of plant metabolism, and after the addition of the sulfur in whatever form, there results an α-keto acid such as, according to Knoop, should be readily converted to a methionine derivative by standard biological routines.

The addition products (XV) of benzalpyruvic acid have been made with benzyl and p-tolyl mercaptans, and with thioacetic acid, and identified as their oximes (XVI). Addition of hydrogen sulfide also occurs readily, but no serious attempts have yet been made to isolate the product.

You are asked to consider the hypothetical methionine synthesis thus briefly presented, not as a phantasy that begins and ends nowhere, but as a definite and coherent outgrowth of the more definite results already reported for cystine. It is at least possible that plants actually do make methionine in some such way.

I now wish to change the subject again, and return to cystine. There remain to be discussed the questions as to why cystine is not freely synthesized by animals, and how it may be so synthesized.

Clearly, if we accept the picture offered a few minutes ago, it becomes necessary to assume that the whole organic skeleton from which cystine is produced, exists regularly, and quite as a matter of routine, in animals as well as in plants. In plants, a ready synthesis of cystine results. In animals, the synthesis takes place, *if at all*, to a very insufficient extent, unless there is fed either methionine or homocystine. And yet, serine is not an essential amino acid. If the theory is even roughly correct, the difference is simply that the animal body lacks a suitable source of sulfur. The simplest possible source would be sulfide or disulfide ion—the time has not come to discuss whether cystine or cysteine is first formed. But sulfides are definitely toxic to animals, and the animal body has developed rather efficient mechanisms for preventing their accumulation in any considerable concentration.

Naturally, one cannot feed inorganic sulfides and expect them to arrive at the site of synthesis, and with the animal normal. But there might be some other method by which the necessary sulfur could be supplied.

As already pointed out, we know two substances which are, up to the present, unique in being able to supply cystine deficiencies. We do not actually *know* that methionine and homocystine replace cystine by *causing cystine formation*, but this is certainly much the simplest assumption. The fact that homocystine is as effective as methionine encourages the idea that it is an intermediate in the metabolism of methionine. The further stages in the degradation of homocystine must be somewhat hypothetical. But Knoop's well known oxidative deamination would lead to the α-keto acid. This, according to the principles already discussed in detail, should yield (see, for instance, XII→XI) reversibly hydrogen disulfide and methylenepyruvic acid.

It must be recalled that this oxidative deamination should take place at just the time and place (perhaps the liver) at which the dehydrogenation of the alanyl peptides is going on, to produce the intermediates necessary for cystine formation. And here it is assumed that the cystine formation occurs.

A purely inorganic deficiency would thus have been overcome through the addition of a rather complex organic compound. The thesis at this moment is essentially this: that methionine or homocystine can cause the animal body to produce cystine, but without contributing anything whatever to the organic skeleton of the resulting cystine.

Dr. Brand,[8] who has also interested himself in this problem, has made certain suggestions, some of which he has tested by feeding experiments. None of the tested compounds have as yet produced cystine when fed. The most ingenious of his suggestions, to my mind, is that the intermediate between homocystine and cystine might be a mixed sulfide, $HO_2CCH(NH_2)CH_2CH_2SCH_2CH(NH_2)CO_2H$ (XVIII). This substance has not yet been synthesized for feeding experiments, but I shall ask you to note two things about it. It is possible for it to break down according to a mechanism essentially like that already suggested, to produce cystine; and in that case the

[8] Brand, Block, Kassell, and Cahill, Proc. Soc. Exp. Biol. and Med., **35**: 501. 1936.

latter would again have been formed without the contribution of any carbon atoms from the homocysteine portion. Furthermore, the only important change required in the reactions already outlined would be one of order. The sulfur of homocysteine would merely have to become a part of the molecule which was to yield cystine, *before* the degradation of the homocysteine, instead of after it.

Unfortunately, I cannot at present offer you any further evidence as to the course of these reactions. The work has not been completed, and you must share the responsibility for having made me discuss it at this stage. The current plan is to label the homocystine chain by the synthesis of γ-methyl or γ-phenylhomocystine. If one of these, when fed, should show the power to make good cystine deficiencies in a diet, it would be rather clear that its carbon skeleton was not being used for the synthesis.

Dr. du Vigneaud has imagined a mechanism by which three carbon atoms of the chain in homocystine would be retained in the cystine produced. We are in most friendly disagreement, to the extent that I consider his mechanism for this particular reaction as possible rather than probable. He would perhaps make a similar statement about mine.

He is now engaged in a subtler attack on this problem, which involves labeling the homocystine or methionine to be fed, not with methyl or phenyl groups, but with strategically located atoms of deuterium. Neither of us would really ask for anything better than to have the question definitely settled, by whatever process, and with whatever result.

Exactly how this information, when obtained, may be applied to the economic supplementing of deficient diets, is by no means clear. On the other hand, such a possibility exists, and there is also the chance of developing new tools for the study of metabolism.

With the background which I have laid, I should like to shift the field of discussion once more. Dr. Csonka[9] has somewhat recently made a very interesting generalization with regard to the behavior of the various amino acids occurring in proteins, when fed to animals which have been treated with phloridzin. He suggests the rule that those amino acids which are freely produced by animals, cause sugar formation under these conditions. On the other hand, "essential" amino acids, which animals are apparently unable to synthesize, or to synthesize in adequate amount, should not cause sugar formation.

[9] Csonka (unpublished); presented at Am. Soc. Biol. Chem., Washington, April 1936.

Rather generally, the results of experiment fit the prescribed pattern. But cystine and methionine blur the picture somewhat. Both produce sugar. Now methionine is rather definitely, by present data, essential. Cystine I have already spoken of as "nearly essential," for reasons I have given, though Dr. Csonka prefers to call it non-essential, for reasons with which I cannot very fully agree.

The logic behind this generalization of Dr. Csonka's is, it seems to me, this. If a given amino acid, in the course of its biological breakdown, produces any essential substance in the chain of reactions by which the body normally breaks down and builds up sugars, it will, in phloridzinized animals, cause sugar production.

If one assumes, not unreasonably (although the logical necessity is not entirely complete), that most or all of these reactions are biologically reversible, then the odds are very good that, if a given amino acid produces sugar under these circumstances, the normal metabolism of sugar will produce also the organic intermediates required to allow the body to produce the amino acid in question. Stated thus, the principle has a simple basis, and we should expect it to be moderately general, as indeed it appears to be.

But there is no reason at all why it should be *completely* general. To my notion, one might well *expect* a limited number of exceptions. These would become, not arguments against the generalization, but simply challenges to explain why the observed variation exists.

Our earlier discussion of mechanisms of formation of cystine and methionine has already made clear a possible explanation of these two exceptions—the sulfur fragment required for synthesis. In the case of methionine there is an additional point involved, but there is not time to discuss it here. I think I should personally have had definite cause to worry, if these two acids, specifically, had *not* been sugar formers.

These exceptions, if we assume them to be thus explained or an occasional additional exception, may perhaps add to the value of Dr. Csonka's rule as much as they detract from it. While the rule will have to be used somewhat tentatively in deciding whether a given amino acid is or is not "essential," the exceptions themselves may occasionally help to decide among various mechanisms assumed for the synthesis, by animals, of various amino acids.

If you now have the impression that I have discussed the problems of cystine sulfur exhaustingly, you may be right. But if you think I have considered them exhaustively, you are altogether wrong. There is, just for instance, the theory of Schöberl, buttressed by a certain number of facts, and based almost entirely on "model" experiments. I shall later have arguments about that with some of you—but not tonight.

Of those of you who have followed me thus far, I am sure that many will agree with me that biochemistry by analogy may be a most dangerous adventure. Certainly, any conclusions reached by such a process should be most carefully controlled by more direct experiments, as soon as these become possible.

But I can at least hope to have some of you agree that processes of the type outlined possess a considerable fascination, which is perhaps not merely that of their danger, and that they may at the very least be profitable for their power to suggest theories which must later be tested more rigorously.

PALEONTOLOGY.—*Oligocene faunas from the lower and upper beds on the A. L. Parrish farm, Washington County, Florida.*[1] W. C. MANSFIELD, U. S. Geological Survey.

The locality from which the fossil material, on which this paper is based, was obtained is in a small ravine, the stream in which disappears in the bottom of a sink, back of the house on the A. L. Parrish farm, about 3½ miles southeast of Wausau, Washington County, Florida. The first reference to this locality is given by Mossom (1). He reports twenty feet of cream-white soft limestone in a sink at this locality. He states that the contained fossils indicate, based on a letter of Miss Julia Gardner, that it is older than the Chipola marl and probably belongs to the Tampa. An analysis of the limestone as reported by Mossom, which probably is from the lower part of the exposure, showed a percentage of 94.7 of calcium carbonate. The limestones were not differentiated.

The second reference is by Cooke and Mossom (2). They state that the lower part of the limestone is white, finely granular, apparently pure, and contains few fossils; the upper part is more argillaceous and carries an abundant fauna, which appears to be of Tampa age.

The third reference is by Dr. T. W. Vaughan (3a). Doctor Vaughan states:

"The third collection, sink on A. L. Parrish farm, 3½ miles southeast of Wausau, Washington County, Florida, contains poorly-preserved specimens, but I think a definite opinion as to the geologic age is justified. One specimen undoubtedly represents the same species as Cushman's *L. chattahoocheensis*

[1] Received January 24, 1938.

and another is clearly the one which I have been calling *L. gigas* var. Other specimens seem to represent the same species as the smaller, thin, flattish or saddle-shaped megalospheric specimens found near Duncan Church. Therefore, I have no hesitancy in expressing the opinion that this material is also Glendon, middle Oligocene age."

It is not stated from which bed the foraminifera were collected, but evidently they came from the lower bed.

The fourth reference is by Mansfield (4). In referring to this locality Mansfield writes:

"The limestone is separable into two beds, the lower of which is believed to be of the same age as that of the limestone exposed at Duncan Church." In reference to the fauna of the upper bed the writer states "this fauna has not been studied sufficiently to determine definitely its relation to the Tampa fauna."

The first lot of fossils collected from the A. L. Parrish farm was obtained by F. G. Clapp in 1920 (U.S.G.S. No. 8854–5–6). Although his station numbers record different levels in a "40-foot outcrop," all the fossils appear to have been taken from the upper fossiliferous bed; the second lot by Dr. C. W. Cooke and Dr. Julia A. Gardner in 1921 (U.S.G.S. No. 10461); and a third lot by the author and G. M. Ponton, 1932, and F. Stearns MacNeil, 1936, and C. W. Mumm, 1937 (U.S.G.S. No. 12723).

An examination by the writer of the section at this place revealed the existence of two beds. The lower bed consists of a soft, nearly white limestone composed almost entirely of large foraminifera but without any observed mollusks. About 8 feet of this bed is exposed in the lowest part of the sink at the place where a small stream disappears. The upper or overlying bed, which may be as much as 25 feet thick here, consists of a limestone containing many mollusks preserved as molds. As there has been much slumping of the strata surrounding the sink, it is difficult to determine with exactness the original position of the upper fossiliferous bed, but it appears to be near the top of the section here. No unconformity was observed between the two beds, the separation being based on the differences in the lithologies and the faunas.

The photographs used for illustrations were made by Nelson W. Shupe, and the prints were retouched by Frances Wieser, both of the U. S. Geological Survey.

Comparison of species from the A. L. Parrish farm with species in outside formations:

MOLLUSKS (upper bed)

SPECIES FROM A. L. PARRISH FARM	SPECIES IN OUTSIDE FORMATIONS
Terebra sp.	Not determined
Conus, ? aff. *C. cookei* Dall	*Conus cookei*, Flint River formation, upper Oligocene
Conus aff. *C. imitator* Brown and Pilsbry	*Conus imitator* Brown and Pilsbry, Baitoa formation, Dominican Republic, and Gatun formation, Canal Zone.
"*Drillia*" sp.	Not determined.
**Olivella* aff. *O. mississippiensis* Conrad	*O. mississippiensis*, Oligocene
**Mitra* sp.	Cf. undescribed species from the Flint River formation, upper Oligocene.
**Phos parrishi*, n. sp.	Not determined
**Cassis* sp.	Probably near an undescribed form from the Flint River formation.
Ficus aff. *F. mississippiensis* Conrad	*F. mississippiensis*, Oligocene
Strombus aff. *S. liocyclus* Dall.	*S. liocyclus*, Tampa limestone
**Clava parrishi*, n. sp.	Not found elsewhere
†*Turritella gatunensis* Conrad	Vamos-a-Vamos bed and lower bed of Gatun formation; also Chickasawhay
Xenophora sp.	Not determined
Ampullina? sp.	Not determined
**Anadara macneili*, n. sp.	*A. dodona* Dall, Oak Grove sand
**Anadara mummi*, n. sp.	*A. santarosana* Dall, Oak Grove sand; Chickasawhay
Thracia?	Not determined
Crassatellites sp.	Not determined
Venericardia sp.	Not determined
Phacoides (*Miltha*) cf. *chipolana* Dall	*P. chipolana*, Chipola formation and Oak Grove sand
Divaricella sp.	May be the same as undetermined species from upper bed at Falling Water
†*Cardium* aff. *C. hernandoense* Mansfield	*C. hernandoense*. Suwannee limestone; also probably Chickasawhay
**Chione* cf. *C. spenceri* Cooke	Tampa limestone at Cherokee sink and upper bed at Falling Water
Semele aff. *S. smithii* Dall	*Semele smithii*, Chipola formation
Psamosolen aff. *P. sancti-dominica* Maury	*P. sancti-dominica*. Bowden marl. Jamaica; Cercada and Gurabo formation, Dominican Republic
Spisula? sp.	Not determined
Panope cf. *P. parawhitfieldi* Gardner	*P. parawhitfieldi*, Oak Grove sand, Florida

* Rather abundant. † Very abundant.

SPECIES FROM A. L. PARRISH FARM	SPECIES IN OUTSIDE FORMATIONS
Teredo? *incrassata* Gabb	Suwannee limestone, Oligocene; Chickasawhay; Cercado formation, Dominican Republic, Miocene

The following notes on the Foraminifera from the upper and lower beds are by Lloyd G. Henbest of the U. S. Geological Survey:

Two collections of limestone from an outcrop in a sink on the A. L. Parrish farm, 3½ miles southeast of Wausau, Washington County, Fla., were recently submitted to me by W. C. Mansfield for age determination. These two collections represent two horizons. The lower one (U.S.G.S. 13857) is a very soft, porous, friable limestone containing an abundance of Orbitoididae and nullipores. The collection from the upper horizon (U.S.G.S. 12723) consisted of about 25 small pieces of well-indurated matrix that originally surrounded shells of Mollusca.

Lower bed.—Collection 13857, from the lower bed, contains *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman, *L.* (*Eulepidina*) *undosa* Cushman, *L.* (*Eulepidina*) *favosa*? Cushman. The search has not been exhaustive, and other species may be present.

This fauna is identical with that described by W. Storrs Cole (3). On p. 21 Cole states that a collection from a sink on the A. L. Parrish farm, 3½ miles southeast of Wausau (same locality as 13857) was also a subject of study and definitely implies that it contains the same orbitoidal fauna as that from the Duncan Church locality. Although Cole does not state whether his collection was derived from the upper or lower parts of the section, the detailed similarity of the orbitoidal fauna in our collections from the same locality indicates that his collection also came from the lower bed.

Cole, quoting opinions by Vaughan (3, pp. 21, 22) concludes that the Duncan Church orbitoidal fauna definitely represents Oligocene age and strongly indicates the middle Oligocene. From my own brief study of this collection I find no evidence for contradicting or materially adding to that already presented by Cole; accordingly, there is no need to review his argument here.

Upper bed.—I find in this material (collection 12723) numerous scraps of echinoderm plates and a few small nullipore colonies. Miliolids (including *Quinqueloculina*, etc.), *Amphistegina*?, *Archaias*??, and a few other forms recognizable only as foraminifers were intersected by the sections. In these exposures their specific and in some instances even their generic identity is not definitely determinable. A peculiar, uniserial peneroplid was encountered whose generic position is uncertain and may represent a new genus. The foregoing list of forms merely suggests Cenozoic age and nothing closer. Of more significance, however, are a few more or less worn fragments of a minute species of *Lepidocyclina*. Fewer unworn or incompletely exposed but subgenerically unidentifiable specimens were found. Two isolated proloculi of *Lepidocyclina* (*Nephrolepedina*) and two specimens of a minute species very closely related to *Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* were found. The two specimens of *L.* (*L.*) *yurnagunensis* differ from those described by Cole from the Duncan Church locality by being more nephrolepidine. Their slightly smaller size may be accounted for as merely individual variation. Another poorly preserved specimen in equatorial section resembles *L. supera*, but a definite identification cannot be made without better sections.

If these lepidocyclines from the upper bed are indigenous and *not erratics derived from the lower bed*, the age is also Oligocene. A closer age determination should not be attempted at the present time on this fragmentary evidence. The other Foraminifera cannot be regarded as supporting or contradicting this evidence, because in their unrecognizable condition they merely indicate Cenozoic age and nothing more exact.

It is probably significant in this connection that though various genera of Foraminifera, including a peneroplid, are present, the faunule does not include any of the highly specialized Peneroplidae that characterize the Tampa and Chipola Miocene in the same general region.

FAUNAS OF THE LOWER AND UPPER BEDS

Lower bed.—So far only specimens of Foraminifera have been collected from the lower bed. Relying on the determinations of these Foraminifera by Cole, Vaughan and Henbest, the age evidently is middle Oligocene.

Upper bed.—Although the sculpture of the external molds of the mollusks has been well preserved, impressions taken of these molds reveal in most cases only parts of the original shell and for that reason the relationships to better preserved specimens from outside localities are difficult to determine.

The molluscan fauna is interesting because a number of forms show a relationship either to the lower part of the Gatun formation or to the Vamos-a-Vamos beds of the Canal Zone and to certain faunas of the West Indies, thereby probably indicating a migration of the faunas either northward or southward, during this or a closely related geological epoch.

The age of the fauna is believed to be not later in time than that of the Tampa limestone, lower Miocene, or earlier than that of the upper part of the Flint River formation (upper Oligocene). However, the evidence, so far deduced, for placing it in the upper Oligocene is stronger than placing it in lower Miocene, Tampa limestone.

The absence of certain genera of mollusks as *Pecten* and others make the correlation with other deposits that contain these genera more difficult. The possibility of procuring some of these lacking genera and better preserved specimens in the future would aid in determining more precisely the age of the bed.

The molluscan forms that indicate an Oligocene age are: *Conus*,? aff. *cookei; Olivella* aff. *mississippiensis; Cassis* sp.; *Anadara macneili* (an intermediate form between *A. lesueuri* (Dall), an Oligocene species, and *A. dodona* Dall from the Oak Grove sand, but nearer the former); *Cardium hernandoense* Mansfield, Suwannee limestone, upper Oligocene; *Teredo*? *incrassata* Gabb, and perhaps others.

It is the purpose to discuss the Chickasawhay marl of Mississippi and Alabama in this paper only in so far as to indicate the probable relationship of the fauna under discussion with it.

So far as can be observed, the faunas in the upper bed at the A. L. Parrish farm and that of the Chickasawhay are largely contemporaneous. The same *Turritella, Arca, Cardium, Chione* and *Teredo* appear to occur in both.

Two forms that might suggest Tampa age are: *Strombus* aff. *liocyclus* Dall, and *Chione* cf. *spenceri* Cooke.

The nearest locality to the A. L. Parrish farm at which the Tampa limestone fauna occurs is in bed No. 2 at Falling Water, Washington County, a distance of 9 or 10 miles to the north. At Falling Water only one small specimen of a *Chione* similar to that at the A. L. Parrish farm has been collected; this form is rather abundant at the A. L. Parrish farm. *Chlamys crocus* Cooke, a characteristic Tampa limestone species, occurs at Falling Water. The sediments at Falling Water consist mainly of a coarse grained quartz sand, whereas the material of the upper bed at the A. L. Parrish farm consists of a limestone.

Two forms, *Phacoides* cf. *chipolana* Dall and *Panope* cf. *parawhitfieldi* Gardner, suggest a relationship to the Chipola marl or to the Oak Grove sand. The nearest locality to the A. L. Parrish farm at which Chipola fossils have been collected is in the bed of Econfina River, Bryant Scott's farm, Bay County, sec. 28, T. 2 N., R. 12 W., about 7 miles southeast. This fauna has been placed at the top of the Chipola marl by Dr. Julia A. Gardner (5). This fauna, however, is unlike that at the A. L. Parrish farm.

The fauna of the Baitoa formation, Dominican Republic, contains some forms allied to those at the A. L. Parrish farm. A small cone from the A. L. Parrish farm is similar to *Conus imitator* Brown and Pilsbry (from Baitoa formation) and *Clava parrishi* n. sp. from A. L. Parrish farm is also closely related to an unnamed species from the Baitoa formation.

The *Turritella*, which I have identified as *T. gatunensis* Conrad, is the most abundant species at the A. L. Parrish farm. *T. gatunensis* occurs both in the Vamos-a-Vamos beds (dark-colored beds) and the lower part of the Gatun formation of the Panama Canal zone. Woodring (6) places the Vamos-a-Vamos beds in the lower part of the middle Miocene. The Vamos-a-Vamos beds probably are stratigraphically lower than middle Miocene.

Concerning the fragmental and poorly preserved specimens of foraminifera from the upper bed as determined by L. G. Henbest in this paper, he states "if the *lepidocyclines* found in this bed are indigenous *and not erratics derived from the lower bed*, the age is Oligocene."

A tentative conclusion deduced from a study of the faunas of the upper bed, would indicate that it is Oligocene, and the bed enclosing the faunas is contemporaneous, in part at least, with the Chickasawhay marl of Mississippi and Alabama, the Flint River formation of Georgia, the Suwannee limestone of Florida and the Vamos-a-Vamos beds of the Canal Zone.

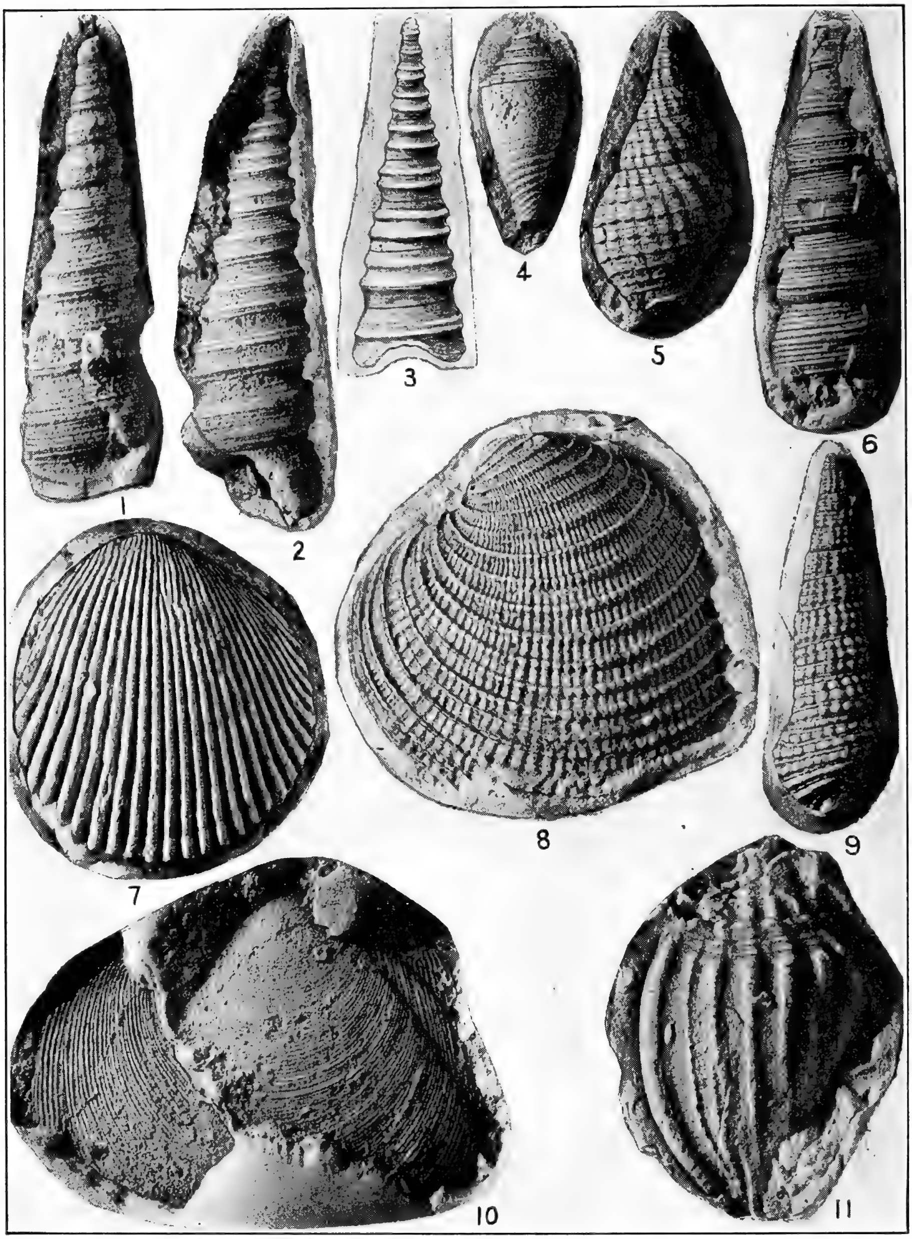
SPECIES OF MOLLUSKS FROM THE UPPER BED

Terebra sp.

One external mold; species not determined.
Occurrence: A. L. Parrish farm.

Conus sp.? aff. *C. cookei* Dall

One rather large external mold showing part of last whorl. The sculpture consists of rather wide spiral bands separated by narrow impressed lines. The nature of the sculpture suggests a relationship to *Conus cookei* Dall from the Flint River formation (upper Oligocene) of Georgia but this relationship cannot be fully confirmed with the material at hand.
Occurrence: A. L. Parrish farm.



Figs. 1, 2, 3, 6.—*Turritella gatunensis* Conrad. Squeezes: 1, ×4; 2, ×3; 3, ×5; 6, ×2. U. S. Nat. Mus. No. 497647. Fig. 4.—*Conus* aff. *C. imitator* Brown and Pilsbry. Squeeze, ×3. U. S. Nat. Mus. No. 497643. Fig. 5.—*Phos parrishi* Mansfield. Squeeze of holotype, ×3. Fig. 7.—*Cardium* (*Trachycardium*) aff. *C. hernandoense* Mansfield. Squeeze, ×2. U. S. Nat. Mus. No. 497653. Fig. 8.—*Chione* cf. *C. spenceri* Cooke. Squeeze, ×3. U. S. Nat. Mus. No. 497654. Fig. 9.—*Clava parrishi* Mansfield. Squeeze of holotype, ×2. Fig. 10.—*Phacoides* (*Miltha*) cf. *P. chipolana* Dall. Squeeze, ×3. U. S. Nat. Mus. No. 497652. Fig. 11.—*Cassis* sp. Squeeze, ×2. U. S. Nat. Mus. No. 497645. (smaller specimen). All enlargements approximate.

Conus aff. *C. imitator* Brown and Pilsbry Fig. 4

Two external molds of small specimens. These specimens have a rather high spire. The whorls are carinate. These specimens closely resemble *Conus imitator* Brown and Pilsbry, a species from the Baitoa formation, Dominican Republic. *C. imitator* also occurs in the Gatun formation of the Canal Zone.

Occurrence: A. L. Parrish farm.

"*Drillia*" sp.

One incomplete external mold, species not determined.

Occurrence: A. L. Parrish farm.

Olivella aff. *O. mississippiensis* Conrad

External molds of a rather large species. These may be related to *Olivella mississippiensis* Conrad, a Vicksburg, Oligocene species.

Occurrence: A. L. Parrish farm.

Mitra sp.

External molds of large shells of *Mitra*. The sculpture of the undetermined species consists of rather widely spaced alternating stronger and weaker spirals over the whole shell. It appears to be closely related to an undescribed species from the Flint River formation of Georgia.

Occurrence: A. L. Parrish farm.

Phos parrishi Mansfield, n. sp. Fig. 5

Shell of moderate size with an acute spire and rather large body whorl, both spirally and axially sculptured, the axials being more strongly developed on the spire than on last whorl. Sculpture of penultimate whorl consists of 4 primary spirals interposed by a single secondary thread. Two secondary threads lie below the suture. Axials stronger than spirals and are weakly nodulated by the overrunning primary spirals.

Holotype (U.S.Nat.Mus. No. 497644) measures: Length about 15 mm; diameter, about 8 mm.

Type locality: A. L. Parrish farm, Washington County, Florida.

Cassis sp. Fig. 11

Internal molds of rather large shells and incomplete external molds of smaller shells are in hand. These larger and smaller specimens, however, may not represent the same species. The smaller external molds have rather strong axials on the body whorl and in this respect indicate some relationship to *Cassis sulcifera* Sowerby but the ribs are stronger than on this species and the spire is higher. The undetermined specimens probably are more closely related to a rather high-spired form in the Flint River formation of Georgia wrongly identified by Dall as *C. sulcifera*, but the material in hand does not warrant at present uniting the two forms under the same species.

Occurrence: A. L. Parrish farm.

Ficus sp. aff. *F. mississippiensis* Conrad

Incomplete external and internal molds showing a medium sized form of the original shell. With the material in hand it is difficult to determine whether the unidentified form is closer to *Ficus mississippiensis* Conrad, a Vicksburg, Oligocene species, or to a larger form from the Chipola marl. The secondary spirals appear to be closer to the Chipola species. However, it may be more closely related to the Vicksburg species. It is larger than most of the specimens from the Oligocene and nearly as large as the Chipola specimens.

Occurrence: A. L. Parrish farm.

Strombus aff. *S. liocyclus* Dall

The material consists of incomplete external molds. The body whorl is without tubercles. Sculpture on the spire consists of broad ribs and spirals situated below the suture. The unnamed species appears to be closely related to *Strombus liocyclus* Dall from the Tampa limestone although it may not be that species.

Occurrence: A. L. Parrish farm.

Clava parrishi Mansfield, n. sp. Fig. 9

Shell of medium size, slender; nucleus not preserved. Whorls nearly straight in outline and shallowly constricted by a distinct suture. Sculpture consists of both spirals and axials—the axials being a little weaker than the spirals. The spiral sculpture on the spire whorls consists of three narrow, equally spaced, uniformly sized, nodulous bands and a single intervening thread. A spiral thread, a little stronger than intervening ones, lies adjacent to and behind the suture. Last whorl with 6 nodulous primary spirals, all intercalated with a single secondary thread except the basal two, which have two secondary threads instead of one. Axials, probably about 15 in number, arcuate, weaker than spirals and extend across each whorl.

Holotype (U.S.Nat.Mus. No. 497646) measures about 26 mm (including broken off tip which probably amounts to about 3 mm); diameter, about 8 mm.

Type locality: A. L. Parrish farm, about 3½ miles southeast of Wausau, Washington County, Fla.

Clava parrishi n. sp. is closely related to an unnamed species from the Baitoa formation, lower Miocene, from the Province of Santiago, Dominican Republic, stations 8668 and 8558. The upper spiral on the Baitoa species is a little stronger than the others whereas this spiral on the new species here described is no stronger than the others.

"Cerithium" praecursor Dall, a species in the Tampa limestone, has a stouter shell and more secondary spirals than the new species here described.

Occurrence: Type locality, quite common. Not found elsewhere.

Turritella gatunensis Conrad Figs. 1–3, 6

Specimens of *Turritella* are very abundant at the A. L. Parrish farm. The depression between the two raised spirals on each whorl on these specimens begins on the early part of the shell and continues over the later whorls. The depression on the early whorls appear to characterize the earliest forms referred to *Turritella gatunensis* from later forms which have a medial carina on the 7 or more earliest whorls which is formed by the upper spiral —the lower spiral, which is developed later, gradually strengthens anteriorly.

In examining specimens referred to *T. gatunensis* from G formations of the Canal Zone two varieties are observed. In one variety, which occurs in the Vamos-a-Vamos bed and in lower faunal zone of the Gatun formation, a depression develops on the early whorls whereas in the second variety occurring in the middle faunal zone of the Gatun formation at the Gatun dam (Station 8365 and other stations) the earliest whorls are medially carinated, the anterior spiral coming in later.

The form at the A. L. Parrish farm more closely resembles those from the Vamos-a-Vamos and in lower faunal zone of the Gatun formation.

The Culebra formation of the Panama Canal Zone contains a different species of *Turritella.*

Turritella gatunensis caronensis Mansfield from the Brasso beds of Trinidad perhaps is more closely related to those in the middle faunal zone of the Gatun formation.

Turritella gatunensis blountensis Mansfield from the upper middle Miocene of Florida have weakly carinated early whorls, a shallower suture and lower primary spirals than those in the Gatun formation.

Two external molds showing the early parts of a *Turritella* have been collected at Station 13396, above the mouth of Limestone Creek, near the middle of sec. 25, T. 9 N., R. 7 W., Wayne County, Mississippi, by Roy T. Hazzard. These probably belong to *Turritella gatunensis* Conrad. Specimens from Station 1/52, Gainstown Ferry, Clarke County, Alabama, referred by Cooke (7) to the Chickasawhay marl member of the Byram marl, are the same as those at the A. L. Parrish farm.

Xenophora sp.

External mold of base, species not determined.

Occurrence: A. L. Parrish farm.

Ampullina? sp.

Internal molds, genus not determined.

Occurrence: A. L. Parrish farm.

Anadara macneili Mansfield, n. sp. Figs. 12, 17, 18

Shell small, ovate, moderately high, inequilateral, and probably nearly equivalve. Beaks weakly depressed medially. Left valve narrowly rounded over anterior side, weakly truncate on posterior side and broadly rounded over the middle. Ribs over beak and early part of the shell single and beaded and separated by interspaces about as wide as the ribs. The ribs begin to divide at about the highest part of the shell forming two closely spaced ribs, the sulcation becoming deeper in advancing ventrally. Near the posterior border each bi-partate rib is shallowly sulcated forming four radials. Right valve, so inferred, has similar ribs as left.

Holotype, left valve (U.S. Nat. Mus. No. 497648) measures length about 25 mm; width about 20 mm; height about 8 mm.

The paratype (Fig. 17) shows only the anterior half of the shell. The species is described from squeezes taken from exterior molds.

Type locality: A. L. Parrish farm, 3½ miles southeast of Wausau, Washington County, Fla.

Compared with *A. lesueuri* (Dall), a Vicksburg species, the new species is larger, relatively higher and wider, with a more medially impressed beak.

The general outline of the shell of the new species, and the character of its ribbing agree closely with that of *A. dodona* Dall, an Oak Grove species. It appears, however, to be an intermediate form between the Vicksburg species and the later species.

The species is named after F. Stearns MacNeil of the U. S. Geol. Survey.

Anadara mummi Mansfield, n. sp. Fig. 14

Shell rather small and moderately high with a truncate posterior side. Ribs slightly wider than interspaces, strongly beaded, single over the umbo but divided over the lower half of the shell. The shell is relatively higher and stouter, more truncate on the posterior side than *Anadara macneili*, and the ribs show no indication of breaking up into four parts.

Holotype, left valve (U. S. Nat. Mus. No. 497651) measures: Length, about 20 mm; width, about 20 mm; height, about 9 mm.

Type locality: A. L. Parrish farm, $3\frac{1}{2}$ miles southeast of Wausau, Washington County, Florida.

The new species appears to be related to *A. santarosana* Dall, an Oak Grove species, apparently differing from the latter in having a smaller shell, with the incisions on the ribs earlier developed.

Compared with *Anadara hypomela silicata* Mansfield, a Tampa limestone subspecies, the new species has a shorter shell, a more truncate posterior side and more beaded ribs.

Other occurrence: Specimens collected at Station 13239, NW$\frac{1}{4}$ sec. 17, R. 8 N., T. 5 W., Bucatunna Creek, Wayne County, Mississippi, appear to belong to the same species.

The species is named after C. W. Mumm of the U. S. Geol. Survey.

Thracia? sp.

Fragment showing internal mold. The ribbing suggests that it may belong to the genus *Thracia*.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Crassatellites sp.

One internal mold, species not determined.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Venericardia sp.

External molds of incomplete shells. Species not determined.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Phacoides (*Miltha*) cf. *P. chipolana* Dall Fig. 10

External mold of an incomplete left valve. The fine concentric sculpture indicates that it is either very close to or the same as *Phacoides* (*Miltha*) *chipolana* Dall, a species occurring in the Chipola marl and the Oak Grove sand.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Divaricella sp.

External mold of an incomplete shell. Species not determined. This may be the same undetermined species as occurs in the upper bed at Falling Water.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Cardium (*Trachycardium*) aff. *C. hernandoense* Mansfield Figs. 7, 13

External and internal molds of several specimens, which probably represent a single species. The ribs are rather closely spaced, triangular in outline and without any observed granules. The specimens have more ribs than

Cardium precursor Dall, a species from the Oligocene at Vicksburg, Miss., but show some affinity to it.

Cardium (*Trachycardium*) *hernandoense* Mansfield from the Suwannee limestone, upper Oligocene, appears to be closely related to it.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Other occurrence: External impressions from Station 13396, Hillside above the mouth of Limestone Creek, Wayne County, Miss. (sec. 25, T. 9 N., R. 7 W.) may be closely related to the unnamed species.

Chione cf. *C. spenceri* Cooke Figs. 8, 16

Material consists mainly of a number of external molds. These external molds compare closely with *Chione spenceri* Cooke from Antigua but specific identity with that species is not confirmed.

The molds show a moderately large shell, inflated, about as long as wide, and weakly depressed behind the middle. Sculpture consists of erect, concentric lamellae and rather strong radials. These lamellae are about 2 millimeters apart over the whole shell. These radials undulate the margins of the lamellae and ornament their ventral slopes and extend across the rather wide interspaces.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Other occurrence: Tampa limestone at Cherokee sink, Wakulla County (two small valves); upper bed at Falling Water, Washington County, Fla. (one small valve). Although the specimens from the Tampa limestone are smaller than the specimens from the A. L. Parrish farm, the sculpture on the specimens from the three localities appear to be identical.

The unidentified species differs from *Chione bainbridgensis* Dall, a species occurring in the Flint River formation, upper Oligocene of Georgia, in having (especially over the umbonal area) wider spaced concentric sculpture and stronger radials.

Semele aff. *S. smithii* Dall

The material consists of internal and external molds. The concentric sculpture consists of closely spaced lamellae. The undetermined species appears to be related to *Semele smithii* Dall from the Chipola formation. It has a smaller shell than *Semele chipolana* Dall and the concentric sculpture on it is finer but it may be as closely related to *S. chipolana* as to *S. smithii* Dall.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Psamosolen aff. *P. sancti-dominica* Maury

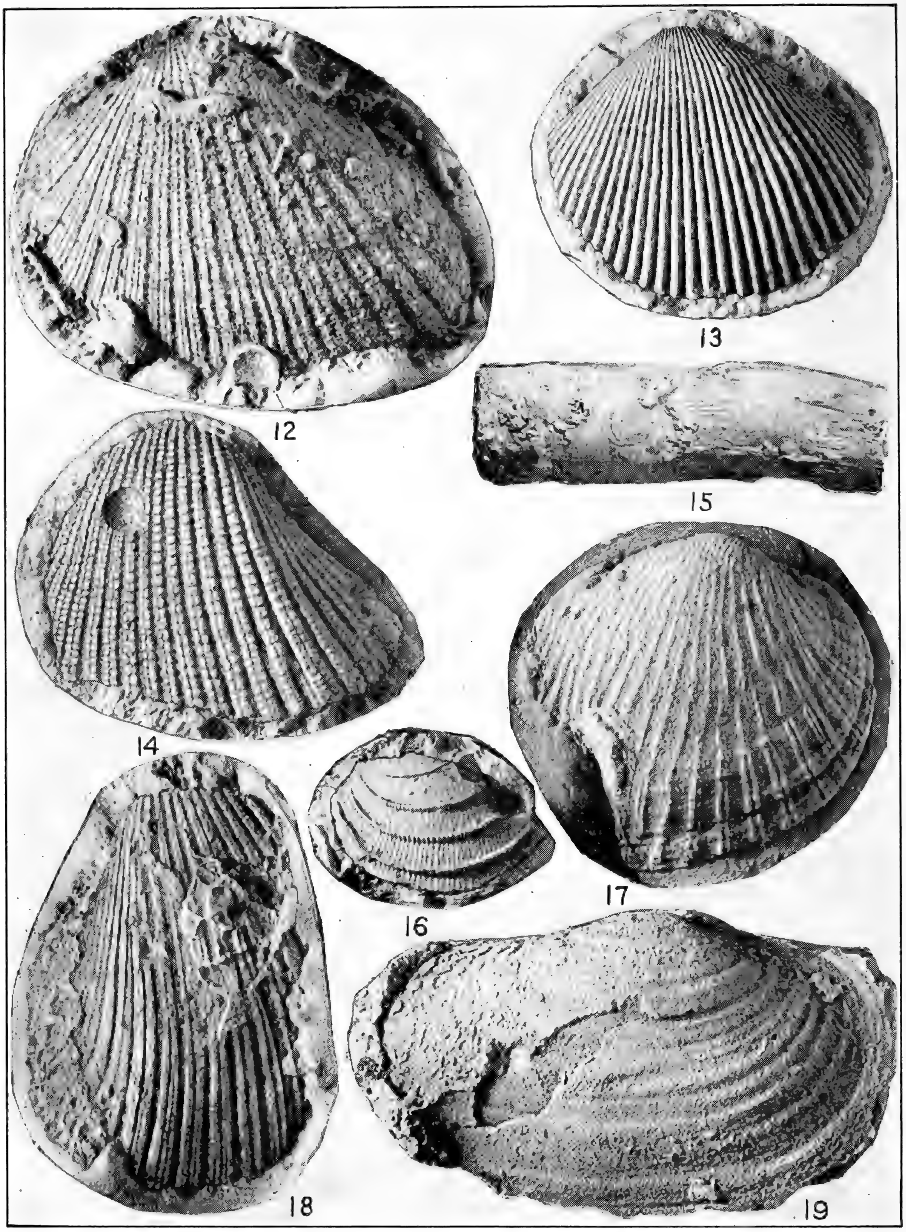
The material consists of an external mold showing about half of the original shell. The exact relationship of this specimen to other species is difficult to determine with the material in hand but it appears to be related to *P. sancti-dominica* Maury, a species reported to occur in the Bowden marl of Jamaica and in the Cercado and Gurabo formations of the Dominican Republic. The genus is widely distributed in the warmer seas.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Spisula? sp.

The material consists of an external mold of part of the original shell. This specimen probably is a *Mactra* or *Spisula*. Not knowing the genus the relationship to other forms cannot at present be determined.

Occurrence: A. L. Parrish farm, Washington County, Florida.



Figs. 12, 17, 18.—*Anadara macneili* Mansfield. 12, squeeze of holotype, ×3; 17, squeeze of paratype, ×3. U. S. Nat. Mus. No. 497650; 18, squeeze of paratype, ×3. U. S. Nat. Mus. No. 497649. Fig. 13.—*Cardium* (*Trachycardium*) aff. *C. hernandoense* Mansfield. Squeeze, ×3. U. S. Nat. Mus. No. 497653. Fig. 14.—*Andara mummi* Mansfield. Squeeze of holotype, ×3. Fig. 15.—*Teredo*? *incrassata* Gabb, ×1. U. S. Nat. Mus. No. 497657. Fig. 16.—*Chione* cf. *C. spenceri* Cooke. Squeeze, ×4. U. S. Nat. Mus. No. 497655. Fig. 19.—*Panope* cf. *P. parawhitfieldi* Gardner, ×2. U. S. Nat. Mus. No. 497656.

Panope cf. *P. parawhitfieldi* Gardner Fig. 19

The material consists of an internal mold of both valves. This specimen measures: Length, about 40 mm; altitude, about 25 mm. The umbo is rather low and is situated about 18 mm from the anterior end. So far as can be determined this specimen most closely resembles *P. parawhitfieldi* Gardner, a species occurring in the Oak Grove sands of Florida; however, an adult specimen of the same species might show differences.

Occurrence: A. L. Parrish farm, Washington County, Florida.

Teredo? *incrassata* Gabb Fig. 15

The material consists of fairly good sized tubes and a few fragments. These tubes occur abundantly in the Suwannee limestone (upper Oligocene) but have not been found in the Tampa limestone (lower Miocene). They occur in the Cercado formation and other horizons in Santo Domingo not definitely placed stratigraphically.

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BOTANY.—*A new species of* Callirhoë.[1] ROBERT F. MARTIN, Bureau of Plant Industry. (Communicated by S. F. BLAKE.)

Nuttalia pedata Nutt. ex Hook. was described in 1827 and transferred by Gray in 1849 when he resurrected the genus *Callirhoë* of Nuttall. Although in later years Gray realized that the original *Nuttallia pedata* was synonymous with *Callirhoë digitata* Nutt., he did not see fit to publish a new name, and *Callirhoë pedata* has continued to be used to designate the common annual poppy mallow of Texas and Oklahoma. That *Nuttallia pedata* is the same plant as *Callirhoë digitata* is shown by the original figure and by a sheet in the Gray Herbarium collected by Hooker in the Glasgow Garden. This sheet is annotated, "An original of *N. pedata.*" Furthermore, according to Carruthers in a letter to Gray, all of Nuttall's specimens of *N. pedata* sent to the British Museum had large perennial roots. It

[1] Received December 29, 1937.

therefore becomes apparent that the annual has never had a valid name and I propose:

Callirhoë leiocarpa Martin, sp. nov.

Callirhoë pedata A. Gray, Mem. Amer. Acad. N. S. **4**: 16 (Pl. Fendl.) 1849, excluding name-bringing synonym; Bost. Jour. Nat. Hist. **6**: 160 (Pl. Lindh.) 1850, p. p.; Pl. Wright. **1**: 15. 1852.

Callirhoë pedata var. *compacta* hort. Damm.; Sprenger, Gartenflora, **35**: 313. 1886.

Not *Nuttallia pedata* Nutt. ex Hook. Exot. Fl. **3**: 172. 1827.

Annua; caules erecti, 30–80 cm alti, glabri et saepe glauci; stipulae ovatae vel ovato-lanceolatae, 5–10 mm longae, lobatae vel auriculatae, ciliatae; folia 3–5-lobata vel incisa, lobis crenatis, supra strigosa; pedunculus 1-florus, glaber vel strigosus; involucellum nullum; sepala lanceolata, acuminata, 10–14 mm longa; petala obcuneata, 15–25 mm longa, 12–18 mm lata, apice erosa, purpureo-rubra, in ungue barbellata; carpella glabra, valde rostrata, in dorso paene laevia.

Annual; stems erect, 30–80 cm high, glabrous and often somewhat glaucous; stipules lance-ovate, 5–10 mm long, lobed or auricled at base, ciliate; petioles of the basal leaves up to 10 cm long, glabrous, strigose, sparingly stellate-pubescent, or rarely pilose, the blades palmately 3–5-lobed or deeply incised, the divisions crenate to coarsely toothed, strigose above, appressed-stellate beneath; stem leaves similar, or usually more deeply incised into narrower divisions, and with shorter petioles; peduncles glabrous, scabrous, or with appressed simple or stellate hairs, one-flowered; involucel wanting; sepals lanceolate, acuminate, 10–14 mm long, glabrous externally, white-hairy along the margin internally, the nerves often white and thickened; petals obcuneate, 15–25 mm long, 12–18 mm wide, erose at apex, purplish-red or cherry, drying bluish, bearded at the base; staminal column hairy; carpels 10–12, about 4 mm high, glabrous, prominently beaked, nearly smooth on the back.—Prairies and hills, chiefly in dry soil, Texas and Oklahoma. April–June.

Type in the herbarium of the National Arboretum, No. 8099, collected by C. D. Marsh, April 4, 1908, near Spofford, Kinney County, Texas.

Specimens Examined (by counties).[2]

Texas. Bexar: *Palmer* 33780 (M, NY). Burnet: *Tharp* 1340 (NA, T, US). Coke: *Swift*, 1856 (US). Comal: *Lindheimer* 681 (G, M, NY, P, US). Concho: *Reverchon* (*Curtiss* 362**) (M, NY). Duval: *Croft* 14 (NY). Gillespie: *Jermy* 608 (M, US). Goliad: *Williams* 65 (P, T). Hays: *Stanfield*: Spring 1889 (NY). Howard: *Tracy* 7813 (G, M, NY, T, US). Irion: *Cory* 565 (G, US). Kerr: *Milligan* April (US). Kinney: *Marsh* April 4, 1908 (NA, type). Lampasas: *Wolff* 925 (US). La Salle: *Small & Wherry* 11951 (NY). Live Oak: *Tharp* June 18, 1928 (T). Llano: *Fisher* 90 (F). Lubbock: *Demaree* 7669 (M, US). Nueces: *Hanson* June 7, 1919 (M, NY). San Patricio: *Hanson* 49-a (US). Schleicher: *Jones* May 1, 1931 (T).

[2] The following symbols are used to indicate the herbaria in which specimens are deposited: F, Field Museum of Natural History; G. Gray Herbarium; M, Missouri Botanical Garden; NA, National Arboretum; NY, New York Botanical Garden; P, Academy of Natural Sciences of Philadelphia; T, University of Texas; US, United States National Museum.

Tom Green: *Palmer* 10320 (M). Travis: *Tharp* May 1, 1928 (NA, T). Uvalde: *Palmer* 10182 (M, US). Valverde: *Orcutt* 6046 (M). Victoria: *Tracy* 9235 (G, M, NY, T, US). Wilson: *E. Palmer* August 1879 (G).

OKLAHOMA. Comanche: *Clemens* 11690 (M). Custer: *White* 31 (M). Kiowa: *Stratton* 327 (M). Woods: *Stevens* 1634 (G, M, NY, US).

In general appearance this species often strongly resembles forms of *C. digitata*, from which it may be distinguished by the smoother carpels and slender annual taproot.

ZOOLOGY.—*North American monogenetic trematodes. II. The families Monocotylidae, Microbothriidae, Acanthocotylidae and Udonellidae (Capsaloidea).*[1] EMMETT W. PRICE, U. S. Bureau of Animal Industry.

This paper represents the second of a series on the North American monogenetic trematodes and deals with the superfamily Capsaloidea exclusive of the Capsalidae. The organization and purpose of this paper are the same as for the first of the series (Price, 1937). With few exceptions, the species considered in this installment are those previously described by the late Dr. G. A. MacCallum.

Superfamily CAPSALOIDEA Price, 1936

Diagnosis.—Anterior haptors present or absent; when present in form of a weakly developed oral sucker or pseudosucker, or of 2 laterally placed suckers, or of corresponding glandular grooves; head organs sometimes present. Posterior haptor disc-like, usually relatively large and muscular, ventral surface frequently divided by septa into sucker-like depressions, with or without hooks; hooks, when present, never with cuticular supporting bars. Intestine single or consisting of 2 branches frequently provided with median and lateral dendritic diverticula. Genital aperture median or lateral. Cirrus sometimes cuticular, without cuticular accessory structures except in *Anoplodiscus* (Microbothriidae). One or more testes. Vagina present or absent. Oviparous.

Type family.—Capsalidae Baird, 1853.

KEY TO FAMILIES CAPSALOIDEA

1. Anterior haptors in form of a pair of suckers or corresponding glandular depressions 2
   Anterior haptors not in form of a pair of suckers or corresponding glandular depressions 4
2. Intestine single .... UDONELLIDAE Taschenberg
   Intestine double 3
3. Male and female genital apertures close together .. CAPSALIDAE Johnston
   Male and female genital apertures not close together .... ACANTHOCOTYLIDAE Price
4. Posterior haptor provided with hooks .... MONOCOTYLIDAE Taschenberg
   Posterior haptor not provided with hooks ..... MICROBOTHRIIDAE Price

[1] Received January 7, 1938.

Family MONOCOTYLIDAE Taschenberg, 1879

Diagnosis.—Body elliptical or oval, flattened dorsoventrally. Anterior haptor present or absent; when present, in form of an oral sucker or several preoral suckers; cephalic glands present. Posterior haptor disc-like, with ventral surface usually divided by septa into depressed sucker-like areas, and armed with 1 pair of large hooks (absent in *Empruthotrema*) and 14 marginal hooklets. Oral aperture ventral, near anterior end of body; pharynx relatively large; esophagus very short or absent; intestinal branches without diverticula, sometimes united posteriorly. Eyes present or absent. Genital aperture usually median; cirrus heavily cuticularized, except in *Dionchus*. Usually 1 testis, rarely 3 testes or numerous testes. Ovary curved, frequently embracing right intestinal branch. Vagina single or paired, rarely absent.

Type genus.—*Monocotyle* Taschenberg, 1878.

KEY TO SUBFAMILIES OF MONOCOTYLIDAE

1. Posterior haptor without septa . . . . LOIMOINAE Price
   Posterior haptor with septa 2
2. Vagina absent . . . . DIONCHINAE Johnston and Tiegs
   Vagina present 3
3. Vagina single . . . . MONOCOTYLINAE Gamble
   Vagina double 4
4. With oral sucker . . . . CALICOTYLINAE Monticelli
   Without oral sucker . . . . MERIZOCOTYLINAE Johnston and Tiegs

Subfamily MONOCOTYLINAE Gamble, 1896

Diagnosis.—Anterior haptor in form of a weakly developed oral sucker; posterior haptor with central area bounded by a ridge with 7 or 8 septa radiating from it, and armed with 1 pair of large hooks and 14 marginal hooklets. Eyes present or absent. Vagina probably always present, single.

Type genus.—*Monocotyle* Taschenberg, 1878.

KEY TO GENERA OF MONOCOTYLINAE

1. Ventral surface of haptor with 7 radial septa . . . . . . *Dasybatotrema* Price
   Ventral surface of haptor with 8 radial septa 2
2. Three testes . . . . *Tritestis* Price
   One testis 3
3. Oral aperture surrounded by a somewhat membranous pseudosucker . . . . *Monocotyle* Taschenberg
   Oral aperture surrounded by poorly developed sucker . . . . *Heterocotyle* Scott

Genus MONOCOTYLE Taschenberg, 1878

Diagnosis.—Ventral surface of haptor divided by septa into 8 equal sectors, with 1 pair of large hooks; marginal hooklets (?). Oral aperture almost terminal, surrounded by a somewhat membranous pseudosucker. Eyes absent. One testis. Uterine aperture marginal. Cirrus and vagina (?).

Type species.—*Monocotyle myliobatis* Taschenberg, 1878.

The genus *Monocotyle* contains only the type species, *M. myliobatis*, which was described by Taschenberg (1878) from the gills of *Myliobatis aquila* at Naples; the original description was very brief. Perugia and Parona

(1890) gave a fairly detailed description of a species from *M. aquila* which they regarded as the same as Taschenberg's species, and if their observations are correct, this form differs from all other members of the subfamily in having a laterally placed uterine aperture. The anterior pseudosucker-like haptor appears to resemble closely that of *Dasybatotrema* Price.

Genus HETEROCOTYLE Scott, 1904

Synonyms.—*Monocotyle* Auct.; *Trionchus* MacCallum, 1916; *Monocotyloides* Johnston, 1934.

Diagnosis.—Ventral surface of haptor with central depression surrounded by a ridge from which radiate 8 septa; one pair of large hooks and 14 marginal hooklets present. Oral aperture subterminal, surrounded by poorly developed oral sucker. Eyes present or absent. One testis; cirrus slender, cuticularized. Vagina probably always present.

Types species.—*Heterocotyle pastinacae* Scott, 1904.

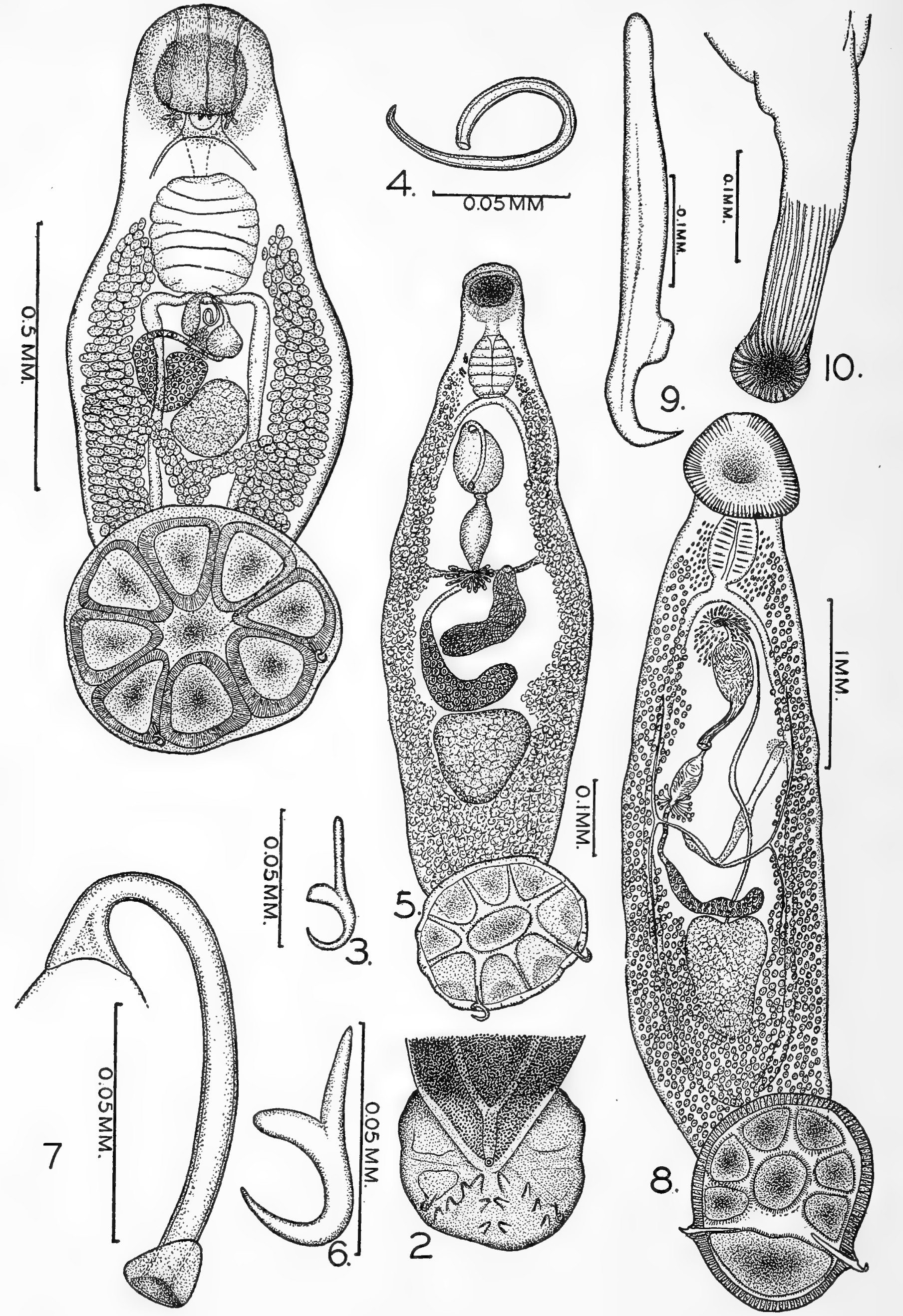
This genus contains the following species: *Heterocotyle floridana* (Pratt, 1910) n. comb.; *H. minima* (MacCallum, 1916) n. comb.; *H. pastinacae* Scott, 1904; and *H. robusta* (Johnston and Tiegs, 1922) n. comb. The first two of these species are from North America and descriptions of them follow.

Heterocotyle floridana (Pratt, 1910), n. comb. Figs. 1–4

Synonym.—*Monocotyle floridana* Pratt, 1910.

Description.—Body more or less elliptical, 1.36 mm long by 500μ wide, flattened dorsoventrally; anterior end with narrow projecting dorsal lip. Oral sucker moderately developed, without definite boundaries, and with 3 cephalic glands imbedded in dorsal wall, the ducts of glands slender and opening at anterior margin of dorsal lip. Haptor disc-like, 480μ wide, surrounded by marginal membrane about 20μ wide; dorsal surface with 2 groups of conical papilla arranged in form of 2 triangles near posterior margin; ventral surface with irregular central area and 8 marginal sucker-like areas, and armed with 2 large hooks and a number (?14) of marginal hooklets. Large hooks about 50μ long, disregarding curve of blade; marginal hooklets about 12μ long, situated on marginal membrane. Oral aperture ventral, 160μ wide, leading into a funnel-shaped prepharynx; pharynx barrel-shaped, 240μ long by 200μ wide; intestinal branches simple, without median or lateral diverticula, uniting near posterior end of body and forming a short common cecum (Pratt stated that this cecum sometimes opens to the exterior through a median, thicklipped pore). Brain dorsal to prepharynx; no eyes. Genital aperture apparently median, ventral, at posterior end of pharynx. Cirrus heavily cuticularized, slender, curved; ejaculatory bulb curved, to right of cirrus. Testis median, about 160μ in diameter, postequatorial. Ovary curved, pretesticular, to right of median line. Vitellaria lateral, extending from level of equator of pharynx to posterior end of body proper, with band of follicles crossing median field distal to testes. No vagina observed. Ootype somewhat piriform, to left of median line; metraterm short, apparently opening to exterior through the same pore as cirrus. Egg, according to Pratt, oval and about 45μ long, with short process at one pole.

Host.—*Aëtobatus fréminvillii* (Le Sueur).



Figs. 1–4.—*Heterocotyle floridana*. 1, complete worm, ventral view; 2, haptor, dorsal view, from Pratt, 1910; 3, large haptoral hook; 4, cirrus. Figs. 5–7.—*Heterocotyle minima*. 5, complete worm, ventral view; 6, large haptoral hook; 7, cirrus. Figs. 8–10.—*Dasybatotrema dasybatis*. 8, complete worm, ventral view; 9, large haptoral hook; 10, cirrus.

Location.—Gills.
Distribution.—United States (Gulf of Mexico).
Specimens.—U. S. N. M. Helm. Coll. No. 39582 (cotypes).

Monocotyle floridana was originally described by Pratt (1910) from specimens collected from a whip-ray, taken in the Gulf of Mexico. The above description is based upon a part of the cotype material. According to Pratt, there is no common genital aperture, and no cirrus or penis. While the writer has been unable to determine the presence of a common genital aperture in the material at his disposal, the arrangement of the genital organs is such as to suggest that such an opening is present. On studying the original drawings and description, there appears to have been some confusion in the interpretation of several structures, the cirrus being mistaken for a vagina, the ejaculatory bulb for a seminal receptacle, and a sharp curve in the vas deferens at the point where it enters the ejaculatory bulb for a vaginal aperture. No vagina was observed in the specimens, but it is possible that fresh material would reveal such a structure. The cephalic glands are shown by Pratt to be 4 in number, but in the specimens at the writer's disposal only 3 could be found; this difference, however, may have no significance, since it is possible that the specimens studied were anomalous with respect to the number of cephalic glands. Pratt also failed to detect the small marginal hooklets occurring in the marginal membrane of the haptor; they are very minute and can be detected only on careful study under the highest powers of the microscope. The exact number of these hooklets could not be determined, but there are probably 14 as in the case of related forms.

H. floridana resembles *H. minima* in size and general appearance, but may be easily differentiated from the latter species by the presence of the 2 groups of conical papillae on the posterior part of the dorsal surface of the haptor, there being no such papillae on the haptor of *H. minima.* Other differences are the presence of eyes and of a conspicuous vagina in *H. minima,* while these structures appear to be absent in *H. floridana;* there is also considerable difference in the cirri of the two species.

Heterocotyle minima (MacCallum, 1916), n. comb. Figs. 5–7

Synonyms.—*Monocotyle dasybatis minimus* MacCallum, 1916; *Monocotyle minima* (MacCallum, 1916) Johnston and Tiegs, 1922; *Trionchus dasybatis* MacCallum, 1916; *Monocotyloides minima* (MacCallum, 1916) Johnston, 1934.

Description.—Body elliptical, flattened dorsoventrally, 945μ to 1.02 mm long by 270 to 340μ wide, anterior end with narrow projecting lip. Oral sucker 76 to 85μ wide; haptor disc-like, 247 to 278μ wide, surrounded by marginal membrane about 25μ wide; ventral surface with oval central area and 8 marginal areas separated by septa, armed with 2 large hooks, 1 hook inserted in each of the postero-lateral septa, and 14 marginal hooklets imbedded in the marginal membrane. Large hooks 53 to 57μ long, disregarding curvature of blade; marginal hooklets about 10μ long. Nature of nervous systerm not ascertainable; remnants of eyes present on each side of pharynx.

Oral aperture ventral, subterminal, about 38μ in diameter. Pharynx barrel-shaped, 95μ long by 68μ wide, marked with 6 or 7 transverse grooves; esophagus very short or absent; intestinal branches simple, extending to near posterior end of body proper, their tips approaching but not fusing. Common genital aperture median, 290 to 340μ from anterior end of body. Cirrus cuticularized, expanded and strongly curved proximally, truncate distally. Ejaculatory bulb oval, 95μ long by 57 to 76μ wide. Testis single, subtriangular with base directed anteriad, about 133μ long by 114μ wide, median, in posterior third of body. Ovary elongate, curved, pretesticular. Vitellaria lateral, extending from level of equator of pharynx to posterior end of body proper, uniting in median field distal to testis. Vagina relatively large, curved, lying largely in median field, opening slightly to left of median line at level of transverse vitelline duct. Mehlis' gland consisting of a number of large cells with relatively long, slender ducts, median, at junction of oviduct and vitelline duct. Ootype oval, relatively large, median. Egg triangular, about 95μ wide, with relatively long, slender filament.

Hosts.—*Dasyatis pastinaca* (Linnaeus), *Squalus acanthias* Linnaeus, and *Pastinachus centrourus* (Mitchill).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.)

Specimens.—U. S. N. M. Helm. Coll. Nos. 35649 (cotypes), 35650 (type of *Trionchus dasybatis*), 35651, 35652, and 35653.

The above description is based upon about 20 specimens, all toto mounts, representing 4 collections made on different dates by the late Dr. G. A. MacCallum. Most of the specimens were not in good condition because of the technique employed in preserving and mounting them. Sufficient detail, however, could be made out to enable the species to be described with a fair degree of accuracy.

This species is very closely related to *Heterocotyle pastinacae* Scott and may possibly be the same species. Scott's (1904) description and figures of his species were not detailed and it is thought best to regard the two forms as distinct until a restudy of *H. pastinacae* can be made.

MacCallum (1916) described as *Trionchus dasybatis,* nov. gen. et nov. sp., a form from the gills of a sting ray. One specimen (U.S.N.M. No. 35650) of this species was available for examination. A comparison of this specimen with specimens of *H. minima* showed the two forms to be identical, since the middle hook of the haptor, the character upon which the genus *Trionchus* was based, was found to be a fragment of lint which had become attached to the posterior septum in such a manner as to appear like a double pointed hook.

Johnston (1934) placed this species in a new genus, *Monocotyloides,* having *M. robusta* (Johnston and Tiegs) as type. A comparison of *Monocotyloides* with *Heterocotyle* shows that the two genera are synonymous.

Genus Tritestis Price, 1936

Diagnosis.—Ventral surface of haptor divided into equal sectors by 8 radial septa as in *Monocotyle.* Oral aperture ventral, not surrounded by sucker; anterior end with 4 pairs of gland termini. Eyes present. Three testes.

Type species.—*Tritestis ijimae* (Goto, 1894) n. comb.

This genus contains only the type species which was collected from the mouth of *Trygon pastinaca* (= *Dasyatis pastinaca*) in Japan. This form differs from *Monocotyle* and *Heterocotyle* in the number of testes and in the nature of the anterior end of the body. The anterior end of *T. ijimae* (Goto, 1894) possesses what appear to be head organs ("sticky glands") arranged as a group of 4 on each side of the anterior end of body similar to those in *Empruthotrema* Johnston and Tiegs.

Genus DASYBATOTREMA Price, 1936

Diagnosis.—Ventral surface of haptor divided into 7 sectors by septa, the posterior sector being the largest; one pair of large hooks and 14 marginal hooklets present. Oral aperture slightly subterminal, surrounded by funnel-like pseudosucker having numerous gland termini around margin. Eyes absent. One testis. Cirrus tubular, composed of cuticular bars. Vagina present, opening laterally.

Type species.—*Dasybatotrema dasybatis* (MacCallum, 1916).

Dasybatotrema dasybatis (MacCallum, 1916), n. comb. Figs. 8–10

Synonym.—*Monocotyle dasybatis* MacCallum, 1916.

Description.—Body elliptical, 5 to 7 mm long by 1.2 to 2 mm wide, flattened dorsoventrally. Oral pseudosucker funnel-like, 680 to 935μ wide, with numerous gland openings around margin. Haptor disc-like, 1.2 to 1.8 mm long by 1.1 to 1.6 mm wide, surrounded by a festooned marginal membrane about 75 to 114μ wide; ventral surface divided by ridges into a more or less circular central area and 7 marginal areas, and armed with a pair of large hooks, 1 hook situated on each posterior ridge, and 14 marginal hooklets situated on marginal membrane. Large hooks 280 to 395μ long; marginal hooklets about 15μ long. Oral aperture at base of pseudosucker and connected with pharynx by a short funnel-like prepharynx; pharynx barrel-shaped, 425μ long by 340μ wide, intestinal branches simple, terminating near posterior end of body proper, their ends approaching but not uniting. Nervous system not observed; eyes absent. Genital aperture slightly to right of median line, about 1 mm posterior to base of pharynx. Cirrus 285 to 304μ long, relatively thick and composed of pointed longitudinal bars arranged so as to form a tubular structure; ejaculatory bulb oval, 340μ long by 255μ wide; vas deferens, before entering ejaculatory bulb, expanding and forming a pars prostatica surrounded by unicellular glands. Testis somewhat cordate, about 850μ long by 510μ wide, median, postequatorial. Ovary slender, curved, pretesticular. Vitellaria extending from level of pharynx to posterior of testis. Vagina long and relatively thick, opening ventrally on left side of body at level of common genital aperture. Ootype oval, surrounded at its base by a number of unicellular glands with long, slender ducts. Egg triangular, about 110μ wide, with relatively short filament.

Hosts.—*Dasyatis pastinaca* (Linnaeus) and *Pastinachus centrourus* (Mitchill).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U. S. N. M. Helm. Coll. Nos. 35654 (type), 35655 (paratypes), 35656, 35657, 35658 and 35659.

MacCallum's (1916) description of this species contains several errors which are corrected in the present redescription.

MacCallum stated that "the genital pore is placed near the division of the ceca in the angle formed thereby," but his figure shows it to be situated at a point opposite the vaginal aperture, which is about 1 mm posterior to the base of the pharynx. He also stated that the cirrus had a cluster of spicules at its tip and that the mouth of the "uterus" was armed with spicules. These spicules are not present in normal specimens, but in several of the specimens prepared by MacCallum the end of the cirrus had been crushed and the pointed tips of the cuticular bars of which the cirrus is composed had become broken off, and it was these pieces which were mistaken for spicules. MacCallum described the haptor as having 8 "chitinous" ridges; actually the ridges or septa are 7 in number and are not chitinous. The posterior median ridge present in *Monocotyle* and *Heterocotyle* is entirely absent, and in this respect the haptor of *D. dasybatis* resembles that of species of *Capsala* and of the related genera *Capsaloides* and *Tristoma.*

Subfamily CALICOTYLINAE Monticelli, 1903

Diagnosis.—Anterior haptor in form of a rudimentary oral sucker; cephalic glands present, opening through a pair of ducts terminating at anterior end of body. Posterior haptor similar to that of *Monocotyle,* with 1 pair of large hooks; marginal hooklets (?). Eyes absent. Testes numerous, intercecal. Vagina double as in *Merizocotyle.*

Type genus.—*Calicotyle* Diesing, 1850.

Genus CALICOTYLE Diesing, 1850

Diagnosis.—Characters of subfamily.

Type species.—*Calicotyle kroyeri* Diesing, 1850.

The genus *Calicotyle* contains six species as follows: *Calicotyle affinis* Scott (1911), *C. australis* Johnston (1934), *C. inermis* Woolcock (1936), *C. kroyeri* Diesing (1850), *C. mitsukurii* Goto (1894) and *C. stossichi* Braun (1899). No representative of this genus has yet been reported from North America.

Subfamily MERIZOCOTYLINAE Johnston and Tiegs, 1922

Diagnosis.—Anterior haptor absent; cephalic glands present, their ducts terminating in distinct head organs. Posterior haptor with numerous sucker-like areas separated by septa, armed with 1 pair of large hooks (absent in *Empruthotrema*) and 14 marginal hooklets. Eyes present or absent. Vagina double.

Type genus.—*Merizocotyle* Cerfontaine, 1894.

KEY TO GENERA OF MERIZOCOTYLINAE

1. Termini of cephalic gland ducts forming numerous head organs.. *Cathariotrema* Johnston and Tiegs

Termini of cephalic gland ducts forming
3 pairs of head organs 2
2. Haptor without large hooks . . . . *Empruthotrema* Johnston and Tiegs
Haptor with 1 pair of large hooks 3
3. Haptor with 5 sucker-like depressions adjacent to central depression . . . . *Merizocotyle* Cerfontaine
Haptor with 4 sucker-like depressions adjacent to central depression . . . . *Thaumatocotyle* Scott

Genus MERIZOCOTYLE Cerfontaine, 1894

Diagnosis.—Anterior end of body with 3 pairs of head organs. Haptor disc-like, with a central oval or circular depression, 6 oval adjacent to central, and 18 marginal depressions, the posterior depression the largest; large hooks and marginal hooklets present. Eyes absent. Testis single.
Type species.—*Merizocotyle diaphanum* Cerfontaine, 1894.

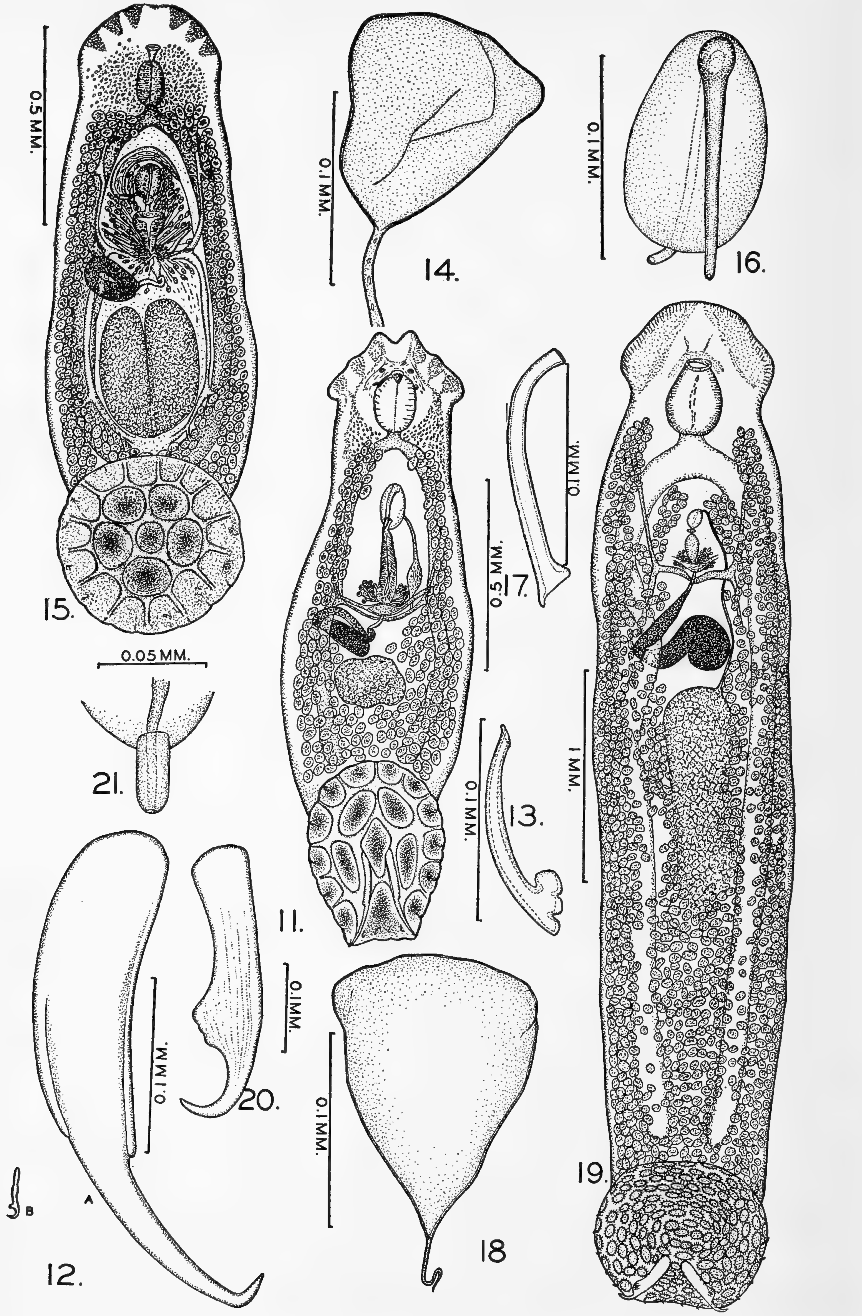
Two species, *M. diaphanum* from *Raja batis* and *M. minus* from *R. oxyrhynchus*, have been described by Cerfontaine (1894, 1898). Neither of these species has been reported from North American hosts.

Genus THAUMATOCOTYLE Scott, 1904

Diagnosis.—Anterior end with 3 pairs of head organs. Haptor with ventral surface divided into sucker-like depressions, 1 central, 4 adjacent to central, and 13 marginal, the posterior marginal depression being largest; large hooks and marginal hooklets present. Eyes present. Testis single.
Type species.—*Thaumatocotyle concinna* Scott, 1904.

Thaumatocotyle dasybatis (MacCallum, 1916), n. comb. Figs. 11–14

Synonym.—*Merizocotyle dasybatis* MacCallum, 1916.
Description.—Body elliptical, 1.5 to 2.6 mm long by 480 to 560μ wide in region of testis, slightly constricted in pharyngeal region. Anterior end slightly expanded, bearing 3 pairs of head organs, these organs being the openings of ducts from numerous unicellular glands located on each side of pharynx. Haptor disc-like, 440 to 600μ long by 370 to 600μ wide; ventral surface with a diamond-shaped central depression, 13 marginal depressions, and 4 depressions between the central and marginal depressions, these depressed areas separated by septa; haptor armed with 2 large hooks and 14 marginal hooklets. Large hooks 224 to 260μ long; marginal hooklets 24μ long. Oral aperture ventral, median, a short distance from anterior end of body; pharynx oval, 160 to 220μ long by 120 to 200μ wide; esophagus very short; intestinal branches simple, without median or lateral diverticula, terminating blindly near anterior margin of haptor. Brain immediately anterior to oral aperture; special sense organs consisting of 2 pairs of eyes located in the brain commissure and 1 pair of sensory papillae at anterior margin of body slightly median to anterior pair of head organs. Genital aperture median, about one-third of body length from anterior end; cirrus cuticular, tubular, 60 to 96μ long; ejaculatory bulb oval, 120μ long by 60μ wide; vas deferens dilated at level of posterior part of ootype forming a fusiform seminal vesicle. Testis irregular in shape, 120μ long by 200μ wide, postequatorial. Ovary tubular, curved, embracing right intestinal cecum, pretesticular. Vitellaria extending from level of base of pharynx to about midway between distal limit of testis and posterior end of body proper.



Figs. 11–14.—*Thaumatocotyle dasybatis*. 11, complete worm, ventral view; 12, haptoral hooks (A—large hook, B—marginal hooklet); 13, cirrus; 14, egg. Figs. 15–18.—*Empruthotrema raiae*. 15, complete worm, ventral view; 16, cirrus and ejaculatory bulb; 17, cirrus; 18, egg. Figs. 19–21.—*Cathariotrema selachii*. 19, complete worm, ventral view; 20, large haptoral hook; 21, cirrus.

Paired vaginae; vaginal apertures ventral, one in vicinity of each intestinal cecum about midway between anterior end and posterior end of body proper. Ootype elongate, muscular, surrounded at its base by numerous unicellular glands with long, slender ducts. Egg triangular, about 100μ wide, with a relatively long slender filament at apex.

Hosts.—*Dasyatis pastinaca* (Linnaeus), *Pastinachus centrourus* (Mitchill) and *Raja erinacea* Mitchill.

Location.—Olfactory organs and gills.

Distribution.—United States (Woods Hole, Mass.)

Specimens.—U. S. N. M. Helm. Coll. Nos. 27553 (cotypes), 35098, 35114, 35163, 35184, 35243, 35659, 35660, 35661, 35662, 35663, 35664, and 35665.

Thaumatocotyle dasybatis appears to be closely related to, if not identical with *Thaumatocotyle concinna* Scott, 1904, from the nasal fossae of "*Trygon pastinaca*" in Scotland. Scott's (1904) description of *T. concinna* was very inadequate as was his figure of the species. However, assuming that the illustration is accurate, the only difference between that form and *T. dasybatis* is in the size of the pharynx, which in *T. concinna* is about one-fifth of the length of the body proper, while in *T. dasybatis* it is about one-tenth of the length of the body proper.

Genus EMPRUTHOTREMA Johnston and Tiegs, 1922

Diagnosis.—Anterior end with 3 pairs of head organs. Haptor with ventral surface divided by septa into sucker-like depressions, 1 central, 5 adjacent to central, and 14 marginal; large hooks absent, marginal hooklets present. Eyes absent. Testis double.

Type species.—*Empruthotrema raiae* (MacCallum, 1916) Johnston and Tiegs, 1922.

Empruthotrema raiae (MacCallum, 1916) Johnston and Tiegs, 1922

Figs. 15–18

Synonym.—*Acanthocotyle raiae* MacCallum, 1916.

Description.—Body elongate, more or less rectangular, 1.6 to 2 mm long by 528 to 700μ wide, anterior end with 3 pairs of head organs, and with numerous unicellular glands on each side of pharynx. Haptor circular, 450 to 575μ in diameter, with a central sucker-like area, 5 similar areas adjacent to central area and 14 marginal areas, all separated from each other by septa; with no large hooks, but with 14 marginal hooklets each about 16μ long. Oral aperture median, ventral, about 100μ from anterior end of body; pharynx 96 to 120μ long by 80 to 96μ wide; esophagus very short; intestinal ceca simple, extending to near posterior end of body proper, tips approaching each other. Nervous system not observed; eyes absent. Genital aperture median, ventral, about one-third of body length from anterior end. Cirrus tubular, cuticular, 120 to 135μ long; ejaculatory bulb oval, 104 to 120μ long by 72 to 80μ wide; distal end of vas deferens expanded and with muscular walls, curving around anterior end of ejaculatory bulb and entering it from right side. Testis double, postequatorial. Ovary sharply curved, embracing right intestinal cecum, equatorial. Vitellaria largely in cecal fields, extending from level of posterior end of esophagus to near posterior end of body proper, with band of follicles crossing median field distal to testis. Paired vaginae as in *Merizocotyle*. Ootype piriform, widest anteriorly, its posterior end surrounded by numerous unicellular glands having long, slender ducts. Egg more or less triangular, about 120μ wide, with relatively short filament.

Hosts.—*Raja erinacea* Mitchill and *R. diaphanes* Mitchill.
Location.—Olfactory organs.
Distribution.—United States (Woods Hole, Mass.).
Specimens.—U. S. N. M. Helm. Coll. Nos. 35160, 35172, 35666, 35667, and 35668.

This species was originally described as belonging to the genus *Acanthocotyle*, but, as Johnston and Tiegs (1922) have pointed out, it is not congeneric with species of that genus. A number of specimens were available to the writer, and a study of these specimens showed that the original description is accurate in most respects. MacCallum stated that there were 2 testes in this species, but instead of 2 testes there appears to be a single testis which is folded in approximately a U-shape. In the original description the size of the egg was given as 20μ, while the writer's measurements show that it is about 120μ wide; however, no very accurate measurements could be obtained as all the eggs present were uterine eggs and had become considerably distorted during the process of dehydration and clearing.

Genus CATHARIOTREMA Johnston and Tiegs, 1922

Synonym.—*Paramonocotyle* Johnston, 1934.
Diagnosis.—Anterior end with numerous gland termini along margins, not in form of head organs as in *Merizocotyle*. Haptor disc-like, wider than long, with its ventral surface divided into a large number of sucker-like depressions; large hooks and marginal hooklets present. Eyes absent. Testis single.
Type species.—*Cathariotrema selachii* (MacCallum, 1916) Johnston and Tiegs, 1922

Cathariotrema selachii (MacCallum, 1916) Johnston and Tiegs, 1922

Figs. 19–21

Synonym.—*Monocotyle selachii* MacCallum, 1916; *Paramonocotyle selachii* (MacCallum, 1916) Johnston, 1934.
Description.—Body elongate, 4.7 mm long by 880μ wide, lateral margins almost parallel, with slight constriction at level of pharynx. Anterior haptors in form of a glandular area on each side of anterior end, the glands opening through numerous duct apertures along margins. Posterior haptor disc-like, 496 to 640μ long by 768 to 825μ wide, its ventral surface divided by septa into numerous oval depressions, armed with 2 large, robust hooks directed postero-laterally and a number (?14) of marginal hooklets. Large hooks 200 to 310μ long; marginal hooklets about 12μ long. Oral aperture ventral, median, about 300μ from anterior end of body; pharynx piriform, 320 to 336μ long by 240 to 280μ wide; esophagus very short; intestinal ceca simple, extending to near anterior margin of posterior haptor. Brain immediately anterior to oral aperture; eyes absent. Genital aperture median, about 400μ posterior to base of pharynx. Cirrus cuticular, about 40μ long; ejaculatory bulb about 128μ long by 80μ wide. Testis elongate, in equatorial zone. Ovary S-shaped, embracing right intestinal cecum; vitellaria extending from level of base of pharynx to posterior end of body, meeting in median line distal to testis. Paired vaginae as in *Merizocotyle*. Ootype oval, relatively small, its base surrounded by numerous unicellular glands having long slender ducts. Egg not observed.

Hosts.—*Carcharias obscurus* (Le Sueur), *C. commersonii* (Blainville), *Sphyrna zygaena* (Linn.) and *Alopias vulpinus* (Bonnaterre).
Location.—Olfactory organs.
Distribution.—United States (Woods Hole, Mass.).
Specimens.—U. S. N. M. Helm. Coll. Nos. 35669 (type), 35670, 35671, 35672, 35673, and 35674.

Johnston and Tiegs have shown that this species does not belong in the genus *Monocotyle* where it was placed by MacCallum, and append it to the Calceostominae. Their action in this case was based on a study of the original description and figures which were from mutilated specimens. The "head-lobes" which these writers regarded as showing affinities with *Calceostoma* do not exist, the figure given by MacCallum being of a crushed specimen.

Subfamily LOIMOINAE Price, 1936

Diagnosis.—Anterior haptor in form of 4 small preoral suckers; posterior haptor disc-like, terminal, without septa, with 1 pair of large hooks and a number (?14) of marginal hooklets. Genital aperture apparently median or submedian; cirrus long, slender, cuticular; testis single. Ovary apparently globular; vagina?
Type genus.—*Loimos* MacCallum, 1917.

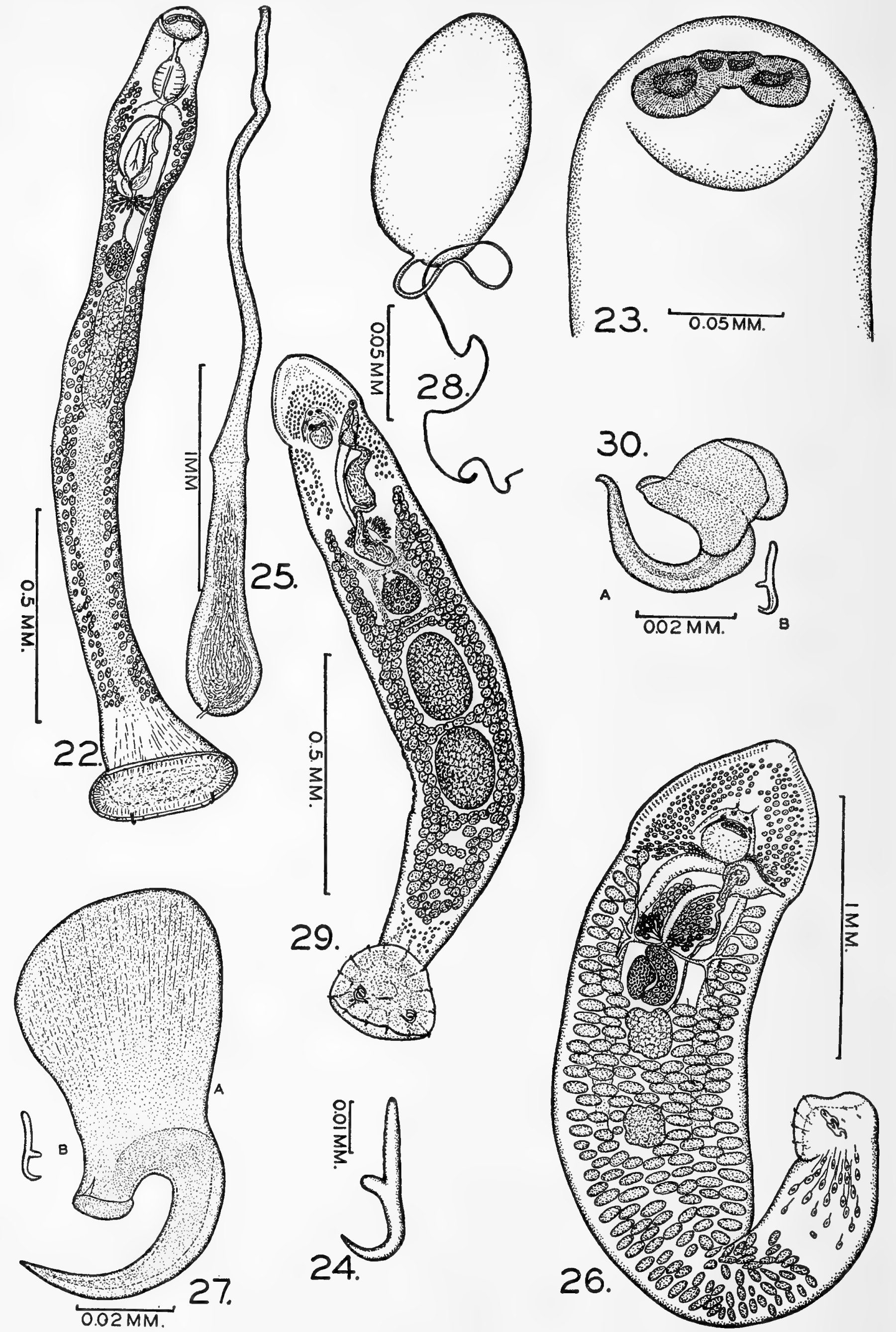
Genus Loimos MacCallum, 1917

Diagnosis.—Characters of subfamily.
Type species.—*Loimos salpinggoides* MacCallum, 1917.

The genus *Loimos* contains only the type species. The affinities of the genus are somewhat questionable, but on the whole it appears to be more closely related to members of the family Monocotylidae than to the family Udonellidae where it was placed by Fuhrmann (1928). The presence of a pair of large hooks and of small hooklets on the posterior haptor, as well as the presence of a tubular, heavily cuticularized cirrus are characters which exclude it from the Udonellidae.

Loimos salpinggoides MacCallum, 1917 Figs. 22–25

Description.—Body elongate, subcylindrical, 2 to 4.5 mm long by about 220 to 4000μ wide. Anterior haptors in form of 4 small preoral suckers arranged in a transverse row, centrals, smaller than laterals and usually one of laterals larger than other. Posterior haptor disc-like, terminal, about 460μ wide, without septa, armed with 1 pair of large hooks and (?) 14 marginal hooklets. Large hooks about 40μ long, similar in form to those occurring on species of *Monocotyle* and *Heterocotyle*, situated at posterior margin of haptor; marginal hooklets about 8μ long. Oral aperture subterminal, about 120μ wide, leading into a somewhat funnel-like prepharynx; pharynx oval, about 80μ long by 65μ wide; intestine apparently consisting of simple ceca. Nervous system not ascertainable in available specimens. Genital aperture apparently median, near posterior end of pharynx, its exact position not ascertainable in available specimens. Cirrus slender, tubular, about 220μ long; ejaculatory bulb elongate, about 95μ long by 30μ wide. Testis single, median, preequatorial. Ovary apparently



Figs. 22–25.—*Loimos salpinggoides.* 22, complete worm, ventral view; 23, anterior end of body, ventral view; 24, large haptoral hook; 25, cirrus. Figs. 26–28.—*Dionchus agassizi.* 26, complete worm, ventral view; 27, haptoral hooks (A—large hook, B—marginal hooklet); 28, egg. Figs. 29–30.—*Dionchus remorae.* 29, complete worm, ventral view; 30, haptoral hooks (A—large hook, B—marginal hooklet).

globular, pretesticular. Vitellaria lateral, extending from level of posterior end of pharynx to near posterior end of body. Vagina (?). Ootype elongate, its base surrounded by unicellular glands with relatively long ducts. Egg oval, 130μ long by 65μ wide, with relatively short filament at posterior pole.

Host.—*Carcharias obscurus* (Le Sueur).

Location.—Gills.

Distribution.—United States (Woods Hole, Mass.)

Specimens.—U. S. N. M. Helm. Coll. 35675 (cotypes).

This rather remarkable trematode was collected by MacCallum at Woods Hole, Mass., August 7, 1916, from the gills of a dusky shark. About 40 of the original specimens (all toto mounts) were available for study, but unfortunately the technique employed in their preparation had distorted most of the specimens so that many of the characters could not be accurately ascertained. A study of these specimens revealed several inaccuracies in the original description (MacCallum, 1917), the most outstanding being the location of the genital aperture, the number of testes, size of the large hooks, and size of the egg. The genital aperture is shown by MacCallum to be on the left side and about the level of the anterior end of the pharynx; no trace of a genital aperture was found in that location and all indications point to its location in median line posterior to the pharynx. In a few specimens the end of the cirrus was in the position indicated by MacCallum but such specimens were more or less crushed and the rather heavy cuticularized cirrus could easily have been forced into the position indicated. There is only 1 testis in this species; it is rather long and cylindrical, and in no specimen was there any indication of 2 testes as shown by MacCallum. The large hooks are about 4 times as long as given in the original description, and the egg more than twice as large. No trace of an excretory pore was observed at the posterior end of the body as indicated in the original description, and it seems reasonable to assume that the excretory apertures are towards the anterior end of the body as in other monogenetic trematodes.

Subfamily DIONCHINAE Johnston and Tiegs, 1922

Diagnosis.—Anterior haptor absent, numerous cephalic glands opening along margin of anterior end of body. Posterior haptor sucker-like, ventral surface with septa, with 1 pair of large hooks and 14 marginal hooklets. Intestinal branches simple, united posteriorly. Eyes present. Genital aperture sinistral, submarginal. Cirrus muscular, unarmed. Two testes, tandem. Vagina absent.

Type genus.—*Dionchus* Goto, 1899.

This subfamily contains only the genus *Dionchus* Goto, and was included by Johnston and Tiegs (1922) in the family Calceostomidae mainly because the cephalic gland ducts did not open through "head organs" as in the case of most of the members of the Monocotylidae. However, the presence of "head organs" is not constant in the Monocotylidae and this character alone does not seem sufficient to exclude *Dionchus* from that family.

Genus Dionchus Goto, 1899

Synonyms.—*Acanthodiscus* MacCallum, 1916, not MacCallum, 1918, not Uhlig, 1906 (mollusk); *Dionchotrema* Johnston and Tiegs, 1922.

Diagnosis.—Characters of subfamily.

Type species.—*Dionchus agassizi* Goto, 1899.

This genus contains only two species, both of which are described below.

Dionchus agassizi Goto, 1899 Figs. 26–28

Description.—Body elongate, 2.2 to 2.8 mm long by 630 to 765μ wide, anterior end triangular, with slight constriction slightly posterior to level of base of pharynx. Anterior haptor absent, but with numerous adhesive glands almost filling anterior end and opening along margins of body anterior to constriction. Posterior haptor sucker-like, divided into 10 marginal areas by as many septa, and armed with 1 pair of large hooks and 14 marginal hooklets; large hooks 95μ long, with strongly curved, pointed tips; marginal hooklets about 15μ long. Numerous large unicellular glands anterior to haptor, with long ducts apparently opening into cavity of haptor. Oral aperture ventral, median, about 340 to 400μ from anterior end of body. Pharynx globular, 95 to 190μ long by 114 to 210μ wide; esophagus very short, with groups of esophageal glands extending laterally; intestinal branches without diverticula, uniting about one-third of body length from posterior end. Brain anterior to oral aperture; 2 pairs of eyes. Genital aperture sinistral, near margin of body; genital atrium large, more or less globular. Cirrus small, muscular; vas deferens wide, more or less convoluted. Testes 2 in number, tandem; anterior testis about 210μ in diameter, posterior testis about 170μ in diameter, separated by relatively wide band of vitelline follicles. Ovary U-shaped, pretesticular, median. Vitelline follicles large, extending from slightly posterior to level of genital aperture to about 500μ from posterior end of body. Vagina absent. Ootype tubular, its base surrounded by relatively large unicellular glands with long ducts; lateral to ootype are large unicellular glands having less affinity for stain than those at base of ootype. Egg oval, 106μ long by about 60μ wide, with long slender filament at one pole.

Hosts.—*Remoropsis brachyptera* (Lowe) and *Echeneis naucrates* Linnaeus.

Locality.—Gills.

Distribution.—United States (New York, N. Y., Newport, R. I., and Woods Hole, Mass.) and West Indies.

Specimens.—U. S. N. M. Helm. Coll. Nos. 35676, 35677, and 35678.

This species was originally described by Goto (1899) from *Remora brachyptera* (=*Remoropsis brachyptera*) and apparently has not been reported since. Seven specimens, representing collections made August 2, 1915, May 4, 1915, and July 10, 1922, are in the U. S. National Museum and were obtained by MacCallum from *Echeneis naucrates* at the New York Aquarium and at Woods Hole, Mass. Several additional specimens, mostly immature, were collected in 1933 by the Johnson-Smithsonian Deep-Sea Expedition from the latter host in West Indian waters.

Dionchus remorae (MacCallum, 1916), n. comb. Figs. 29–30

Synonyms.—*Acanthodiscus remorae* MacCallum, 1916, *Dionchotrema remorae* (MacCallum, 1916) Johnston and Tiegs, 1922.

Description.—Body elongate, about 1.5 mm long by 290μ wide, anterior end rounded and with slight constriction at level of pharynx, posterior part of body slightly attenuated. Anterior haptors absent; cephalic glands numerous, opening along anterior margin of body. Posterior haptor sucker-like, about 220μ in diameter; ventral surface divided into 14 marginal areas by as many septa, armed with 1 pair of large hooks and 14 marginal hooklets. Large hooks 35 to 50μ long, with strongly curved, pointed tips; marginal hooklets 18μ long. Oral aperture ventral, median, about 150μ from anterior end of body; pharynx globular, about 57μ in diameter; intestinal tract not observed. Brain anterior to oral aperture; eyes present, 2 pairs. Genital aperture sinistral, submarginal, slightly anterior to level of oral aperture; genital sinus relatively small. Cirrus short, bulbous, muscular and unarmed. Vas deferens widened distally, forming a tortuous seminal vesicle. Testes oval, tandem, postequatorial; anterior testis 200μ long by 135μ wide; posterior testis 190μ long by 135μ wide, separated from anterior testis by a narrow band of vitelline follicles. Ovary apparently globular, median, separated from anterior testis by a relatively wide band of vitelline follicles. Vitellaria consisting of relatively large follicles, extending from slightly anterior to base of ootype to a short distance from posterior end of body proper. Vagina absent. Ootype slender, relatively long, its base surrounded by a number of unicellular glands having long, slender ducts. Eggs not observed.

Hosts.—*Echeneis naucrates* Linnaeus and *Caranx hippos* (Linnaeus).

Location.—Gills.

Distribution.—United States (New York, N. Y.) and West Indies.

Specimens.—U. S. N. M. Helm. Coll. Nos. 35679 (type), 35680 (paratypes), 35681, 35682, and 35683.

Dionchus remorae was described by MacCallum (1916) as *Acanthodiscus remorae*. Johnston and Tiegs (1922) noted that the genus *Acanthodiscus* to which MacCallum assigned the species was preoccupied, the name having been used by Uhlig in 1906 for a genus of mollusks. These writers recognized the close relationship of the species to *Dionchus*, but owing to the fact that MacCallum figured the species as having a vagina they regarded it as distinct and placed it in a new genus *Dionchotrema*. An examination of MacCallum's original specimens shows that a vagina is absent and the species, therefore, is transferred to the genus *Dionchus*.

The material available to the writer consisted of a number of specimens collected by MacCallum from *Echeneis naucrates* at the New York Aquarium May 16, 19, 29, and 30, 1915, and one specimen from *Caranx hippos* collected May 8, 1915. In addition to this material, several immature specimens were available which had been collected in 1933 by the Johnson-Smithsonian Deep-Sea Expedition from 2 specimens of *Echeneis naucrates* taken in West Indian waters.

In restudying this species, several errors have been detected in the description as given by MacCallum. According to that author, the mouth is terminal, the genital atrium and cirrus are armed, and a vagina is present; however, the present writer finds the mouth to be ventral, the genital atrium and cirrus unarmed, and there is no vagina.

Dionchus remorae is closely related to *Dionchus agassizi* but may be easily distinguished from the latter species by its smaller size, by its more rounded anterior end, by the extent of the vitellaria anteriorly, and by the number of marginal areas of the haptor.

(To be continued)

ENTOMOLOGY.—*A study of the North American ants of the genus* Xiphomyrmex *Forel.*[1] MARION R. SMITH, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

The genus *Xiphomyrmex* Forel, formerly considered as a subgenus of *Tetramorium* Mayr, includes 50 to 75 forms. Species occur in Africa, Madagascar, Indo-Malaya, Australia, and the Sonoran region of North America. According to Wheeler these ants nest in the ground, often forming populous colonies. The following is a translation of Emery's characterization of the genus in Genera Insectorum:

Worker.—Anterior border of clypeus feebly emarginate, the lateral border forming an elevated ridge in front of the antennal fossa. Frontal carinae well separated. Antenna 11-segmented. Antennal scrobe well developed. Hairs simple or clavate.

Queen.—Usually larger than the worker, but similar in structure of head, petiole, and hairs. Antenna 11-segmented. Anterior wing with the radial cell usually closed.

Male.—Mandibles toothed. Antenna 10-segmented, the second funicular segment long and composed of the fused segments 2, 3, 4, 5. Wings as in the queen.

This paper deals with four forms of *Xiphomyrmex* known to occur only in the southwestern section of the United States, and Northern Mexico. These four forms are the species *X. spinosus* and its subspecies *insons*, *hispidus*, and *wheeleri*. The typical form was described by Pergande from 14 workers collected at Sierra, San Lazaro, Cape Region, Lower California, and is known only from these specimens. The subspecies *insons* has been recorded from Texas and Arizona (Wheeler), *wheeleri* from Arizona and Mexico (Wheeler), and *hispidus* from Arizona (Wheeler). The worker of *X. spinosus* bears such a striking resemblance to that of *Tetramorium guineense* (F.) that the two could easily be confused except by careful examination. It differs, however, in the number of antennal segments, the number of carinae on the clypeus, the shape of the petiole and postpetiole, the shape of the humeral angles of the prothorax, etc.

[1] Received December 30, 1937.

In preparing this article I have been fortunate in being able to study cotypes of all four forms. I wish to express my thanks to the American Museum of Natural History and the Museum of Comparative Zoology for the loan of cotypes, and to Dr. W. S. Creighton for the loan of specimens from his personal collection.

My studies have shown that the subspecies of *spinosus* represent extreme variations, and that there are other forms intermediate between the named forms. The existence of these intermediates might justify the synonymizing of the subspecies with the typical form; but, since many recognized subspecific forms of ants are based on characters of no greater strength than those separating the subspecies of *X. spinosus* from the typical form, I prefer to retain these forms as distinct.

Because Pergande's original description of the species is incomplete I have redescribed *X. spinosus* on the basis of type material in the collection of the United States National Museum. The descriptions of the three subspecies consist only of statements of the characters by which they differ from the typical form. Males and queens of the various subspecies have not been available for study.

The key below should serve to distinguish the workers of the various forms of *spinosus*.

KEY TO THE FORMS OF XIPHOMYRMEX SPINOSUS PERGANDE
(for the identification of the workers)

1. First gastric segment finely punctulate, shagreened, subopaque toward the base 2
   First gastric segment entirely smooth, except for scattered, piligerous punctures 3
2. Erect hairs on the head and thorax long, slender, and tapering; metasternal angles acute, spine-like . . . . *spinosus* Pergande
   Erect hairs on the head and thorax short, coarse, and blunt; metasternal angles blunt, not spine-shaped . . . . subsp. *hispidus* Wheeler
3. Metasternal angles acute, spiniform; thorax viewed from above with indistinct mesoepinotal constriction . . . . subsp. *insons* Wheeler
   Metasternal angles blunt, not spine-like; thorax viewed from above with a distinct mesoepinotal constriction . . . . subsp. *wheeleri* (Forel)

Xiphomyrmex spinosus Pergande

Xiphomyrmex spinosus Pergande, Proc. Calif. Acad. Sci., Vol. 5, p. 894 (1895). *Worker*. Mexico.

Worker.—Length 3.2–3.4 mm.

Head, excluding mandibles, subrectangular, slightly longer than broad, with moderately convex sides, rounded occipital angles, and faintly emarginate posterior border. Eye prominent, oval, convex, placed a little more than its greatest diameter from the base of the mandibles. Mandible triangular, moderately convex dorsally, and with 7 or 8 distinct teeth. Clypeus convex, posterior border broadly rounded and extending between the frontal carinae, anterior border very faintly emarginate or impressed medianly. Antenna 11-segmented, the scape distinctly compressed, and when lying in the antennal scrobe made on each side of the head by the frontal carina, not reaching the posterior border of the head; funiculus with a distinct 3-segmented club, which is apparently as long as the remainder of the funiculus. Pronotum from above with broadly rounded humeral angles. Meso-epinotal constriction faint. Epinotal spines prominent, straight, and acute, directed backward and gradually divergent; scarcely longer than the dis-

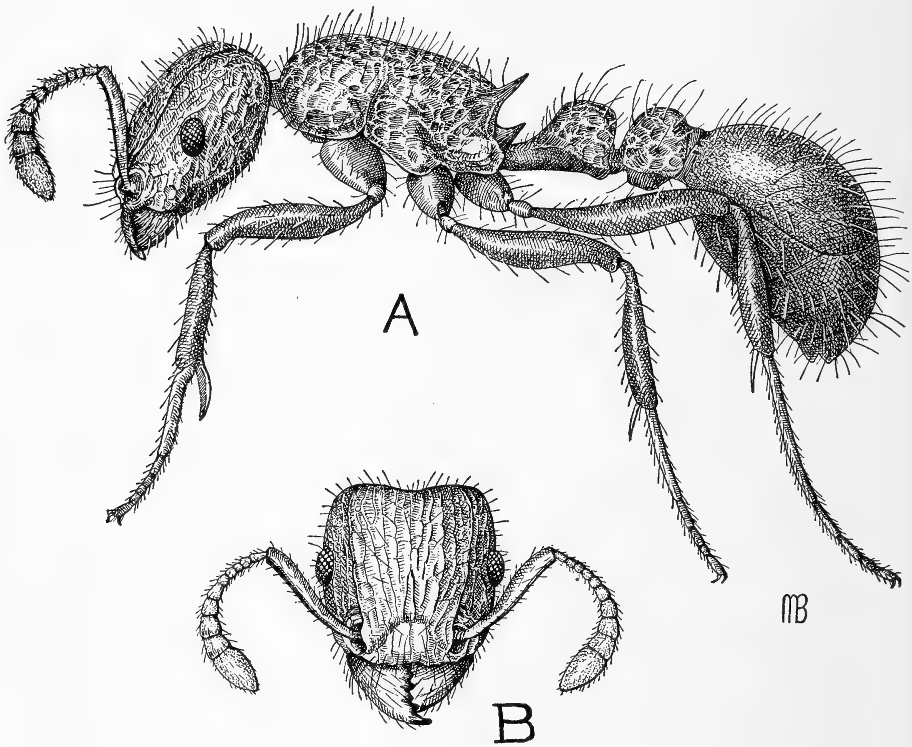


Fig. 1.—*Xiphomyrmex spinosus* Pergande, worker. A, lateral view of body; B, frontal view of head. Illustrations by Mrs. Mary F. Benson.

tance between their bases. Metasternal angles distinct, tooth-like, acute, at least one-half the length of the epinotal spines. Petiole viewed directly from above subcampanulate, postpetiole viewed from the same aspect transversely elliptical. Gaster oval, without pronounced basal angles.

Mandibles with moderately coarse, longitudinal striae. Clypeus with 6 to 8 prominent longitudinal striations, some of which are not complete. Head, thorax, petiole, and postpetiole coarsely rugose-reticulate, the interspaces finely punctulate. The rugae in the center of the head and thorax with a more nearly longitudinal trend than elsewhere. Gaster smooth and shining except for the first segment, the basal half of which is finely punctulate, shagreened, and therefore subopaque.

Hairs rather abundant over all parts of the body; yellowish, erect, but of varying lengths; those on the appendages shorter, and suberect.
Ferruginous; mandibles, clypeus, and legs noticeably lighter.

The above description is based on 7 cotype specimens collected at Sierra, San Lazaro, Cape Region, Lower California, all of which are in the collections of the National Museum.

Xiphomyrmex spinosus subsp. *hispidus* Wheeler

Xiphomyrmex spinosus subsp. *hispidus* Wheeler, Bull. Amer. Mus. Nat. Hist., Vol. 34, p. 415 (1915). *Worker.* Arizona.

Worker.—Length 3.5—3.8 mm.

Posterior border of head very distinctly emarginate. Antennal funiculus not infuscated distally. Metasternal angles blunt, not spineshaped. First segment of the gaster finely punctulate, shagreened and subopaque toward the base. Hairs short, coarse, blunt, and of unequal length.

Description based on 5 cotype specimens labeled "Desert, east of Tucson, Arizona; W. M. Wheeler" (Amer. Mus. Nat. Hist. and Museum of Comp. Zoology).

Wheeler states that he found these ants "nesting in small craters 3 to 4 inches in diameter, in the deserts around Tucson, Arizona (type locality), and from Phoenix in the same state."

Xiphomyrmex spinosus subsp. *insons* Wheeler

Xiphomyrmex spinosus subsp. *insons* Wheeler, Bull. Amer. Mus. Nat. Hist., Vol. 34, p. 416 (1915). *All castes.* Texas, Arizona.

Worker.—Length 3.5–4 mm.

Posterior border of head emarginate but not so strongly as in *wheeleri*. Antennal funiculus not infuscated distally. Mesoepinotal constriction, viewed from above, very weak, scarcely apparent. Metasternal angles acute, spine-like. Gaster smooth and shining except for scattered piligerous punctures. Hairs long and slender, and of unequal lengths; on the tibiae shorter than in *wheeleri*.

Description based on 3 cotype specimens labeled "Austin, Texas; W. M. Wheeler" (Amer. Mus. Nat. Hist.).

Wheeler cites Austin, Texas, as the type locality, and lists the species from the following other localities:

Texas.—New Braunfels, Alamito in Brewster County, Alice, San Angelo, Fort Davis, Kennedy, Langtry, Barksdale and Del Rio.

Arizona.—Miller Canyon (Huachuca Mts.).

I have referred to this subspecies 3 workers taken from the stomach of an armadillo at Junction, Texas, and submitted by the Bureau of Biological Survey, United States Department of Agriculture.

Wheeler, in remarking on the habits of this species, says, "This ant nests in small craters in dry, grassy places. There are scarcely more than 70 individuals in a colony. The workers are very timid and forage singly. The winged phases appear during the first week in June."

Xiphomyrmex spinosus subsp. *wheeleri* (Forel)

Tetramorium (*Xiphomyrmex*) *wheeleri* Forel, Ann. Soc. Ent. Belg., Vol. 45, p. 128 (1901). *Worker.* Mexico.

Xiphomyrmex spinosus subsp. *wheeleri* (Forel) Wheeler, Bull. Amer. Mus. Nat. Hist., Vol. 34, p. 416 (1915). *Worker.*

Worker.—Length 3.5–3.7 mm.

Posterior border of head faintly emarginate. Antennal club distinctly infuscated. Thorax, viewed from above, with a very distinct mesoepinotal constriction. Metasternal angles blunt, not spine-like. Gaster smooth and shining except for the scattered piligerous punctures. Hairs on the tibiae apparently longer and more reclinate than with *spinosus.*

Description based on 3 cotypes from the type locality, Pacheco, Zacatecas, Mexico; W. M. Wheeler (Amer. Mus. Nat. Hist.).

Wheeler states that he took in the Miller Canyon (Huachuca Mts., Ariz.) specimens of a form closely related to *wheeleri* but differing in the size of the epinotal spine, type of rugosity of postpetiole, and infuscation of the antennal club. I have seen specimens from the Ramsey Canyon of the same mountains which seem to belong to this undescribed form mentioned by Wheeler. These were taken by Dr. W. S. Creighton.

Wheeler apparently collected his type specimens from a small colony beneath a stone in the cactus desert.

PALEOBOTANY.—*Two fossils misidentified as shelf-fungi.*[1] ROLAND W. BROWN, U. S. Geological Survey.

In 1936 I described *Polyporites stevensoni* Brown[2] as a Cretaceous shelf-fungus. This specimen megascopically, and in such microscopic details as are preserved, resembles very closely a living species of shelf-fungus growing on *Eucalyptus* in Australia. Recently, however, a chance observation of some Paleozoic corals of the syringopore group caused me to reexamine the supposed fungus with the result that I am now chagrined to admit that *Polyporites stevensoni* is not a fungus but a syringopore coral of probably undeterminable species. Evidently the specimen, which I considered as indigenous to the flora preserved in Upper Cretaceous strata along the Cannonball River in southwestern North Dakota, was a pebble that had been transported from some Paleozoic source far to the west.

The description of *Polyporites stevensoni* followed a precedent set by *Polyporites browni* Wieland[3] as stated in my paper. The mistake in regard to *P. stevensoni,* therefore, aroused suspicions with respect to

[1] Received February 21, 1938.

[2] This JOURNAL **26**: 460-462. 1936.

[3] WIELAND, G. R. *A silicified shelf fungus from the Lower Cretaceous of Montana.* Am. Mus. Nov. **725**: 1-13. 1934.

P. browni, which, however, is said to have been collected from the Cloverly formation (Lower Cretaceous) exposed along Beauvais Creek, 40 miles south of Billings, Mont. Through the courtesy of Dr. Barnum Brown and the American Museum of Natural History I have been permitted to reexamine that specimen. A chemical analysis by E. P. Henderson of the National Museum showed a high percentage of phosphate radical, which is strong, presumptive evidence that the fossil is a bone, not a fungus. With this hypothesis in mind, and with the rather distinctive surface and internal structure of the specimen as a guide, a search with C. W. Gilmore through the National Museum vertebrate collections resulted in the elimination of every available possibility except the dental plates of Jurassic and Cretaceous species of the lung-fish, *Ceratodus*. The correspondence, detail for detail, with these remains is so close that there is little, if any, doubt that *Polyporites browni* represents *Ceratodus*. The specimen is therefore renamed *Ceratodus browni* (Wieland) Brown, n. comb.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

494th meeting

The 494th Meeting was held in the Auditorium of the George Washington University School of Medicine on Thursday, October 14, 1937, President Nicolet presiding.

The program was presented in three sections as follows:

Analytical and Inorganic Chemistry, A. R. Merz presiding.:

John W. Knowlton and Frederick D. Rossini: *Method and apparatus for the rapid conversion of deuterium oxide into deuterium.*—A glass bulb at one end of the evacuated conversion apparatus contains a sealed ampoule holding the liquid deuterium oxide. This ampoule of "heavy" water is broken by placing liquid air around the outer bulb, which is subsequently heated electrically to control the passage of the vapors of deuterium oxide into the reaction tube, containing powdered magnesium at 480°C, where the following reaction occurs:

$$Mg(solid)+D_2O(gas)=MgO(solid)+D_2(gas).$$

The rate of evolution of deuterium can be made as great as one mole in two hours. The evolved deuterium passes through a liquid air trap and is collected as liquid in a 0.05 liter brass bottle immersed in ordinary liquid hydrogen (temperature about −253°C). The connection to the conversion apparatus is closed, that to a 1 liter brass bottle is opened, and the deuterium is permitted to vaporize and fill two brass bottles at room temperature. In this manner 95 percent of the deuterium is obtained in the 1 liter bottle as a gas under a pressure of about 23 atmospheres. (*Authors' Abstract*)

HERMAN J. MORRIS and HERBERT O. CALVERY: *The quantitative determination of arsenic in small amounts in biological materials.*

RALEIGH GILCHRIST: *A new procedure for the analysis of dental gold alloys.*

ORGANIC and BIOLOGICAL CHEMISTRY, N. L. DRAKE presiding:

M. X. SULLIVAN: *New Tests in the guanidine field.*—It has long been known that guanidine and methylated guanidine are more or less toxic to man, but what part they might play in health and disease has been problematical since satisfactory tests have been lacking. In a study of the various guanidine compounds, Sullivan devised colorimetric tests, highly specific for simple guanidine $NH=C(NH_2)_2$ and for unsymmetrical dimethyl-guanidine $NH=C\langle{}^{NH_2}_{N(CH_3)_2}$. It was demonstrated that guanidine reacts on warming with beta-naphtho-quinone-4-sodium sulfonate and dilute NaOH to give a brown color which on cooling and acidifying with conc. HCl and HNO_3 goes to bright red while all other biologically important substances so far tested go to bright yellow. The test is readily sensitive to 0.5 mg of guanidine per cc. The test for unsymmetrical dimethyl-guanidine depends on the finding that of all the substances which react with acetyl benzoyl and alkali, unsymmetrical dimethylguanidine (1 mg per cc) is the only one so far met with that is not discharged to colorless on warming for 1 min. with 0.5 cc 3% H_2O_2. The color remains brownish due to a faint precipitate, and on addition of alcohol or toluene goes to an intense purple, while all other complexes are colorless. Application is being made of these tests in various diseases, such as muscular distrophy and hypertension. (*Author's Abstract.*)

SANFORD M. ROSENTHAL: *Chemical compounds active against bacterial infections.*—A review of recent advances in bacterial chemotherapy with a discussion of the active chemical radicals involved was given. Various modifications of the sulfanilamide molecule in relation to chemotherapeutic effect were shown. New compounds including di-sulfanilamide and the diphenyl sulfones, of superior therapeutic action, were presented. (*Author's Abstract.*)

V. DU VIGNEAUD, G. W. IRVING, H. M. DYER, R. R. SEALOCK: *The differential migration of the blood-pressure-raising and the uterine-contracting hormones of the posterior lobe of the pituitary.*—(The complete article is in press, to be published in the Journal of Biological Chemistry).

C. E. SANDO: *Exhibit: The preservation of agricultural specimens in plastics.*—One portion of this exhibit represented plant materials such as roots, stalks, stems, leaves and flowers, which had been treated chemically in such a manner as to toughen the tissues and set the natural color, after which they were preserved between transparent cellulose acetate sheets. These specimens were prepared by Mr. G. R. Fessenden. The second portion of the exhibit prepared by Dr. Sando consisted of specimens such as seeds, beetles and flowers, imbedded in methacrylates. The three outstanding methacrylate specimens were an ear of corn, which in its imbedded state measured $2\frac{1}{4}'' \times 3'' \times 7''$, an iridescent butterfly, mounted by a process which prevented actual contact between the specimen and the methacrylate, and an imbedded group of red globe amaranth flowers. (*Author's Abstract.*)

PHYSICAL CHEMISTRY, S. B. HENDRICKS presiding:

STEPHEN BRUNAUER, PAUL H. EMMETT and EDWARD TELLER: *Adsorption of gases in multimolecular layers.*—A derivation of an isotherm equation for adsorption of multimolecular layers was carried out on the assumption that the same forces which produce condensation are also responsible for multimolecular adsorption. The method of derivation was a generalization of Langmuir's derivation of the isotherm equation for unimolecular layers. The equation is

$$\text{(A)} \qquad v = v_m c \frac{x}{1-x} \frac{1-(n+1)x^n+nx^{n+1}}{1+(c-1)x-cx^{n+1}}$$

where v is the volume adsorbed at pressure p; x equals p/p_0, p_0 being the saturation pressure; v_m is the volume of gas required to form a unimolecular layer on the adsorbent; c is approximately $e^{(E_1-E_L)/RT}$, E_1 being the heat of adsorption in the first layer and E_L the heat of liquefaction of the gas; and n is the maximum number of layers that can build up on the adsorbent. For small values of x or large values of n the equation reduces to the linear form

$$\text{(B)} \qquad \frac{p}{v(p_0-p)} = \frac{1}{v_m c} + \frac{c-1}{v_m c} \cdot \frac{p}{p_0}$$

Equations (A) and (B) were applied to numerous experimental adsorption isotherms obtained by other investigators as well as by the authors. The equations seem to represent in a satisfactory manner not only the shape of low temperature van der Waals adsorption isotherms, but also their temperature dependence. Values obtained for v_m were in good agreement with those previously estimated empirically directly from the low temperature adsorption isotherms. (*Authors' Abstract.*)

F. W. ROSE, JR: *Quantitative analysis, with respect to the component structural groups, of the infra-red (1 to 2 mu) molal absorptive indices of fifty-four hydrocarbons.*—Data from the previous studies on the infra-red absorption spectra between 1.2 and 1.8μ (5400 to 8900 cm^{-1}) for 54 hydrocarbons have been correlated. The total molal absorptive index, K, at any wave length, is shown to follow, within the limits necessary to define the number of groups, the formula

$$K = n_a\alpha + n_b\beta + n_c\gamma + n_d\delta$$

where n_a, n_b, n_c, n_d are the number of $-CH_3$, $>CH_2$, $\geqslant CH$, and $>CH$ (aromatic) groups and α, β, γ, and δ are the values, respectively, of the absorptive index for a unit group. The formula is demonstrated to hold, with modifications, for paraffins, cycloparaffins (naphthenes) and aromatic hydrocarbons, including 10 of high molecular weight (C_{24} to C_{32}). The accuracy of the method, as well as restrictions on its application are given, and its use is demonstrated by an example of the identification of the number of $-CH_3$, $>CH_2$, and $\geqslant CH$ groups in an unknown branched-chain paraffin hydrocarbon. (*Author's Abstract.*)

A. R. GLASGOW, JR., and S. T. SCHICKTANZ: *A study of ball packings for laboratory rectifying columns.*—The efficiency, liquid hold-up, and surface area of packings composed of glass balls 2.95 and 3.80 mm in diameter, lead balls 2.05 and 4.05 mm in diameter, and copper balls 4.00 mm in diameter, have been determined. The description and operation of the glass experimental column are given. For a column 2.6 cm in diameter packed with balls 0.2 to 0.4 cm in diameter, it is found that: (1) the heat conductivity and the nature of the material of the packing have no effect on the efficiency of separation, liquid hold-up, or through-put of the still; (2) the efficiency is substantially in direct proportion to the total surface area exposed in the packed column, and approximately linear with the reciprocal of the diameter of the balls; and (3) the hold-up is approximately linear with the total surface area. (*Authors' Abstract.*)

R. E. GIBSON: *The Hoffmeister series of anions and cations, and some thermodynamic properties of solutions.*

495TH MEETING

The 495th meeting was held in the auditorium of the Cosmos Club on Thursday, November 11, 1937, President NICOLET presiding.

The program was preceded by the annual elections of officers for the ensuing year. The following were elected: *President:* NATHAN L. DRAKE, University of Maryland; *Secretary:* FRANK C. KRACEK, Geophysical Laboratory; *Treasurer:* RAYMOND M. HANN, National Institute of Health; *Councilors:* L. B. BROUGHTON, V. DU VIGNEAUD, R. E. GIBSON, H. T. HERRICK, G. E. F. LUNDELL, Ben H. NICOLET; *Board of Managers:* NORMAN BEKKEDAHL, H. L. HALLER, M. M. HARING, S. B. HENRDICKS, E. R. SMITH, K. T. WILLIAMS

The Society was addressed by FRANK C. WHITMORE, President-Elect of the American Chemical Society and Dean of the School of Chemistry and Physics of the Pennsylvania State College, upon the subject of *Hydrocarbons.* The speaker discussed in considerable detail the research and economic aspects of hydrocarbon chemistry, stressing particularly the relation of these compounds to current trends in organic chemistry in general.

496TH MEETING

The 496th meeting was held in the auditorium of the Cosmos Club on Thursday, December 9, 1937, President NICOLET presiding.

The Society was addressed by HERBERT J. WOLLNER, Consulting Chemist to the Secretary of the Treasury on the subject of *the denaturation of industrial alcohol.* The speaker explained some of the problems encountered in the rapidly increasing use of alcohol by the expanding chemical industry, both from the standpoint of legitimate use and from the standpoint of preventing illegal diversion of the article for non-industrial uses. More and more exacting demands on specification, resulting from greater chemical control of ultimate products, require the continual modification of denaturing formulas to suit the requirements of processing. An extensive survey has been completed on all the industrial uses of alcohol in the United States. This survey has been paralleled by laboratory studies of the behavior of denaturants. The results of this study and survey direct the attention to that particular group of aliphatic compounds which contain oxygen atoms as providing the greatest promise for denaturants to meet industrial requirements. In this group are the ketones, higher alcohols, and ethers.

497TH MEETING

The 497th meeting, which also was the 54th annual meeting of the Society, and the 44th annual meeting of the Society as the Washington section of the American Chemical Society, was held in the Auditorium of the Cosmos Club on Thursday, January 13, 1938, with President DRAKE in the chair.

The first part of the meeting was devoted to the annual reports of the officers. The Secretary reported that the Society had 611 members on December 1, 1937. Of these, 5.4 per cent were in arrears. During 1937 the Society lost 51 members by removal, resignation and deaths, and gained

109, the net gain being 58. The following members died during the year: Louis W. Mattern, Alfred Oberle. Eight regular meetings were held during the year, with an average attendance 157, or 27.2 per cent of the paid up membership. Percentage attendance for all the years of the Society's existence is 27.1. The Hillebrand Prize for 1936 was awarded to Vincent du Vigneaud, Professor of Biochemistry at the George Washington University School of Medicine in recognition of his work on *the biologically important compounds of sulfur*. The award was presented to the recipient at the annual dinner of the Society, held in March. The previous recipients of the Prize, and the subjects of the award, published here for the first time, were:

1925: Richard F. Jackson, on *Levulose*.
1926: George W. Morey, on *Constitution of Glass*
1927: Edward P. Bartlett, on the *Gas Laws at high Temperatures and Pressures*.
1928: James H. Hibben, on *Radiation and Collision in Chemical Gas Reactions*
1930: Claude S. Hudson, on the *Ring Structure of the Sugars*.
1931: G. E. F. Lundell, on the book, *Applied Inorganic Analysis*, by Hillebrand and Lundell.
1932: F. B. Laforge and H. L. J. Haller, on the *Structure of Rotenone*.
1933: Edward W. Washburn, posthumously, on the *Electrolytic method of Separation of the Isotopes of Hydrogen*.
1934: Frederick D. Rossini, on the *Thermochemistry of the normal aliphatic Hydrocarbons and alcohols*.
1935: Oliver R. Wulf, on the *Chemistry of the earth's Atmosphere in its Relation to absorbed Solar Radiation*, and on his work on *Infrared absorption Spectra*.

The treasurer reported receipts $656.22, expenditures $534.74, unexpended balance, $121.48. Total resources, as of December 31, 1937: $5,423.98. The auditing committee (A. R. Merz, Chairman, P. H. Groggins, Wm. H. Ross) had examined the books and had found them to be in order.

The following committees were appointed to serve during 1938: *Communications:* G. E. Hilbert, Chairman, J. F. Schairer, H. P. Newton, S. B. Hendricks, N. K. Richtmyer, H. S. Isbell. *Entertainment:* E. R. Smith, Chairman, L. W. Butz, K. T. Williams, A. L. Pitman, Stephen Brunauer, L. A. Shinn, C. M. Smith, Florence King, D. Ready, E. M. Nelson, J. J. Fahey, N. K. Richtmyer, C. E. White, *Membership:* M. M. Haring, Chairman, F. E. Allison, E. O. Haenni, W. J. Hamer, H. M. Harshaw, H. S. Isbell, James McLaren, J. H. Roe, J. R. Spies, F. P. Veitch, Jr. *Budget:* J. F. Couch, Chairman, H. T. Herrick, C. W. Whittaker. *Finance and Investment:* Edward Wichers, M. X. Sullivan, A. K. Balls.

After the presentation and acceptance of the reports, the Society was addressed by the retiring President, Ben H. Nicolet, on *Biochemistry by Analogy: The Sulfur of Cystine*. (Published in This Journal, page 84.)

Frank C. Kracek, *Secretary*.

Obituary

JOHN NAPOLEON BRINTON HEWITT, ethnologist, Bureau of American Ethnology, Smithsonian Institution, died at his home in Washington, D. C., October 14, 1937. In his death there passed from the field of anthropology the last of that notable group of students of the American Indian which Major J. W. Powell assembled when he founded the Bureau of American Ethnology. Mr. Hewitt was born in the neighborhood of Lewiston, Niagara Co., N. Y., Dec. 16, 1859. His mother, Harriet Brinton (Hewitt), was of French, English, and Tuscarora Indian descent and his father was a Scotch physician. Young Hewitt received his early education in the public schools of Niagara County, and later pursued classical courses in Wilson Union and Lockport Union academies. His field studies began in 1879, when, as assistant to Mrs. Erminnie A. Smith, ethnologist, he was engaged for seven years in investigating the language mythology, and social organization of the Tuscarora and Onondaga Indians. In 1886 he was called to the Bureau of American Ethnology where he continued in this line of research to the end of his life, soon coming to be regarded as the leading authority on the organization of the Iroquois League and the ceremonials, customs, and usages of the tribes composing it. He acquired an intimate knowledge of the languages of the League, including a speaking knowledge of Mohawk and Onondaga, and also became acquainted with several Algonquian dialects.

During the later years of his active life Mr. Hewitt collected some material in the Chippewa, Ottawa, and Delaware dialects of Algonquian, but most of his personal investigations were devoted to the Iroquois and their immediate relatives. He was painstakingly conscientious in his work but it moved so slowly that only a small part was actually printed. In the manuscript collections of the Bureau there are over 250 entries under his name including nearly 8000 manuscript pages and 10,000 cards, over half under the heading Onondaga, but with considerable bodies of Mohawk, Tuscarora, and Seneca material. He edited the narratives of Denig and Kurz, early explorers among the western Indians. These were published by the Bureau in 1930 and 1937. Much of Mr. Hewitt's time was also devoted to the preparation of articles for the Handbook of the American Indians, edited by Mr. F. W. Hodge, Ethnologist-in-Charge, well over a hundred having been contributed by him. On March 19, 1918, Mr. Hewitt was appointed a member of the U. S. Board on Geographical Names and continued in that capacity until his death. He was a founder of the American Anthropological Association and a member of the Anthropological Society of Washington, which he served as treasurer from 1911 to 1926, and as President from 1932 to 1934. He was a member of the Washington Academy of Sciences.

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MICROBIOLOGY.—*A microbiologist digs in the soil.*[1] Charles Thom, Bureau of Plant Industry.

PROLOGUE

For his last official appearance, custom has awarded this platform to each president of the Washington Academy of Sciences, without restriction in his choice of topic. For one night he can choose the title of his address and expand it without consulting with the Meetings Committee. Since he usually expects to continue living in this community, he is under prudential obligation to broaden his message to reach members of the Academy who care little for the specific field which he may have cultivated for half a lifetime.

His first embarrassment is the search for material which will satisfy this requirement. You will pardon me if I analyze this dilemma in a somewhat personal way. I have been a biologist for about sixty years; my father set me to trapping ground squirrels when I was six. Some of the experience of that first ecological assignment will appear in what is said here.

If you are to trap a squirrel, first you must find the squirrel's hole. Human philosophy will fail you. A squirrel selected the place to dig—only the squirrel knew why. How about a scientist! Here the safest course is to "*tell one*" on myself.

Many years ago, a trustee of the institution in which I was working brought a friend into my laboratory and said, "Tell us about your work." I knew that man's history—he had built success in life for twenty years around milking cows from 4 to 8 every morning and from 4 to 8 at night. I spent an hour discussing my project and showing the results attained. I thought I had done it rather well. Without a word or look at me, he turned to his guest and said, I'd hate to "earn my living as this fellow does." They went out.

Let us go back to our squirrel. Like the scientist, he is industrious. He piles up dirt about his hole as the scientist does monographs. But

[1] Address of the retiring president of the Washington Academy of Sciences, delivered February 17, 1938. Received February 18, 1938.

for the most part he is out of sight down his hole. No doubt he does a good job—down the hole. But down there his vision is limited by the crooks in his burrow. Now and then he ventures out, mounts his little pile and utters the chatter of his species. Equally the scientist appears before the Academy and when the brickbats begin to fly, dives back into his burrow whence a noxious flow of polysyllabic, technical jargon discourages all who seek to pursue.

I am not condemning the squirrel type of scientist. Sometimes a man is inspired to go off by himself and break into new ground. Again, it is either physically impossible to fit new ideas into existing systems, or, necessary to leave the integration of results to a coming generation. But it is always worth while to halt excavation operations until one has defined the real reason for digging.

Do not misunderstand me—I am quite sure that many a man can serve his generation best by selecting a limited field in which he digs deep and disregards his fellows—provided he definitely continues to dig and to monograph, but refrains from deciding all of the weighty problems of the world from data acquired—down his hole. I equally well know that the man who really digs deep, like the squirrel, comes upon roots of many kinds which lead in many directions so that a lifetime in what appears to be a very narrow hole, may develop contacts with the "ends of the earth." Nevertheless, for most of us it remains better that we confine ourselves to our monographs and refrain from settling all of the affairs of earth and heaven by what we find down our holes.

Thus I come to my subject.

A MICROBIOLOGIST DIGS IN THE SOIL

If a microbiologist who digs in the soil is to find excuse for discussing a series of questions of interest to those who care little for the description of microbes and microbial activities, it must be in the borderline of his field—not in its purely technical aspects. The broad significance of his work will appeal to some, whereas his points of contact with men and movements outside, as viewed from his special angle, will interest others. The details of his laboratory and field operations only reach those critically familiar with both soil technology and microbiological procedures.

However dead the earth may look and be considered in our thoughtless moments, the experience of man far back beyond his written records has led him to associate trouble capable of multiplying itself as coming from dirt. Bacillus tetanus, amoebic dysentery, thermophilic spoilage, actinomycosis and botulism, are new terms, but the need of freedom from earth in wounds, in food, and in clothing is no recent discovery. The demonstration that soil, instead of being all dead, harbors millions of organisms, releases that flight of imagination which pictures the soil as a sort of Lilliputian zoo in which some magic hand has eliminated all barriers and set free every grade of minute but rapacious monster to go roaring after the next lesser grade as its lawful prey. Thus the soil is pictured to us in terms that lead us to ask what manner of thing it is.

The mass is firm. We walk upon it. We dump into it the waste, the worthless and the unwanted. Somehow all disappear. We look at it and thoughtlessly think of it as the product of the disintegrating power of cold, heat, rain, snow and all the other lifeless forces of the earth, yet the late Professor Marbut in one of his lectures said, "However fundamental climatic forces may be, they are destructive, not constructive." In their effect upon the surface layer of the earth, "They stop with gravel, sand, silt and clay." No one familiar with the waste places of earth fails to recognize in these words the desert. Then Marbut added, "Climate produces parent material, life makes it soil." Yet nowhere does the living micropopulation constitute more than a minute fraction of the soil mass.

The Soil Profile:—A vertical section of the soil is called a soil profile and its more or less apparent layers are designated horizons. The orthodox soil sampler interprets soil as earthy material hence brushes away all of the accumulated waste such as dead leaves, stems, and bits of animal matter which he calls the A_0 horizon. His soil begins only when he reaches amorphous material. From this, after his sample is taken, he discards all visible masses—recognizable as vegetable or animal in origin, and minerals larger than sand. The more progressive soil microbiologists, however, can not accept a distinction between pieces of root, for example, easily picked out, and the multitude of bits of living or dead roots which escape detection hence remain in the sample. They therefore have adopted this no man's land (horizon A_0) as microbiologically interesting, important and logically part of their territory.

Below this layer of organic matter we see a surface layer (A) the soil proper (solum) containing the black or brown organic substance known as humus, a second layer (the subsoil, B) partly colored or streaked with humus, and a third layer (C) composed of mineral soil materials. The organic factor in the upper layers constructively distinguishes them from the soil materials—mineral in character below.

The transition from one horizon to the other may be gradual or abrupt. On the basis of the structure and chemical composition of these horizons, the Soil Survey has listed and described something like 1,700 varieties or types of "virgin" soil in the United States alone, and a myriad more of types in other parts of the world. We are bewildered by the endless diversity in description of superficial form and structural arrangement; we are confused by formidable geological theories and impressive chemical diagrams. Regardless of these differences, some of us find evidences everywhere of fundamental homogeneities. Soil forming processes are great levellers. Universally distributed groups of organisms and universal organic processes are involved in the decomposition of plant and animal remains and in the subsequent transformation of the by-products of this decomposition into food for green plants. These processes follow lines which are much the same throughout the world, hence the heterogeneity of the picture is in detail—the really striking thing is, that a significant homogeneity can be traced through so complex a mineral substratum grown through and through by multitudes of individual organisms belonging to diverse groups.

Constructively below ground, the microbiologist is academically free. He can report his exact findings without risk of controversy outside the soil group. Within that group, controversy is the rule, not the exception. Geologist, chemist, physicist, botanist and agronomist—each claims a proprietary interest in the soil. Each looks at it from a different angle. Each feels abundantly able to defend his claims.

Academic freedom among scholars is limited by discretion. Within the narrow field in which a man has earned the right to speak, he is commonly heard with respect. Outside that area he is just another commentator from second-hand data with no special right to consideration. If he generalizes too broadly from the findings of his narrow field, he is promptly challenged by some one equally learned and equally sure that he has gleaned the truth, but a different truth from another line of investigation. Unfortunately the temptation to let our tongues run at large is always present.

I heard a man once report some very stimulating experiments with (shall I say?) geese—and apply the results to support his own view of a controversy about man involving not only physical but intellectual and social values. Another paused in a purely earthly discussion to regret that the Christian's idea of God is "not yet extinct." Such incidents are legion; one can stand in awe before him who is ready to die for a conviction but in some cases he would be tempted to applaud the executioner. In our field there does not seem to be any ground to cavil at the oath of allegiance and it is hard to see any definite relation of our data to meditative philosophical systems.

Generalizing from the particular is an ancient sin. Experiments with soil are expensive, laborious and time consuming. One man uses undescribed earthy material in which he plants millet, a second plants tomatoes, a third rye, and all summarize by discussing the reactions of "plants in soil." The microbiologist is not free from guilt—he weighs out 50 grams of "soil" adds 2 grams of this or that, incubates, analyzes and decides that microbial activity in "soil" is measurable in "x" milligrams or "y" parts per million of "A". The complexity of the micropopulation, further complicated by the difficultly measurable environmental factors, warns us that the most explicit statement of materials and procedures, will add greatly to the usefulness of our data. We are always thankful to the man who tells us exactly what he has done, how he did it and who details his results in sharply defined terms. We are also interested in the way he believes those results to fit into some philosophic whole to round out our knowledge of a particular field. But if he chooses to break over into the field of abstract meditation, we have only one request—that he shall not spoil the value of his scientific contribution by confusing his meditations with his observations.

Having attended a great many meetings of "learned" societies, having published rather freely, having read bales of "proceedings," and having stood at the foot of several martyr monuments, I sometimes wonder how much philosophical turmoil and physical violence might have been avoided if men had always distinguished clearly between essentials of truth in their experience and weird meditation which had no basis in truth.

But let us get back to our soil population. One of the first questions raised is—how large is this micropopulation? Some figures may be cited. The Rothamsted group reports between 15 and 25 millions to the gram; Brown and his colleagues in Iowa consistently found 2 to 6 millions; Waksman in New Jersey got 30,000 to 8 or 9 millions; Conn in New York State reported 5 to 400 millions. Each claimed to have determined the total population; the methods used diverged widely. These figures are sufficient to show that numbers alone help little, even though determined in a punctiliously taken representative sample, composited and homogenized from a series of cores taken at specified distances with the sampling tube. If such determinations are correlated with the factors in that soil which determine its usefulness, then if those factors are subsequently altered, and the soil is reexamined by the same worker, we obtain useful contrasts. We conclude that such bacterial counting by any method rigidly standardized may establish a population level or partial population-level or density, characteristic of a particular type of soil in a particular condition. Marked rise or fall of that micropopulation from that level may be correlated with favorable or unfavorable cropping conditions. At best, we have not yet reached the point where we feel warranted in trying to use such bacterial counts for practical ends. The great volume of work done has given us a general concept of population levels, related but not very closely, to soil descriptions.

This micropopulation has been described as composed of "myriads of interlocking units" which make up a "microcosm." Counts of this population as already cited run from a few thousands to the gram in a very acid soil to some hundreds of millions or more under special conditions. Sir John Russell and his colleagues at Rothamsted conclude that "about 20,000,000 bacteria per gram of soil is now considered a fair average number." This figure is based upon the "plate count" of the bacteriological laboratory made from samples of a good grade of cropping soil. If we add to Russell's figure the remainder of the population—molds, yeasts, protozoa, algae, etc., many of which scarcely appear in the ordinary "colony count" of the culture laboratory—we might increase it perhaps 25 per cent. This would make 25,000,000 as an average total population figure for the type of sample used as a representative.

A few generalizations about these organisms may be worth giving. Dig into the soil and you find here and there a larger animal or more frequently, a burrow—but you see none of these millions. You might roll the whole 25 millions into a pellet and it would be as large as a very small grain of sand. It would take about 25,000 such pellets to make a cubic centimeter. Yet their activities are measurable in various ways. Tests show that carbon dioxide evolved by respiration of these organisms escapes constantly in measurable quantities from the surface of the soil. Daily and hourly counts show constantly changing numbers. There is activity as long as reaction, temperature, moisture and food supplies permit. Few of them are destroyed by summer's heat or winter's cold, by flood or by drought. Even after the laboratory sampler has air-dried his earth, thrown out every piece of so-called foreign matter which he could see, crushed it with a roller to powder, then run it through a 2 mm sieve—those bacteria are yet there. Pour a little of that soil into a sterile container of fermentable material and in a few hours of incubation it becomes a seething mass of microorganisms.

Statistical Analysis:—The totals of population cited from different authorities vary sufficiently to require further discussion. If we scrutinize the figures for each tubeful of earth composited in making up the sample for determining these population totals, we find divergences in successive sampling from the same area so great as to trouble those bacteriologists to whom mathematical expressions of this kind are presumed either to have an exact meaning or, in their variation to hide something discernible by proper analysis. From such studies they have published page after page of graphs purporting to synthesize in a statistical way, totals of bacterial counts varying (let us say) from 13 to 23 millions and searching for a mathematical meaning in such differences from samples taken out of a single field. Physical, chemical and general biological data in these samples were ignored. Despite their efforts to obtain homogeneity, those long familiar with the hundreds of millions or even billions of bacteria per gram associated with actively rotting substances elsewhere, would be surprised if spaced samples from such a heterogeneous mass as soil gave totals varying less than 25, 50 or even 100%. Physical examination of the soil profile reveals so great variety of visible components as to forbid anticipation of close correspondence in bacterial populations in such samples even though the operator may throw out all visible pieces of rotten vegetation, living earthworm or dead cat, that happen to be caught by his sample tube. One wise old soil chemist expressed the opinion that he lost essential and valuable information if the laboratory helper put the sample through the homogenizing process before he saw it.

No one doubts the important service of statistics in fields where hundreds and thousands of items of reasonably nearly the same kind must be brought together for a specific purpose. In fields such as soil bacteriology in which physical limitations reduce the samples which one group can examine, to numbers readily grasped as individual figures in a table, the significance of the actual figures and their relation directly to characters within each sample, commonly far surpass in importance any generalization by statistical analysis of the group of samples. The question is not, shall statistics be applied, but where shall they be applied that they may contribute to, rather than obscure our search for truth.

If future studies of total soil populations are to yield important information, the samples taken must be fully integrated with all we know about the soil.

This changed attitude is represented in recent Canadian papers by Timonin and Gray in which series of samples were taken from well identified soil types. Temperature, water content, reaction, and organic matter were measured and recorded against the bacterial counts of every sample. The results point the way for future studies in this field.

If we accept the fact of a large micropopulation, we are faced with problems of analysis and interpretation. What do we know of these microbes and how can we use them? Intelligent control of the organisms encountered in farm operations, with the exception of a single group, stops at the surface of the ground. Nature has furnished the farmer with his soil-type and with his climate. The farmer knows how to handle such crop-associates as weeds, nurse-crops, or cover crops. At its entrance into the soil, his crop-plant passes into an environment which is unknown to the farmer, and almost unknown to the scientist. There the crop-plant must compete with a multitude of species of molds, bacteria and protozoa as well as more complex animal and plant forms. Of these we know something about certain species which are destructive parasites; we have actually learned to utilize the legume nodule bacteria, but the multitudinous remainder continue to be a task for the future. We have at present no consistent picture of what goes on—below ground.

Our twenty-five millions of microorganisms to the gram present a whole series of other problems that lead in different directions. To the systematist of a generation just past, they presented a new and great floristic field which yielded long lists of species new to science, and ecological situations of the utmost interest, because related in so many ways to human welfare.

American attempts at classifying soil organisms began scarcely 40 years ago. Some of those who set the original landmarks are still at work—notably Chester and Lipman. None of us are real pioneers. Decomposition of organic matter as a phenomenon had been common knowledge of mankind for ages. The use of manures for crop growing was already ancient in Bible times. Legumes as soil improvers were known to the Romans. The outlines of the nitrogen cycle had been already drawn and values measured step by step by chemists. Even sterilization of media goes back to Pasteur who was not interested in soil. We may as well confess that biologists did not start investigations in soil bacteriology; they were dragged in by the demand that the organisms whose presence was predicated by facts well established, be identified and studied. To satisfy this demand, men entered bacteriology from two directions. The botanists brought morphology bolstered by a smattering of chemistry into the study of microscopic species. The chemists brought quantitative analytical methods but little morphology and too often, no desire for any.

The earlier studies were largely morphological and attributable to such outstanding figures as DeBary, Brefeld and Ferdinand Cohn among the botanists. The microbiological literature of that period (1850 to 1870) was filled with descriptions of polymorphism in the fungi. Men who knew that they could plant an acorn or a potato, and follow its whole life history, thought a mold or a bacterium was different. In the early days of the culture laboratory men started with what they thought was one species and ended with a menagerie. They gravely described the whole aggregation as different manifestations of a single form of life—the dissertations of that period are interesting. Be it known we still receive cultures—supposed to be particular molds, in which two or three fungi, a half dozen bacterial strains, an occasional mite and a few protozoa may be found to complicate identification.

The idea of pure culture developed slowly; some have not caught it even now. A microorganism often presents strikingly different appearances upon different culture media. What appears to be strictly a green Aspergillus on a pair of moldy shoes, becomes a dense layer of yellow to orange fruit bodies (perithecia) upon 40% sucrose agar. Is it any wonder that polymorphism caught the fancy of whole groups of men between 1850 and 1880? Similar contrasts are easily cited for soil bacteria. With improvement of apparatus, it became easy to separate species whose mixtures presented great difficulties to Brefeld.

In the swing away from polymorphism taxonomists accepted the idea that fundamentals of structure (what are fundamentals anyway?) could be assumed to be fixed species characters. Color, shape of units, size of units, aggregation into chains, plates or "packets" were selected as diagnostic. Although whole series of strains did not fit into the preconceived scheme of things, for the time they were discarded with a pretext for dismissal. The idea of dependably fixed but abstract species-characters developed, and remains today, an endemic infection in many strata of workers who deal with microorganisms.

The botanical bacteriologists had started with floristic studies. They made lists of microorganisms found in particular soil populations; they isolated and described new species. They carried over into bacterial characterization, detailed description of the color, size and shape of cells, of cilia, of flagella, of spores, of thickness of cell walls, of aggregations of units into filaments or masses. Every variation from type description was given a new name. In accord with botanical usages, the substratum in which the species was first found was designated as habitat, and the geographical region was entered in the record as locality. The arbitrary conventionalism that the substratum and place of first discovery typifies the species, has made constant trouble in subsequent studies of higher plants: when applied to microorganisms it produces chaos.

To the early taxonomist the description of a microorganism was a simple process. Nature was assumed to be made up of units which as collected represented species. It was assumed that if the original specimen were described and preserved, succeeding workers had but to fit their findings to existing diagnostic literature and label their material accordingly.

From such activity, we inherit long lists of names for species whose type-habitat is *soil*. Believing the numbers of species few and readily separated by brief morphological diagnoses the early describers made simple task of it. Only a few of their species are safely identifiable today and still less of them are correlated with their distribution and function in nature.

Nomenclature and classification of organisms great and small dominated biology for many years. Perhaps it has been partially brushed aside on account of sins of scholarship, but no one has yet suggested a practical method of conveying information useful to his fellows, about a particular organism, without some kind of name and grouping definite enough to identify it to his reader or hearer. The vast literature of biology opens only to him who has for his organism the name under which that organism has been discussed by his predecessors. How can we understand each other if a microorganism appears in the soil under one name, and in medical bacteriology under another, or perhaps two more? This is no impossible conception. Examples are easily cited. Every organism great or small, eventually comes upon or into the soil. There are probably 100,000 kinds of fungi and nobody knows how many bacteria. Finding an organism in the soil may mean much or little—it may open vistas in soil biology; it may prove to be an inconspicuous saprophyte; or it may be a pathogen well-known to medical bacteriologists, if proper steps are taken to identify it.

Identification of species is more important today than ever before. Long, tedious and expensive investigations of incorrectly identified organisms have been repeatedly published to plague us indefinitely with citations of activity which no one can verify and no one can refute. Whatever excuse may be offered for the past, there should be no place in publication today for elaborate discussion of unidentifiable material.

One looks in vain through Bergey's Manual for recognition of many species which were long ago named and described for activities in the soil. Although the old barriers between groups of bacteriologists have partially broken down, there are still men working in medical laboratories, or dairy laboratories, who forget that dirt does get into almost everything hence lists of soil organisms should be searched before new species are described from other sources. Yes, and there are soil men whose eyes rarely see anything but dirt and to whom medical bacteriology is not only a foreign field, but one upon which they rarely even look—over the fence. We can no longer shirk recognition that any bacterium of any type-habitat, may come up to plague us in our soil studies. Special brands of biologists can hardly hope to live by themselves and do work in peace. Professor Bailey once made the remark that a particular scientist had relieved the situation by resigning, adding, "We never had but the one man about here who tried to put a high fence around his field and keep the rest of us out. We all took special delight in throwing our 'dead cats' over that fence."

The chemical bacteriologists likewise developed two lines of attack. Some tested for biological activities in mass. Thousands of samples of soil were taken by standardized procedure, analyzed, incubated and re-analyzed; I saw 5,000 flasks (Göttingen, 1905) incubating at one time for nitrification testing in a great laboratory; such results were aggregated into generalizations about soil fertility but the agents active were assumed, not known, and unfortunately sometimes they were not there. Broad differences in nitrification within great soil groups were readily established: when applied to particular cropping areas, the results were disappointing.

Such tests continue in use today but for restricted purposes or special intensive comparisons only; standardization in soil testing in the laboratory loses sight of so many biological factors operating in the field that the results can only apply within narrow limits to the solution of particular cropping problems. However suggestive the theoretic considerations may have been, very few of the tables covering thousands upon thousands of such determinations have any interest today.

The procedures of bacteriology have automatically tended to center activity upon the laboratory so completely as to give color to the charge that a pint of soil sent in by a correspondent can keep a whole group working for several years without feeling the necessity of going back to examine the field. The sum of abstract human knowledge perhaps grows thereby but perspective in presenting the specific information as a part of an integrated whole, is wanting.

In such studies, the single organism, the species and even whole groups were lost to consideration. Whole populations were dealt with in mass. The existence of discordant elements in such populations showed here and there in the results obtained. The biochemist had perforce to turn to the single species in pure culture to analyze his troubles. Here again there is a long story but only time for a few glimpses of its development.

As an example, Beijerinck's *Azotobacter* which fixes atomospheric nitrogen very accommodatingly in the laboratory, caught the imagination of soil men over the whole world. Publications by hundreds deal with *A. chroococcum* in the laboratory, or, with merely finding it in the field. Imaginative calculators have estimated its service to agriculture as an annual contribution in fabulous figures, but when what we actually know about *A. chroococcum* in the field is put to the crucial test that units of particular bacterial species must be present in countless millions if that species is to play a large part in soil processes, the probable significance of *Azotobacter* shrinks toward the mythical. No one has been able to find more than a few thousands to the gram anywhere and sometimes it is difficult to find at all. While hope still lingers that Beijerinck's organism may somehow and sometime be found to satisfy the fond dreams of its laboratory devotees, the iconoclasts have largely turned away in quest for some other agent to explain the nitrogen fixation known to occur.

Frequency of appearance in routine culture does not necessarily indicate significant responsibility for biochemical activity in the soil. *Aspergillus fumigatus* is world-wide in its distribution in the soil, but it is equally common in decaying vegetation and in and upon cereal grains; it is parasitic in the lungs of birds and sometimes even in man. It grows readily from near the freezing point to 45°C. Like most cosmopolitan organisms it is also omnivorous; it produces a wide variety of enzymes. In laboratory test one strain of it from the soil broke down cellulose so readily that its finder, not knowing the species, called it *Aspergillus cellulosae.* Nevertheless, there is little evidence that this species produces in the soil sufficient masses of vegetative mycelium to be a real factor in the breakdown of plant remains. This is only one example: Soil mycology papers list whole series of species easily isolated, universally distributed, but on account of their limitation in mass development, only capable of being minor contributors to the aggregate of biochemical changes in the soil. Nevertheless we have extensive researches upon the biochemical activities of many of these species.

As an example in sharp contrast, matted mycelium was easily seen throughout the top inch of the mineral soil in several acres of a wooded area in southern Virginia. Conspicuous fruit bodies connected directly with the strands in this top soil identified the organism as a species of *Clavaria*, yet no one has ever reported *Clavaria* in laboratory cultures from soil nor has anyone tested this Hymenomycete for biochemical significance. The mushrooms, puffballs and related forms are constant members of the soil population and form great masses of vegetative mycelium but only a few of them fruit readily in laboratory culture. Identification of their mycelia when they do appear is commonly impossible. Aside from the cultivated mushroom, we know therefore exceedingly little of the vegetative activity of the soil inhabiting members of this whole group with its thousands of species, although there is constant evidence of their presence in mass in the field. A new line of attack will be necessary if we are to evaluate their contribution to soil changes.

Search for organisms capable of special activity has taken many forms. One of the commonest has been the preparation of the so-called "enrichment" media. For this purpose, culture solutions prepared to contain approximately the necessary elements for growth have been used to test for species capable of attacking wide ranges of organic and inorganic substances. Cellulose fermenting forms have been studied extensively. Iron bacteria, sulphur bacteria and selenium fungi have been given recent and rather conspicuous attention. Once in the laboratory few of these organisms have been followed back to the soil to prove their significance or establish their exact relationship to soil processes.

The classic nitrification work of Winogradsky, and the arsenic studies of Gosio, go back to the 1890's. A few years ago we had occasion to repeat arsenic work of Gosio and found other species in the soil capable of disclosing the presence of arsenic by volatilizing it when present even in very small quantities. We were promptly called upon to produce fungi capable of volatilizing 1,500 pounds of lead-arsenate to the acre, that we might rid certain areas of this excess. Even if it had been possible to produce a mold population capable of this activity within a reasonable time, man and beast would have needed to move from that neighborhood during the process to escape the odors evolved.

To read some of this literature one would expect Gosio's mold to be a conspicuous example of a species with specialized relations to the environment, but in fact it (*Penicillium brevicaule* or *Scopulariopsis*) is a cosmopolitan saprophyte which is found in the soil everywhere; it produces ammonia in cheese cellars; it contaminates stored meat; it has been found abundantly upon poorly cured hay, and in a thousand other places. Its effect upon arsenicals does not seem to have any necessary connection with its growth and development in nature.

Whole series of studies of "named" species have been made in which no evidence of significant relation to soil problems is presented. Unless a species can be found capable of development in mass under actual soil conditions, the demonstration of such an activity *in vitro* merely raises the possibility of function somewhere in nature: it does not establish the importance of the species as a biochemical agent in the soil.

The history of this quantitative literature about single species is most interesting. The idea of specificity of activity had crept into microbiological literature far back in the 19th Century. Each organism was pictured to us as performing one function. The organic cycle became the original pattern for the factory assembly line. Decomposition was supposed to be accomplished step by step. The first agent performed one process then ceased. A second organism performed the next process and so on until the end. Recomposition was the same process reversed. The only difficulty about it is that it is not true. The agents of decomposition are a tremendously complex aggregation of competing units of many groups; some of them are capable of performing many functions although no species perhaps is able to complete the whole process. Such a thing as a succession of organisms exists perhaps in theory but under natural conditions these activities overlap so completely, and duplicating species are so numerous, that the old certainties of succession are gone. Nevertheless we find persistent faith in the traditions of our great authorities.

In the purely chemical scheme of things a microorganism became a special kind of reagent which was to be procured from a morphological systematist and which could be kept in a bottle with a name on it, and called upon at will to produce one definite measurable effect under specific conditions. We are told that if a proper survey of these activities were made, the whole course of nature would be predictable. The biometrists would reduce biology to equations. The doctrine is defended as a legitimate part of a mechanistic philosophy. But we face the fact that the simplest of those complex biological processes as worked out in the laboratory, took the genius of a generation of chemists to unravel and constantly requires the intelligent skill of expert chemists to operate. The infinitely complex processes which we see undescribed would need omniscience to reduce to formulae and mechanism, and take both omniscience and omnipotence to operate. So far as the present situation appears, we have done little more than substitute a new batch of incomprehensible terms for the usages of the old time vitalist. We must welcome every determination and every observation which helps establish our control of new processes and our restatement of old problems, but the limitlessness of the fields opened up give little promise of completed knowledge thus far.

Obviously each step we have discussed tended to carry us farther and farther away from the soil: There are other soil problems to be considered.

Dependence on food supplies:—Many descriptions of great micropopulations report the organisms as growing in the soil but do not recognize the necessity of organic remains as food supply back of such aggregates. Even discussions of root rot fungi sometimes put forward the bald assumption that as vegetative mycelia they start from some point then spread blindly in all directions, attacking and killing roots of crop plants when encountered at any point on the advancing front. To meet this hypothetical picture, Miss Morrow and her co-workers in Texas excavated whole root systems of cotton plants and demonstrated that root rot fungi follow visible roots and pass to new plants where interlacing rootlets meet between the rows of host plants. Lines of infection are not due to "scout" mycelia hunting new victims but to contact transference. Fungi and bacteria in the soil follow food supply—they do not search blindly for it. Parasitism upon living roots, however important to the crop grower, accounts for little of the soil microbic activity.

The complex interlacing root systems represented by a sod are familiar. Dittmer computed that his rye plant specially grown in a box 12 by 12 by 22 inches for 4 months, produced a root system containing some 13 millions of units, totalling 387 miles in length. We may disregard these exact figures but they emphasize the completeness of penetration of the soil by the roots of crop plants as ordinarily spaced in the field. If you cut a block from the forest floor, the mass is often held together with interlacing tree roots forming half its volume. At the end of a cropping season in a humid area, the whole surface soil is readily seen to be matted with roots of corn, wheat or cotton. Microorganisms are present along every millimeter of these root systems while living. The background is thus prepared for the development of immense numbers of bacteria when the surface growth is destroyed and the root systems die. Even in the unplowed land, root pruning both of trees and of herbaceous perennials furnishes a continuous supply of dead and dying plant material. Decomposition of annuals, becomes an explosive process involving the development of countless millions of bacteria. There is thus a continuity of food supply under soil conditions that provides for great micropopulations; there is microbial activity continuous but fluctuating widely with the abundance of food and the variation of climatic conditions.

Soil microbiologists have done something toward describing what we find in these tremendously complex aggregates of roots and microbes. In one single group they have gone farther and found that particular bacteria may be isolated by proper methods and inoculated or planted upon the seed or in the soil, to produce a known and desirable end. Nodules occur upon the roots of a long list of leguminous plants. By proper culture, we isolate the organisms, *Rhizobia*, from the nodules, propagate them in pure culture, and put them back in the soil or upon plants of the same kind, and render these plants effective and profitable crops in poor soils in which they grew feebly without these bacteria. This symbiotic relation makes possible the accumulation and fixation of nitrogen from the air—hence this whole group of leguminous plants becomes immensely valuable in our campaign for land improvement. The history of this achievement is told in a book by Fred and his colleagues, who cite their sources in 2,000 publications produced mostly within the last 50 years.

Repeated attempts to exercise such control with other crops and other bacteria have failed. Our people working in Texas have in the past two years, inoculated plants with particular organisms and appear to recover those organisms at will—but thus far attempts at practical applications have not succeeded. That field is open and scarcely explored today. There is every reason to believe that it has great possibilities.

This tale of mine might have been designated, confessions. It tells of failures, of futile ideas followed until the worker reached the dilemma of the Experiment Station which was said to have "spent so much money on Dr. A's attempt to climb a tree that they did not dare let him come down." It recites the history of things partly done and abandoned. It lists unfinished tasks. But it also tells of visions of problems worth doing which are brought into bold relief by the work already done.

Bacteriology, as a branch of biology, is new. There are men in this room who can remember how the world hailed the pioneer discoveries of Robert Koch in the 1880's. It took twenty years more to bring the procedures of the bacteriological laboratory to a stage in which the worker could keep his vision partly on the ends to be obtained instead of solely upon the manipulations necessary to reach any results.

Microbiologically, "below ground" was outside the field of science a half century ago. Like the squirrel of our prologue, the worker had to feel his way. Is it any wonder that sometimes he got lost?

Twenty-five millions of organisms to the gram of soil! Bacteria, molds, actinomycetes, myxomycetes, algae, protozoa and more complex!—they fill a microbiological jungle in which friends and foes, saprophytes and parasites, symbionts and antagonists compete with each other and with crop plants for space and food. They are a challenge to our skill in culture, to our discrimination in interpretation and to our constructive imagination in devising means to control and direct these myriads to useful ends.

GEOLOGY.—*Prismatic jointing in Triassic diabase of Virginia.*[1]

ROLAND V. WARD and JOSEPH K. ROBERTS, University of Virginia. (Communicated by ROLAND W. BROWN.)

Prismatic jointing in Triassic diabase of Virginia was first observed during the summer of 1929 when a quarry for road metal was opened in Fauquier County, approximately 4 miles northwest of Remington, near U. S. Highway 29. At the present time the quarry is in operation, and the enlarged dimensions have been sufficiently extensive to expose the jointing in fresh condition, which has enabled a more detailed investigation, especially in the mineral content of the diabase. The quarry is approximately 100 by 200 feet, and about 15 feet deep.

Diabase is widespread over the Triassic belts of Virginia, also over much of the Piedmont and Blue Ridge, and a portion of the Valley province. This rock occurs both as intrusives and extrusives in the Border conglomerate, Manassas sandstone, and Bull Run shales of

[1] Received February 3, 1938.

Fig. 1.—A block of diabase after blasting, showing prisms of diabase.
Fig. 2.—View of the prismatic diabase in place.

Upper Triassic age. In the above mentioned quarry the diabase occurs in the form of an extrusive sheet, and it has the apparent strike of N-70-E to N-80-E, and the prisms dip from 68° to 72° in a N-15-E direction. If the prisms were originally in a vertical position, their present position is to be accounted for by later movements. Of the twenty prisms measured, thirteen are pentagonal and seven hexagonal. None with three, four, or more than six sides were observed anywhere in the quarry. The sides of the prisms are generally smooth although a few are curved and irregular. Some taper to a slight extent. The usual transverse breaking into convex and concave surfaces was observed in only a few specimens. Width of the faces ranges from 3 to 10 inches. Only a very few prisms show any tendency toward equilateral faces as in the Giant's Causeway, the Devil's Tower, or the extrusive sheets of Idaho, Oregon, and Washington. The prisms fit tightly together in the fresher diabase, and even more compactly in the weathered rock.

The fresh diabase shows a dull, dark blue color but changes with the degree of weathering to a reddish brown. The fresh rock is hard and brittle, and maintains a remarkable uniformity in physical properties over the Triassic areas of Virginia. The most highly weathered phases of the diabase crumble easily, and form a characteristically red residual soil. The megascopic texture is fine grained to dense as observed in the quarry. On one side of the quarry the diabase is jointed, while on the other side it appears sheet-like. In the latter form the amygdaloidal structure occurs, and less frequently in the prismatic diabase. The amygdules vary from a fraction of a millimeter up to 30 millimeters. In practically all of the amygdules are found silica in the form of chalcedony, and subordinate amounts of quartz and calcite. There are white stringers of chalcedony, and calcite filling fissures whose length rarely exceeds 8 centimeters, and width 2 millimeters. No evidence of flow structure has been observed, even under the microscope. Amygdaloidal structure does not show in the weathered zone, which extends down about five feet.

Microscopically the prismatic diabase shows a typical ophitic texture, an intergrowth of lath-shaped feldspars and pyroxenes. These crystals are small, suggest a slower rate of cooling than would have occurred in the uppermost layers of an extrusive sheet, but compose a much finer texture than would have resulted from the cooling of an intrusive sheet of any considerable dimensions. This intergrowth shows a greater abundance of feldspar and a smaller proportion of pyroxene than much of the Triassic diabase of Piedmont Virginia,

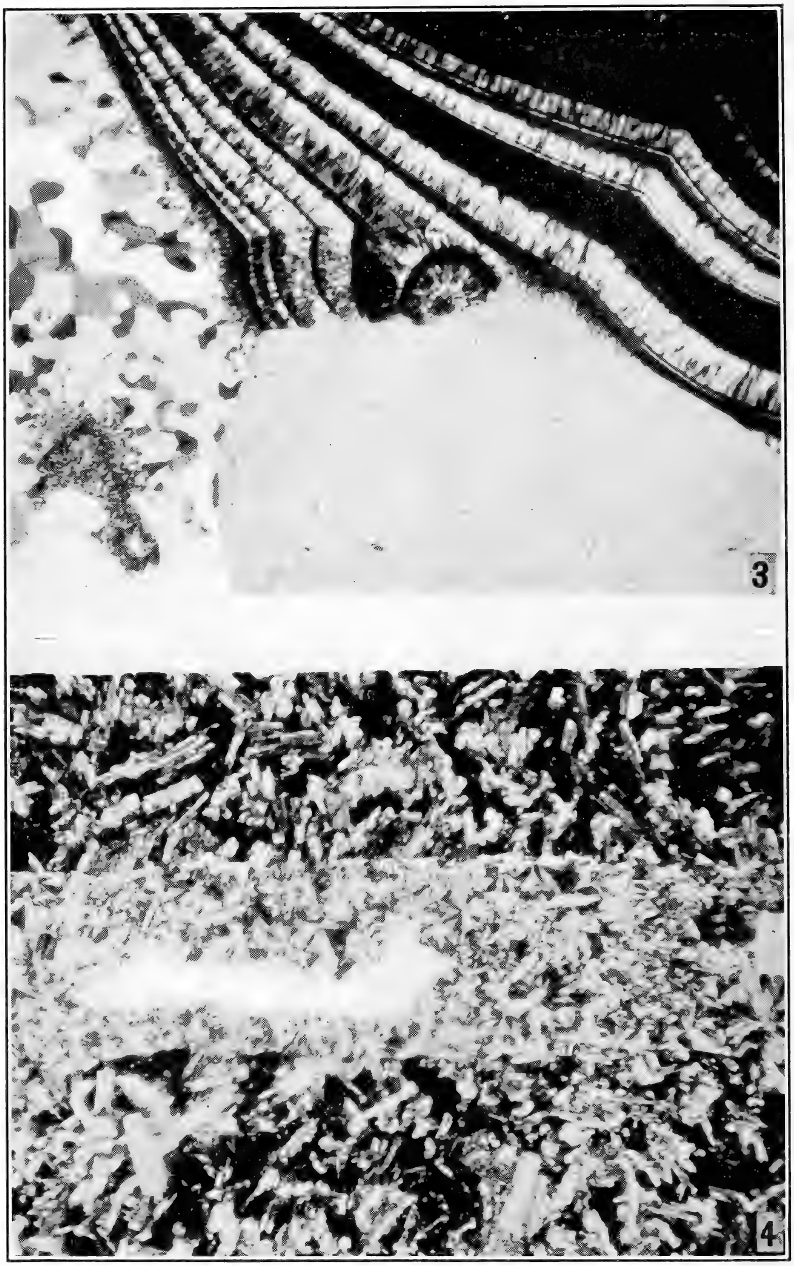

Fig. 3.—Photomicrograph showing banded chalcedony, a spherulite lying near a calcite crystal, and granular quartz. ×50. Fig. 4.—Photomicrograph of diabase showing a stringer of opalized silica with a long calcite crystal. ×50.

otherwise it differs in no way from that of the other diabase of dikes and stocks of the Triassic. The fabric is generally even but in places irregular. The texture of the prisms remains quite uniform in both vertical and horizontal directions.

The principal minerals are labradorite and augite. The labradorite shows twinning despite the variable degrees of weathering, which cause it to appear as corroded. The augite has apparently undergone more alteration than the labradorite. Some of it has altered to chlorite magnetite, and other undetermined oxides of iron. Certain pyroxene crystals too small to be identified with certainty are believed to be hypersthene.

The accessory minerals which occur in small and variable amounts are small anhedral grains of quartz scattered through the rock, occasional crystals of apatite, and ghost crystals of olivine. Small amounts of biotite were observed in some sections. Secondary minerals comprise subordinate proportions of chlorite, calcite, sericite, magnetite, other iron oxides, and chalcedony. Stringers are filled with chalcedony, which under the microscope give the appearance of typically opalized silica with elongated areas of intergrown calcite. The chalcedony which fills the amygdules is banded in most specimens, and there are small spherulites of the same. Mixed with the chalcedony are areas of small quartz grains and large crystals of calcite. The spherulites are formed of radiating fibers. The chlorite occurs as small flakes, and appears to be due to hydrothermal alteration of the augite, replacing the original crystal wholly or in part. Quartz is found towards the center of the chlorite. Sericite is scattered rather profusely through the labradorite. The calcite occurs in both the stringers and amygdules in irregular masses.

Prismatic jointing in Triassic diabase has been known and described from New Jersey, Pennsylvania, and New York. Attempts have been made to determine the cause of the jointing in the exposures in Virginia. Some twenty years ago a comprehensive study of prismatic jointing was made by Sosman[2] in which distinctions were recognized from field studies as between jointings due to contraction, convection, and those due to weathering. In the light of all available evidence bearing upon jointing in the Virginia diabase, it seems that it can best be explained as resulting from contraction on cooling. Using the criteria cited by Sosman in support of the contraction theory, there was observed as follows: (1) the pentagonal nature of the greater

[2] SOSMAN, ROBERT B. *Types of Prismatic structure in igneous rocks.* Jour. Geol. **24**: 215–234, 5 figs. 1916.

number of prisms, (2) small diameters of the prisms as compared with those of the Giant's Causeway and the Devil's Tower (the latter attaining as much as six feet) (3) no apparent change in texture from the center to the periphery of the prisms, (4) great irregularity of faces on the prisms, and (5) relative scarcity of convexity and concavity in cross-jointing. The amygdaloidal structure suggests that the diabase is a sheet which was extruded towards the close of Upper Triassic (Keuper) time in Virginia.

PALEONTOLOGY.—*Five new genera of Carboniferous Crinoidea Inadunata.*[1] EDWIN KIRK, U. S. Geological Survey.

Owing to a series of misunderstandings, mischances, and mistakes the genera *Zeacrinus*, *Woodocrinus*, *Pachylocrinus*, *Scaphiocrinus*, and *Graphiocrinus* have been involved in a maze of nomenclatorial difficulties. Springer (1911) was well on the way toward clearing up the situation in part and did extricate *Pachylocrinus* from the confusion, which was his immediate purpose. He suggested the separation of one group of species under a new genus, but unfortunately did not give it a name, referring the species to *Woodocrinus*? instead. Subsequently Springer (1926) threw typical members of this latter group back into *Zeacrinus*, under which they had first been described in the main. This action again made *Zeacrinus* a catch-all for Carboniferous crinoids whose "only stable character," according to Springer (1926, p. 78), "is the heterotomous arm-branching, with mostly uniserial, short and distally quadrangular brachials." It is only fair to state that this paper was written by Springer under most adverse conditions, with seriously impaired health and without access to specimens and limited access to literature. It seems probable that he overlooked his own conclusions of 1911, for otherwise he certainly would have mentioned them and given reasons for their abandonment.

In the present paper a number of species will be considered, most of which have been referred to *Zeacrinus* at one time or other, chiefly by Wachsmuth and Springer and by Springer. To these are added some species that seem referable to the genera here described. It is not my purpose at this time properly to assign to their respective genera the large number of species that at one time or other have been referred erroneously to *Zeacrinus*. In earlier days Meek considered *Zeacrinus* a probable synonym of *Hydreionocrinus*. Meek and Worthen, Shumard, and Lyon considered the possibility that *Zea-*

[1] Published by permission of the Director, Geological Survey, United States Department of the Interior. Received Feb. 1, 1938.

crinus and *Graphiocrinus* were synonyms. Later, Miller and Gurley's species of *Zeacrinus* were about equally divided between *Zeacrinus* and *Phanocrinus*. Some species referred to *Zeacrinus* will fall into *Pachylocrinus*. The reference of many of the described species to their respective genera can best be made after the genera involved are clearly defined, each with a nucleus of characteristic species referred to it. Short of a monographic study of the Inadunata, a treatment such as that given here seems the most feasible method of attack on an admittedly difficult problem. The group more or less centering about *Zeacrinus* was chosen because it seemed to be the one most involved in nomenclatorial difficulties, and the species of which historically were the most uncertain of placement.

An attempt is here made to create generic groups on the basis of genetic relationship and evolutionary trends. In the Carboniferous thousands of specimens of Inadunata are available for study in the collections, representing a long and not greatly interrupted period of geologic time. It should then be possible to segregate lines of descent and express the results in terms of classification. Undue emphasis on one structural feature, such as the ventral sac or the plates of the posterior interradius, is unfortunate. It has been found that combinations of characters, with varying weights given to different factors dependent on the stage in phylogeny, give the most satisfactory results. Such genera do not lend themselves well to placement in analytical charts, but this may be an advantage rather than otherwise. Such genera, however, if properly made, possess the merit of having definite stratigraphic value and can be used intelligibly in the discussion of biologic problems. A discussion of the criteria used in discriminating the genera would be desirable but in itself would prove to be a work of considerable size. The criteria after all are essentially those used by critical workers in the past. In the brief generic diagnosis an attempt is made to present the norm for the genus, with brief indications of permissible variants in structure.

In the lists of species the dates and authors' names alone are given for bibliographic reference, and the complete citations may be found by referring to the bibliography at the end of the paper. No attempt is here made to indicate synonymy of species or quote synonymies hitherto made by authors. Either would be of little value at this time. I have had access to the types of the majority of the species, or reasonably authentic specimens identified by Wachsmuth. In the case of several of the species illustrations are wanting and in others are of poor quality. The types of some of these species have apparently been lost. Many species have been based on immature individuals, and these are particularly difficult to place. Horizons and localities are quoted as given in the original descriptions. Amended citations of stratigraphic horizons are given in parentheses, where available and when known to differ from the original text.

The genotypes of five of the six genera discussed in this paper, *Alcimocrinus, Cercidocrinus, Eratocrinus, Zeacrinus*, and *Linocrinus* are very fully illustrated by Springer (1926). For the illustration of the genotype of *Adinocrinus* one must refer to the original description of Wachsmuth and Springer.

Zeacrinus Troost

Zeaecrinites, nom. nud., Troost, p. 419, 1849; p. 61, 1850.
Zeacrinus Troost, in Hall, p. 544, 1858.

Genotype.—Zeacrinus magnoliaeformis Troost.

Generic diagnosis.—

Crown. Ovoid.

Dorsal cup. Basin-shaped with deeply invaginated base.

IBB. Small, forming bottom of basal pit, covered by column.

BB. Variable in size and shape but typically elongate, lanceolate, taking part in the basal pit.
Post B, when in contact with anal x, greatly elongated.

RR. Radial facet extends full width of R, suture not gaping. Articulating face at high angle.

Anal plates. Variable in size, shape, and arrangement. Typically three plates in cup. Anal x in contact with post B, meeting it on a narrow oblique face. RA penetrates deeply between post B and R post B, sometimes completely separating them. RA meets post B laterally and r post B on a very narrow face. In later phylogenetic stages the anal plates tend to migrate out of the cup. RT sometimes may do so. Anal x may lose contact with post B, its position being taken by RA, which in turn separates from post B.

IBr. One or two in anterior radius. One in other rays.

Arms. Endotomous. Rami laterally appressed, stout, with slightly convex backs. Br quadrangular.

Ventral sac. Pyramidal, with broad base.

Characteristic species of the genus.—

Zeacrinus magnoliaeformis Troost

Zeaecrinites magnoliiformis, nom. nud., Troost, p. 419, 1849.
Zeaecrinites magnoliaeformis, nom. nud., Troost, p. 61, 1850.
Zeacrinus magnoliaeformis Troost, in Hall, p. 544, 1858.
Zeacrinus magnoliaeformis Springer, p. 81, pl. 22, figs. 4–11, 1926.

Geologic and geographic distribution.—Zeacrinus as known is widely distributed in rocks of upper Mississippian age. In the United States it is one of the most characteristic crinoids of the Chester group. In Europe typical species of the genus are known in beds of equivalent age in England and Scotland.

Relationships.—I conceive the ancestor of *Zeacrinus* to be an undescribed genus, the earliest known species of which is found in the Keokuk. The genus carries on in the Borden of Indiana, the Warsaw of the Mississippi Valley, and the St. Louis of the same region. The early history of *Zeacrinus* proper seems to lie in the gap between the St. Louis and Chester. Forms referable to *Zeacrinus* may be expected in the Pennsylvanian as the genetic line continued to the Permian, *Parabursacrinus* of this age differing little from *Zeacrinus* other than in the structure of the posterior interradius.

Adinocrinus, n. gen.

Genotype.—*Zeacrinus nodosus* Wachsmuth and Springer.

Generic diagnosis.—

Crown. Expanding slightly to level of II A x, then more rapidly to level of III A x, then curving inward.

Dorsal cup. Depressed basin-shaped, small in comparison with the size of the crown, sharply pentagonal in outline.

IBB. In bottom of central depression, covered by column or slightly projecting beyond it.

BB. Relatively very small, typically showing as triangles separated by the RR, which in such case contact with the IBB. Post B larger than the others. In one specimen (young?) three of the BB meet laterally, but by very narrow faces.

RR. Proportionally very large. Radial facet extends full width of R. Suture gaping. Articulating face at high angle and very deep.

Anal plates. RA long and narrow, sometimes touching, sometimes not touching r post B; meeting post B on long lateral face. Anal x usually high in cup, separated from post B and lying in line with RA, on which it rests. RT resting on sloping upper right shoulder of anal x and either on the truncated upper face of RA or a narrow facet on upper left shoulder of post R.

IBr. Five in anterior radius in the three specimens seen. One in all other radii. IBr_1 of ant. R very high with oblique upper face.

Arms. Isotomous, with two divisions above the main dichotom. The rami are very stout, with rounded backs and composed for the most part of quadrangular Br. Below the finials many of the Br show a pronounced taper, but in all cases the Br extend the full width of the ramus. All axillaries are nodose, and the proximal Br of each series is larger than the succeeding Br and is strongly convex to nodose. This applies to all three species of which the arms are known. Below the III A x there are processes on the lateral margins of the Br which interlock with similar processes of the Br of the juxtaposed ramus.

Ventral sac. Unknown.

Characteristic species of the genus.—

Adinocrinus compactilis (Worthen) n. comb.

Zeacrinus compactilis Worthen, in Meek and Worthen, p. 536, pl. 21, figs. 5a, b, 1873. "Lower Carboniferous, Cumberland County, Kentucky." (Figured on plate labeled "Chester Beds."); Wachsmuth and Springer, p. 128 (351), 1880; Wachsmuth and Springer, p. 243 (167), 1886.

Adinocrinus nodosus (Wachsmuth and Springer), n. comb.

Zeacrinus nodosus Wachsmuth and Springer, p. 243 (167), pl. 6, fig. 9; pl. 9, fig. 3, 1886. "Keokuk limestone." Whites Creek Springs, near Nashville, Tenn., (New Providence equivalent).

Geologic and geographic distribution.—The genus *Adinocrinus* is known only from the New Providence formation, lower Mississippian, of Kentucky and an approximately equivalent horizon at Whites Creek Springs, near Nashville, Tenn.

Relationships.—With a dorsal cup resembling *Zeacrinus* near the end of its line, and with arms of such extraordinary character, one is at a loss to indicate relationships or point out any genus which might serve as an antecedent type. I do not think *Adinocrinus* should be placed in the same family as *Zeacrinus.* The pentagonal cup and the narrow posterior interradius were probably induced by the unusually heavy arms. The narrow posterior interradius combined with the upward migration of anal plates, a tendency common to many Inadunate lines, has given us a cup strikingly like *Zeacrinus* of the later type. There all resemblance to *Zeacrinus* and its allies ceases. If we lack an antecedent type there is a later type that has some of the outstanding peculiarities of *Adinocrinus. Protencrinus* Jaekel (1918) from rocks of Pennsylvanian age in Russia has similar small subtriangular BB separated by the RR, which extend down to the IBB. Very heavy arms with cuneate nodose Br also favor the relationship. In *Protencrinus* the arms remain simple above the first dichotom, but this is permissible, as a reduction in the number of rami can be demonstrated in other crinoid lines. In *Protencrinus* the anal plates have passed entirely out of the cup, which would be expected in a descendant of *Adinocrinus.* A dorsal cup from the Permian of Timor has been referred to *Protencrinus* by Wanner (1924), and a dorsal cup from the Viséan of Germany has been identified as *Protencrinus* by Schmidt (1930).

Alcimocrinus, n. gen.

Genotype.—*Zeacrinus girtyi* Springer.

Generic diagnosis.—

Crown. Subcylindrical, slightly spreading distad.

Dorsal cup. Depressed basin-shaped, invaginated at base.

IBB. Small, in central depression, concealed by column.

BB. Subequal, relatively large.

RR. Radial facet extending full width of R, suture not gaping.

Anal plates. RA rests subequally on sloping shoulders of post and r post BB, not penetrating deeply between them. Anal x rests on the wide, horizontal distal face of post B.

IBr. Two in all rays, but more might be expected in ant. R.

Arms. Endotomous. The outer portion of the half-ray is essentially an arm-trunk, very stout and reminding one of certain Camerate types, such as *Ctenocrinus.* The rami given off to the inner side of the ray are more numerous than in any genus of this group and resemble ramules more than true arm branches. The Br of the main arm-trunks are quadrangular in the main but with interspersed cuneate ossicles. The Br of the side rami are quadrangular.

Ventral sac. The ventral sac is long and club-shaped, extending beyond the tips of the arms.

Characteristic species of the genus.—

Alcimocrinus girtyi (Springer), n. comb.

Zeacrinus girtyi Springer, p. 84, pl. 23, figs. 9, 9a, 1926. "Morrow formation of the basal Pennsylvanian; near Crittenden in northeastern Oklahoma." (Wapanucka limestone *fide* Ulrich.)

Geological and geographical distribution.—The only known species of the genus is found in the early Pennsylvanian (Morrow group) of Oklahoma.

Relationships.—*Alcimocrinus* differs from *Zeacrinus* in important respects. The dorsal cup, though depressed basin-shaped, has essentially the structure of the early Mississippian species here referred to *Eratocrinus*, as pointed out by Springer (1926, p. 85). The presence of two IBr in the rays other than ant. R is of importance in a type as late as this. The long club-shaped ventral sac is also reminiscent of *Eratocrinus*, though considerably longer than in that genus. The arms of *Alcimocrinus*, which are in effect arm-trunks with lateral ramules, differentiate the genus from any other known. *Parabursacrinus* Wanner of the Permian, which Wanner probably with justice derives from *Zeacrinus*, is essentially *Zeacrinus* as to arms and shape of crown. It is probable that *Alcimocrinus* lies outside the *Zeacrinus* line, and the two are to be derived from a common but fairly remote ancestor.

Cercidocrinus, n. gen.

Genotype.—*Poteriocrinus bursaeformis* White.

Generic diagnosis.—

Crown. Spreading gradually from base.

Dorsal cup. Turbinate, not invaginated at base.

IBB. Plainly visible in lateral view, relatively large.

BB. Subequal, of nearly same height as breadth.

RR. Radial facet the full breadth of the R, suture not gaping.

Anal plates. Three in cup, RA resting subequally on upper sloping shoulders of post and r post BB, x resting on horizontal wide truncated distal face of post B.

IBr. Three to four or more in ant. radius, one or two in other radii. A single IBr (other than in the ant. R) seems normal for Burlington time, though exceptions have been seen in single rays. In the Kinderhook one new species has two in all rays, except the anterior, which has seven.

Arms. Endotomous, long, rounded, sides not flattened, showing that the rami were not normally closely appressed. Br very low, quadrangular.

Ventral sac. Unknown.

Characteristic species of the genus.—

Cercidocrinus blairi (Miller and Gurley), n. comb.

Poteriocrinus blairi Miller and Gurley, p. 61, pl. 4, figs. 1, 2, 1895. "Burlington group, at Sedalia, Missouri."

Cercidocrinus bursaeformis (White), n. comb.

Poteriocrinus bursaeformis White, C. A., p. 10, 1862. "Lower division of the Burlington limestone, Burlington, Iowa."

Zeacrinus bursaeformis Wachsmuth and Springer, p. 128 (351), 1880.
Woodocrinus bursaeformis Wachsmuth and Springer, p. 242 (166), 1886.
Woodocrinus? bursaeformis Springer, p. 147, 1911.
N. Gen. bursaeformis Springer, p. 148, 1911.
Zeacrinus bursaeformis Springer, p. 79, pl. 21, fig. 1, 1926.

Cercidocrinis cirrifer (Laudon), n. comb.

Pachylocrinus cirrifer Laudon, p. 63, pl. 6, figs. 3, 4, 1933. "Gilmore City formation, Gilmore City, Iowa."

Cercidocrinus fimbria (Laudon), n. comb.

Pachylocrinus fimbria Laudon, p. 64, pl. 5, figs. 2, 3, 1933. "Gilmore City formation, Gilmore City, Iowa."

Cercidocrinus infrequens (Laudon and Beane), n. comb.

Zeacrinus infrequens Laudon and Beane, p. 257, pl. 17, figs. 11, 12, 1937. "Hampton formation, Le Grand, Iowa."

Cercidocrinus? sampsoni (Miller and Gurley), n. comb.

Poteriocrinus sampsoni Miller and Gurley, p. 65, pl. 4, figs. 9, 10, 1895. "Chouteau limestone at Sedalia, Missouri." (Dorsal cup only.)

Geological and geographic distribution.—*Cercidocrinus* is known only from the Kinderhook, Chouteau (?), and Burlington formations of Iowa and Missouri. It reached its maximum size in the lower Burlington, and this seems to have been its latest appearance. The maximum number of species has been found in the Kinderhook. In addition to those listed there are at least two additional new species from that horizon.

Relationships.—It is difficult to draw conclusions in regard to the interrelationships of *Cercidocrinus*. Lacking knowledge of its ontogeny or its Upper Devonian antecedents we can only attempt a placement according to our knowledge of the behavior of similar crinoid stocks. Its relationships seem to be nearest to forms commonly referred to *Pachylocrinus*.

In arm structure *Cercidocrinus* most nearly resembles *Eratocrinus* from which in its known characters its most notable difference is the turbinate dorsal cup and the prominent infrabasals. The crown has a different habit, spreading gradually distad, and the rami were not tightly appressed, as against the pyriform crown of *Eratocrinus* with its normally tightly packed rami. In the form of its dorsal cup *Cercidocrinus* approaches the British genus *Woodocrinus*, from which it chiefly differs in the structure of the arms, In *Woodocrinus* the arms are relatively short, stout, tapering rapidly distad. and isotomous in their division. *Coeliocrinus* differs chiefly from *Cercidocrinus* in its cuneate brachials, approaching a biserial condition. The ventral sac of *Cercidocrinus* being unknown, comparisons with that of *Coeliocrinus* are out of the question. The stress laid on the character of the distal portion of the ventral sac in classification among the Carboniferous Inadunata has been greatly overdone. Such structures should be made subsidiary and considered only as accessory features in evaluating a genus.

Eratocrinus, n. gen.

Genotype.—Zeacrinus elegans Hall.

Generic diagnosis.—

Crown. Elongate, usually with closely appressed arms, typically inverted pyriform in shape.

IBB. Small, concealed in basal pit.

BB. Of medium size, helping form the basal depression.

RR. Radial facet full width of radial, suture not gaping.

IBr. Two to five in the anterior radius, invariably one in other rays in all known species. [The two IBr in the r post R of fig. 2a, pl. 21 (Springer, 1926) are incorrect.]

Arms. Endotomous with slightly convex to rounded backs, composed of unusually low, quadrangular Br. Rami laterally appressed. Early species of *Eratocrinus* or young specimens may be expected to show isotomous arm divisions, with but one division above the main dichotom. Such structures are to be found in the lower Burlington *Eratocrinus pikensis* (Worthen) and *Eratocrinus scoparius* (Hall). In *E. scoparius* the arms usually bifurcate but once above the dichotom and are isotomous. Rays are to be found, however, where there is a second division above the dichotom, producing an endotomous structure. Judging from the figure of *E. pikensis,* a similar condition obtains in that species. It seems reasonably certain that the evolutionary stage preceding endotomy is isotomy, with a single division above the primary dichotom.

Anal plates. Three in cup. RA not penetrating deeply between post and r. post BB. Anal x resting on wide horizontal distal face of post. B.

Ventral sac. Moderately long, typically not reaching to tips of arms, club-shaped.

Column. Pentagonal with rounded angles, to round. Long, relatively stout cirri borne in whorls to within a short distance of the crown.

Characteristic species of the genus.—

Eratocrinus commaticus (Miller), n. comb.

Zeacrinus commaticus Miller, p. 36, pl. 5, figs. 10, 11, 1891. "Keokuk group, at Booneville, Cooper County, Missouri." (Warsaw).—Springer, p. 80, pl. 22, figs. 1–3a, 1926.

Eratocrinus coxanus (Worthen), n. comb.

Zeacrinus coxanus Worthen, p. 27, 1882.—Worthen, p. 302, pl. 28, fig. 1, 1883. "Upper beds of the Keokuk limestone, Hamilton, Illinois."

Woodocrinus coxanus Wachsmuth and Springer, p. 302 (226), 1886.

Eratocrinus elegans (Hall), n. comb.

Zeacrinus elegans Hall, p. 547, pl. 9, figs. 1, 2, 1858. "Burlington limestone, Burlington, Iowa."—Wachsmuth and Springer, p. 128 (351), 1880.

Woodocrinus elegans Wachsmuth and Springer, p. 242 (166), 1886.

Woodocrinus? elegans Springer, p. 147, 1911.

N. Gen. elegans Springer, p. 148, 1911.

Zeacrinus elegans Springer, p. 80, pl. 21, figs. 2–4, 1926.

Eratocrinus faggi (Rowley and Hare), n. comb.

Zeacrinus faggi Rowley and Hare, p. 103, pl. 2, fig. 20, 1891. "Upper Burlington limestone in Spencer Creek, 2 miles north of Curryville, Missouri."

Eratocrinus orbicularis (Hall), n. comb.

Scaphiocrinus orbicularis Hall, p. 311, 1861.—Hall, p. 7, 1861a. "Keokuk limestone, Keokuk, Iowa."—Hall, pl. 5, figs. 7–9, 1872.
Eupachycrinus? orbicularis Wachsmuth and Springer, p. 138 (361), 1880.
Eupachycrinus orbicularis Wachsmuth and Springer, p. 249 (173), 1886.
Zeacrinus orbicularis Wachsmuth and Springer, p. 334 (Index), 1886.—Worthen, p. 97, pl. 14, figs. 2, 2a, 1890.

Eratocrinus pikensis (Worthen), n. comb.

Zeacrinus pikensis Worthen, p. 29, 1882.—Worthen, p. 304, pl. 30, fig. 3, 1883. "Lower part of the Burlington limestone, Montezuma, Pike County, Illinois."
Scaphiocrinus pikensis Wachsmuth and Springer, p. 237 (161), 1886.

Eratocrinus ramosus (Hall), n. comb.

Zeacrinus ramosus Hall, p. 548, pl. 9, fig. 3, 1858. "Burlington limestone, Burlington, Iowa." (Upper Burlington).—Wachsmuth and Springer, p. 129, 1880.
Woodocrinus ramosus Wachsmuth and Springer, p. 242 (166), 1886.—Springer, p. 147, 1911.

Eratocrinus raymondi (Laudon and Beane), n. comb.

Pachylocrinus raymondi Laudon and Beane, p. 255, pl. 18, fig. 4, 1937. "Hampton formation, Timber Creek quarry, 2 miles west of Le Grand, Iowa."

Eratocrinus sacculus (White), n. comb.

Zeacrinus sacculus White, p. 12, 1862.
Zeacrinus sacculus var. *concinnus* White, p. 13, 1862. "Upper division of the Burlington limestone, Burlington, Iowa."

Eratocrinus salemensis (Miller and Gurley), n. comb.

Zeacrinus salemensis Miller and Gurley, p. 37, pl. 3, fig. 17, 1894. "Keokuk group at Salem, Indiana."

Eratocrinus scoparius (Hall), n. comb.

Zeacrinus scoparius Hall, p. 305, 1861.—Hall, p. 8, 1861a. "Burlington limestone, Burlington, Iowa." (Probably lower Burlington.)

Eratocrinus serratus (Meek and Worthen), n. comb.

Zeacrinus serratus Meek and Worthen, p. 151, 1869.—Meek and Worthen, p. 428, pl. 1, fig. 6, 1873. "Burlington group at Burlington, Iowa." (Upper Burlington).—Wachsmuth and Springer, p. 129 (352), 1880.
Woodocrinus serratus Wachsmuth and Springer, p. 242 (166), 1886.
Woodocrinus? serratus Springer, p. 147, 1911.
N. Gen. serratus Springer, p. 148, 1911.

Eratocrinus troostanus (Meek and Worthen), n. comb.

Zeacrinus troostanus Meek and Worthen, p. 390, 1861.—Meek and Worthen, p. 186, pl. 16, fig. 2, 1866. "Burlington limestone, Cedar Creek, Warren County, Illinois."—Wachsmuth and Springer, p. 129 (352), 1880.
Woodocrinus troostanus Wachsmuth and Springer, p. 242 (166), 1886.

Woodocrinus? troostanus Springer, p. 147, 1911.
N. Gen. troostanus Springer, p. 148, 1911.

Geographic and geologic ranges.—*Eratocrinus* as known has a geologic range in the lower Mississippian from the Kinderhook to the Warsaw inclusive. It is doubtful if this geologic range will be extended greatly by future finds. Geographically the genus is widely distributed in the upper Mississippi and Ohio Valleys, having been found in Iowa, Illinois, Missouri, Tennessee, and Indiana. As represented in the collections and based on field experience, the genus was most prolific, both as to number of species and individuals, in the Burlington. As reflected in the specific separations, this was likewise the time of maximum variability. Maximum size was reached in Keokuk time.

Besides the species here listed there are interesting new forms from horizons of approximately Keokuk age in Tennessee and Indiana. From Whites Creek Springs, near Nashville, Tennessee, there is a set of typical arms, as well as several dorsal cups. The largest of these cups has an approximate diameter of 25 mm. From the Borden group of Indiana, near New Ross, is a complete crown some 80 mm. in height and with a dorsal cup 25 mm. in diameter. In the upper Borden of Indian Creek, Montgomery County, Indiana, is a new species referable to *Eratocrinus.*

Relationships.—*Eratocrinus* resembles *Zeacrinus* superficially in the shape of the dorsal cup and in the possession of endotomous arm structures. The crown of *Eratocrinus* is elongate inverted pyriform, as against the ovate shape of *Zeacrinus.* The cup of *Eratocrinus* is relatively deeper than in *Zeacrinus,* being bowl-shaped rather than depressed basin-shaped. The arm facets in *Eratocrinus* are shallower than in *Zeacrinus* and are nearly horizontal as against the high-angled facets of *Zeacrinus.* The BB of *Zeacrinus* are typically elongate, the post B being disproportionally so. RA in *Zeacrinus* penetrates deeply between post and R post BB, meeting post B on a very narrow face, if at all. RA in *Eratocrinus* rests subequally on the upper sloping shoulders of post and r post BB. Anal x in *Eratocrinus* rests on the broad horizontal truncated distal face of post B. In *Zeacrinus* x either does not contact with post B, or when it does it usually rests on a very narrow oblique face. The arms of *Eratocrinus* are proportionally longer and more slender than in *Zeacrinus.* The ventral sac of *Eratocrinus* is elongate club-shaped as against broad-based pyramidal sac of *Zeacrinus.* Aside from formal differences a casual glance will serve to separate the dorsal cups, or sets of arms of the two genera.

I do not believe that *Eratocrinus* and *Zeacrinus* are nearly related. I conceive the ancestor of *Zeacrinus* to be an undescribed genus, the earliest known species of which is found in the Keokuk, and which is more unlike *Eratocrinus* than is *Zeacrinus.* Very young specimens of *Eratocrinus elegans* in general habit resemble *Zeacrinus* more than do the adults, though, of course, such details as the relative positions and shapes of the plates of the dorsal cup are quite unlike *Zeacrinus.*

Linocrinus, n. gen.

Genotype.—Linocrinus wachsmuthi, n. sp.

Generic diagnosis.—

Crown. Expanding gradually, then incurving distad.

Dorsal cup. Bowl-shaped, flattened and slightly invaginated at base. Plates typically rugose in adult stages.

IBB. Small, in central depression, concealed by column.

BB. Subequal, taking part in the flattened basal area, then flexing upward to help form the sides of the cup.

RR. Radial facet extending full width of R, suture gaping.

Anal plates. Three in cup. RA rests subequally on sloping shoulders of post and r post BB. Anal x rests on horizontal distal face of post B.

IBr. Three to five in ant. R, one in all others. The IBr_1 is sharply keeled.

Arms. Endotomous, except in anterior radius, which is isotomous as seen. Rami relatively stout, frequently with median longitudinal keels or nodose Br. In some species the Br of juxtaposed rami tend to interlock by lateral processes. Br quadrangular, but somewhat cuneate.

Ventral sac. In the type species extending to near the tips of the arms and turned back on itself in the distal portion.

Characteristic species of the genus.—

Linocrinus arboreus (Worthen), n. comb.

Zeacrinus arboreus Worthen, p. 534, pl. 20, fig. 5, 1875. "St. Louis limestone? near Huntsville, Alabama." (Probably Gasper formation of the Chester group, Monte Sano, east of Huntsville, Alabama.)

Poteriocrinus (Pachylocrinus) arboreus Wachsmuth and Springer, p. 116 (339), 1880.

Woodocrinus arboreus Wachsmuth and Springer, p. 242 (166), 1886.

Linocrinus asper (Meek and Worthen), n. comb.

Zeacrinus asper Meek and Worthen, p. 150, 1869.—Meek and Worthen, p. 430, pl. 1, fig. 7, 1873. "Upper division of Burlington group, Burlington, Iowa." (Lower Burlington)

Pachylocrinus asper Wachsmuth and Springer, p. 116, 1880.

Zeacrinus asper Wachsmuth and Springer, p. 128, 1880.

Woodocrinus asper Wachsmuth and Springer, p. 242, 1886.

Linocrinus cariniferous (Worthen), n. comb.

Zeacrinus cariniferous Worthen, p. 535, pl. 20, fig. 4, 1873, "St. Louis limestone? near Huntsville, Alabama." (Probably Gasper formation of the Chester group, Monte Sano, east of Huntsville, Alabama.)

Coeliocrinus cariniferous Wachsmuth and Springer, p. 133 (358), 1880.

Linocrinus compactus (Laudon), n. comb.

Zeacrinus compactus Laudon, p. 66, pl. 5, figs. 4, 5, 1933. "Gilmore City formation, Gilmore City, Iowa."

Linocrinus lautus (Miller and Gurley), n. comb.

Poteriocrinus lautus Miller and Gurley, p. 30, pl. 2, figs. 18, 19, 1896. "Keokuk group, at Booneville, Missouri." (Warsaw)

Linocrinus penicillus (Meek and Worthen), n. comb.

Scaphiocrinus penicillus Meek and Worthen, p. 142, 1869.—Meek and Worthen, p. 414, pl. 2, fig. 7, 1873. "Upper division of the Burlington group, at Burlington, Iowa."—Wachsmuth and Springer, p. 113 (336), 1880.

Linocrinus perangulatus (White), n. comb.

Zeacrinus perangulatus White, p. 11, 1862. "Upper division of the Burlington limestone, Burlington, Iowa."
Pachylocrinus perangulatus Wachsmuth and Springer, p. 116 (339), 1880.
Woodocrinus perangulatus Wachsmuth and Springer, p. 242 (166), 1886.

Linocrinus praemorsus (Miller and Gurley), n. comb.

Scaphiocrinus praemorsus Miller and Gurley, p. 48, pl. 8, fig. 11, 1890. "Keokuk group, in Washington County, Indiana."

Linocrinus scobina (Meek and Worthen), n. comb.

Zeacrinus scobina Meek and Worthen, p. 149, 1869.—Meek and Worthen, p. 426, pl. 1, fig. 2, 1873. "Upper division of the Burlington group, Burlington, Iowa."—Wachsmuth and Springer, p. 129 (352), 1880.
Woodocrinus scobina Wachsmuth and Springer, p. 242 (166), 1886.
Woodocrinus? *scobina* Springer, p. 147, 1911.
N. Gen. scobina, Springer, p. 148, 1911.

Linocrinus spinuliferus (Worthen), n. comb.

Poteriocrinus spinuliferus Worthen, p. 27, 1884.—Worthen, p. 86, pl. 14, fig. 3; p. 90, pl. 17, figs. 1, 1a, 1890. "Chester limestone near Columbia, Monroe County, Illinois."

Linocrinus wachsmuthi, n. sp.

Ste. Genevieve formation of the Chester group, about 7 miles south of Huntsville, Alabama.

Geologic and geographic distribution.—The genus *Linocrinus* as recognized at present extends from the Kinderhook to the Chester and has a geographic distribution coextensive with the Mississippian deposits. It seems to be one of the most ubiquitous of the Inadunate genera.

Relationships.—The norm for the genus is a line of small species that has a remarkable similarity of structure, form, and ornamentation from the earliest appearance of the genus to the end. The interrelationships of Linocrinus seem to be with *Decadocrinus* and *Pachylocrinus. Decadocrinus* with its rugose plates, keeled Br, and gaping suture seems to come nearest to *Linocrinus.* An endotomous *Decadocrinus* with a few minor changes would give *Linocrinus,* just as a *Decadocrinus* with two isotomous divisions above the main dichotom is essentially *Pachylocrinus.* From *Eratocrinus, Linocrinus* differs in the rugosity of the cup plates, its keeled Br, and its well-marked gaping suture between the R and IBr_1.

Linocrinus wachsmuthi, n. sp.

Types.—As types of the species I have chosen part of the specimens figured by Springer (1926) as illustrating "*Zeacrinus arboreus* Worthen."

As holotype I have chosen the specimen illustrated as figure 5, plate 16, and as paratypes the specimens illustrated as figures 4 and 6 on the same plate. The types are in the Springer collection in the United States National Museum. The genotype is dedictated to Charles Wachsmuth, to whose tireless efforts in the field and study we owe a great part of our knowledge of American crinoids. The specimens chosen as types were collected by him and his wife.

Description.—The species has a small, compact crown expanding somewhat distad. The dorsal cup is basin-shaped with a flattened base. The plates of the cup are rugose, the surface ridges falling into definite but interrupted patterns. Ridges extend from center to center of the BB and from the centers of the BB across on the RR. There is usually a well-defined median, vertical ridge on each radial.

The IBB are small and concealed by the column. The BB are large, taking part in the flattened basal area, and flexing upward to form part of the sides of the cup. The RR are large with a straight articulating facet extending the full width of the radial. The suture with the IBr is broadly gaping.

There are from 4 to 5 IBr in the ant. R, the first primibrach being very large. In the other rays there is but one IBr to the ray. The first primibrach is traversed by a median vertical keel. The arms are relatively short, stout, and endotomous. Two divisions above the main dichotom are usual. The Br to the second division are usually traversed by a longitudinal keel. The Br are quadrangular, with a slight taper in the lower portions of the arm. Distad the Br are cuneate. Laterally there may be spinous processes that tend to interlock with similar processes on juxtaposed rami.

The ventral sac is somewhat shorter than the arms, reflexed in the distal portion, and with three rather prominent, median rows of plates that tend to be spinous.

Horizon and locality.—The main locality for *Linocrinus wachsmuthi* is about seven miles south of Huntsville, Alabama, near the foot of the ridge east of the road. They occur in the Ste. Genevieve formation of the Chester group. Having been at the type locality with Mrs. Wachsmuth I am able to give a locality somewhat better than the stereotyped "Huntsville, Alabama."

Relationships—From *Linocrinus cariniferous* (Worthen) and *Linocrinus arboreus* (Worthen) from stratigraphically higher beds of the same region, *Linocrinus wachsmuthi* can be distinguished most readily by the greater rugosity of the cup-plates, the plates of the later species being tumid with depressions at the angles, or with obscure, rounded ridges. Worthen's type of *Linocrinus arboreus* is either a young specimen or a small species. There are no marked juvenile characters in the specimen, judging from casts of the type, but it may well be the young of *L. cariniferous.* The arms of *L. arboreus* are relatively stouter than in *L. wachsmuthi,* and the Br are almost rectangular in outline, despite the original figure. The dorsal cup of *L. arboreus* is relatively much higher than in *L. wachsmuthi.*

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BOTANY.—Raouliopsis (*Asteraceae*), *a new genus of "vegetable sheep" from the high páramos of Colombia.*[1] S. F. BLAKE, Bureau of Plant Industry.

The "vegetable sheep" of New Zealand—species of *Haastia* and *Raoulia*, genera belonging to two different tribes of Asteraceae—are among the oddities of the vegetable kingdom. The repeatedly branched stems, only a few inches or sometimes a couple of feet high and about as thick as the finger with their dense covering of linear to cuneate, densely pilose, many-ranked, long-persistent leaves, are compacted into convex or flattish, rounded or amorphous, brownish or greenish cushions, sometimes as big as an ordinary sofa and so dense that the point of a pencil or "even of a pin" cannot be thrust between the branches.[2] The small or medium flower heads, in both genera lacking rays but provided with filiform pistillate florets, are borne singly[3] at the tips of the branches, sunken among the leaves and almost hidden by them. The extreme compactness of the plants and their dense covering of hairs are obviously correlated with their habitat, bare rocky hill slopes at about 40° S. latitude, where the hot dry winds of summer and the winter's snows, low temperatures, and violent gales expose them to a perpetual alternation of desert and arctic conditions. These extreme modifications of structure, however, are specific rather than generic, and are shown by only about 9

[1] Received January 6, 1938.
[2] According to E. Low, Trans. N. Z. Inst. **32**: 151. 1899, in her account of the vegetative organs of *Haastia pulvinaris*.
[3] Or, in a single variety (*Raoulia grandiflora* var. *fasciculata* (J. Buch.) Cheesem.), in 3's.

species[4] of the two genera. The remaining species (3 in *Haastia,* 14 in *Raoulia*), although revealing in their low stature, small, often leathery leaves, and usually dense hairy covering the result of response to similar but less extreme environments, are by no means as outstanding in appearance in their groups.

It now appears that the high páramos of the Sierra Nevada de Santa Marta in northeastern Colombia harbor two species so closely similar to the *Raoulia eximia* group not only in habit but also in most technical characters that if they were found in New Zealand they might readily be placed in that genus, although as somewhat aberrant members. Differences in the pappus (in the only species in which the flowers are known) of some taxonomic importance, reinforced by the occurrence of these species in a region so remote as Colombia, quite without phytogeographical alliances with New Zealand, make it advisable to place them in a separate genus and to regard their resemblance in habit to the *Raoulia eximia* group, a resemblance so close that it amounts to virtual identity, as the result of the action of similarly extreme habitats on two old branches of the *Gnaphalium* stock rather than as an indication of very close genetic relationship.

Raouliopsis Blake, gen. nov.

Celaena Wedd. Chlor. And. **1:** 231. 1857, nomen provisorium.

Fruticuli densissime caespitosi, pulvinos fulvescentes efformantes; caules v. rami numerosissimi densissime compacti suberecti foliis dense obtecti 5–12 mm crassi apice mammiformes; folia alterna densissime conferta multifaria linearia v. oblonga sessilia 1–3-nervia integerrima patentia infra submembranacea apice subcoriacea subtus in margine et intus infra apicem glabra alibique densissime fulvopilosa, pilis comam cuneiformem efformantibus; capitula apice ramorum solitaria v. plura parva sessilia inter folia immersa. Capitula heterogama disciformia ca. 26-flora, floribus fem. quam flor. hermaph. verisim. fertilibus paullo pluribus; involucri ca. 3-seriati paullum gradati phyllaria linearia acuta subchartacea lutescenti-albida, apice scarioso lutescenti-albido v. albo erectiusculo non conspicuo; receptaculum parvum nudum planum; flores fem. 15, corolla filiformi breviter inaequaliterque 5-dentata, stylo exserto, achenio oblongo obscure angulato 4–5-nervio glabro, pappi setis 1-seriatis 12–15 subcapillaribus apice non incrassatis hispidulis prope basim nudis basi ima connatis; flores hermaph. 11 fertiles?, corolla anguste cylindrico-infundibuliformi 5-dentata, achenio oblongo 4-nervio glabro, pappi setis 1-seriatis ca. 13-15 anguste linearibus manifeste complanatis quam eis fl. fem. subtriplo latioribus acutis v. acuminatis hispidulis prope apicem hispidulo-subciliatis apice non incrassatis basi

[4] *Haastia pulvinaris* Hook. f. (tribe *Astereae*); *Raoulia eximia* Hook. f., *R. mammillaris* Hook. f., *R. goyeni* T. Kirk, *R. rubra* J. Buch., *R. buchanani* T. Kirk, (?) *R. loganii* (J. Buch.) Cheesem., (?) *R. bryoides* Hook. f., *R. haastii* Hook. f. (tribe *Gnaphalieae*). These species are listed primarily on the basis of the descriptions in Cheeseman's *Manual of the New Zealand Flora,* ed. 2; I have examined only *H. pulvinaris* and *R. eximia.*

per $\frac{1}{6}$–$\frac{1}{3}$ longit. inaequaliter connatis; styli rami fl. hermaph. oblongi erecti truncati dorso et apice minute papillosi; stamina 5 appendicibus triangularibus acutis v. acuminatis donata, basi alte sagittato-auriculata auriculis angustis acuminatis liberis.—Species typica *R. seifrizii*, sp. nov.

This genus is closely allied to *Raoulia* Hook. f., of New Zealand, the more compact species of which genus it very closely simulates in habit. The material available is unfortunately very scanty. The description of the floral characters given above is based on the dissection of the single head containing flowers found on the type sheet of *R. seifrizii;* all the other heads on this sheet have lost their flowers. The floral characters of *R. pachymorpha* are unknown except for those furnished by a few achenes of pistillate flowers from which the corollas have fallen. The principal distinctive characters separating it from *Raoulia* are furnished by the pappus. In *Raouliopsis* the pappus of the pistillate and hermaphrodite flowers differs decidedly, that

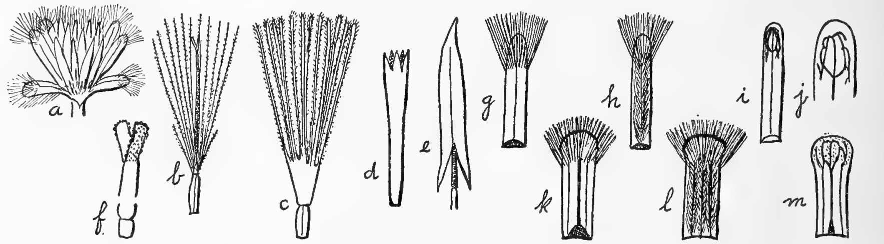


Fig. 1.—*a–j*, *Raouliopsis seifrizii*, from the type; *a*, head with surrounding leaves somewhat separated, ×2; *b*, pistillate flower, ×7; *c*, disk achene with pappus, ×7; *d*, disk corolla, ×7; *e*, stamen, ×15; *f*, style of disk flower, ×15; *g*, leaf, upper side, ×2½; *h*, leaf, lower side, ×2½; *i*, leaf, upper side, the hairs removed to show venation, ×2½; *j*, tip of leaf with hairs removed, ×5; *k–m*, *Raouliopsis pachymorpha*, from *Schlim* 1002; *k*, leaf, upper side, ×2½; *l*, leaf, lower side, ×2½; *m*, leaf with hairs removed, ×2½.

of the pistillate flowers being composed of about 12–15 subcapillary hairs, shortly connate at base and deciduous in a ring, that of the hermaphrodite flowers of about the same number of distinctly flattened bristles, about three times as wide as those of the pistillate flowers, hispidulous-subciliate at apex and connate for about $\frac{1}{6}$ to $\frac{1}{3}$ their length. In *Raoulia* two groups are recognized based on the structure of the pappus. In the subgenus *Psychrophyton* Beauverd (section *Imbricaria* Benth. & Hook.) the pappus bristles are 15–25, 1-seriate, decidedly flattened, free and naked at base, toward apex thickened and clavate-papillose. In the subgenus *Euraoulia* Beauverd (section *Leptopappus* Benth. & Hook.) the pappus hairs are much more numerous (about 50–150), several-seriate, very slender, subfasciculate, naked below, above hispidulous and at apex loosely barbellate. In both groups the pappus in the female and hermaphrodite flowers is similar.

Heads solitary at tips of branches; leaves linear, 1-nerved below, rounded and not widened at apex; branches including leaves about 5–8 mm thick. 1. *R. seifrizii.*

Heads clustered at tips of branches; leaves oblong, 3-nerved below, subtruncate or broadly rounded and slightly widened at apex; branches including leaves 7–12 mm thick. 2. *R. pachymorpha.*

Raouliopsis seifrizii Blake, sp. nov.

Fruticulus pulvinos fulvos rotundatos in specimibus visis 8 cm diam. et ca. 1.5 cm altos efformans, ramis inter folia densissime conferta longe pilosis; folia linearia apice rotundata sessilia basi non angustata plana 6–6.5 mm longa 1–1.2 mm lata, per $\frac{3}{4}$ longit. submembranacea in margine scariosa lutescenti-albida 1-nervia, in dorso margine glabro excepto dense pilosa in ventre glabra, apice viridia subcoriaceo-herbacea 3-plinervia supra dense subtus densissime pilosa, pilis ca. 2 mm longis rectis sicc. tortilibus comam cuneiformem efformantibus; capitula apicibus ramorum solitaria sessilia inter folia immersa oblongo-campanulata ca. 5.5 mm alta 2.8 mm crassa; involucri flores subaequantis phyllaria lanceolata acuminata ca. 0.5 mm lata chartacea lutescenti-albida supra in margine et in apice anguste scariosa erecta, exteriora basi longe pilosa interiora glabra; corollae fl. fem. ut videtur pallide brunneae glabrae 1.8 mm longae, dentibus inaequalibus triangularibus acutis apice in pilum brevem desinentibus; corollae fl. hermaph. ut videtur pallide brunneae subcylindricae sursum parum ampliatae glabrae 2.9 mm longae, dentibus 5 triangularibus acutis; achaenia fl. fem. anguste oblonga obscure angulata ad apicem paullum contracta 4–5-nervia glabra 0.7 mm longa, pappi setis ca. 12–15 subcapillaribus hispidulis basi nudis subaequalibus 3 mm longis, paucis brevioribus exceptis; achaenia fl. hermaph. oblonga sub-4-angulata 4-nervia glabra 0.6 mm longa, pappi setis ca. 13–15 anguste paleiformibus linearibus 3.2 mm longis ca. 0.1 mm latis manifeste complanatis quam eis fl. fem. triplo latioribus hispidulis in apice non dilatato hispidulo-subciliatis per $\frac{1}{6}$–$\frac{1}{3}$ longit. connatis flavescenti-albidis; styli rami (fl. hermaph.) oblongis erectis 0.4 mm longis.

Colombia: Páramos of the Sierra Nevada de Sante Marta, about 30 miles inland from Dibulla, Dept. Magdalena, alt. ca. 4875 m (16,000 ft.), July 1932, *William Seifriz* 516 (type no. 1,572,506, U. S. Nat. Herb.).

Raouliopsis pachymorpha (Wedd.) Blake

Oligandra pachymorpha Wedd. Chlor. And. **1**: 230. 1857.
Celaena pachymorpha Wedd. Chlor. And. **1**: 230. 1857, as syn.

Colombia: Sierra Nevada, "Prov. of Río Hacha,"[5] alt. 4115 m ("13,500 ft."), March, 1846–52, *L. Schlim* 1002 (type coll.; U. S. Nat. Herb., no. 1,628,290).

The rather ample material of *R. pachymorpha* in the U. S. National Herbarium, obtained in exchange from the Brussels Botanical Garden, is for the most part broken up into separate branches or small groups of branches, but enough remains to show that the plant must have had essentially the same habit as *R. seifrizii*. The longest piece, consisting of a main branch continued by a subterminal erect lateral branch, is 5 cm long. Weddell described the plant as "jaune obscur," so that it was no doubt originally of essentially the

[5] Río Hacha is a town on the coast of Colombia about 40 miles east of Dibulla. The locality where Schlim's specimens of *R. pachymorpha* were collected must have been in the same general region as that where Seifriz found *R. seifrizii*.

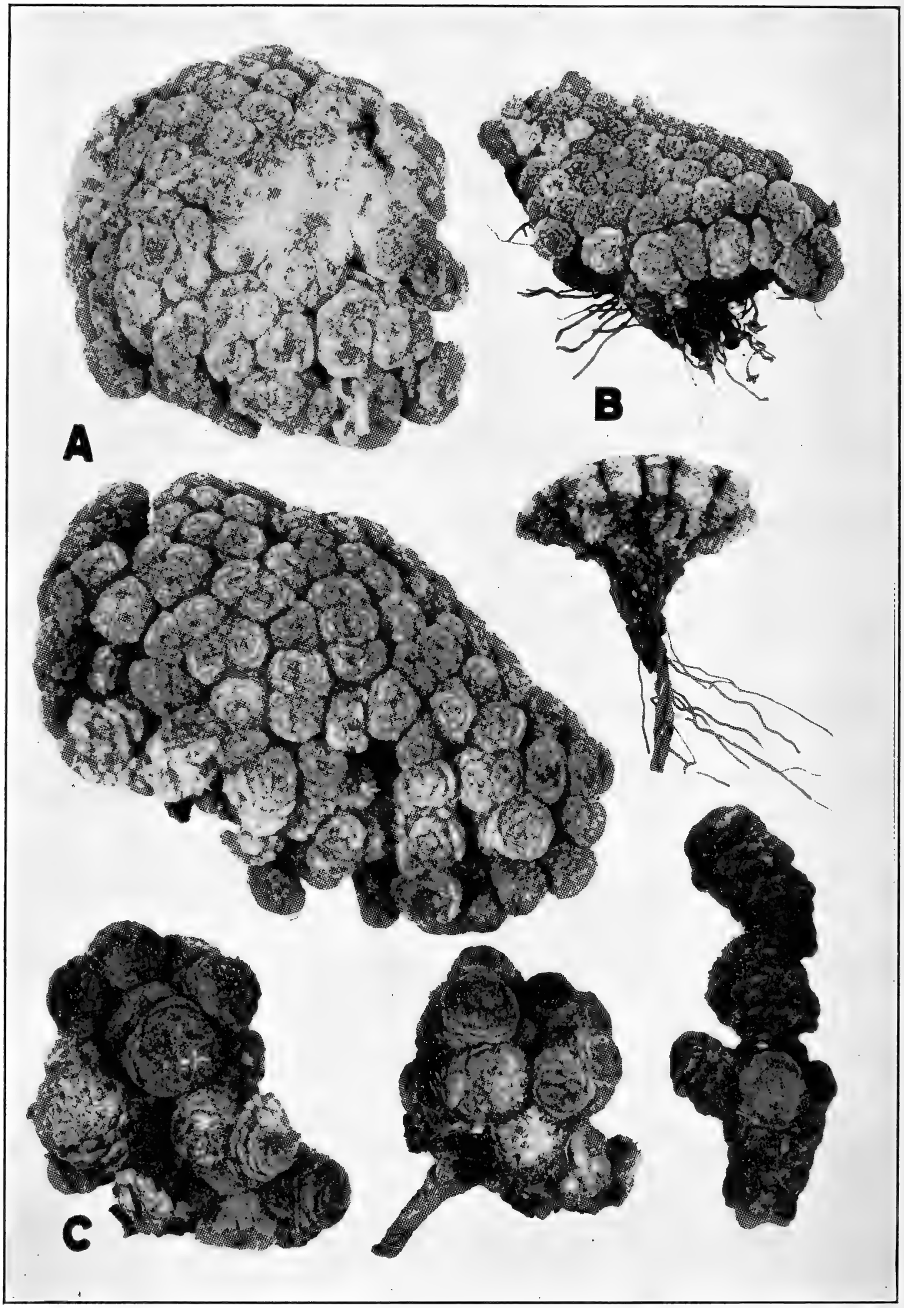


Fig. 2.—*A*, *Raouliopsis seifrizii* (two specimens), type; *B*, *Raoulia eximia* Hook. f., the upper figure from *Cockayne* 7048, the lower from *A. W. Anderson* 241, both from New Zealand and in the herbarium of the Arnold Arboretum; *C*, *Raouliopsis pachymorpha* (three specimens), type collection. All natural size.

same fulvous color as *R. seifrizii*, but with the lapse of more than eighty years the pubescence has become deep brown or even in places blackish. Many of the branches bear clusters of heads at their apices, the barely exposed tips of the phyllaries being in some cases narrow, whitish, and scarious, in others (where weathered ?) brown and more chartaceous, but, like Weddell, I have been unable to discover any corollas. The few achenes examined, either from the heads or caught in the pubescence, are evidently from the pistillate flowers. The achenes are glabrous, slender, 0.9 mm long, and the pappus consists of about 16 slender whitish bristles about 2.2 mm long, moderately hispidulous except toward the essentially naked base, not thickened at apex, connate at base into a ring about 0.1 mm long, and deciduous as a whole.

This species was published by Weddell as *Oligandra pachymorpha* under the heading "Oligandrae species dubia," with the synonym "*Celaena pachymorpha* Wedd., mscr." Weddell was unable to find any flowers on the specimens, but did find some achenes which he ascribed to the pistillate flowers. He described the achenes as glabrous and the pappus bristles as a little thickened above and fasciculate-connate at base. His failure to discover any trace of staminate or hermaphrodite flowers led him to suspect that the plant might be dioecious. At the close of his discussion, he remarked: "A vrai dire, cette plante est presque intermédiaire entre les genres *Oligandra* et *Merope*, et si, plus tard, on juge utile d'en faire le type d'un groupe distinct, on pourra, si l'on veut, donner à celui-ci, le nom d'une autre pléiade, et l'appeler *Celaena*."

Although the close similarity in habit between this species and *R. seifrizii* leaves little doubt of the propriety of referring both to the same genus, the adoption of the generic name suggested by Weddell has not seemed either necessary or desirable. Weddell's name is not supported by a generic description, and comes in the category of "provisional" names especially indicated as invalid in the amendments to the International Rules of Botanical Nomenclature adopted at Amsterdam in 1935. As the floral characters on which the genus rests are drawn solely from *R. seifrizii*, that species must be taken as type of the new genus, and it would be unwise to resuscitate for this a lapsed generic name originally based on another species which might later, when its floral characters become known, prove to belong to a generically different group.

BOTANY.—*The Carpet grasses.* AGNES CHASE,[1] Bureau of Plant Industry.

Carpet grass, *Axonopus compressus* (Swartz) Beauv., has always been a puzzling complex. The type from Jamaica, collected by Swartz and described by him as *Milium compressum* has not been located but the original description (Prodr. 24. 1788) and the later amplified description (Fl. Ind. Occ. **1**: 183. 1797) leave no doubt that the name applies to the broad-leaved form with glume and sterile lemma pointed beyond the fruit, common in the West Indies and Brazil. In the herbarium of the Königliches Botanisches Museum at Munich is a specimen labeled, but not [?] in Swartz's script, "*Milium compressum* Sw., Jamaica, O. Swartz." This, which is probably part of the type collection, is the typical West Indian form with broad blades and spikelets with glume and sterile lemma extending well beyond the fruit.

Of the 17 names referred as synonyms to *Axonopus compressus* in Hitchcock's Manual of Grasses of the United States (page 804) the type specimen has been examined of all but two, *Milium compressum* Swartz and *Paspalum laticulmum* Spreng., the first from Jamaica. A specimen from Jamaica collected by Swartz was examined in the herbarium at Munich. Sprengel's description of *P. laticulmum* points to *Axonopus compressus*, and he cites *Milium compressum* Swartz as a synonym. All the types are the typical form of the American tropics with broad blades often slightly plicate, broad-leaved coarse stolons, and spikelets 2.2 to 3 mm long, the glume and sterile lemma extending beyond the fruit. In the United States this form is known only from Florida and Louisiana. The narrow-leaved form with glume and sterile lemma not or scarcely pointed beyond the fruit, common in the Southern States, rare in Western Cuba and southern Mexico, and infrequent in Central America, has not been described as a distinct species.

The difference from true *Axonopus compressus* is slight and there are intergrades, but on the whole specimens may be segregated with relatively few intermediates. The late Professor C. V. Piper was at one time positive that the narrow-leaved form was distinct, at first declaring it was not stoloniferous. But the writer showed him short arching stolons on some of the specimens he collected. As a whole this form is less commonly stoloniferous than is true *A. compressus*, but sometimes develops extensive stolons. Field notes by the writer on

[1] Received January 21, 1938.

narrow-leaved plants in the vicinity of Lake Charles, Louisiana, state that sterile plants form a carpet in woods of pine, oak, Liquidamber, and hickory, the flowering culms being relatively few. The specimens from this colony are tufted, with short rhizomes but no stolons.

The two forms have been recognized as distinct by various authors, the broad-leaved one generally under the name *Paspalum platycaulon* Poir. or *Anastrophus platycaulis* (Poir.) Nash, the narrow-leaved under the name *Paspalum compressum* (Swartz) Rasp. But Swartz's species is undoubtedly the same broad-leaved form as Poiret's type from Puerto Rico.

Carpet grass is esteemed as a good pasture grass from the southern Coastal Plain to Texas. In a paper on Carpet Grass by C. V. Piper and Lyman Carrier (Farmers' Bulletin 1130, U. S. Dept. Agr. pp. 1–12. 1920) it is said to be introduced into this country. The map (page 3), showing distribution from North Carolina to Texas, indicates that both forms of carpet grass are included, since the broad-leaved is known only from Florida and Louisiana. The illustration (page 5) represents the narrow-leaved form. This form is undoubtedly native, the center of distribution apparently being the Gulf Coast from Florida to Louisiana. It, like the wide-leaved form, is introduced in the tropical and subtropical regions of Asia, Africa, and Australia. The broad-leaved form is the only one known from the West Indies, except from western Cuba. It may possibly have been introduced into the Gulf States but more probably it is native though less widespread than the narrow-leaved form in the United States. It is the common form of carpet grass from Mexico to Paraguay.

No distinction in forage value seems to be made between the two forms in this country, but Dr. J. N. Whittet, agrostologist of the Department of Agriculture, Sydney, New South Wales, on a recent visit to the Office of Grass Investigations, stated that in Australia the narrow-leaved form is regarded as a pest, invading pastures of *Paspalum dilatatum* Poir. and taking possession of them, since the animals graze the paspalum and leave the carpet grass to go to seed. It is not, as might be supposed, a case of mistaken identity, because specimens of both forms from Australia are in the National Herbarium and Dr. Whittet readily recognized them. Australia produces seed of carpet grass for export, shipping it even to the United States, but, Dr. Whittet says, this is the only country that does not object to the intermixture of seed of the narrow-leaved form. The Economic Index kept by the Office of Grass Investigations contains numerous notes on carpet grass from various tropical and subtropical regions, most of them favorable, such as "valuable, especially on poor lands," and "one of the best pasture grasses for the tropics." But in the Agricultural Gazette, New South Wales (**47**: 555. 1936), is a note on "narrow-leaved carpet grass" to the effect that it is spreading rapidly, grows well in poor soil, but tends "to invade *Paspalum dilatatum* pastures on better soil," and in the Queensland Agricultural Journal (**43**: 503. 1935) a note states that it "invades paspalum pasture and if it gets a good hold may ruin the pasture." It seems probable that the narrow-leaved carpet grass may be only less palatable than *Paspalum dilatatum*, that in regions where the paspalum is wanting or scarce, animals readily graze the narrow-leaved as well as the broad-leaved carpet grass.

Mr. Mason A. Hein, Agronomist of the Division of Forage Crops and Diseases, kindly sent inquiries as to palatability of the two forms of carpet grass to field men in the Division, and their replies confirm this opinion.

Since *Axonopus compressus* in this country is only found in Florida and southern Louisiana and is the common form in the tropics, whereas the narrow-leaved form ranges from North Carolina to Arkansas, it would appear that the latter is more winter hardy than is *A. compressus*. All factors considered, it seems better to recognize the narrow-leaved form as a distinct species.

Axonopus affinis sp. nov.

Ab *Axonopo compresso* differt: culmis et stolonibus gracilioribus, laminis angustioribus; spiculis brevioribus, 2 mm longis, obtusis vel subacutis.

Plants more tufted than in *A. compressus*, sometimes forming dense mats with short rhizomes, the flowering culms in such colonies relatively few; stolons slender, apparently mostly developing after the flowering of the primary culms, at first arching, sometimes creeping as much as 30 cm, the internodes short, and the blades not, as in *A. compressus*, conspicuously shorter than the culm blades; culms erect to geniculate-ascending, on the average more slender than in *A. compressus*, commonly 25 to 35 cm tall, rarely to 75 cm, the nodes glabrous (often bearded in *A. compressus*); sheaths compressed, on the average narrower than in *A. compressus;* blades flat or folded in drying, 2 to 4, rarely to 5 or 6 mm wide, mostly 5 to 15 cm long, rarely to 28 cm long, the apex sometimes splitting; peduncles very slender, 1 to 3 from the uppermost sheath, finally elongate; racemes 2 to 4, ascending, 2 to 10 (mostly 3 to 7) cm long; spikelets oblong-elliptic, rather more plump than in *A. compressus*, sometimes purple-tinged, 2 mm long, 0.8–0.9 mm wide, blunt or abruptly subacute, the glume and sterile lemma equal, covering the fruit or slightly pointed beyond it, 4-nerved, the midnerves suppressed, very sparsely silky-pilose at base and summit and sometimes in a line along the nerves; fruit pale, 1.7 to 1.8 mm long, blunt.

Type in the U. S. National Herbarium, no. 928710, collected "in low moist ground, Waynesboro, Mississippi, October 2, 1896, by Thos. H. Kearney, Jr. Much grazed by cattle."

Intermediate specimens are found with blades to 7 mm wide and spikelets 2.2 to 2.3 mm long, slightly pointed (*Combs* 414 and *Curtiss* 5879 in part, both from Quincy, Florida). Others with the habit of *A. compressus*, with pubescent nodes and short broad stolon blades, have spikelets 2 to 2.2 mm long but with the glume and sterile lemma pointed beyond the exceptionally short fruit (*Combs* 1324, Bradenton, and *Curtiss* 6638, Mabel, both Florida).

Low commonly moist, often sandy meadows, open woods, old fields, pastures and waste places, sometimes forming a turf, North Carolina to Florida and west to Arkansas and Texas. "Forms bulk of native pastures in open woods of Red River valley, Louisiana" C. R. Ball (no. 115). Also in western Cuba, southern Mexico.

The following specimens are in the U. S. National Herbarium:

North Carolina: Wilmington, *Hitchcock* in 1905.

Georgia: Union, *Harper* 1086. Savannah, *Kearney* 197.

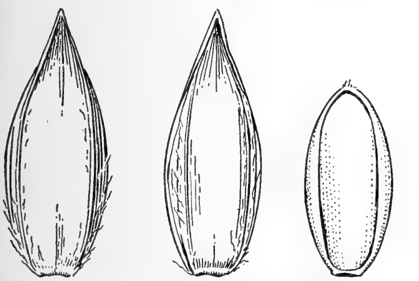


Fig. 1.—*Axonopus compressus.* Two views of spikelet, and fruit, ×10. (Type of *Paspalum tristachyon* Lam.)

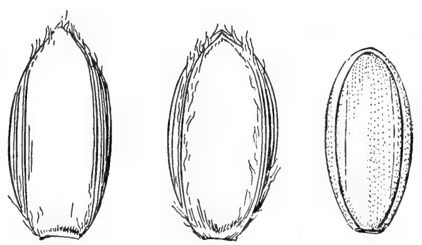


Fig. 2.—*Axonopus affinis.* Two views of spikelet, and fruit, ×10. (Type.)

Florida: Avondale, *Combs* 494; Pensacola, *Combs* 517; Apalachicola, *Kearney* 111; Tallahassee, *Combs* 362, 363; *Kearney* 87; Madison, *Combs* 265, 244; Jefferson County, *Hitchcock* 2462, 2463; Monticello, *Combs* 313; De Funiak Springs, *Combs* 450; Baldwin, *Combs* 51; Jacksonville, *Combs* 1; *Curtiss* 3565, 4023, 5077, 5589, *Hitchcock* in 1900 and 1903; Duval County, *Fredholm* 5255; Quincy, *Curtiss* 5879; Chipley, *Combs* 544; Suwannee County, *Hitchcock* 2518; Lake City, *Combs* 78; *Combs & Rolfs* 109, 135, 155, 176, 181; *Hitchcock* 2461; *Rolfs* 981; Gainesville, *Combs* 733; Waldo, *Combs* 694; Ellzey, *Combs* 830; Titusville, *Chase* 3969; Sanford, *Hitchcock* 783; Eustis, *Nash* 1219; Hillsborough County, *Fredholm* 6379; Fort Meade, *McFarlin* 3724; Winter Haven, *McFarlin* 5760; Lakeland, *Hitchcock* 831; Bartow, *Combs* 1243; Bradenton, *Combs* 1332; Myers, *Hitchcock* 502, 503; Palmetto, *Tracy* 7047; Immokalee, *Swallen* 5313; Alva, *Hitchcock* in 1900.

Alabama: Tuskegee, *Carver* 37; Selma, *Kearney* 6; Spring Hill, *Bush* 201, 203; Tuscaloosa, *Mohr* 17.

Mississippi: Nicholson, *Kearney* 356; Biloxi, *Chase* 4333; *Ricker* 862; *Swallen* 1937; *Tracy* 3862; Ocean Springs, *Seymour* 18; *Tracy* 72, 6506.

Arkansas: Texarkana, *Eggert* 138; *Letterman* in 1894; Arkansas County, *Adair* 3368.

Louisiana: Royville, *Ball* 11. Coushatta, *Ball* 115; Shreveport, *Hitchcock* in 1903; Calhoun, *Ball* 55; Oberlin, *Ball* 224; Lake Charles, *Chase* 6100, 6109; *Hitchcock* 1121; Baton Rouge, *Billings* 18; Covington, *Arsène* 11257, 11278, 12223; Pointe-a-la-Hache, *Langlois* 24, 149; Houma, *Wurzlow* in 1913, Avery Island, *Hitchcock* 19835.

TEXAS: Houston, *Bebb* 1247, 1264; *Hall* 813; *Ravenel* in 1869; Waller, *Hitchcock* 1218; Columbia, *Bush* 285; Beaumont, *Plank* 23, 28; Gonzales County, *Bogusch* 1302; Bay City, *Silveus* 901; Tom Green Co., Tweedy in 1880.

MEXICO: Jalapa, *Hitchcock* 6588; Minatitlan, *J. G. Smith* 574.

GUATEMALA: Cobán, *Türckheim* 1253.

EL SALVADOR: La Union, *Hitchcock* 8783½.

CUBA: Habana, *Léon* 298; Herradura, *Ekman* 10786; *Hitchcock* 486; Without locality, *Wright* 3850.

HAWAII: Kona (Oahu), *Hitchcock* 19699.

ASIA: Malay Peninsula, Singapore Botanic Garden, *Furtado* 25877.

AUSTRALIA: "North Coast districts, naturalized and common in New South Wales," *Whittet* B in 1930.

This species forms much the greater part of the "carpet grass" of the Southeastern States where it is esteemed as a good pasture grass, and where it may be established "in open forests, or cut-over land, without going to the expense of clearing. . . . Under close grazing most of the native bunch grasses will be killed by the end of the first season and carpet grass will occupy the land." (Piper & Carrier, U. S. Dept. Agr. Farmers' Bull. **1130**: 8. 1920).

Paspalum conjugatum Berg., a common but worthless grass of the tropics and subtropics, has sometimes been confused with *Axonopus compressus*, which it resembles. Reports of forage value of *Paspalum conjugatum* (under several local names including "sour grass" in the British West Indies, "Mission grass" in Queensland) are almost certainly based on mistaking *A. compressus* for *P. conjugatum*. The two have much the same habit and often grow together. In Matto Grosso, Brazil, the writer examined native pasture of *A. compressus* and *P. conjugatum* where cattle were grazing. The *Axonopus* was closely grazed while the *Paspalum* growing with it was left untouched.

ZOOLOGY.—*North American monogenetic trematodes. II. The familes Monocotylidae, Microbothriidae, Acanthocotylidae and Udonellidae (Capsaloidea).*[1] Emmett W. Price. U. S. Bureau of Animal Industry.

Family MICROBOTHRIIDAE Price, 1936

Synonyms.—Dermophagidae MacCallum, 1926; Labontidae MacCallum, 1927.

Diagnosis.—Anterior haptors present or absent; when present, in form of sucker-like structures. Posterior haptor small, without septa or hooks. Eyes usually absent. Intestinal tract consisting of 2 branches, with or without lateral diverticula. Genital apertures close together or opening into a common genital sinus. Cirrus cuticularized, or muscular with a heavily cuticularized ejaculatory duct. Vagina single or double.

Type genus.—*Microbothrium* Olsson, 1869.

The family names Dermophagidae MacCallum (1926) and Labontidae MacCallum (1927) are unavailable, since the genus *Dermophagus* MacCallum was preoccupied, and the genus *Labontes* MacCallum, which was proposed to replace *Dermophagus*, is shown later on in this paper to be a synonym of *Microbothrium* Olsson.

KEY TO SUBFAMILIES OF MICROBOTHRIIDAE

One or two testes..............................MICROBOTHRIINAE Price
Numerous testes..........................PSEUDOCOTYLINAE Monticelli

Subfamily MICROBOTHRIINAE, new name

Synonyms.—Anoplodiscinae Tagliani, 1912; Dermophaginae MacCallum, 1926; Labontinae MacCallum, 1927; Paracotylinae Southwell and Kirshner, 1937.

Diagnosis.—Anterior haptor in form of an oral sucker or of adoral pseudosuckers. Eyes present or absent. One or two testes. Vagina usually single (double in *Leptobothrium*).

Type genus.—*Microbothrium* Olsson, 1869.

KEY TO GENERA OF MICROBOTHRIINAE

1. Two testes............................*Dermophthirius* MacCallum
   One testis..2
2. Eyes present............................*Anoplodiscus* Sonsino
   Eyes absent...3
3. Intestinal branches without lateral dendritic diverticula..............
   ....*Leptocotyle* Monticelli
   Intestinal branches with lateral diverticula........................4
4. Vagina single............................*Microbothrium* Olsson
   Vagina double............................*Leptobothrium* Gallien

Genus Microbothrium Olsson, 1869

Synonyms.—*Dermophagus* MacCallum, 1926, not Dejean, 1833; *Labontes* MacCallum, 1927; *Philura* MacCallum, 1926.

[1] Continued from Vol. 28, No. 3. This Journal. Received February 12, 1938.

Diagnosis.—Anterior haptors in form of 2 bothria-like structures opening into oral cavity; posterior haptor an elliptical, heavily cuticularized groove. Oral aperture subterminal, groove-like; intestinal branches with lateral, dendritic diverticula. Genital aperture median. Cirrus long, muscular, with heavily cuticularized ejaculatory duct. Testis single, equatorial. Vagina single, not opening into genital atrium.

Type species.—*Microbothrium apiculatum* Olsson, 1869.

This genus at present contains only the type species. Olsson (1869) questionably assigned to this genus a form from the dorsum of "*Rajae Batidis,*" which he named *Microbothrium* (?) *fragile.* This form is now generally believed to be a parasitic triclad turbellarian, possibly identical with *Micropharynx parasitica* Jägerskiöld.

Microbothrium apiculatum Olsson, 1869 Figs. 1–2

Synonyms.—*Pseudocotyle apiculatum* (Olsson, 1869) Braun, 1890; *Philura orata* MacCallum, 1926; *Dermophagus squali* MacCallum, 1926.

Description.—Body elliptical, 1.7 to 3.2 mm long by 700μ to 1.6 mm wide, convex dorsally, flattened or slightly concave ventrally. Cephalic glands present. Anterior haptors in form of 2 sucker-like organs opening into mouth cavity; posterior haptor an elliptical opening, 150 to 225μ long, at posterior end of body, unarmed, its cavity lined with thick cuticle. Oral aperture slit-like, subterminal; prepharynx relatively long; pharynx ovoid to piriform, 190 to 300μ long by 200 to 266μ wide; esophagus very short; intestinal tract consisting of 2 relatively slender branches with a number of lateral, more or less dendritic diverticula. Nervous system not observed. Genital aperture median, about one-third of body length from anterior end. Cirrus long, muscular, lying in a rather spacious genital sinus; the ejaculatory duct, which passes through the center of the cirrus, strongly cuticularized and expanded proximally to form a more or less globular ejaculatory bulb. Vas deferens relatively large and expanded distally; seminal vesicle globular, about 80 to 170μ in diameter, at level of ovary. Testis circular in outline, with smooth or indented margins, 340 to 510μ in diameter, in equatorial zone. Ovary globular, 85 to 170μ in diameter, immediately pretesticular, to right of median line. Vitellaria extending from level of pharynx to within about 500μ from posterior end of body, meeting in median line posterior to testis. Vagina strongly muscular, convoluted, its proximal end expanded and forming a seminal receptacle, 40 to 115μ in diameter, between ovary and seminal vesicle; vaginal opening at level of genital aperture near left intestinal branch. Ootype piriform, about 190μ wide, surrounded by unicellular glands. Egg oval, about 130μ long by 80μ wide, with relatively short polar process.

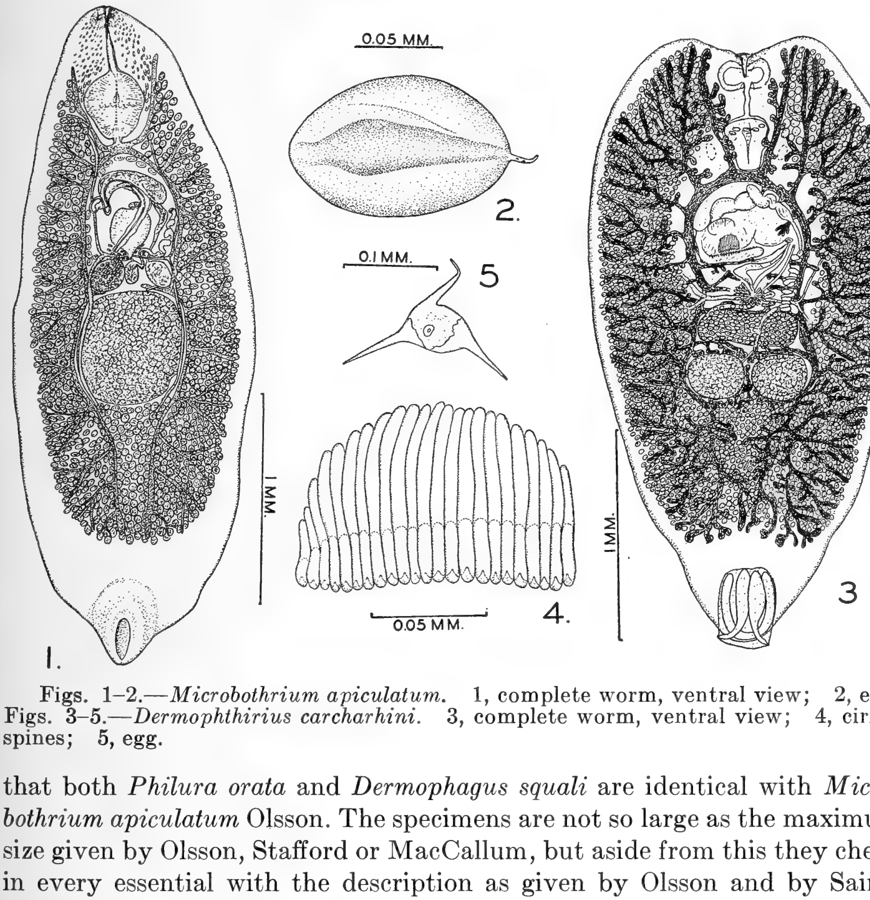
Hosts.—*Squalus acanthias* Linn., and *Carcharias commersonii* (Blainville).

Location.—Skin.

Distribution.—United States (Woods Hole, Mass.) and Canada.

Specimens.—U.S.N.M. Helm. Coll. Nos. 35684 (cotypes of *Dermophagus squali*), 35685 (cotypes of *Philura orata*) and 35686.

Microbothrium apiculatum was first described by Olsson (1869) from specimens collected from the dorsum of "*Acanthiae vulgaris*" taken in the Skagerrak. The description was not very complete as to details of the genital systems; these details were supplied later by Saint-Remy (1891). The first report of this species in North America is that by Stafford (1904) who listed *Pseudocotyle apiculatum* (=*Microbothrium apiculatum*) from *Squalus acanthias*, the specimens having been collected at the Canadian Marine Biological Station. MacCallum (1926) described as *Philura orata* n. g., n. sp., an ectoparasitic fluke from the skin of "*Carcharhinus commersonii*" collected at Woods Hole, Mass., and later in the same year (1926) he described as *Dermophagus squali*, n. g., n. sp., a somewhat similar fluke from *Squalus acanthias* also collected at Woods Hole, Mass. A study of these forms reveals



Figs. 1–2.—*Microbothrium apiculatum*. 1, complete worm, ventral view; 2, egg. Figs. 3–5.—*Dermophthirius carcharhini*. 3, complete worm, ventral view; 4, cirrus spines; 5, egg.

that both *Philura orata* and *Dermophagus squali* are identical with *Microbothrium apiculatum* Olsson. The specimens are not so large as the maximum size given by Olsson, Stafford or MacCallum, but aside from this they check in every essential with the description as given by Olsson and by Saint-Remy.

Genus LEPTOBOTHRIUM Gallien, 1937

Synonym.—*Pseudobothrium* Gallien, 1937, nec Guiart, 1935.

Diagnosis.—Oral aperture subterminal, surrounded by a pseudosucker. Posterior haptor small, unarmed. Intestine with lateral non-dendritic diverticula, not uniting posteriorly. Eyes absent. Testis single; cirrus simple. Ovary small, pretesticular. Vagina present, bifurcating to form 2 branches both opening into genital atrium. Other characters similar to those of *Microbothrium*.

Type species.—*Leptobothrium pristiuri* (Gallien, 1937) Gallien, 1937.

The type and only species of this genus was described by Gallien (1937), from specimens collected from the skin of *Pristiurus melanostomus* taken in European waters.

Genus LEPTOCOTYLE Monticelli, 1905

Synonym.—*Paracotyle* Johnstone, 1911.

Diagnosis.—Anterior haptor in form of a weakly developed oral sucker. Intestinal branches without lateral dendritic diverticula. Other characters similar to those of *Microbothrium.*

Type species.—*Leptocotyle minor* (Monticelli, 1888) Gallien, 1937.

Leptocotyle was proposed by Monticelli (1905) as a subgenus of *Pseudocotyle* to contain *Pseudocotyle minor,* a species named by Monticelli (1888) but not described until 1890. Johnstone (1911) described a form which seems to be identical with *P. minor* Monticelli, naming the species *Paracotyle caniculae.* Tagliani (1912) raised the subgenus *Leptocotyle* to the rank of a genus but failed to include in it the species for which the subgenus was originally proposed; he did, however, recognize the identity of *Paracotyle* and *Leptocotyle.* Recently Jones (1933) redescribed Johnstone's *Paracotyle caniculae* and considered it congeneric with *Microbothrium apiculatum* Olsson; he apparently did not know of *Pseudocotyle minor* Monticelli, as no mention of it was made. In comparing the descriptions and figures of *P. minor* Monticelli with those of *Paracotyle caniculae* Johnstone, there appear to be no essential differences and it is the writer's opinion that the two forms are identical; this conclusion supports that of Gallien (1937).

Genus DERMOPHTHIRIUS MacCallum, 1926

Diagnosis.—Anterior haptors in form of 2 bothria opening into oral cavity; posterior haptor consisting of 2 clamp-like cuticular jaws resembling the valves of a clam shell, unarmed. Oral aperture slightly subterminal; intestinal branches similar to but more conspicuous than those of *Microbothrium.* Genital aperture sinistral. Cirrus muscular, armed with a group of 2 overlapping rows of stave-like spines in the thicker ventral wall and a single row of short simple spines in the thinner dorsal wall. Two testes, side by side, postequatorial. Vagina single.

Type species.—*Dermophthirius carcharhini* MacCallum, 1926.

Dermophthirius carcharhini MacCallum, 1926 Figs. 3–5

Description.—Body elongate, ovoid, 1.9 to 2.9 mm long by 850μ to 1.5 mm wide at level of pharynx. Anterior haptor in form of bothria opening into oral cavity; posterior haptor clam shell-like, about 340μ long, strongly cuticular, its inner surface roughened but without hooks. The exact shape and function of this haptor could not be ascertained in the specimens available owing to the large amount of detritus caught in its jaws. Oral aperture slightly subterminal; prepharynx moderately long and spacious; pharynx piriform, widest anteriorly, 190 to 245μ long by 95 to 228μ wide, projecting into a widened prepharynx; esophagus absent; intestinal branches with long lateral and shorter median dendritic diverticula. Nervous system not ascertainable; eyes absent. Excretory apertures dorsal, at level of pharynx. Genital aperture to left of median line and about midway between base of pharynx and anterior margin of ovary. Genital sinus spacious. Cirrus muscular and of peculiar shape; ventral wall greatly thickened and bearing on its inner surface 2 rows of stave-like spines, the innermost row of about 25 spines 19 to 40μ long and outermost row of about 25 spines 25 to 70μ long; dorsal wall thinner and bearing a single row of about 28 straight spines having a maximum length of about 20μ. Vas deferens convoluted proximally, widening and forming a seminal vesicle slightly anterior to level of cirrus, then passing into a long, conspicuous, convoluted prostatic portion lying immediately anterior to cirrus; prostatic portion lined with high columnar epithelium. Testes round, 150 to 285μ in diameter, side by side, immediately postovarial. Ovary elongate transversely, 90 to 190μ long by 230 to 455μ wide, median, slightly postequatorial. Vitellaria consisting of relatively large follicles occupying greater part of body, except that occupied by genital organs, extending from anterior end of body to posterior limits of intestinal diverticula. Vagina slender, opening near genital aperture. Ootype median, surrounded at its base by unicellular glands; metraterm short and thin walled. Egg tripolar, about 76μ long (excluding polar prolongations).

Host.—*Carcharias commersonii* (Blainville).

Location.—Olfactory organs and skin of back.

Distribution.—United States (Woods Hole, Mass.).

Specimens.—U.S.N.M. Helm. Coll. Nos. 35687 (cotypes), 35688, and 36644.

This species has been described very accurately by MacCallum (1926) except for a few details. The common genital aperture is not median but somewhat sinistral; the vaginal aperture is also somewhat sinistral. The posterior haptor is not in the form of a shallow groove, as originally figured and described, but consists of a pair of jaw-like cuticularized structures which have somewhat the appearance of the valves of a clam shell. In most of the specimens the posterior haptor has been torn off and the description of the posterior sucker or haptor as given by MacCallum was obviously from one of these mutilated specimens. The exact detail of the haptor could not be made out because of the mass of detritus clamped between the jaws; it must possess enormous powers of attachment as it had been torn from all but 3 of about 20 specimens examined.

Genus ANOPLODISCUS Sonsino, 1890

Diagnosis.—Anterior haptors in form of a pair of pseudosuckers situated at anterior end of body. Posterior haptor cup-like, unarmed. Eyes present. Cirrus cuticularized, with accessory piece. Testis single, preequatorial. Ovary pretesticular. Vagina present.

Type species.—*Anoplodiscus richiardii* Sonsino, 1890.

The type species of *Anoplodiscus*, *A. richiardii*, was originally described by Sonsino (1890) from the gills of *Pagrus orphus* from the Mediterranean, and was subsequently redescribed by Monticelli (1905); neither description is adequate. The only other species so far included in this genus is *A. australis* which was described by Johnston (1930) from specimens collected from the fin of *Sparus australis* taken at Sydney Harbour, Australia.

The systematic position of the genus *Anoplodiscus* is not well established. Monticelli placed it in the Anisocotylinae Monticelli, 1903—a subfamily without a corresponding genus and consequently invalid—and later Tagliani (1912) erected for it the subfamily Anoplodiscinae, elevating Monticelli's invalid Anisocotylinae to the status of an invalid family Anisocotylidae. Johnston and Tiegs (1922) consider *Anoplodiscus* as possibly belonging to the Calceostomidae, subfamily Dionchinae, while Fuhrmann (1928) and Gallien (1937) place it in the Pseudocotylinae. The present writer has, without prejudice, included *Anoplodiscus* in the Microbothriinae, mainly because the general organization and the lack of haptoral hooks suggest relationship with such genera as *Microbothrium*, *Leptocotyle* and *Leptobothrium*. On the other hand, the presence in *Anoplodiscus* of eyes and a cirrus with accessory piece suggests affinities with genera of the Gyrodactyloidea. It is possible that a restudy of the species of *Anoplodiscus* may show the haptor to be armed with minute hooks in which case it should be transferred to the family Calceostomatidae (Gyrodactyloidea).

Subfamily PSEUDOCOTYLINAE Monticelli, 1903

Diagnosis.—Anterior haptors absent; posterior haptor small, suckerlike, unarmed. Eyes absent. Genital apertures close together, median. Testes numerous. Vagina double, not opening into genital atrium.

Type genus.—*Pseudocotyle* Beneden and Hesse, 1865.

Genus PSEUDOCOTYLE Beneden and Hesse, 1865

Diagnosis.—With characters of subfamily.

Type species.—*Pseudocotyle squatinae* Beneden and Hesse, 1865.

The genus *Pseudocotyle* contains only the type species; it has not been reported from North America.

Family ACANTHOCOTYLIDAE Price, 1936

Synonym.—Anisocotylidae Tagliani, 1912, in part.

Diagnosis.—Anterior haptors in form of retractile suckers or of weakly developed suckers surrounded by openings of cephalic gland ducts. Posterior haptor small, bearing usually 1 pair of centrally placed hooks and 14 marginal hooklets; sometimes with large disc-like pseudo-haptor bearing rows of spines, or with radial septa. Genital apertures separate; male aperture median or sublateral; female aperture lateral and marginal. Vagina (?). Testis single or multiple.

Type genus.—*Acanthocotyle* Monticelli, 1888.

The family Acanthocotylidae is erected to include 3 genera, viz., *Acanthocotyle* Monticelli, *Lophocotyle* Braun and *Enoplocotyle* Tagliani. The first two of these genera are included in the subfamily Acanthocotylinae Monticelli and the third in the subfamily Enoplocotylinae Tagliani.

Recent writers, including Johnston and Tiegs (1922) and Fuhrmann (1928), are not in agreement as to the affinities of these genera. Johnston and Tiegs place the genera *Acanthocotyle* and *Lophocotyle* in the Acanthocotylinae which they append to the superfamily Gyrodactyloidea; they do not mention the genus *Enoplocotyle*. Fuhrmann apparently does not recognize either the subfamily Acanthocotylinae or Enoplocotylinae, placing *Acanthocotyle*, *Lophocotyle* and *Enoplocotyle* in the family Monocotylidae.

The present writer regards the affinities of *Acanthocotyle, Lophocotyle* and *Enoplocotyle* such as to warrant the erection for them of a family separate from the Monocotylidae. In these genera the male and female genital apertures are relatively far removed, while in the Monocotylidae the male and female apertures are close together. Furthermore, in both *Acanthocotyle* and *Enoplocotyle,* and possibly also in *Lophocotyle,* the cephalic gland ducts open around the margins of the anterior sucker-like haptors; this is not the case in the Monocotylidae.

KEY TO SUBFAMILIES OF ACANTHOCOTYLIDAE

Posterior haptor very small, situated at margin of large disc-like pseudohaptor bearing radial rows of spines, or with muscular septa...ACANTHOCOTYLINAE Monticelli
Posterior haptor relatively large, without pseudohaptor...ENOPLOCOTYLINAE Tagliani

Subfamily ACANTHOCOTYLINAE Monticelli, 1903

Diagnosis.—Anterior haptors in form of 2 retractile suckers, or of corresponding concentrations of cephalic gland ducts. Posterior haptor very small, at margin of large disc-like pseudohaptor. Testes numerous.
Type genus.—*Acanthocotyle* Monticelli, 1888.

The posterior adhesive organs in members of the Acanthocotylinae differ from those occurring in other representatives of the Capsaloidea in consisting of a large sucker-like structure provided with a small armed disc situated at its posterior margin. The large sucker bears on its ventral surface either radial ridges (*Lophocotyle*) or radial rows of spines (*Acanthocotyle*); this structure has been termed a pseudohaptor (Price, 1937). The small disc is the true haptor and is undoubtedly homologous with the haptor of gyrodactylids, dactylogyrids, monocotylids and capsalids, since it is armed with hooks which are distributed as in the above forms. The spines of the pseudohaptor have usually been referred to as hooks, but since they are not provided with muscular attachments they can not be regarded as hooks in the same sense as those of the true haptor. In the present paper, as well as in others by the writer, the term *hook* is reserved for those cuticularized or chitinized structures which are freely movable due to muscular action, and the term *spine* is used for similar structures not provided with muscles; we may have, therefore, spine-like hooks as well as hook-like spines.

KEY TO GENERA OF ACANTHOCOTYLINAE

Pseudohaptor with radial rows of spines.........*Acanthocotyle* Monticelli
Pseudohaptor without radial rows of spines............*Lophocotyle* Braun

Genus Acanthocotyle Monticelli, 1888

Diagnosis.—Anterior haptors in form of 2 retractile suckers; cephalic glands present, opening around margins of suckers. Pseudohaptor large, bearing radiating rows of irregularly shaped spines. Intestinal branches without lateral diverticula.
Type species.—*Acanthocotyle lobianchi* Monticelli, 1888.

The genus *Acanthocotyle* contains at present 9 apparently valid species as follows: *A. branchialis* Willem (1906), *A. elegans* Monticelli (1890), *A. lobianchi* Monticelli (1888), *A. monticellii*[2] Scott (1902), *A. oligoterus* Monticelli (1899), *A. pacifica* Guberlet (1937), *A. pugetensis* Guberlet (1937), *A. verrilli* Goto (1899), and *A. williamsi*, n. sp.; all except the last four of these species occur on European rays and are not known to occur on North American hosts.

Acanthocotyle williamsi, n. sp. Fig. 6–9

Description.—Body linguiform, flat, 3.7 to 4.4 mm long by 1.3 to 1.6 mm wide. Anterior sucker-like haptors 150μ long by 110μ wide, retracted into groove-like depressions. Cephalic glands present, opening around margins of haptors as in other species of the genus. Pseudohaptor disc-like, 1.2 to 1.3 mm in diameter, its ventral surface provided with 20 rows (21 rows in 1 specimen) of strong spines, the 2 most posterior rows with 3 to 6 spines each and the other rows with 6 to 10 each; outermost spines longest, truncate at tips. Posterior haptor 55 to 65μ in diameter, situated at distal margin of pseudohaptor, armed with 16 hooks, 2 centrals and 14 marginals, each about 18 to 20μ long. Oral aperture ventral, median, about 240μ from anterior end of body. Pharynx globular, 320 to 400μ in diameter. Esophagus very short; intestinal branches simple, without diverticula. Brain anterodorsal of oral aperture; no eyes; one pair of sensory papillae near anterior margin, immediately median to haptors. Excretory vesicles anterior to vitellaria, opening dorsally near lateral margins of body. Male genital aperture median or slightly submedian, immediately posterior to base of pharynx. Cirrus pouch relatively large, curved, containing an internal seminal vesicle and a relatively short cirrus; vas deferens enlarged and constricted to form 2 external seminal vesicles, the most posterior being rosette-shaped. Paired prostatic vesicles present, one on each side of cirrus pouch, extending from level of middle of anterior seminal vesicle to genital aperture; these lie entirely outside the cirrus pouch and are often voluminous. Testes 32 to 57 in number, in intercecal field posterior to ovary. Ovary globular, 270 to 320μ in diameter, median, about one-third of body length from anterior end. Vitellaria extracecal, consisting of large elongate follicles, extending from level of ovary to near posterior end of body proper. Seminal receptacle present, postero-dorsal of ovary; vagina absent. Ootype elongate, in median field, uniting with uterus by means of a short slender duct; uterus cylindrical, relatively short, opening into relatively large club-shaped muscular metraterm. Female aperture dextral, dorsal, at level of anterior part of pharynx. Egg 275μ long, exclusive of filament, by 68μ wide.

Host.—"Skate."

Location.—Skin.

Distribution.—Aleutian Islands (Salt Island).

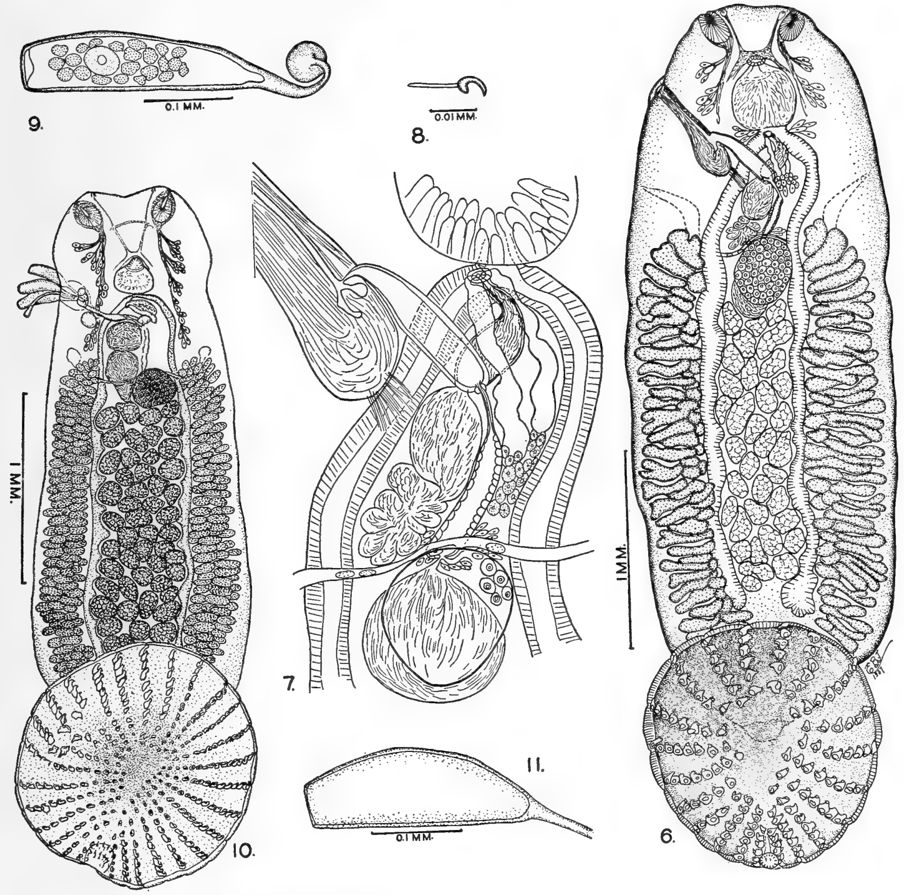
Specimens.—U.S.N.M. Helm. Coll. No. 9033 cotypes; collected July 7, 1936, by C. S. Williams, for whom the species is named.

This species appears to resemble more closely *A. branchialis* Willem than any of the other species of *Acanthocotyle*. The two species differ mainly in the number of pseudohaptoral spines, there being 7 to 8 spines in the most

[2] *Acanthocotyle concinna* Scott, 1902, appears to be a lapsus for *A. monticellii;* the name is mentioned only once and then in connection with a comparison of *A. monticellii* with other species of the genus.

posterior rows and 9 to 14 in the others in *A. branchialis*, and 3 to 6 in the most posterior rows and 6 to 10 in the others in *A. williamsi*.

A study of specimens of this and some other species of *Acanthocotyle* has convinced the writer that Monticelli (1899) was in error in interpreting parts of the male and female genital systems in species of this genus. According to Monticelli's descriptions and very elaborate figures of these systems



Figs. 6–9.—*Acanthocotyle williamsi*. 6, complete worm, ventral view; 7, male and female genital complex; 8, haptoral hook; 9, egg. Figs. 10–11.—*Acanthocotyle verrilli*. 10, complete worm, ventral view; 11, egg.

in the species described by him, there is a large cirrus sac containing a cirrus, internal seminal vesicle and a prostatic vesicle. He also described and figured a vagina extending from the seminal receptacle and opening near the male aperture. According to the present writer's observations on serial sections and toto mounts of several specimens of *A. williamsi*, as well as observations on specimens of *A. verrilli* and two species kindly supplied by Kelsaw Bonham, University of Washington, Seattle, Wash., the cirrus pouch is very delicate and encloses only a small cirrus and a large internal seminal vesicle; the prostatic vesicles are two in number, both lying free in the parenchyma, one on each side of the cirrus pouch, and opening opposite each other in a shallow genital atrium. There is no trace of either a vaginal aperture or a vagina in any of the species studied, and it appears that what was regarded as a vagina by Monticelli was one of the prostatic vesicles. The conclusion that a vagina is absent in species of *Acanthocotyle* is supported by Willem (1906) who stated that he was unable to demonstrate this structure in specimens of *A. branchialis.*

Acanthocotyle verrilli Goto, 1899 Figs. 10–11

Description.—Body linguiform, almost rectangular, flat, 3.5 to 3.89 mm long by 1.2 to 1.3 mm wide, slightly constricted at level of pharynx. Anterior haptors in form of a pair of suckers, each about 114μ wide, retracted into groove-like depressions. Cephalic glands present, their ducts opening at margins of anterior haptors. Pseudohaptor disc-like, 1.28 to 1.36 mm in diameter, slightly concave, with 30 radial rows of irregularly shaped spines, 4 to 15 in each row, outermost spines longer than others and with truncate tips; posterior haptor about 130μ in diameter, at posterior margin of pseudohaptor, armed with 16 hooks, 2 centrals and 14 marginals, each about 30μ long. Oral opening ventral, about 340 to 425μ from anterior end of body. Pharynx piriform, 190 to 285μ long by 247 to 293μ wide; esophagus extremely short; intestinal branches with slight median diverticula, terminating near posterior end of body proper. Nervous system not completely ascertainable; brain immediately anterior to oral aperture; eyes absent; 1 pair of sensory papillae situated at anterior margin of body, 1 papilla median to each haptor. Excretory vesicles immediately anterior to vitellaria, opening dorsally near lateral margins of body. Male genital aperture submedian, about 570μ from anterior end of body; cirrus relatively short; vas deferens dilated and constricted to form 2 seminal vesicles. Paired prostate vesicles present, one opening on each side of male genital aperture. Testes about 57 in number, in interintestinal field posterior to ovary. Ovary globular, 210 to 228μ in diameter, submedian, pretesticular. Vitellaria extracecal, consisting of large follicles and extending from ovarial zone to posterior end of body proper. Vagina absent. Ootype relatively wide, extending anteriad in median line, joined by slender duct to the relatively long uterus; metraterm relatively wide. Egg 259μ long, exclusive of filament, by 80μ wide.

Hosts.—*Raja erinacea* Mitchill, *R. radiata* Donovan, and "blue fish."

Location.—Skin.

Distribution.—United States (North Atlantic). Reported from Cape Cod, Mass., by Goto (1899); from Canada by Stafford (1904); and from off the coast of Maine by Manter (1926).

Specimens.—U.S.N.M. Helm. Coll. No. 7175.

The description given here is based on 2 specimens from a "blue fish," collector unknown, which were found in the U. S. National Museum.

This species appears to be somewhat variable, as considerable difference was noted between the specimens studied by the writer and those described by Goto (1899) and by Manter (1926); these differences, however, were more or less minor, being in the number of testes and in the number of rows of spines on the pseudohaptor. Goto reported the number of testes as 37 and

Manter as 52, while in the writer's specimens there were at least 57. The number of rows of spines on the pseudohaptor was given as 34 by Goto and 32 by Manter; in the writer's specimens there were 30 rows. In spite of these differences there seems to be no reason for regarding the specimens from the 3 collections as representing different species.

Acanthocotyle pacifica Guberlet, 1937

This species was reported by Guberlet (1937) as occurring on the skin and only rarely on the gills of *Raja binoculata* Girard, *R. stellulata* Jordan and Gilbert and *R. rhina* Jordan and Gilbert from the Pacific Coast. The only character given for this species was that the pseudohaptor bears 32 or more rows of spines.

Acanthocotyle pugetensis Guberlet, 1937

This species was reported as occurring principally on the gills of the same hosts as *A. pacifica.* The pseudohaptor bears 20 rows of spines.

Genus Lophocotyle Braun, 1896

Diagnosis.—Anterior haptors in form of 2 groups of cephalic gland duct openings. Pseudohaptor similar to that of *Acanthocotyle* but with muscular radii instead of rows of spines. Intestinal branches with lateral diverticula. Male and female genital apertures apparently not so widely separated as in *Acanthocotyle;* testes numerous.

Type species.—Lophocotyle cyclophora Braun (1896).

The type and only species of this genus was based on 2 specimens, collected at Puerto Toro by the Hamburg Magellan-Expedition "wahrscheinlich von der Haut eines Fisches der Gattung *Notothenia.*" The specimens apparently were not in good condition as certain features of the worm were not well described. The general appearance, however, indicates a very close relationship with members of the genus *Acanthocotyle.*

Subfamily ENOPLOCOTYLINAE Tagliani, 1912

Diagnosis.—Anterior haptors in form of 2 very weakly developed suckers, with ducts of cephalic glands opening around them. Posterior haptor relatively large, with 1 pair of centrally placed hooks and 14 marginal hooklets, each of the latter located in center of an oval sucker-like depression. Testis single, immediately postovarial.

Type genus.—Enoplocotyle Tagliani, 1912.

Genus Enoplocotyle Tagliani, 1912

Diagnosis.—Characters of subfamily.

Type species.—Enoplocotyle minima Tagliani, 1912.

This genus contains only the type species; it is not known to occur in North American hosts.

Family UDONELLIDAE Taschenberg, 1879

Diagnosis.—Body elongate, cylindrical or subcylindrical; cuticula with distinct or indistinct annulations. Anterior haptors present or absent, when present, in form of 2 small suckers or sucker-like structures; cephalic glands present. Posterior haptor sucker-like, without radii, unarmed. Pharynx well developed, protrusible. Intestine simple, sac-like, unbranched, sometimes fenestrate in testicular and ovarian zones. Genital aperture median or submarginal; cirrus absent; testis single. Ovary pretesticular, median. Egg oval or elongate piriform, with long filament at one pole.

Type genus.—*Udonella* Johnston, 1835.

Genus Udonella Johnston, 1835

Synonyms.—*Lintonia* Monticelli, 1904; *Calinella* Monticelli, 1910.

Diagnosis.—Anterior haptors in form of 2 small suckers or sucker-like structures; posterior haptor terminal, sucker-like, unarmed. Pharynx without hooks or spines; intestine simple, sac-like, sometimes fenestrate in ovarian and testicular zone.

Type species.—*Udonella caligorum* Johnston, 1835.

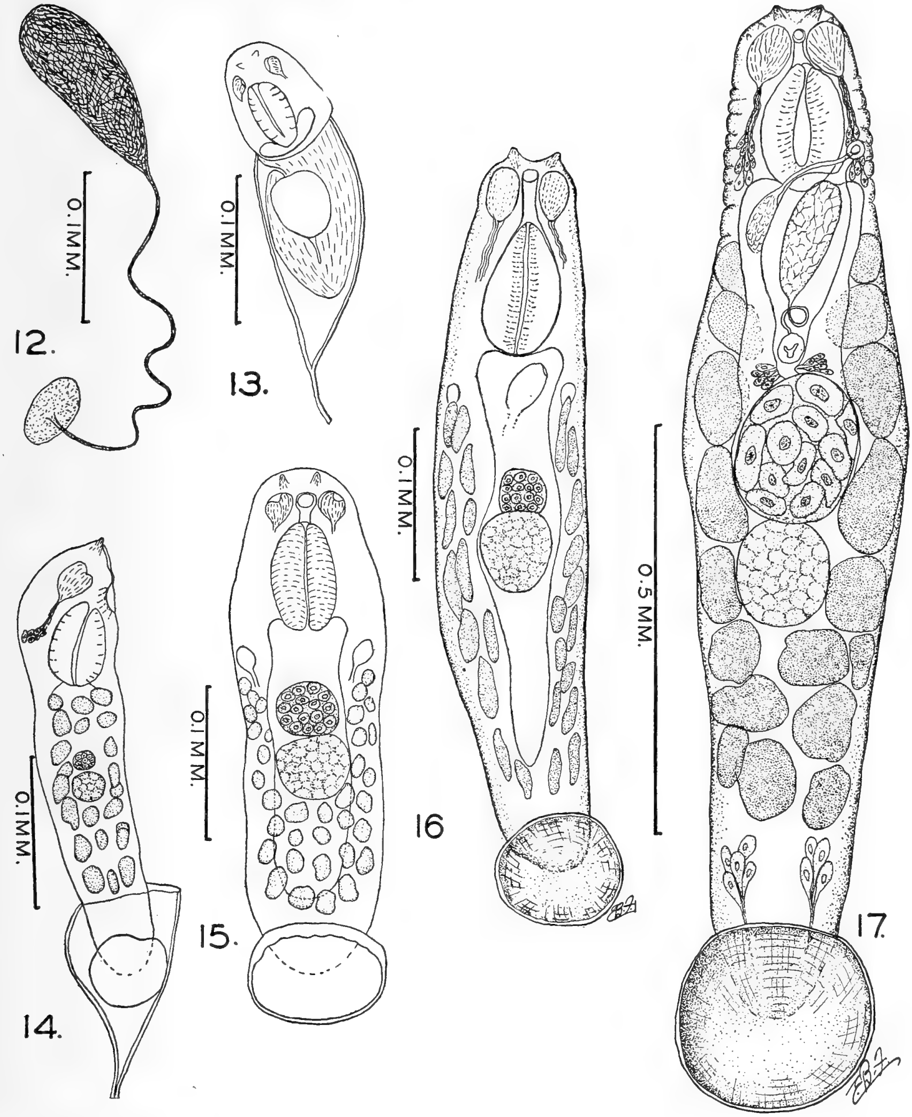
The genera *Lintonia* Monticelli (1904) and *Calinella* Monticelli (1910) are regarded as synonyms of *Udonella* Johnston, as the characters given for these genera are of no more than specific value. The type of *Lintonia, L. papillosa* (Linton), is shown further on in this paper to be the same as *Udonella socialis* Linton, and both are apparently identical with *U. caligorum* Johnston. *Calinella craneola* Monticelli shows a fenestration of the simple sac-like intestinal cecum but otherwise appears to be very similar to *U. caligorum;* this single character is not regarded as generic.

The genus *Udonella* contains at the present time the following species: *U. caligorum* Johnston, *U. craneola* (Monticelli), *U. lupi* Beneden and Hesse, *U. merlucii* Beneden and Hesse, *U. pollachii* Beneden and Hesse, *U. sciaenae* Beneden and Hesse, and *U. triglae* Beneden and Hesse. Of these species only the first two, *U. caligorum* and *U. craneola,* appear to be distinguishable; the remaining species are imperfectly described and probably not all congeneric.

Udonella caligorum Johnston, 1835 Figs. 12–17

Synonyms.—*Nitzschia papillosa* Linton, 1898; *Lintonia papillosa* (Linton, 1898) Monticelli, 1904; *Udonella socialis* Linton, 1910; *Calinella myliobati* Guberlet, 1936.

Description.—Body elongate, 1.1 to 1.36 mm long by 255μ wide at ovary, subcylindrical; cuticula of anterior end of body in mature specimens showing pseudoannulations. Anterior haptors sucker-like, retractile, about 42 to 57μ wide; cephalic glands present, their ducts leading apparently to anterior haptors. Posterior haptor sucker-like, 187 to 210μ in diameter, without septa or hooks. Caudal glands present, arranged in 2 submarginal groups near posterior end of body proper. Oral aperture subterminal, median. Pharynx oval, 150 to 152μ long by 85 to 95μ wide, apparently partially protrusible. Intestine simple, sac-like, unbranched, extending to near posterior end of body proper. Nervous system not observed; eyes absent; one pair of conspicuous sensory papillae present at anterior end of body. Excretory vesicles submarginal, at or slightly posterior to level of base of pharynx, conspicuous in small specimens. Genital aperture sinistral, submarginal, slightly anterior to level of posterior end of pharynx. Cirrus apparently absent; ejaculatory duct slender and leading from an oval seminal vesicle lying to right of anterior end of ootype. Testis single, median, 76 to 95μ in diameter, equatorial. Ovary globular, 133μ in diameter, median, pretesticular. Vitel-



Figs. 12–17.—*Udonella caligorum.* 12, egg; 13 and 14, egg hatching; 15 and 16, young forms showing different degrees of maturity; 17, adult worm.

laria consisting of few relatively large follicles, extending from slightly posterior to pharynx to a short distance anterior to posterior end of body. Vagina absent. Ootype large, vesicular, its base surrounded by unicellular glands; metraterm very short. Egg from balsam mounts elongate piriform, 133μ long by 42μ wide, with long slender filament expanded at tip to form an adhesive disc; the eggs were all considerably contracted and wrinkled and the measurements given are no doubt much less than would be those of unpreserved eggs.

Life history.—Immature forms in all stages of growth from escape of the larva from the egg to the fully mature adult were observed on the slide mount of *Udonella socialis.* These various growth stages showed very little of special significance. At the time of escape from the egg the worm appears to be virtually mature except for size; the smallest individual observed was 210μ long by 57μ wide. The most noticeable change during growth appears to be in the relative sizes of the ovary and testis; in immature stages the ovary is always distinctly smaller than the testis, while in fully grown adults the reverse is true. The life history of this species, so far as represented in the available material, is essentially the same as that given by Beneden (1858).

Hosts.—"*Argulus* sp." in mouth of *Neomaenis griseus; Caligus* sp., on *Gadus callarias* Linnaeus; and *Trebius latiturcatus,* parasite on *Myliobatis californicus* Gill.

Location.—Body and appendages of copepod.

Distribution.—United States (Woods Hole, Mass., Tortugas, Fla., and Monterey Bay, Calif.) and (?) Canada.

Specimens.—U.S.N.M. Helm. Coll. Nos. 4874 (cotypes of *Nitzschia papillosa*) and 8537 (cotypes of *Udonella socialis*).

Udonella caligorum was first reported from this country by Linton (1898) as *Nitzschia papillosa,* the description being based upon specimens collected by the late Vinal N. Edwards at Woods Hole, Mass., December 15, 1885, from the (?) gills of *Gadus callarias.* The description was very incomplete and the illustrations inadequate. Owing to the incompleteness of the description and figures, Monticelli (1904) secured the cotype specimens and redescribed the species as *Lintonia papillosa,* placing his newly created genus *Lintonia* in the family Monocotylidae. Later, Linton (1910) described as a new species, *Udonella socialis,* a form which he found on "*Argulus* sp." from the mouth of *Neomaenis griseus* at Tortugas, Fla. More recently Guberlet (1936) described *Calinella myliobati* from specimens found on a copepod, *Trebius latifurcatus,* parasitic on *Myliobatis californicus* from Monterey Bay, California. A comparison of the type specimens of *N. papillosa* (=*L. papillosa*), *U. socialis* and *C. myliobati* has shown that these species are apparently identical with the European *Udonella caligorum* Johnston (1835) from *Caligus* sp. parasitic on the halibut, *Hippoglossus vulgaris. U. caligorum* has also been reported by Stafford (1904) from *Caligus* sp. on *Gadus callarias* from Canada; none of the latter species was available for study.

U. caligorum seems to be quite variable as regards size, the variation in length ranging from "about 4 lines," according to Johnston (5 to 6 mm according to Beneden (1858); 4 mm according to Stafford (1905)), to less than 2 mm in specimens available to the writer. The specimen of *U. caligorum* from England reported by Baylis and Jones (1933) were made available for comparison through the courtesy of Doctor Baylis, and a study of these specimens showed no essential differences, either in size or in other respects, between them and the specimens from the United States.

Genera inquirenda

Genus ECHINELLA Beneden and Hesse, 1863

Diagnosis.—Body elongate, cylindrical, annulated. Posterior haptor relatively large, sucker-like. Pharynx with 2 chitinous hooks; intestine (?).
Type species.—*Echinella hirundinis* Beneden and Hesse, 1863.

Genus PTERONELLA Beneden and Hesse, 1863

Diagnosis.—Body elongate, annulated when young. Anterior end with ciliated aliform membrane. Posterior haptor relatively large, sucker-like. Pharynx armed with a large number of chitinous stylets; intestine (?).
Type species.—*Pteronella molvae* Beneden and Hesse, 1863.
No representatives of these very inadequately characterized genera have been reported from North America.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

40th annual meeting

The 40th Annual Meeting of the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, January 20, 1938 with 50 members present. President Charles Thom called the meeting to order at 9:15 P.M.

The minutes of the 39th Annual Meeting were presented and approved. The Corresponding Secretary, Nathan R. Smith, submitted the following report on the membership and activities of the Academy:

Membership: During 1937, 38 were elected to resident and 1 to non-resident active membership. Of these, 28 have qualified for resident membership to date. Six were elected in recognition of their work in Chemistry; 4 in Electricity and Radio; 4 in Zoology; 3 in Geology; 3 in Bacteriology; 3 in Entomology; 3 in Medicine; 2 in Soil Science; 2 in Phytopathology; 2 in Biology; 2 in Forestry; 2 in Physics; and 1 each in Plant Physiology, Engineering and Meteorology. There were 4 resignations (1 resident and 3 non-resident), and 12 deaths. Twenty-one were dropped for non-payment of dues (12 resident and 9 non-resident). The net loss in membership was, therefore, 9.

The following deaths were reported:

Clarence B. Moore, Philadelphia, Pa., 1936
F. V. Coville, Washington, D. C., January 9, 1937.
Wm. M. Beaman, Washington, D. C., March 2, 1937.
Wm. A. White, Washington, D. C., March 7, 1937.
Elihu Thomson, Lynn, Mass., March 13, 1937.
C. H. Smyth, Jr., Princeton, N. J., April 4, 1937.
Wm. M. Wheeler, Cambridge, Mass., April 19, 1937.
O. P. Hood, Washington, D. C., April 22, 1937.
Paul V. Roundy, Washington, D. C., June 21, 1937.
A. B. Clawson, Washington, D. C., June 30, 1937.
J. N. B. Hewitt, Washington D. C., October 14, 1937.
Lord Rutherford (Honorary Member), Cambridge, England, Oct. 19, 1937.

On January 1, 1938, the membership consisted of 13 honorary members, 3 patrons and 515 active members, one of which was a life member. Of the active members, 388 were classed as resident and 127 as non-resident. Since the By-Laws limit the number of active members to 400 resident and 200 non-resident, but do not include retired active members of which there are 22 resident and 6 non-resident, there were, therefore, 34 vacancies in the resident and 79 vacancies in the non-resident membership.

The Board of Managers held five meetings during the year, with an average attendance of 17.

The Recording Secretary presented the following report:

The 40th year of the Academy began with the 276th meeting and ended tonight with the 283rd meeting.

The 267th meeting was a joint meeting with the Washington Section, American Institute of Electrical Engineers; the Washington Section, American Society of Mechanical Engineers; the Washington Post of the Society of American Military Engineers and the Washington Society of Engineers. The meeting was held on February 18, 1937 in the Department of Commerce Auditorium with about 450 in attendance. The address was to be given by VLADIMIR KARAPETOFF, Professor of Electrical Engineering, Cornell University. On account of illness Professor KARAPETOFF was forced to cancel the engagement at the last minute. As a substitute, an address was given by GEORGE OTIS SANFORD of the Bureau of Reclamation on the *Grand Coulee and Boulder Dam Projects* illustrated with moving pictures.

The 277th meeting was a joint meeting with the Philosophical Society of Washington and the Washington Section of the Institute of Radio Engineers. The meeting was held in the Assembly Hall of the Cosmos Club on March 18, 1937 with about 250 in attendance. The address was given by ROBERT R. MCMATH, Director of the McMath-Hulbert Observatory of the University of Michigan. The subject of the address was *Solar Phenomena in Motion Pictures* and *A Motion Picture Journey to the Moon.*

The 278th meeting, a joint meeting with the Biological Society, was held on April 8, 1937 in the Auditorium of the National Museum with about 347 in attendance. The address was given by ARTHUR A. ALLEN, Professor of Ornithology, Cornell University on *American Ornithology, Past and Present.* The address was illustrated with sound moving pictures reproducing the songs of various birds.

The 279th meeting was held in the Assembly Hall of the Cosmos Club on April 29, 1937 with about 200 in attendance. An illustrated address was given by F. SIMON, Oxford University, England, on the subject, *The Production and Measurement of Extremely Low Temperatures.*

The 280th meeting was held on October 21, 1937 in the Assembly Hall of the Cosmos Club with about 50 in attendance. The address was given by STUART A. RICE, Chairman of the Central Statistical Board on the subject, *The Census of Partial Employment, Unemployment and Occupation.*

The 281st meeting was held on November 18, 1937 in the Auditorium of the National Museum with about 120 in attendance. The illustrated address of the evening was given by C. W. GILMORE, Curator, Division of Vertebrate Paleontology, National Museum. After the lecture those in attendance were taken through the exhibition halls and laboratory rooms of the division of vertebrate paleontology to view the exhibits under the leadership of the speaker.

The 282nd meeting on December 16, 1937 was held in the Assembly Hall of the Cosmos Club with about 60 in attendance. An illustrated address was given by R. R. WILLIAMS, Chemical Director, Bell Telephone Laboratories, on the subject, *The Quest for Vitamin* B_1.

The 283rd meeting of the Academy was held in the Assembly Hall of the Cosmos Club on January 20, 1938 with 60 persons present. An illustrated address was given by F. R. MOULTON, Permanent Secretary of the American Association for the Advancement of Science on the subject, *Celestial Science.*

The report of the Treasurer, H. G. AVERS, was read by HOWARD S. RAPPLEYE:

CASH RECEIPTS AND DISBURSEMENTS

RECEIPTS			
From Back Dues		$ 125.00	
From Dues for 1937		2365.00	
From Dues for 1938		15.00	
From Subscriptions for 1937		875.80	
From Subscriptions for 1938		312.70	
From Sales of Journals		124.29	
From Payments for reprints		306.50	
From Sale of halftone plate		6.10	
From Sales of Directory for 1937		38.00	
From Interest on Deposits		47.95	
From Interest on Investments		1064.50	
From Sale of Bond of Potomac El. Power Co.		999.35	
From Sale of Bond of Amer. Tel. & Tel. Co.		2199.00	
From Sale of Bond of So. Bell Tel. & Tel. Co.		1049.25	
Total receipts		$9528.44	
Cash Balance January 1, 1937		4635.63	
To be accounted for			$14,164.07
DISBURSEMENTS			
For Secretary's Office, 1936		$ 37.95	
For Secretary's Office, 1937		276.23	
For Treasurer's Office		179.11	
For Journal Printing, 1936		336.11	
For Journal Printing, 1937		2359.29	
For Journal Reprints, 1936		139.20	
For Journal Reprints, 1937		440.85	
For Illustrations, 1937		339.09	
For Meetings Committee, 1936		41.21	
For Meetings Committee, 1937		378.55	
For Printing of Directory		685.21	
For Projection lens		98.70	
For Dues of Retired members returned		45.00	
Bank Debit Memos, as follows:—			
Dues	$0.35		
Subscriptions	.11	.46	
Total Disbursements		$5356.96	
Cash Balance December 31, 1937		8807.11	
Total			$14,164.07

The investments listed amounted to $16,046.37.

The Auditing Committee, Arthur A. Baker, William A. Dayton and Gordon M. Kline 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 sheet's 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, R. W. BROWN, E. H. TOOLE and F. D. ROSSINI submitted the following report covering the publication of Volume 27 of the Journal for the year 1937:

"Volume 27 consisted of 12 issues amounting to 548 pages, 6 pages less than Volume 26. It contained 69 original papers, 7 less than in 1936. Of these papers, 41 were by members of the Academy, and 28 were communicated; 56 came from contributors residing in or near the District of Columbia, 13 from outside sources. Five contributors of communicated papers in this or preceding volumes of the Journal were elected to membership in the Academy during the past year. Original papers were illustrated by 54 line cuts and 17 half-tones. In several instances contributors either furnished engravings or paid for those in excess of the normal number allowed by the Journal. Space in Volume 27 was distributed as follows:

	Papers	Pages	Percent of space
Anthropology	2	12.9	2
Botany	15	93.2	17
Chemistry	4	45.6	8
Entomology	9	59.5	11
Geology	7	68.3	13
Mathematics	1	4.3	1
Ornithology	3	13.0	2
Paleontology	11	46.8	9
Physics	2	32.0	6
Zoology	15	118.0	22
Obituaries	13	11.2	2
Proceedings		35.2	6
Index		8.0	1

"The total cost of printing and distributing the Journal was $3,046.83, or $5.56 per page. This is 46 cents per page higher than in 1936, a rise due to increased costs of paper, illustrations, and printing."

The tellers, L. V. JUDSON, S. F. BLAKE and J. H. ROE reported the election of the following officers: President, PAUL E. HOWE; Non-resident Vice Presidents, JAMES FRANCK and W. T. THOM, JR.; Corresponding Secretary, NATHAN R. SMITH; Recording Secretary, OSCAR S. ADAMS; Treasurer; H. G. AVERS; Board of Managers, F. G. COTTRELL and N. M. JUDD.

The Corresponding Secretary read the list of nominations for vice-presidents submitted by the affiliated societies as follows:

Philosophical Society—N. H. HECK
Anthropological Society—HENRY B. COLLINS, JR.
Biological Society—H. C. FULLER
Chemical Society—F. C. KRACEK
Entomological Society—C. F. W. MUESEBECK
National Geographic—A. WETMORE
Geological Society—R. C. WELLS
Medical Society—FRED O. COE
Historical Society—ALLEN C. CLARK

Botanical Society—W. A. DAYTON
Archaeological Society—ALES HRDLICKA
Foresters—G. F. GRAVATT
Washington Engineers—PAUL C. WHITNEY
Electrical Engineers—H. L. CURTIS
Mechanical Engineers—H. N. EATON
Helminthological Society—E. W. PRICE
Bacteriological Society—L. A. ROGERS
Military Engineers—C. H. BIRDSEYE
Radio Engineers—H. G. DORSEY

By vote of the Academy, the Recording Secretary was instuctd to cast one vote for the list as read and the vice-presidents were declared elected.

President THOM appointed Past Presidents MEINZER and TUCKERMAN to escort President-elect HOWE to the chair. President HOWE took over the gavel and addressed the Academy briefly.

Adjournment followed at 10:10 P.M.

OSCAR S. ADAMS, *Recording Secretary*

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

278TH MEETING

The 278th regular meeting was held in the assembly hall of the Cosmos Club, January 5, 1937, President GEORGE M. DARROW presiding; attendance 110.

Program.—T. K. PAVLYCHENKO: *Root systems of certain forage crops in relation of management of agricultural soils* (lantern). Root studies were reported on three grasses: *Bromus inermis, Agropyron tenerum,* and *A. cristatum,* in relation to their efficiency in controlling weeds and binding soil. Complete root systems were carefully studied and measured. Special methods for excavating, washing and studying the roots were described and illustrated. *A. cristatum* excelled in ability to combat weeds and bind soil. *Bromus inermis* and *A. tenerum* ranked second and third respectively.

A special meeting of the Botanical Society was held in the assembly hall of the Cosmos Club, January 19, 1937; attendance 137. Governor George D. Aiken of Vermont gave an illustrated lecture on *Pioneering with Wild Flowers.*

279TH MEETING

The 279th regular meeting was held in the assembly hall of the Cosmos Club February 2, 1937, President GEORGE M. DARROW presiding; attendance 110. L. W. BOYLE and NEIL WADE STUART were elected to membership.

Program.—MERLE T. JENKINS: *Recent advances in the use of hybrid vigor in corn production.* Hybrid corn has been developed as a result of the inbreeding investigations of G. H. Shull and E. M. East which began in 1905. The publication of Shull's suggestions in 1908 and 1909 for the development of inbred lines of corn and their utilization in hybrids marked the beginning of a new era in corn breeding. These suggestions are still the underlying procedures of the present hybrid corn program. However, there has been considerable progress in the methods and techniques connected with their application, in the isolation of better inbred lines, in the testing of these lines in hybrid combinations and in the kinds of hybrids in use. The first hybrid seed corn was sold in 1921, only 16 years ago. It is estimated that 3.5 million acres will be planted to hybrid corn in 1937.

H. L. WESTOVER: *Plant exploration in Turkey.* The speaker, accompanied by Frederick L. Wellman of the Division of Horticultural Crops and Diseases, spent seven months in Turkey in 1936, searching for new plants, particularly drouth resistant grasses and legumes, and disease resistant vegetables. Approximately 3500 lots of seed, bulbs, etc., were collected on this expedition.

280TH MEETING

The annual banquet and 280th regular meeting of the Botanical Society was held in the ball room of the Kennedy-Warren Hotel March 9, 1937; attendance 157.

Program.—HOMER L. SHANTZ gave a lecture on the vegetation of Arizona, which was illustrated with lantern slides, many of which were colored.

A special meeting was held March 23, 1937, in the auditorium of the Department of Agriculture.

The Department of Agriculture kindly presented four interesting motion picture films dealing with several phases of plant investigation, culture and exploration, entitled: *Explorations in Ceylon, Sumatra and Java; Bamboos—The giant grasses of the Orient; Persimmon harvesting and storage in China;* and *Life of plants.*

281ST MEETING

The 281st regular meeting was held in the assembly hall of the Cosmos Club April 6, 1937, President GEORGE M. DARROW presiding; attendance 53. H. H. THORNBERRY, LENA ARTZ and LOUISA AMES were elected to membership.

Program.—PAUL CONGER: *The Diatom, an economic plant.* Probably few people have thought of the diatom specifically in such terms, yet diatoms satisfy all qualifications of the definition of an economic plant. They grow so prolifically, wide spread, and abundantly in practically all waters of the earth, as to produce inestimable quantities of substance. This substance is indirectly important to man, in serving as a primary food supply of fish, oysters, and innumerable other organisms on which they feed, just as economic grasses support farm animals. In certain places, as the oyster beds of France, their propagation is even encouraged by artificial culture. More directly diatoms are useful to man in producing a material, their silica shells, which, in quantity, comprise diatomaceous earth, a substance essential to many industrial processes or products, for purposes of insulation, filtration, as a filler, an absorbent, an abrasive and many other industrial uses. The high oil content of the diatom cell has probably also contributed to the oil reserves, of great economic importance to man. Though much time may have elapsed since the life of the plant and the availability of the material produced, it is none the less economic.

Diatoms, though generally useful, may not always be beneficial to man. They may, at times, interfere with fish life, and city filtration or sanitary systems, or give unpleasant odor to drinking water. Thus in the sense that harmful insects largely make up the work of economic entomology, diatoms may again be considered economic plants affecting adversely the economy of man.

In the broader and philosophical sense everything is economic, in that all contribute to the smooth and rhythmic functioning of a unified, balanced and orderly world. In this sense diatoms play a most significant role in the broader cycles of nature. Our sense of relative economic importance should extend beyond the more obvious and direct, to the ecological importance as well.

H. D. BARKER: *Some observations on useful and wild plants in Haiti.*

282ND MEETING

The 282nd regular meeting was held in the assembly hall of the Cosmos Club, May 4, 1937, President GEORGE M. DARROW presiding; attendance 109.

Program.—ROBERT F. GRIGGS: *Timberlines in the northern Rocky Mountains.* The demonstration previously made that the forest is invading the tundra in Alaska raises the question of the extent of the migration. Much evidence indicates that in the southwest vegetation is static. In Greenland, excavation of the Old Norse Colony indicates great deterioration of climate within the last thousand years. In the northern Rocky Mountains, many timberlines are advancing as at Kodiak. All trees are young and without dead wood or other evidence of climatic control, but all cases examined were secondary advances repossessing ground deforested by fire or grazing. Except for local retreats in some sections, alpine timberlines from Wyoming to Jasper are stable, showing therefore that the climatic improvement indicated in Alaska does not extend into the Canadian Rockies.

W. T. SWINGLE: *Plant relationships, how determined and for what use, especially in plant breeding.*

283RD MEETING

The 283rd regular meeting was held in the assembly hall of the Cosmos Club October 5, 1937, President GEORGE M. DARROW presiding; attendance 70. RUSSELL G. BROWN, MARK W. WOODS, EDGAR P. WALLS, CORNELIUS B. SHEAR and C. L. LEFEBVRE were elected to membership.

Notes and Reviews.—W. W. DIEHL brought to the attention of the meeting an interesting case of a fungus attacking the inside of a wooden apple made in Japan and sold to merchants in Winchester, Virginia, to be used as an apple-candy container.

Program.—R. KENT BEATTIE: *A new disease threatening the future of the persimmon.* The American persimmon tree is important in preventing soil erosion and in furnishing food for wild life. It supplies high grade wood for the making of gold stick heads.

Recently a serious wilt disease has been found in Tennessee southeast of Nashville. This disease kills the trees rapidly. It has proved to be due to a species of *Cephalosporium.* The fungus forms spores very abundantly under the bark when it loosens after the death of the tree and in crevices of trees killed by the disease. No remedies are known. Susceptibility and resistance in other persimmon species have not yet been determined.

W. R. CHAPLINE: *Ecology in the restoration of the western range.* Restoration of depleted ranges is of vital concern to the social and economic welfare of the western United States. The range resource and its use affecting 728 million acres, nearly two-fifths of the continental United States, presents a biological problem of first magnitude. It concerns the production of native forage crops and their utilization in livestock and wildlife production; and management of the land and its forage cover to obtain erosion control and water delivery for irrigation agriculture, power, and municipal use.

Past use has failed to maintain the resource, resulting in serious and practically universal range and soil depletion with its related social and economic losses. Ecological research makes possible a better understanding of man's destructive forces on range lands. Likewise it aids in pointing the way to remedial measures that will stop depletion and restore and maintain the range under continued use, essential features in the formulation of policies and programs for range restoration and management.

284TH MEETING

The 284th regular meeting was held in the assembly hall of the Cosmos Club, November 2, 1937, President GEORGE M. DARROW presiding; attendance 147. EDWARD H. GRAHAM. ALTON A. LINDSEY, VERA E. MILLSAPS, L. P. MCCANN and ALBERT H. TILLSON were elected to membership.

Notes and Reviews.—CHAS. THOM gave a brief resume of the work of A. F. BLAKESLEE with colchicine used to double the number of chromosomes in several species of plants.

Program.—S. L. EMSWELLER: *Cytology and flower breeding.* An introductory discussion of the field of general cytology was presented, which included the historical background which has led up to the modern conception. There were also presented some generalizations as to chromosome pairing in normal balanced species as compared to species hybrids. The manner in which cytology can aid in explaining problems of sterility and failure to secure crosses was discussed. It was pointed out that doubling the chromosome number of a hybrid in which there is complete failure of pairing will ordinarily give rise to an amphi-diploid. Such a new condition will not result in crossovers and recombinations between the two unrelated genoms.

J. W. MCKAY: *Cytology and nut breeding.* The results of breeding work with plants are determined by the number and behavior of chromosomes that are distributed to the germ cells. In many genera, such as *Rubus* and *Triticum*, there is a series of chromosome numbers that are multiples of a common base number, and the products of species hybridization are dependent upon the behavior and distribution of the chromosomes in the hybrid individuals.

Among nut-producing plants the genus *Hicoria* offers the only case of a polyploid series, one group of species exhibiting 32 and another group 64 somatic chromosomes. The following somatic chromosome numbers are found in nut species: walnuts, 32; hazelnuts and filberts, 28; chestnuts, 24; almonds, 16.

The embryo of the seed is the edible portion of the fruit in all of the nut species. The embryo develops only after a viable zygote has been produced by fertilization of the egg by a sperm nucleus. Thus, in order that nut trees be productive, it is necessary that the reproductive processes in the flowers function in a normal manner. A study of the chromosomes in the cells which produce the pollen and eggs may disclose irregularities that help to explain why many varieties and species are unproductive.

A. E. CLARKE: *Cytology and potato and onion breeding.* A serious problem facing the potato breeder is the difficulty in obtaining seeds. *Solanum tuberosum* is either tetraploid or octoploid in origin and, during meiosis, there is considerable secondary association between different pairs of chromosomes, resulting in chromosomal irregularities and pollen sterility. Environmental factors, such as length of day, temperature and humidity, are important because they influence flower production and the abscission of buds before pollination. Cytological studies are being carried on to show whether these environmental influences also affect pollen fertility. By providing optimum conditions it may be possible to secure some viable pollen from varieties ordinarily sterile. Wild species form a polyploid series. The cytologist can assist in analyzing and interpreting the results obtained from interspecific hybridization.

Cytological examination of a sterile onion, which is also mildew resistant, has so far failed to disclose any chromosomal irregularities. Commercial varieties of garlic never produce seed. Further cytological studies may solve these sterility problems.

H. DERMEN: *Cytology and fruit breeding.* Methods have been devised to facilitate quick determination of the cytological constitution of plants dealt with at the United States Horticultural Station at Beltsville, Maryland. Recently induction of polyploidy by artificial means has indicated interesting possibilities of creating new forms, some of which may be of great value commercially. Some factors found to influence polyploidy include temperature changes, genetic factors, narcotics and chemicals, diseases or insects, osmotic changes, treatment with X-ray or ultra-violet light, chromosomal incompatibility in species hybrids, mechanical disturbance by centrifuging, physiological disturbance by breaking the rest period. Some possible advantages of polyploids are large size of the plant as a whole, increased vigor, wider distribution, resistance to disease and to cold. Some annuals are changed to perennials, and sterile hybrids may be changed to fertile ones.

285TH MEETING

The 285th regular meeting was held in the assembly hall of the Cosmos Club, December 7, 1937, Vice-president G. F. GRAVATT presiding; attendance 60. EARNEST A. WALKER was elected to membership.

Program.—ERSTON V. MILLER: *Plant pigments with special reference to citrus fruits.* The pigments responsible for the great array of color in the higher plants may be grouped as follows: (1) the water-soluble and (2) the ether-soluble or plastic pigments. In the first group are the anthocyanins (red, blue and purple) and the flavone and flavonol pigments (yellow). In the second group are the chlorophylls (green) and the carotenoids (yellow). Though it is customary to think of the carotenoids of green leaves as consisting of carotene and xanthophyll, it is now known that there might be two or three isomeric carotenes and as many as twelve xanthophylls present, and the whole list of carotenoids that have been isolated from different plants is so great now that only a specialist can keep this list up to date.

Carotenoid pigments have been found in the rinds of mature green limes, lemons and grapefruit, but these pigments diminish in quantity as the fruit degreens. This is true whether the fruit is degreened with ethylene or is permitted to degreen on the tree. Oranges, on the other hand, show an increase in carotenoid content of the rind as they attain full color on the tree.

37TH ANNUAL MEETING

The 37th annual meeting was held immediately following adjournment of the 285th regular meeting, Vice-president G. F. GRAVATT presiding; attendance 44.

M. B. WAITE, H. L. WESTOVER and WM. A. DAYTON made brief remarks on the lives and works of FREDERICK V. COVILLE, HARRY N. VINALL and ARTHUR B. CLAWSON, respectively.

O. F. COOK, G. G. HEDGCOCK and S. L. JODIDI were elected to honorary membership.

The following officers were elected for 1938: President, G. F. GRAVATT; Vice-President, H. H. McKINNEY; Recording Secretary, ALICE M. ANDERSEN; Corresponding Secretary, ERSTON V. MILLER; Treasurer, NELLIE W. NANCE.[1]

Nominated for Vice-President Washington Academy of Sciences, WM. A. DAYTON.

H. H. McKINNEY, *Recording Secretary.*

[1] Resigned. KENNETH B. RAPER appointed by the Executive Committee.

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WASHINGTON ACADEMY OF SCIENCES

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JOURNAL
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Vol. 28 May 15, 1938 No. 5

CHEMISTRY.—*Five hundred meetings of the Chemical Society of Washington.*[1] Frank C. Kracek, Geophysical Laboratory, Carnegie Institution.

As Dr. Browne has clearly brought out in his two papers in this issue of the Journal, the Chemical Society of Washington was founded by men who believed in the liberty of opinion and action of the individual. Several of them had been influential in the original organization of the American Chemical Society in 1876 in New York, but they later broke away, feeling out of sympathy with the spirit and procedures of that Society, which at that time was in effect a purely local group of chemists confined to New York City and its environs.

On January 31, 1884 these men held a formal meeting at which a constitution was adopted, and officers elected to serve during the ensuing year. The officers elected were: Thomas Antisell, President; Wm. Mew and F. W. Clarke, Vice-Presidents; H. W. Wiley, Secretary; W. H. Seaman, Treasurer; E. T. Fristoe, Thos. M. Chatard, J. H. Kidder and A. C. Peale, Members of the Executive Committee. The object of the Society "shall be the cultivation of chemical science, pure and applied." The membership of the Society consisted of 33, of whom 3 were connected with educational institutions, 7 were of private status, and the rest were in the service of the Government. As was to be expected, the early meetings were devoted to papers dealing with the professional activities of the members. No presidential address was delivered at the end of the first year; however, at the end of the second year, F. W. Clarke, the second president, delivered an address on the "Relation of the Government to Chemistry," and the custom thus started has been continued to the present day.

On December 10, 1893, at its seventieth meeting, the Society became affiliated with the re-organized American Chemical Society,

[1] This and the following two papers are published in commemoration of the 500th meeting of the Chemical Society of Washington, held on April 14, 1938. Received March 29, 1938.

as its "Local Section." It retained the management of its internal affairs and its name, although in the records of the national society it appears to be referred to as the "Washington Section." The events leading up to this step are recorded in detail by Dr. Browne. However, as part of the record, it is worth repeating here that F. W. Clarke and H. W. Wiley were primarily responsible in the re-organization of the American Chemical Society, and hence, the affiliation of the Chemical Society of Washington with the latter organization was a logical part of their larger plan.

To facilitate the administration of its affairs the Society was incorporated in the District of Columbia on March 25, 1926, formal action of the Society having been taken at its 376th meeting held at the Cosmos Club on March 11, 1926.

An event of great importance to the Society took place in the fall of 1924, when the executive committee first discussed the question of offering a prize for a "worthy contribution" by a member of the Society. The idea was adopted on an annual basis at the February 1925 meeting of the Executive Committee, and was made a permanent institution of the Society on February 9, 1928, at the 398th meeting. On June 6, 1933, the income from One Thousand Dollars was set aside to finance the Prize. This became known as the Hillebrand Prize Award, named in honor of W. F. Hillebrand, for many years an outstanding member of the Society.[2] The prize has unquestionably stimulated interest in the more outstanding contributions to chemistry by members of the Society, and has served to emphasize the fact that important advances in the science are being made within the Society in spite of the somewhat circumscribed sphere of research peculiar to the professional connections of the great majority of the members.

In its early days the Society published a "Bulletin" of which 9 volumes were published covering the years 1884–1895. Publication was resumed again in 1919, but lapsed after that year. In 1898 the Joint Commission of Scientific Societies of Washington was re-organized as the Washington Academy of Sciences. The Chemical Society, a member of the Joint Commission from its inception, became one of the seven founder societies of the Academy. When the Academy established its JOURNAL in 1911, the Chemical Society published its Proceedings in the JOURNAL up to and including the 300th meeting.

[2] The list of awards given to 1937 will be found in the "Proceedings," J. Wash. Acad. **28**, 131 (1938). The award for 1937 was to Sterling B. Hendricks on the "Relation of Crystal Optics to Crystal Structure" and on the "Determination of Molecular Structures by X-Ray and Electron Diffraction."

Recently publication was resumed beginning with the 494th meeting.

In the preceding 54 years of its existence the Society has held 496 meetings, an average of 9.2 per year. There are 8 regular meetings per year, the odd figure above being accounted for by special meetings. Until quite recently the regular meetings were devoted to communications by members of the Society, outside speakers being heard at special meetings. In the more recent years this custom has

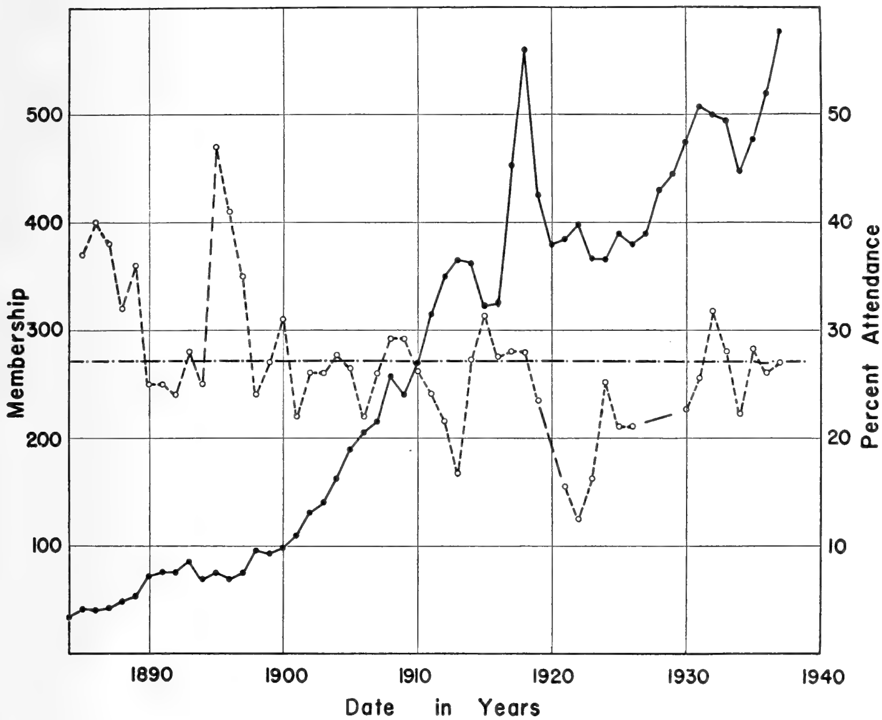

Fig. 1.—Chart of membership and percentage attendance of the Chemical Society of Washington from 1884 to 1937. Filled circles denote membership, open circles, percentage attendance. The horizontal dot and dash line represents average attendance for 54 years.

been losing ground, somewhat to the detriment of the members being afforded opportunities to present their original results before the Society. This, however, has been partially compensated for by holding one or two divisional meetings each year, with usually 9 or more papers being read by members in different sections. This procedure affords the Society an opportunity to listen to outstanding chemists from elsewhere in the United States and from abroad at many of its regular meetings. An expression of opinion from the membership would be valuable in this connection. At present the responsibility for the type of meetings held rests with the Committee on Communications who can not be expected to be clairvoyant, but who make every effort to arrange programs that will be of interest to a large proportion of the membership.

The question arises whether the attendance is influenced by factors other than the obvious ones, such as the weather conditions and the type of program being presented. Proceeding on the assumption that precisely these factors will tend to average out over any one year, leaving factors of less obvious but deeper significance operative, the writer has calculated from the minutes of the Society the data presented in the accompanying diagram. We plot here the membership and the average percentage attendance along the ordinate, as a function of the years along the abscissa. It will be noted that over the entire period of years there has been a more or less steady increase in the membership, with no indication that the saturation point is being approached. There are some significant dips in the curve. These will be considered later. The irregularity in the curve of membership in the years just preceding the world war is not functional, being caused by the separation of the Maryland and the Virginia sections of the A. C. S. from the jurisdiction of the Washington Section. Similarly, the great increase in membership during the war years is abnormal, being the result of the location of chemists with military duties in the various government departments in Washington. Immediately after the conclusion of the war most of these wartime chemists returned to their usual spheres of activities; nevertheless, it was not until 1920 that the membership resumed its normal proportions. Significant arrests in the trend of the normal growth of the Society occur over the periods 1894–96, 1899–1900, 1908–10, 1922–25, 1925–27 and 1933–35.

The average percentage attendance over the 54 years is 27.1. The yearly average curve shows wide fluctuations. The years before 1890 were abnormal in the sense that the early enthusiasm connected with the founding of the Society had not had time to subside. From 1890 to 1894 attendance was normal, but in 1895 to 1897 attendance rose to the record proportions 41 percent over the three years, never even approached at any time since. It is significant that this did not occur immediately after affiliation with the national society. Subsequent to this period, there are attendance peaks at 1900, 1904, 1908–09, 1915, 1924 and 1932. The troughs are at 1898, 1901, 1906, 1913, 1922 and 1934. The data for the years 1927 to 1930 are insufficient in detail, unfortunately, to be recorded other than a bare estimate. There is an interesting lag between the periods of economic depression and the peaks and the valleys in the attendance curve. Of particular interest are: the trough of subnormal attendance covering the period of the golden twenties, and the recent limited but sharp recession in 1934. In both cases, both the membership and attendance appear to have decreased and advanced simultaneously. The question of what happened to the government chemist during these two periods can be posed, to be answered by a competent sociologist. On the other hand, there is another question which the chemists can best answer themselves: Are the chemists only 27.1 percent alive, and if so, why?

This brief review of the activities of the Society must not be allowed to end without some mention of the commendable attitude adopted by it on questions involving the relation of chemistry and public welfare. Whenever such questions have arisen, from the early days when a sanitary water supply in most of our cities was a thing of the future, to as late as the present year, when the question of advocating adequate safeguards against the indiscriminate sale of possibly dangerous drugs, such as the "elixir of sulphanilamide" arose, the Society has always upheld the interests of the public. It is to be hoped that this will always be so in the future.

CHEMISTRY.—*Dr. Thomas Antisell and his associates in the founding of the Chemical Society of Washington.*[1] C. A. BROWNE, Bureau of Chemistry and Soils.

The Chemical Society of Washington owes its existence to the marked stimulus that was given to the chemical activities of the various Governmental Departments in the early eighteen eighties. The Government began to employ chemists a half century before this date but for the most part they were non-residents of Washington. Benjamin Silliman, Sr., Professor of Chemistry at Yale University, for example, was authorized by the Treasury Department in 1832 to make a chemical study of the cane sugar industry of the United States and his report on this subject, published in Washington in 1833, was the first chemical publication to be financed by the United States. With the coming of Prof. A. D. Bache to Washington in 1844, as Superintendent of Weights and Measures in the Coast Survey Office, another chemical research was assigned to Richard S.

[1] Delivered before the Chemical Society of Washington on April 14, 1938. Received March 29, 1938.

McCulloh, formerly professor of chemistry in Jefferson College, Penn., and later melter and refiner in the United States Mint in Philadelphia. His four reports on "Sugar and Hydrometers" were published in 1848 under the authorization of the Treasury Department as a Senate Document of 653 pages. It is a classic work which even now can be consulted with profit.

With the rapid growth of the work of the Patent Office, which was established in Washington in 1836, the services of resident chemists became necessary in order to examine the increasing number of patent claims relating to chemical subjects. One of these early chemical employees of the Patent Office was Dr. Thomas Antisell.

Dr. Antisell, like another famous American physician and chemist, Dr. William Macneven, was a native of Ireland. He was born of French Huguenot ancestry in Dublin on January 16, 1817, and was educated at Trinity College of that city. He then studied at the Dublin School of Medicine and the Irish Apothecary's Hall where he obtained his first chemical instruction under the well-known chemist, Sir Robert Kane. Antisell's medical education was completed at the Royal College of Surgeons in London from which he obtained his medical degree in November 1839. After a semester in the chemical laboratory of Pelouze in Paris he became assistant to his former teacher Kane with whom he remained three years. In 1844 he continued his chemical studies on the continent under such eminent teachers as Pelouze, Biot, Dumas and Berzelius. He then began the practice of medicine in Dublin, but, becoming involved in the political activities of the "Young Ireland Party," was sentenced to exile and imprisonment. He avoided this penalty, however, by escaping to America as surgeon on an outgoing vessel. His career as traveling student, doctor, chemist, Irish political agitator, exile to America and patriotic citizen of the United States tallied exactly with that of his fellow countryman Macneven of a generation before.

When Antisell sailed from Ireland in 1848, this young physician of 31 left behind him a considerable record of accomplishment in several branches of science. He had very early taken a deep interest in agriculture and in 1845 published a "Manual of Agricultural Chemistry with its Application to the Soils of Ireland." This was followed in 1847 by his "Outlines of Irish Geology" and his "Sanitary improvement of the City of Dublin."

Antisell landed in New York on November 22, 1848, and practiced medicine in that city for the next six years with occasional intermissions when he lectured on chemistry at the Berkshire Medical Institution in Pittsfield, Mass., and at the Medical College of Woodstock, Vt. He became quickly identified with the civic affairs of his new home and during the twenty-second annual fair of American Institutes at Castle Garden in October 1849 delivered a series of addresses on "The Philosophy of Manufactures." He compiled also in 1852 a "Cyclopedia of the Useful Arts," a convenient 690-page illustrated handbook of progress and invention in different branches of applied science. It was a work requiring wide knowledge and great labor.

Wanderlust was a malady from which Antisell always suffered and in 1854 he dropped his medical practice to become geologist under Lieut. J. G. Parke in command of the Pacific Railroad survey. Antisell's geological reconnaisance of Southern California and the Arizona Territory was published in 1856 in volume seven of "United States Explorations and Surveys" of which a review is given in the 1904 Report of the Smithsonian Institution (pp. 453–5). After terminating this geological expedition Antisell came to Washington where on June 1, 1856, he was appointed first assistant examiner in the Patent Office. In connection with his duties as examiner he operated a small chemical laboratory in the basement of the old Patent Office building. The position, which paid a salary of $1,500, was apparently not wholly congenial to Antisell's versatile tastes as we may infer from the following letter which he wrote in 1857 to his friend, Dr. C. M. Wetherill:

"Washington
Patent Office
Nov. 15, 1857

My dear Wetherill:

"Let me refresh your memory by recalling your attention to my existence: which for the last few months has pursued the even tenor of its way without disturbance either by elevation or dismissal which has made moves abundant around me. I believe I told you in a former letter that I was an assistant Examiner here in the Chem. Department in the office: a place not very suitable to me but which has kept the wolf from the door until in Micawber phrase something better turns up. We have connected with this (Chemical) room a small laboratory where we can keep in our fingers in old ways—and it is in connection with it that I chiefly now write to you: Our gas arrangements for ignition purposes are very incomplete and Mr. Schaffer and self thought if we could get your apparatus as described in the *Franklin Journal* it would be a great matter to us and I have written to you to know could we order a Tilgenaus burner, & a Burner holder such as you have described with a Burner for distilling purposes or Sand bath as found on pp. 274, 275 & 276 of Vol. 28 of *F. Journal,* from any one in Philadelphia or could you recommend us to a man who would do them for us & to let us know what sum probable would cover the expense of same: we have to get a sum allowed by the Commissioner for that purpose. Could you also tell us the cost of a Duffys Balance for coarse purposes—to weigh from 1 lb. downwards to a dram. We have already two fine balances but not one coarse one.

"Situated as we are in a city where nothing out of the common run is to be had we have to depend on our friends for assistance. You will therefore excuse this trouble, & if I can be of any use to you here call upon me. May I enquire after your wife and ask whether she is a disciple of Malthus or not?

Believe me
Sincerely yours,
Thomas Antisell

C. M. Wetherill, M.D.,
or &c.
Philadelphia."

We know from this letter of Antisell and from other contemporary notices that there was not at this time a well equipped chemical laboratory in the whole city of Washington.

Between the years 1842 and 1862 the Patent Office in addition to its regular activities discharged the agricultural functions of the Government, and Antisell, in the midst of his other duties, devoted a part of his time to the chemical examination of soils and other agricultural products. His opinions on agricultural chemical research are well expressed in an address which he gave before the U. S. Agricultural Society in 1858 "On the Application of Chemical Science to Agriculture" from which the following quotations are made:

"Occupied as the writer has been since 1840, with analyses of soils, the value of which was then brought prominently forward by Liebig, and having made from that period to the present time nearly 2,000 analyses (certainly above 1,800) of various soils, both of this country and of Europe, he is glad on the present occasion, after an experience of nearly 20 years, to state his conviction of the value of the present relation of chemistry to agriculture.

"In 1840, an ardent believer in the value of analyses of soils, every year's experience has tended to shake his conviction in its utility as carried on, and confirmed him in the belief, that it was both incomplete in its object, and deceptive in its result. That ardent belief has merged into sober caution, and has ended in positive distrust, that a mere chemical analysis of the soil can be of any, even the smallest use to the farmer, for he has come to understand that the constitution of a soil is not that simple matter formerly believed: so complex is it, that no analytic formula properly expresses it, and as usually performed, the analysis is of no value, either to science or to practice" (pp. 1–2).

"Manuring is still too much carried on as if it were to benefit the soil—instead of the plant—and the farmer enriches his soil with elements in manure, which he does not know whether his crop requires at all, or requires at the time when it is added" (p. 2).

"The question then arises: Do we know sufficient of the mineral constitution of plants, so as to state what that constitution precisely is in each species? We must in truth say we do not fully know the exact mineral formula of any plant: and yet as far as we do know, it would seem that a species differs somewhat from every other species, in either the quality or the quantity of its ash.

"If we do not know these constituents of a plant, how can we safely recommend special manures? Thus, the practice and the prosperity of the art of agriculture depends so far on the knowledge which chemistry has yet to impart to the farmer" (pp. 2–3).

"There is as much difference between the flour of Massachusetts and Alabama as between the wheat flour of Scotland and Egypt. This is attributed to climate, but what does climate effect? How is it that climate produces more gluten? Does it also increase the phosphates? Or, can the phosphates applied in liberal amount, replace the influence of climate? In other words, can the use of special manures in the northern states replace the latitudinal effects and solar influences of the south? Chemical analysis, as conducted at present, gives us no data from which any conclusion on so important a subject could be drawn" (p. 8).

"The majority of analyses found in our text books are derived, as stated, either from soils or plants of European countries, and as the ash bears a certain relation to the soil, that relation is lost for want of reference to the soils of this country. The knowledge of the constituents of the ash of a crop is but a portion of the knowledge derivable therefrom, when unaccompanied by the constitution of the soil" (p. 8).

"We want experiments which shall go to determine what are the mineral elements of a plant which are found in connexion with and which go to build up the various food and respiration elements in the plant. What salts assist in putting up gluten; what aid in sugar, starch, &c.? Or, stating the question in general terms, what are the mutual relations between the organic and the inorganic parts of plants?

"It is too much to ask the agriculturist in the field, or the chemist in the laboratory, to devote, unaided, both time and skill to elucidate this complex problem, involving a large number of experiments of growth and of chemical analysis. This would be the experiments suitable for a State agricultural farm and a State chemist. The function of the latter officer should not be confined to making analyses of soils or testing manures, to be conducted at cheaper rates than private men of science can perform such analyses for, and which only result in the benefit of a few individuals, and are of no benefit beyond that of the moment. But the business of a State chemist should be that of elucidating and philosophizing upon the various circumstances which combine to augment the growth and the produce of our food plants. The office of State or model farms should be, by well devised experiments upon the growth of plants, to raise agriculture from its present position of an *empirical art*, to the condition of a *science*" (p. 9).

"It is believed that a portion of the grant so generously bestowed by the federal government, for the benefit of agriculture, could not be better employed than by devoting some portion of it for this end" (p. 9).

All this is the soundest kind of agricultural chemical doctrine. The passages quoted illustrate the clarity of Antisell's views with regard to the true field of agricultural chemistry—views that might well be adopted as a statement of purpose at the present time.

Antisell, whether working as chemist or geologist or patent examiner, could never forget that he was first of all a physician and very soon after his arrival in Washington he began lecturing to the medical students of Georgetown College on chemistry, toxicology and physiology of which subjects he was for many years a professor. On several occasions he gave valedictory addresses to the graduating medical students of Georgetown who were so impressed by their excellence that they printed them each year in small pamphlet form as tributes of affection to their teacher. As an additional evidence of Antisell's industry and versatility it should be mentioned that he published in 1859 a book on the "Manufacture of Photogenic and Hydrocarbon Oils from Coal."

The outbreak of the Civil War had a very depressing effect on chemical research in the United States from which it did not fully recover for twenty years. The activities of chemists, both North and South, were diverted to military purposes. Antisell, although promoted on May 3, 1861, to the position of principal examiner in the Patent Office, resigned on September 30th of this year to devote all his energies as physician and surgeon to the care of sick and wounded soldiers. He entered the army as brigade surgeon of volunteers, with the rank of major. Dr. W. H. Seaman, President of the Chemical Society of Washington in 1894, has left this record of Dr. Antisell's military service:[2]

"He served first with Banks' division and the Fifth army corps, then became successively medical director of the Department of the Shenandoah, Second corps, Army of Virginia, and Twelfth army corps; in October, 1862, was in Harewood hospital, Washington, D. C., and in 1863 president of a medical examining board, and post surgeon to August, 1865. He was brevetted lieutenant colonel, United States volunteers, March 13, and honorably mustered out of service October 7, 1865. In the service he was noted for his reckless disregard of personal danger for himself or his assistant surgeons when the wounded required attention in the rear of the line of battle, and probably saved the life of many a poor fellow by the prompt and skillful aid he rendered."

In connection with his military duties as medical officer, Antisell presented several reports in 1864 to the Medical Society of the District on the sanitary condition of Washington.

It is somewhat remarkable that the Department of Agriculture should have had its birth in 1862 during the turmoil of a bitter war. The first scientist appointed to this new organization was Dr. Antisell's friend, Dr. Charles M. Wetherill, a distinguished chemist, who had studied under Liebig at Giessen, and was eminently qualified to

[2] Bul. of the Philosophical Society of Washington, Vol. 13, p. 368, 1895–1899.

fill the position of Department Chemist. He equipped a laboratory in the basement of the old Patent Office building but had scarcely entered upon his new duties when he was detailed by President Lincoln to make experiments for the War Department on a new type of ammunition. The furlough was longer than at first intended and when Wetherill returned to his old post he was curtly informed by Commissioner Newton that his salary with the Department of Agriculture had ceased with his detail to the War Department and that his services were no longer needed. President Lincoln tried to intercede for Wetherill but Newton was stubborn and Wetherill to avoid the stigma of a dishonorable dismissal appealed to Congress. Congress completely exonerated Wetherill and, as a rebuke to Newton, directed the Secretary of the Treasury to pay Wetherill "the sum of seven hundred and fifty dollars in full for his services as chemist of the Agricultural Department." The case aroused much indignation in scientific circles. Wetherill's unhappy experience was typical of many other later cases where Government scientists have been made the victims of autocratic injustice.

Wetherill was succeeded as Chemist of the Department of Agriculture by Dr. Henry Erni, later one of the founders of the Chemical Society of Washington, who after two years of faithful service resigned his position. Dr. Antisell, who had just been mustered out of military service, was then appointed by Commissioner Newton to the office of Department Chemist and, more fortunate than his predecessors, remained for five years in this position for which he was splendidly qualified by past training and experience. He was a skilled analyst; well versed in geology, medicine, botany and physiology; and the author of numerous books and articles relating to agricultural subjects.

If sufficient time were available I could speak to you at some length about Dr. Antisell's work as Department Chemist. I have brought with me one of his laboratory notebooks, written in beautiful script, with a full record of his analytical reports between January 2, 1868, and his resignation on June 30, 1871. In this three and one-half year period there was an interruption between July and November 1868 when the Department moved its quarters from the Patent Office to the new brick building on the Mall. In conformity with custom the laboratory in the new building as in the old was consigned to the basement and there it remained for over twenty years. A long hard battle with ancient prejudice had to be won before chemists were permitted to ascend from darkness to higher levels.

Antisell describes in this notebook the analysis of 189 samples of which only 117 can be called agricultural. Sixty samples or about one-third of the total number were minerals, such as pyrites, ores of metals, etc., sent in for the most part by Congressmen to satisfy the curiosity of over-credulous constituents. For many years Government chemists had their time frittered away with such trivialities, "to the detriment of science and the benefit of nobody," as Dr. Clarke, one of our early presidents, once caustically remarked. Antisell called attention to this evil in his first report for 1866 in which he made the following very pertinent suggestion:

"The propriety of any department of the government authorizing work to be done for the benefit of private enterprise is questionable, and as there are at all times abundant sources of employment for chemical science in connection with agriculture . . . the work in the laboratory should be confined within its proper sphere of limitation."

This is sound doctrine but several decades had to elapse before the principle here announced was put into effect.

Of the agricultural samples in this notebook that were analyzed by Antisell, 26 were marls, 24 soils, 16 fertilizers, 12 wines and musts, 12 waters, 5 tanning materials, 5 medicinal plants and a long list consisting of sugar beets, fruits, Indian plants, sugars, peat and other miscellaneous products. Antisell did also much service work for other departments, such as investigations of cancelling inks for the Post Office and of building stone for the Treasury Department.

In May 1869 Antisell wrote a long interesting report to Commissioner Capron on the fertilizing value of the mud from the bottom of the old canal which once transported produce from the Potomac along what is now Constitution Avenue to the city market. This canal received much sewage and its muddy deposits were supposed by many to have great fertilizing value. Antisell showed that the wet mud, at the very highest estimate for its content of lime, phosphoric acid, potash, ammonia and other ingredients, had a manurial value of only 98 cents per ton which would not pay the farmer for hauling it away. Antisell condemned the canal as a menace to the health of the city because of its highly offensive emanations, which he regarded, in accordance with the old theory of miasms, as "potent causes of disease."

Antisell's reports as Department Chemist are included in the annual reports of the Commissioner of Agriculture for the years 1866 to 1870 inclusive. In the 1866 report he published a special article on "Cultivation of the Cinchona in the United States" which contains suggestions that were afterwards tried but have not been realized largely because of economic reasons. Antisell's 1867 report is a chemical plea for the establishment of a domestic beet sugar industry. His arguments were sound and undoubtedly had an influence in after years in promoting this enterprise. Antisell was mistaken, however, in his view that the culture of the sugar cane in the south was soon destined to disappear.

In addition to his chemical duties at the Department of Agriculture Antisell continued his practice of giving lectures before the medical students of Georgetown College which signified its appreciation of his learning by conferring upon him the honorary degree of Doctor of Philosophy. In 1869–70 he also taught chemistry at the Maryland Agricultural College.

Commissioner Newton died in 1867 and was succeeded by General Horace Capron under whom Antisell served during the whole period of his office. In 1871 Capron resigned to accept a call by the Japanese Government to head a commission for improving agricultural conditions in that nation and Antisell accompanied him on this expedition as technologist. He was decorated by the Emperor of Japan with the Order of the Rising Sun and received other honors in recognition of his services. The climate of Japan, however, was injurious to the health of Mrs. Antisell, so he returned after six years to Washington where on May 10, 1877, he was reappointed to the place in the Patent Office that he had resigned in 1861. He remained in this position until ill health obliged him to retire in 1891. In his last years of sickness he was tenderly cared for by his daughters. He died on June 14, 1893, in his seventy-seventh year and was buried in the Congressional Cemetery.

It will be seen from this brief sketch that Dr. Antisell was a man of deep learning, wide experience and great industry. According to his friend, Dr. Seaman, who was associated with him for many years in the Patent Office, Antisell in official life "had the reputation of being reserved and even somewhat brusque, but among his friends he was cordial and even warmhearted, with an abundant supply of the wit and humor for which the Irish race has been always noted."

Chemists, who in point of numbers now excel the other scientists of Washington, were few and far between in the decade following the Civil War. Dr. F. W. Clarke, in his presidential address before our local Society in 1885, relates that when he first came to Washington in 1873, chemistry had gained but a precarious foothold. In the various Governmental institutions there were probably at that time not

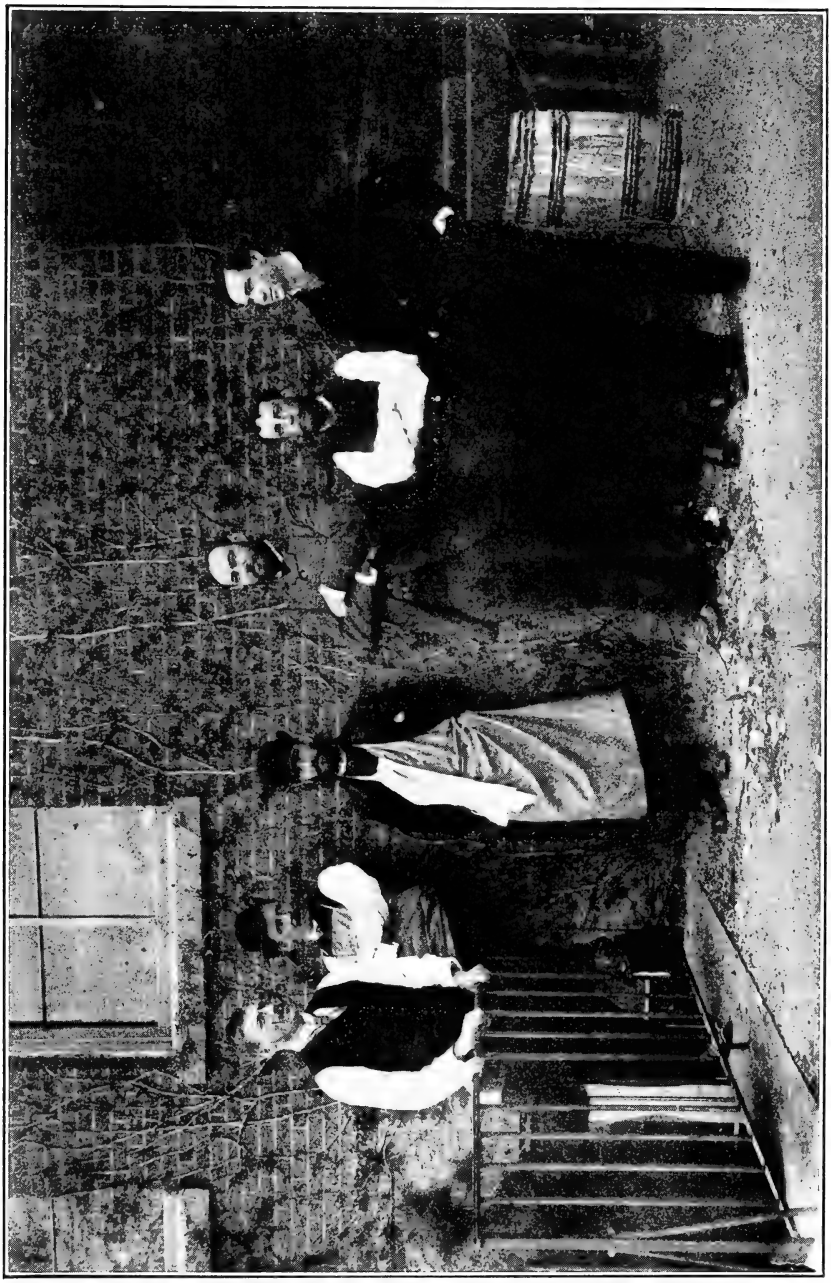

Fig. 1.—Personnel of the Divison of Chemistry of the United States Department of Agriculture in the year 1885. Left to right: E. Richards (on lower level), A. E. Knorr, John Dugan, C. A. Crampton, H. W. Wiley, T. C. Trescot, Miles Fuller.

a dozen men who could qualify to the title of chemist. But about the time of Dr. Antisell's return to Washington, in the late seventies there was a marked increase in the chemical activities of the various Federal departments.

There were probably at least fifty chemists who could have qualified as foundation members of the Chemical Society of Washington. The need of an organization had been felt for several years but nothing was done until January 12, 1884, when a meeting was called in the office of Dr. Wm. Mew in the Army Medical Museum and the following resolution was adopted:

"*Resolved*, That it is desirable to organize a Chemical Society in the District of Columbia; said Society to have for its object the cultivation of chemical science, pure and applied."

A committee was appointed to arrange the time and place of an organization meeting, to notify interested chemists and to draw up a constitution.

At the organization meeting which took place on January 31, 1884, thirty-three chemists of the District took part. Of these founders of our local Society, 6 belonged to the Patent Office, 5 to the Department of Agriculture, 4 to the Geological Survey, and 4 to the National Museum. The Treasury Department, Columbian University, Howard University, the Smithsonian Institution, Bureau of Education, City High School, Museum of Hygiene and Army Medical Museum were represented with one member each. There were also six founders of a private status. Other chemists were admitted at subsequent dates until at the 32nd meeting of the Society, which took place on April 12, 1888, just 50 years ago last Tuesday night, there was a membership of 45 resident and 10 non-resident chemists.

It was most fitting when the Chemical Society of Washington was organized that Dr. Antisell should have been elected its first president. He does not seem, however, to have taken an active part in the Society's meetings. He presented no papers and there is no record of his having given a presidential address. The foundation members of our local Society were mostly young men in their early thirties and Dr. Antisell, as a staid veteran of 67, may have felt somewhat abashed in the presence of such a group of exuberant youngsters. As an old time chemist of the eighteen thirties and forties he was perhaps also a little unsympathetic with the new movements in chemistry when atomic weights and formulas were being drastically revised. I remember how my father, a self-taught chemist, was shocked when I came home one day in 1889 from college and told him that the formula for water was not HO, as he had led me to believe, but H_2O.

Professor E. T. Fristoe, who preceded Dr. Charles E. Munroe as Professor of Chemistry at Columbian University, and was president of our local society in 1887, was proud of asserting that he was one of the earliest American chemists to adopt the new reforms by which the formula of water and the atomic weight of oxygen were changed. Dr. Wiley, who preceded Fristoe as president, tried to humble his pride, however, by proving from holy scripture that the formula HO was correct. He quoted from the beginning of the 55th Chapter of Isaiah, "HO, everyone that thirsteth, come ye to the waters," in which not only the formula but the name and use of the aqueous fluid are mentioned. This was said "off the record" for no mention of it is found in the minutes or discussions of the Society.

Next to Antisell, Professor Fristoe was one of the oldest chemists among the founders of our Society. He was born in Rappahannock County, Va., in 1827 and was educated at the Virginia Military Institute and the University of Virginia from which he received the A.M. degree in 1855. In 1862 he entered the Confederate Army where he served with distinction as colonel of cavalry until the close of the war. In 1865 he was elected to the chair of chemistry in the Columbian College in Washington and in 1871 was appointed professor of chemistry in the Medical Department of Columbian University—a position which he held until his death in 1892.

Fristoe taught chemistry in the old Columbian University laboratory on the site of the present Woodward Building, in the auditorium of which the early presidents of our local Society gave their annual addresses. Several of Fristoe's pupils (among whom are K. P. McElroy, E. G. Runyan and Geo. Steiger of Washington, and H. O. Chute of New York) tell interesting stories of his methods of instruction. Fristoe was progressive not only in adopting the new chemical notation but in emphasizing the importance of chemistry in the college curriculum. In his presidential address on "Chemistry as Factor in Education" he announced that we "live, move, and have our being by the grace of Chemistry" and advocated, on practical, cultural, and even religious grounds, that the old trivium of Latin, Greek and mathematics should give way to the newer claims of chemistry.

H. W. Wiley of the Department of Agriculture and F. W. Clarke of the Geological Survey were the chief moving spirits and most active members of our early organization. In the first five years of its history Wiley presented twelve papers and Clarke nine. W. H. Seaman of the Patent Office followed a close third with eight papers. All of these men were presidents, Clarke succeeding Antisell in 1885, Wiley succeeding Clarke in 1886 and Seaman coming later in 1894. Clarke's presidential address on "The Relations of the Government to Chemistry" contains an eloquent plea for the consolidation of the Government's scattered chemical activities into a single well-equipped and thoroughly organized National Laboratory whose chemists should be free from political interference or caprice and independent of fear or favor. Wiley was also at this time a great believer in a centralized national Laboratory but the rapid growth of specialization in the scientific work of the different Departments prevented the realization of this ambitious scheme.

Wiley's presidential address on "Our Sugar Supply" related to a subject in which at that time he was very actively interested, as he had experiments under way upon the production of sugar from the sugar cane, the sugar beet and the sorghum in different states of the country. In this era of Governmental regional laboratories it is well to remember that Wiley was the first to inaugurate technological field investigations of this kind. His address is typically Wileyesque. He quotes apt phrases from the Latin, Greek and German and refers to his much censured sugar undertakings by remarking:

> "On this billowy sea, and amid these dangerous rocks, like a saccharine Ulysses, with taffy-occluded ears, I have tried to steer the frail bark of scientific investigation."

Clarke and Wiley were great wits and the hilarity which they imparted to the early meetings of our local Society had a contagious quality. Like Kidder, Chatard, Richardson, Munroe, Diller and several other Washington chemists of a half century ago they were Harvard graduates and, like members of a well trained crew, these men always pulled together. The effective work of Clarke and Wiley in completely reorganizing the American Chemical Society was told in my address of four years ago.

Next to Clarke and Wiley the most influential member among the founders of our local chemical society was William Henry Seaman. For many years he was professor of chemistry at Howard University and an examiner in the Patent Office. He was a member of the committee for revising the U. S. Pharmacopaeia of 1880–90 and was an active participant in the work of many local scientific societies. His papers before this organization cover a wide class of subjects ranging from models of molecular structure to the Sloper gas machine.

Seaman was a great stickler on the proper spelling of chemical terms. According to Patent Attorney K. P. McElroy "Doctor Seaman was the chemist who took the ph out of sulphur and induced the

American Chemical Society to like it that way." The spelling of sulfur and all its derivatives with an f is a thorn in the flesh of the Government Printing Office as it is to all our British chemical friends. I have always wondered who the miscreant was that first put the ph in sulfur where it had no business, either scientific or etymological, of belonging. Hats off to Doctor Seaman who made us move in the right direction.

Another picturesque figure in the Patent Office group of founders, to which Antisell and Seaman belonged, was Dr. D. B. Kelley. He was an Irishman and has been described as a rather portly man with florid countenance, very loquacious and somewhat of an epicure in his choice of foods. His fondness for mushrooms nearly cost him his life as it did that of his friend, the Italian Count Achilles de Vecchi. They mistook the poisonous fly amanita toad-stool for the edible kind: de Vecchi died but Kelley was saved by the liberal use of atropine. In the delirium produced by the poisonous mushroom alkaloid muscarine Kelley thought he had actually died and gone to heaven but St. Peter sent him back with the remark that his time had not yet come. This was a famous case and an account of it by Kelley and his attendant physician was given before our Washington Chemical Society in the late eighteen nineties.

A somewhat similar alkaloidal story concerns another founder—Dr. William M. Mew of the Army Medical Museum in whose office the preliminary organization meeting of the Washington Chemical Society was held. Mew who was an Englishman was exceedingly fond of smoking and found that he could immunize himself against the effects of overindulgence in the weed by taking strychnine. On one of these occasions he took an overdose of strychnine. He felt coming on the characteristic constriction of the facial muscles produced by this alkaloid and then rapidly reasoned that if strychnine is an antidote for nicotine then conversely nicotine should be an antidote for strychnine. He therefore began puffing a strong cigar and forthwith the effects of the strychnine passed away. A deduction of this kind, which reminds one of a back titration in volumetric analysis, could have been conceived only by a person with strong chemical imagination. Mew was greatly interested in the chemistry of alkaloids and in the old laboratory notebook of the Department of Agriculture's chemical division, which I have brought with me, is a letter of his to Dr. William McMurtrie, chemist of the Department from 1872 to 1877, wherein he describes a method for determining morphine.

The fifth president of the Chemical Society of Washington was Dr.

Jerome Henry Kidder of the Smithsonian Institution. He was born in Baltimore and graduated from Harvard in the class of 1862. He served as Medical Cadet in the Union Army during the Civil War and obtained his medical degree from the University of Maryland in 1866. Like Antisell and other founders of our Society he was interested in many branches of science. He wrote on big game shooting in Alaska and prepared two articles on the natural history of Kerguelen Island in connection with the American Transit-of-Venus expedition of 1874–5 of which he was a member. He served for many years as a surgeon in the U. S. Navy but resigned in 1884 to accept an appointment as chemist to the Fish Commission. He was a very active member of our early Society and his papers related to such subjects as the nesslerizing of air washings, the Bower-Barff rustless iron process and the gilding of glass. His presidential address in February 1889 upon Air was illustrated by many photo-micrographs of suspended air impurities such as dust, pollen, spores, bacteria and crystals. Kidder died from pneumonia two months after the delivery of this address and his passing was lamented by a host of friends.

The sixth president of the Society, Edgar Richards, and the seventh president, Dr. Charles A. Crampton, were members of the Chemical Division of the Department of Agriculture. Richards was a native of New York City and a graduate of the Columbia School of Mines. He was assistant chemist of the Department of Agriculture from 1882 to 1887 and chemist of the Bureau of Internal Revenue in the Treasury Department from 1887 to 1892 when he returned to New York to practice as a consultant. His papers before our early Chemical Society related to milk analysis, oleomargarine and methylated alcohol. His presidential address in 1890 on "Some Food Substitutes and Adulterants" is a reflex of the campaign which Dr. Wiley and his staff were then conducting against deceptions in the sale of food.

Dr. Crampton, whom many of this audience remember, followed Richards from the Department of Agriculture to the Treasury Department and was chief of its Division of Chemistry from 1893 until his death in 1915. His early papers before the Society were partly collaborative with Dr. Wiley and T. C. Trescot and related to such food products as starch, sugar, malt liquors and fats and oils. Crampton's presidential address, on "Food Preservation and Food Preservatives" in January 1891, covered a subject that provoked immense agitation fifteen years later when Dr. Wiley began to enforce his new Pure Food Law. Crampton in his address took the position long held

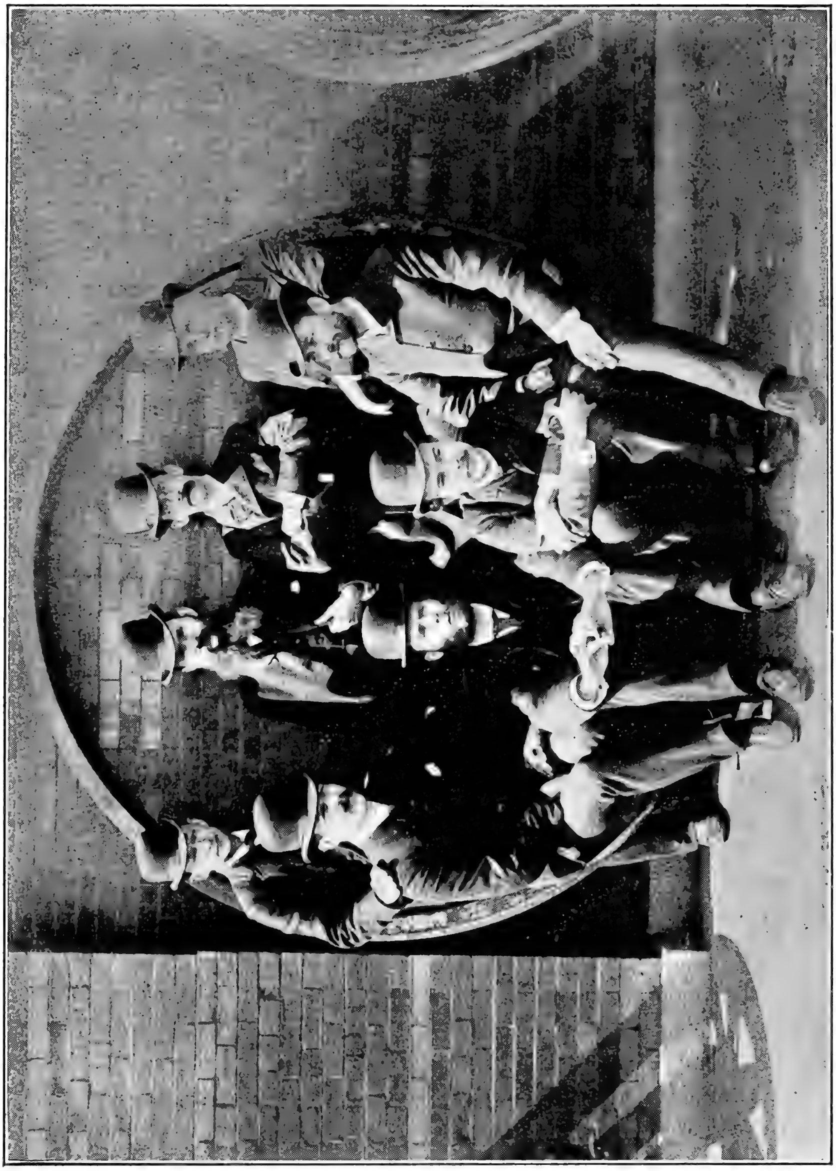

Fig. 2.—Chemists and Physicists of the United States Geological Survey in the year 1887. Seated, left to right: J. E. Whitfield, F. A. Gooch, C. Barus (physicist), R. B. Riggs. Standing, left to right: F. W. Clarke, W. F. Hillebrand, T. M. Chatard, W. Hallock (physicist).

by Wiley that "the world and its food supply would be better off today if the use of antiseptics as food preservatives had never been discovered."

Crampton, Wiley and other early colleagues of this Society should be remembered also for their having founded and laid out with streets and trees the present suburb of Somerset, which was started primarily as a place of residence for Government chemists. It was there that Crampton erected a beautiful home and even now several of our members reside in this pleasant community.

It would be a serious omission in discussing the early founders of our Society if I failed to refer in this anniversary lecture to its ninth president, Dr. Thomas M. Chatard. He was born at Baltimore, graduated from Harvard in 1871 in the same class with his life long friend, Dr. Charles E. Munroe, and obtained his Ph. D. degree from Heidelberg in 1876. Chatard then served as assistant chemist in the Torpedo Corps of the U. S. Navy from 1870 to 1872 and as instructor in Chemistry at Pennsylvania from 1872 to 1874. After working as mine and mill manager from 1877 to 1883 he served as chemist of the U. S. Geological Survey from 1883 to 1892 when he resigned to take up the practice of consulting chemist. In 1900 he became a special agent of the Census Bureau. The report of Munroe and Chatard upon "Chemicals" in Volume X, Part 4, of the Twelfth Census (pp. 525–679) is a classic and will long be referred to. Chatard's papers before our early Society relate to silicate analysis, the manufacture of salt and western alkali deposits. His presidential address in January 1893 on "The Abuse of Explosives with Suggestions for Preventive Laws" deals with a subject of perennial importance and can still be read with profit.

A half century ago there was a group of younger assistant chemists in Washington who made their first attempts in authorship at the early meetings of our Society. Reference will be made to only two of these—Dr. Guilford L. Spencer, a foundation member, and Augustus E. Knorr who joined the Society at its third meeting. Spencer followed Dr. Wiley from Purdue to Washington in 1883 and for the next twenty years, as assistant chemist and Chief of the Sugar Laboratory of the Bureau of Chemistry, conducted field experiments in sugar technology that were of world wide importance. He designed the sucrose pipette and many other time-saving pieces of apparatus and was the author of a Handbook for Cane Sugar Manufactures that is still the leading work of its kind. Spencer spent the last twenty years of his life as supervisor of sugar manufacture for several large estates in Cuba. It was in discharging the duties of this position that he died suddenly in harness on March 23, 1925. His papers before the early Society relate to the estimation of phosphoric acid, the extraction of sugar from molasses, the fibre of Louisiana sugar cane and the estimation of theine in tea.

Augustus Knorr, who was a member of the Chemical Division of the Department of Agriculture from 1884 to 1892, was an interesting combination of the chemist and glass blower. He designed many novel pieces of apparatus which were much used in their day. His papers before the early Society describe various pieces of laboratory equipment which he devised such as a gas regulator and an extraction apparatus without corks or stopper. The latter utensil, known as Knorr's extractor, was described with other pieces of his apparatus in the Proceedings of the Association of Official Agricultural Chemists for 1890.

At the fourth meeting of our Society on April 24, 1884, two chemists joined who afterwards won great distinction as non-resident members in their respective fields. These were Dr. William Frear, then assistant chemist in the Department of Agriculture, and later Professor of Agricultural Chemistry at the Pennsylvania State College, and Dr. Frank Gooch, then chemist of the U. S. Geological Survey and afterwards Professor of Inorganic and Analytical Chemistry at Yale. Frear became known for his work on food standards while Gooch is best remembered for his invention of the crucible that bears his name. Frear presented a paper at our ninth meeting on the determination of gluten and Gooch read a paper at our tenth meeting on filtration by means of easily soluble and easily volatile filters. Frear and Gooch remained on our roster as non-resident members many years after their retirement from Washington.

There were also among our early members several scientists who could hardly be classified as chemists. Among these was Dr. W J McGee best known for his work in geology, archeology, ethnology and anthropology. He prided himself upon being a member of all the scientific societies of Washington and it was probably for this reason, and not for any particular love of chemistry, that he joined our Society at its fifteenth meeting. McGee was wrong, however, in stating that he was a member of all the scientific societies of Washington. There was one organization to which his entrance was eternally barred; it was "The Women's Anthropological Society." McGee was generally known by his nickname "No Stop" for the reason that he permitted no periods to be inserted after the letters W J, which he insisted were not initials but his actual name. Wherever the name W J McGee was signed, or attached, or indexed you will find no stop or period to interfere with its continuity. It is rumored, however, that his full name was actually William John McGee.

The Chemical Society of Washington at its foundation meeting had an enrollment of 33 members. This number had increased at the end of the year to 40. In the following years there was an average annual increase of about 8 members, including non-residents, until by the year 1893, at the time of the amalgamation with the American Chemical Society, the membership of the Local Society reached a total of 97, of whom 70 were resident and 27 non-resident. In this period of independent existence the Society held about seven meetings a year, the number of papers presented at each meeting varying from 0 to 5. With its small membership, of whom only about one third were contributors of papers, it was not always easy to arrange a program and hurry calls were often sent out a few days before a meeting for a scratch contribution. But after all one main object of a scientific meeting, then as now, was to bring the men together for personal contacts. We often derive more benefit from the random exchange of ideas in the interlude of a meeting, or at a society dinner, than from the papers of a prearranged program.

The attendance at the early meetings of our Society was small. The average of those present including guests during the first five years of its history was only eighteen. It fell at some meetings as low as nine and was never more than twenty-five. These numbers were vastly exceeded, however, at the annual meetings when the President gave his retiring address. On these occasions which were first held in December and after 1888 in January or February, members of the Philosophical Society, Anthropological Society, Biological Society, Entomological Society, Microscopical Society and the Cosmos Club with ladies and guests were invited to be present and the capacity of the hall was then sometimes filled to overflowing. The monthly gatherings of the early Society were usually held in what is now the east end of the main reception room of the Cosmos Club, this meeting place being separated from the rest of the room by a folding door. For the larger annual meetings the entire reception room was sometimes thrown open, but the capacity of this was too small to seat the combined membership of all the scientific bodies of Washington and their guests. When a very large attendance was expected the meetings were usually held in the auditorium of Columbian University.

The records of the early meetings of our Society with its programs, results of elections, resolutions, reports of committees, presidential addresses, constitution, by-laws, lists of members, etc., were published as an annual bulletin. This appeared for nine years until May 1895 when further issues were suspended. It is greatly to be regretted that this publication came to an end. A continuous run of these bulletins for 54 years would have now a decided historic value. The discontinuance of the bulletin was of course a result of the amalgamation of our early organization with the American Chemical Society. The Journal of the latter took the place of the bulletin. It is one of the costs of any kind of consolidation that the individual surrenders a part of his identity and this inevitable loss is proportionate to the magnitude of the unification. This law applies not only to scientific societies but to trusts, to Government bureaus and to totalitarian states. After a lapse of twenty-four years the reconstituted Chemical Society of Washington recognized this loss and attempted in February 1919 to recover a part of its lost identity by bringing out a new issue of its old bulletin but somehow the heart of the membership was not in it and the revived publication soon perished from lack of support.

This closes my attempt to picture for you a few of the individualities, the scientific attainments, the witticisms, the eccentricities, and the foibles of some of the early founders of the Chemical Society of Washington. Lack of time has prevented me from including something about Dewey, Diller, Hitchcock, Israel, Kalusowski, Lawver, Littlewood, MacLean, Merrill, Packard, Peale, Read, Robinson, Taylor, White and Yeates, all worthy members about whom much could be said. In this group of men were representatives from England, Scotland, Ireland, the Continent of Europe and from many states of the Union;—men who had fought on opposite sides in the Civil War but who now united were all anxious to do their part in the upbuilding of a restored nation.

Our early organization was a small Society but what was lacking in numbers was made up in enthusiasm and good fellowship. It was a collection of the choicest spirits. The great Harvard trio, Frank Clarke, Harvey Wiley and Charles Munroe, was alone sufficient to keep any society agoing. Only a few of our founders are now left but those disconsolate words "*Pulvis et Umbra*" are not to be inscribed upon their monuments. The inspiration of their personalities and the influence of their work will always continue.

CHEMISTRY.—*The Chemical Society of Washington and its part in the reorganization of the American Chemical Society.*[1] C. A. Browne, Bureau of Chemistry and Soils.

The year 1934, which is the semi-centennial of the founding of the Chemical Society of Washington, is distinguished for a large number of chemical anniversaries. It is also the semi-centennial of the founding of the Association of Official Agricultural Chemists. It is the hundredth anniversary of the birth of Mendeleeff, Schorlemmer and Sprengel among European chemists and of G. C. Caldwell, a former President of the American Chemical Society, among American Chemists. It is also the hundredth anniversary of the publication of Prout's "Bridgewater Treatise on Chemistry" a famous work which exercised a great influence at the time both upon chemical and religious thought. This year is also the two hundredth anniversary of the birth of the famous English chemist, Thomas Henry, and of the death of Stahl, the founder of the doctrine of Phlogiston.

But it is not about these men that I have been requested to speak this evening but about a few of the founders of the Chemical Society of Washington and their relations to some of the chemical developments in the United States of a half century ago. The decade between 1880 and 1890 in which this chemical society came into existence was one of the several transition periods that seem to appear in the history of American chemistry at approximately 50-year intervals. There was a similar transition period in the decade between 1830 and 1840 and we are passing through another of these very disquieting epochs in the present decade of 1930 and 1940. These periods of readjustment come inevitably after a time of severe business depression when the stability of industries and institutions is threatened. They are usually the aftermath of some great war, such as the War of 1812, or the Civil War, or the recent World War.

The changes that took place in the transition period of 1880–1890 were manifested not only in industry but were evident also in the fields of education and scientific organizations. The attempt to merge the loosely organized local lyceums and other scientific organizations of fifty years ago into large national groups of chemists, biologists, engineers, etc. was rendered extremely difficult by a spirit of strong individualism and independent freedom of action. The leading founders of the local Chemical Society of Washington—men such as Clarke and Wiley, to name only two of those whom I knew so long personally

[1] Read before the Washington Chemical Society, April 26, 1934. Received March 29, 1938.

—were strong individualists. They belonged to the old school which believed in liberty of opinion and action, and their strong spirit of individualism gave these men a rugged picturesque type of personality that is lacking in the present generation. The clash between these opposing tendencies of individual and unified action can be exemplified in no better way than by observing what took place in the early history of the American Chemical Society and the Chemical Society of Washington. The details of this movement, which were narrated to me by various members of the opposing factions who have now nearly all passed away, are not generally known and they deserve to be recorded as an interesting phase in the annals of American Chemistry.

The American Chemical Society, as at present constituted, is the composite result of various streams of influence acting from both within and without over a long period of time. Indeed, the consecutive steps in organizing a national society of chemists in the United States might almost be called an experimental method of trial and rejection and many years had to elapse before events could finally develop into the type of organization with which we are now familiar. American chemists seem to have been interested more at first in the establishment of journals than in the organization of a society. The Journal of Applied Chemistry, the Boston Journal of Chemistry and The American Chemist all began publication before the first movement was made to organize a national chemical society.

The first steps towards effecting a national organization of American chemists were taken on August 25, 1873, at the meeting of the American Association for the Advancement of Science in Portland, Maine, when a subsection upon chemistry was formed. Of the chemists present on that occasion it may be noted that seven of them—G. F. Barker, F. W. Clarke, T. S. Hunt, S. W. Johnson, William McMurtrie, C. E. Munroe and H. W. Wiley—afterwards became presidents of the American Chemical Society. The formation of this chemical subsection of the American Association is important because of the influence which it afterwards had upon the organization of a national chemical society. Of the charter members of this subsection (which became Section C in 1882) it is interesting to note that four of them—Clarke, Munroe, Warder and Wiley—were afterwards presidents of the Chemical Society of Washington.

The next important event that led to the formation of a national chemical society occurred on July 31 and August 1, 1874, when a group of some seventy leading American chemists met at the old home of Dr. Joseph Priestley in Northumberland, Pennsylvania, to celebrate the one hundredth anniversary of Priestley's discovery of oxygen. Every chemist who attended that meeting felt the stimulating influence of his contact with colleagues from all parts of the country and the wish was generally expressed that the members there gathered might form the nucleus of a national society of chemists. A plan for such an organization was soon formulated and after much preliminary discussion the American Chemical Society was founded on the evening of April 6, 1876, in the Lecture Room of the College of Pharmacy in the old building of New York University on Washington Square of New York City. The new Society started out under favorable auspices and soon could count in its membership many of the leading chemists of the United States.

Unfortunately the Directors of the American Chemical Society at the time of its inception made the fatal mistake of attempting to centralize everything locally within New York City where the majority of its members were living. There was then among this New York group a certain obstinate clique, wholly unsympathetic with American traditions, which for a long time blocked every effort to make the Chemical Society a truly representative national organization. The result was that, almost as soon as formed, the Society began to disintegrate into its original units. On January 4, 1877, F. W. Clarke submitted his resignation within two months after his election. Clarke's resignation was followed by those of G. F. Barker, William McMurtrie, W. F. Hillebrand, Edgar Smith, H. W. Wiley and Ira Remsen. In other words, within five years after the Society's organization seven of its future presidents, four of them Washingtonians withdrew from the membership. In this group of malcontents who either resigned or were suspended for the nonpayment of dues must also be counted Edward Hart, who was editor of the Journal of the American Chemical Society from 1893 to 1901, S. P. Sadtler, W. D. Mason and numerous other chemists of national prominence. Evidently things were not going well in this first effort to establish a national chemical society.

The primary cause of the spirit of disunion which threatened the existence of our chemical society in the first decade of its existence was the fact that its board of directors were all residents of New York, that its monthly meetings were all held in New York and that chemists who lived at great distances from this metropolis were unable to take part in the Society's activities. Chemists outside of New York, therefore, looked upon the Society as a purely local organization and were unable to see that conditions for them were any better than before its foundation. In order to dispell the belief that the Society was only a local affair, the policy was adopted of selecting its presidents from chemists who lived outside of the Metropolitan area. This palliative measure, however, was wholly ineffective in promoting an increase in the members of the Society. The total membership of the American Chemical Society in 1881 was only 243, of whom 119 resided in the Metropolitan district of New York and 124 in the regions beyond. Six of the latter lived here in the City of Washington, of whom four, E. T. Fristoe, B. S. Hedrick, W. P. Lawver and W. M. Mew, were among the founders of the Chemical Society of Washington.

Another cause of discontent was the very meager size of the Journal of the Society. As compared with its predecessor, "The American Chemist," which it superseded, the new Journal was an inferior publication as regards both quality and quantity of contributions.

It seems to us at the present time rather strange that the New York City group of chemists did not recognize sooner the futility of attempting to conduct a national society upon the basis of the status quo as it existed in 1880 and that they did not come sooner to the correct solution of the problem of securing cohesion between widely scattered independent groups of chemists within a national organization. The local independent group development, already existent in the old lyceums, took a more definite form with the foundation of the Cincinnati Chemical Society in the early eighties and of the Chemical Society of Washington on January 31, 1884.

The moving spirits in the organization of this local Washington Society were F. W. Clarke, H. W. Wiley and other malcontents who had seceded from the American Chemical Society with headquarters in New York City. Twenty-seven chemists belonging to different Government and local organizations, and six chemists of private status constituted the charter members of the Washington Society. This was a good representation of the various local organizations at a time when chemistry was just beginning to play a part in Government Research.

It is interesting now to inquire as to the effect of the organization of the Chemical Society of Washington upon the American Chemical Society. One result was a gradual transfer of the allegiance of the local chemists who were still members of the American Chemical Society to the new Washington Society. The policy of these men at first seems to have been one of watchful waiting. At the end of 1886, three years after the founding of the Chemical Society of Washington, only two of the local group of four who at first belonged to both societies continued as members of the American Chemical Society, Dr. Hedrick having died and Dr. Mew having resigned. Dr. Friscoe and Dr. Lawver dropped out in 1887 and for the next three years the American Chemical Society was without a member in the City of Washington.

Meantime the membership of the American Chemical Society, so-called, had been steadily declining. The enrollment of 243 members in 1881 had declined to 167 in 1889 of whom only 76 lived beyond the New York district. The Journal of the Society appeared at only irregular intervals and for the year 1889 numbered only 158 pages.

At this time when the affairs of the American Chemical Society were at their lowest ebb, Dr. F. W. Clarke of the Chemical Society of Washington and also a most active member of Section C of the American Association for the Advancement of Science, was taking active steps towards organizing a National or Continental Chemical Society. A committee of Section C was appointed with Clarke as Chairman to confer with various chemical societies upon the best plan of accomplishing such an organization. In this work Clarke was ably supported by Dr. H. W. Wiley who at the Sixth annual Convention of the Association of Official Agricultural Chemists in Washington on September 11, 1889, strongly recommended the organization of a national chemical society. Wiley mentioned that this plan had aroused some opposition, one objection being the existence of a society which claimed to be the American Chemical Society. He had once been a member of that society but the only benefit which he received from the connection was a receipt for his annual dues. He had, therefore, after paying his dues, resigned. It was now time, Wiley stated, for the chemists of the country to form a national association strictly and purely American in its character. It was intended not to confine it to the United States but to include the chemists of Mexico and Canada and in fact the whole continent of North America.

Following Dr. Wiley's remarks at this meeting of the Association of Official Agricultural Chemists, Dr. Clarke made a statement which is interesting because it is one of the earliest forecasts of the type of organization which the American Chemical Society was soon destined to assume. As a result of Clarke's canvass of chemists, which he made as Chairman of the Committee of Section C of the American Association for the Advancement of Science, "the general consensus of opinion seemed to be that in order to avoid the danger of localizing the society it would be necessary to follow to some extent the example of the Society of Chemical Industry in Great Britain, which has a number of sections in different parts of the Kingdom. There was a London section, a Liverpool section, sections at Manchester, Birmingham, Newcastle, Glasgow, and other points, the several sections all cooperating through one journal. Probably the same plan would be feasible in this country, where there were already a goodly number of centers of chemical industry."

In conformity with the plan thus outlined Clarke and Wiley issued in 1889 a circular letter to the chemists of America which had for its purpose: "To organize a Continental Chemical Society, representative of all North America, by affiliating together as far as possible existing local organizations. The society as a whole to hold an annual meeting at such time and place as may be agreed upon from year to year; while local sections, like the sections of the British Society for Chemical Industry, shall have their regular frequent gatherings in as many scientific centers as possible, all publishing their work in one official journal." (Proceedings, Amer. Assoc. Adv. Sci. 1890, p. 141–2.)

Obviously this movement of Clarke and Wiley to establish a chemical society that would be truly American could not be without some influence upon the officials of the American Chemical Society so-called. Certain of its own members had long foreseen the need of reform. Among these was Prof. C. E. Munroe, then of Newport, R. I., who, thoroughly aroused at the spirit of indifference which was hampering the initiation of necessary reforms within the society, attempted to bring about from the inside what Clarke and Wiley were endeavoring to accomplish from without. His views upon the holding of general meetings and the establishment of local sections were expressed in a letter which was read at a meeting of the American Chemical Society in New York on November 1, 1889. This letter seems to have been instrumental in securing action, for at the next meeting on December 6 plans of reorganization were fully discussed, in which connection President Chandler expressed the hope that this might be effected upon the plan of the Society of Chemical Industry. The good influence of these efforts was reflected in a very optimistic editorial in the first issue of the Journal for 1890 regarding the reorganization of the Society so as to make it truly national and also in an announcement upon the revision of the Society's Constitution in which suggestions were invited by the Committee from the different members. A revised constitution was thereupon prepared and adopted by a majority vote of the Society at its meeting in New York on June

6, 1890. The new constitution provided for the establishment of local sections of the Society but the New York group continued to assert its claim of leadership by maintaining that the headquarters of the Society should be the City of New York and that the annual meeting for the election of officers and committees should be held at the headquarters.

Another article of the new constitution was the provision for holding general meetings of the American Chemical Society in localities outside of New York. In view of the fact that this reform had been suggested by Prof. Munroe, the duty of demonstrating its success was now put squarely up to him and accordingly the Directors voted to hold the first general meeting of the Society at Munroe's home city of Newport on August 6 and 7, 1890, and nominated him the chairman of the local committee of arrangements. This meeting was a great success, there being present a representative gathering of forty chemists from different parts of the United States. On the second day of this meeting there was a general consideration of the question of organizing the chemists of America and Dr. Clarke opened the discussion by sketching a brief history of the new movement for a "Continental" society. As a result of this discussion a committee of the American Chemical Society was appointed to confer with representatives of other societies and organizations of chemists as to a plan of consolidation.

In reply to the arguments of Clarke and Wiley to establish an entirely new national chemical society, the representatives of the American Chemical Society urged in behalf of their own title to national standing that it had had a continued existence for fourteen years, that it published a journal and had built up a library. They showed also from the lists of its presidents that there had been no discrimination in favor of New York against chemists of other localities. In a subsequent report by F. W. Clarke, H. C. Bolton and Edward Hart for the Committee of Section C of the American Association upon a national chemical society (Proceedings, Indianapolis meeting, 1890, p. 139–140) it was said of the American Chemical Society: "It has surely been national in spirit though local by force of circumstances. Towards the movement which we have initiated it is in no wise hostile, and it seems quite clear that by means of mutual concessions of a wholly minor sort a union with it can be effected." This is the first indication of a possible healing of the breach which had so long existed between New York and Washington. A new spirit of conciliation seems to have prevailed as soon as the old American Chemical Society manifested a willingness to meet with its critics and to consider their suggestions in the organization of a national chemical society.

At a second general meeting of the American Chemical Society, held in Philadelphia on the 30th and 31st of December 1890, at which seventy-five chemists were in attendance, the conference committees of the different chemical societies were announced who were to consider the plans for a national organization of chemists. These committees represented seven different organizations of chemists—the American Chemical Society, the Chemical Section of the American Association for the Advancement of Science with Dr. F. W. Clarke as Committee Chairman, the Association of Official Agricultural Chemists with Dr. H. W. Wiley as Committee Chairman, the Washington Chemical Society with Prof. W. H. Seaman as Committee Chairman, the Chemical Section of the Franklin Institute, the Chemical Section of the Brooklyn Institute and the Manufacturing Chemists' Association of the United States.

Meanwhile, without waiting for the completion of these plans for organizing a national society, the chemists of Rhode Island under the leadership of Professors C. E. Munroe and J. H. Appleton had resolved to form a local section of the American Chemical Society in accordance with Article X of the revised constitution adopted by the New York chemists. A petition was accordingly submitted to the directors of the Society (all thirteen of whom were New York chemists) on December 31, 1890, for the establishment of a Rhode Island Section of the American Chemical Society and this petition was granted on January 21, 1891. Thus was created the first local section of the American Chemical Society. The point of special significance in this connection is that the Rhode Island group, most of whom were then members of the American Chemical Society, chose to work out the problems of reorganization within the Society itself. Their petition, however, was a tacit recognition of a New York directorship in the management of the Society's affairs, which was the very thing that Washington secessionists under the leadership of Drs. Clarke and Wiley desired to abolish.

As a result of the invitation of Dr. Clarke the third general meeting of the American Chemical Society was held in Washington on August 17 and 18, 1891, in conjunction with the meeting of the American Association for the Advancement of Science. At this meeting members of conference committees of ten different chemical societies met on August 17 to draw up plans for a general organization of chemists. These societies in the order of membership were the American Chemical Society with 290 members, the Chemical Section of the American Association for the Advancement of Science with 200 members, the Association of Official Agricultural Chemists with 75 members, the Chemical Section of the Brooklyn Institute with 75 members, the Washington Chemical Society with 70 members, the Chemical Section of the Franklin Institute with 70 members, the Chemical Society of the University of Michigan with 60 members, the Louisiana Sugar Chemists' Association with 52 members, the Cincinnati Chemical Society with 29 members and the Manufacturing Chemists' Association of the United States of unknown membership. The committees of these different organizations, representing approximately 1000 American chemists, passed by unanimous vote the following resolution:

Resolved, That it is the opinion of this conference, 1st, That the American Chemical Society be so extended as to include the members of all local societies in its membership; 2nd, That the New York members of the American Chemical Society be requested to organize a local section of the American Chemical Society in New York.

This resolution was the determining factor which solved the preliminary difficulties of organizing a national chemical society in the United States. The New York group was placated by the retention of the old name, American Chemical Society, but was deprived of all claims of priority or leadership by being requested to reorganize upon the basis of a local section. Except in name the proposed reorganization was an entirely new chemical society.

The immediate result of this resolution was its acceptance by all the interested chemical organizations. As a first indication of the reestablishment of harmonious relations the two Washington leaders of the secession movement, F. W. Clarke and H. W. Wiley, were reelected members of the American Chemical Society on October 2, 1891. The hatchet was not altogether buried, however, for there were still certain objectionable features in the existing constitution and charter of the American Chemical Society that required correction before Clarke and Wiley would consent to bringing the chemists of the societies which they represented into the fold of the reorganized American Chemical Society. It should be noted, however, that with the resumption of their old membership in the American Chemical Society by Clarke and Wiley, the remaining reforms which they strove to accomplish were worked out within the Society itself.

The revised constitution, which the local American Chemical Society had accepted on June 6, 1890, had first to be revamped in order to meet the acceptance of the new National organization. At the fourth general meeting of the Society held in New York on December 29 and 30, 1891, a committee was accordingly appointed on the revision of the constitution, the draft of which was presented by Dr. Wiley at the Fifth General Meeting which was held at Rochester on August 16 and 17, 1892. Dr. Wiley also moved at this meeting that a committee of three be appointed to amend the old charter of the American Chemical Society so as to remove the objectionable section requiring that a majority of the Board of Directors shall be residents of New York.

The revised constitution of the American Chemical Society, which was finally adopted, removed practically the last semblance of control of the Society's affairs by the old local group of New York chemists.

The final consummation of all the plans for the reorganization of the American Chemical Society was achieved with the election of Dr. Wiley as President at the Sixth General meeting in Pittsburgh on December 28 and 29, 1892, when an entirely new arrangement of affairs came into existence. A considerable amount of politics, of the old horse-trading type, characterized the election of Dr. Wiley at this critical juncture of the American Chemical Society's affairs. The New York chemists, realizing again the necessity of selecting a non-resident of their city as the next president, favored the nomination of a candidate from the newly established Rhode Island Section whose members although not wholly satisfied had remained loyal to the then existing organization. Professor Munroe and Professor Appleton were mentioned as candidates in this connection but it was soon realized that if the strong rebellious Washington faction was to be fully placated it would be the best policy to put in a Washingtonian as the next president. After considerable canvassing and maneuvering it was decided that the election of Dr. Wiley would probably help most towards welding the various local groups of American chemists into a unified national organization. Dr. Wiley was accordingly elected and the wisdom of his selection was shown both by the rapid increase in the membership of the American Chemical Society and by the great quickening of interest in chemistry in all parts of the country that took place during the two years of his administration.

The first important indication of these new developments was the transference of the entire membership of the Washington Chemical Society to the rolls of the American Chemical Society. The advisability of making this change in the status of the Chemical Society of Washington was debated among the individual members both without and within the meetings of the Society. The topic of discussion at the sixty-third meeting of the Society on December 8, 1892, with President T. M. Chatard in the chair, was "National Chemical Society Plans." Some opposition was expressed at this meeting against the plan of incorporating the local Washington society as a section of the American Chemical Society. Professor Munroe, who had recently transferred his residence from Newport to Washington, spoke at this meeting upon the advantages of such an incorporation and because of the leading part which he played in the formation of the first local section of the American Chemical Society in Rhode Island early in the previous year, his remarks were no doubt instrumental in winning many adherents to the plan.

According to the abstracts of the Proceedings of the Chemical Society of Washington for its sixty-seventh meeting on April 13, 1893 with President Dewey in the chair (Bulletin of the Society, No. 9, p. 65), "the question of becoming a local section of the American Chemical Society was ordered to be submitted by the Secretary to the members of the Society individually, their action to be reported at the May meeting." This action, however, seems to have been only a delayed effort to secure official confirmation of an agreement which had been formed two months previously, for in the Minutes of the Council of the American Chemical Society for February 26, 1893 (Jour. Am. Chem. Soc. *15* (1893), p. 296) we read that a petition had already been submitted to the Board of Directors "to incorporate the Washington Chemical Society as a local section of the American Chemical Society" with the signatures of H. W. Wiley, E. A. de Schweinitz, F. W. Clarke, Geo. Steiger, Charles E. Munroe, W. M. Mew, Robt. B. Warder, Wm. H. Seaman, Jas. H. Griffin and Claude A. O. Rosell.

At this point an interesting complication arose for the petition requested the incorporation of the Washington Chemical Society as a local section of the American Chemical Society whereas the constitution of the latter did not provide for incorporating any other organization as a local section but merely for the formation of a local section "by the Board of Directors on the receipt of a written request to that effect, signed by ten members of the society and endorsed by a majority of the Council." The signers of the petition were accordingly requested to make out a new petition in conformity with the requirements of the constitution to the Board of Directors who thereupon issued to the ten signatories under date of May 10, 1893, a charter for the formation of a local section of the American Chemical Society in the city of Washington. The members of the new Washington section for their own local purposes retained the name of their old organization, "The Chemical Society of Washington," but added thereto in parentheses from this time on (Local Section of the American Chemical Society).

Meanwhile, acting apparently individually but unquestionably in conformity with a concerted plan, fifty-seven members of the Chemical Society of Washington had already been duly elected members of the American Chemical Society on March 13, 1893 (Minutes of the Council, Jour. Am. Chem. Soc. *15* (1893), pp. 58–59) which it will be noted is two months earlier than the granting of the charter and also two months earlier than the official report of the secretary of the Chemical Society of Washington at its sixty-eighth meeting on May 11, 1893 (Bulletin 9, p. 66) that "sixty members of the Society had reported in favor of becoming a section of the American Chemical Society." The local society as an official body was evidently slow in keeping up with the activities of its own members.

The final act in this reorganization of the Chemical Society of Washington was the appointment by President Dewey at this same meeting of May 11, 1893, of a committee consisting of Messrs. Wiley, Chatard and Peale to revise its Constitution and By-Laws in accordance with the action of the Society. The Constitution, as revised by this Committee, was adopted on December 14, 1893.

The incorporation of the Chemical Society of Washington as a section of the American Chemical Society was a dramatic event for it marked definitely the healing of the old breach between New York and Washington which began with the resignation of F. W. Clarke from the American Chemical Society over sixteen years before.

Another important event during Dr. Wiley's presidency, coincident with the changes just mentioned, was the transfer in the management of the Society's Journal. Until 1893 the publication of the Journal of the American Chemical Society had remained entirely in the hands of a New York editorial committee whose chairman was the late Professor A. A. Breneman—an able man who for many years had rendered most faithful service in helping to keep the Society going until a national organization could be perfected. Under the new scheme of ruthlessly eliminating all New York affiliations the old editorial committee was now abolished and on April 12, 1893, Professor Edward Hart of Easton, Pa., was elected Editor, who, with Professor Edgar F. Smith of Pennsylvania and Professor J. H. Long of Chicago, constituted the new Committee on Papers and Publications.

As an ex-member and past chairman of the New York Section of the American Chemical Society I wish to commend the willing spirit of the fine old group of New York Chemists to submit without protest to these severe acts of discrimination. Many of these men were my closest friends and now that they have all gone to their final reward I wish to state that their feelings were decidedly hurt. They did not resign, however, but continued to show their loyalty to the reorganized Society by working always for its best interests. I have always felt that it would have been a kind and magnanimous act to have retained Professor Breneman, at least for a time, upon the editorial board of the reorganized Journal. Society politics of the period seems, however, to have dictated the slogan that no good could come out of Gotham.

Professor Hart, the new Editor of the Journal, was also the head of the Chemical Publishing Company and the owner of the Journal of Analytical and Applied Chemistry. Under the new arrangement Hart became not only the Editor but also the publisher of the Journal of the American Chemical Society. He agreed at the same time to suspend the publication of his own Journal with the issue for June, 1893 sending to his subscribers for the rest of the year the numbers of the Journal of the American Chemical Society. This act of consolidation proved to be very beneficial to the Society.

A third chief event of Dr. Wiley's presidency of the American Chemical Society was the International Congress on Chemistry held at the Columbian Exposition in Chicago August 21–26, 1893. Eighty-three members of the American Chemical Society attended this Congress of which Dr. Wiley was chairman of the Joint Committee.

In welcoming the members of the Congress, at which were many distinguished foreign chemists, Dr. Wiley thus referred to conditions existing in the United States:

> "In this country our chemical workers have been widely scattered. Our friends from abroad must not, therefore, be surprised to find less *esprit du corps* among us than in their own countries. We have been whirled hither and thither in the wild molecular melange of a rapidly growing country. But now there are many centers of crystallization forming, and soon you will find among us more unity of action, more mutual helpfulness. One of the organizations which I have the good fortune to represent at this time is bringing into intimate relations large numbers of our American chemists and cementing them into a body which gives promise of lasting good in the future. Already more than half a thousand American chemists have joined hands, and it is their united hand, big, brawny, and right honest in its grasp, which is extended to you today."

It is interesting also to record that at this meeting Dr. Wiley suggested the establishment of a Triennial International Congress on Chemistry to meet in different countries. This recommendation led ultimately to the establishment of the International Congresses of Pure and Applied Chemistry which were held at triennial periods until the outbreak of the World War and are now being revived in 1934 with the present meeting in Madrid.

Dr. Wiley was reelected president of the American Chemical Society for the year 1894. As an evidence of the new vigor which was infused into the American Chemical Society during the two years of his presidency it should be noted that the membership of the organization more than doubled during this period having increased from 351 to 722 and that the size of the Journal also more than doubled having increased from 402 pages in 1892 to 891 pages in 1894. His administration may, therefore, be considered to mark the turning point in the affairs of the American Chemical Society and the beginning of its present phenomenal growth.

Such in brief is the story of the movement which led to the founding of the Chemical Society of Washington and to its subsequent incorporation as a section of the American Chemical Society.

The question might be asked in conclusion whether the problem of reorganization could not have been worked out more amicably within the Society according to the plans advocated and followed by Professor C. E. Munroe without the disagreeable secession movement which was initiated and fostered by Dr. Clarke. This is a hard question to answer but my opinion is that a secession of some kind was inevitable and necessary in order to enforce upon the minds of certain obstinate members of the old society the lesson that a national scientific society cannot be organized except upon a basis of the strictest local sectional equality.

It is to be hoped that the need for such a movement may never again arise in the history of our American Chemical Society. But if it should arise let us hope that the work of reform may be conducted as worthily and as effectively as it was carried out by two of the founders and early presidents of this Chemical Society of Washington—those doughty champions of the right of individual freedom of opinion and action—Frank W. Clarke and Harvey W. Wiley.

CHEMISTRY.—*Response to the award of the Hillebrand Prize for 1937.*[1] STERLING B. HENDRICKS, Bureau of Chemistry and Soils. (Communicated by FREDERICK D. ROSSINI.)

One appreciates the Hillebrand award not so much for the personal recognition as for recognition of a particular field of work. In this case it is the determination of geometrical arrangements of atoms in crystals and in molecules. Diffraction, most conveniently of x-rays and electrons, is the only general method for doing this. Spectroscopic methods are applicable to gases of simple molecular structure and while they are very useful they will not further concern us.

Before discussing a few points connected with this particular award I should like to acknowledge my indebtedness to a number of people. An adequately equipped laboratory for diffraction work with x-rays and electrons represents considerable investment and requires constant mechanical service and improvement. Splendid facilities in this respect have been made available in the Fertilizer Division of the Bureau of Chemistry and Soils. Dr. Knight and Dr. Kunsman as directors have not been insistent that all of the work be of an applied nature and by this attitude they have permitted me and my associates to stay abreast with rapidly advancing fields. It has been my good fortune to be associated with Dr. Maxwell, Mr. Mosley and Mr. Jefferson in this work. Some of the work closely connected with this award was carried out with Dr. Deming who has always been ready with mathematical advice. It has also been my pleasure to have had stimulating contacts with the personnel of many other organizations in Washington, especially with the Geophysical Laboratory, the National Museum, and the Geological Survey in work on minerals.

When waves fall upon a repeated network a diffraction pattern is obtained and some knowledge of the network can be gained from study of positions and intensities of the interference maxima in this pattern. Crystals are formed by regular repetition of units containing a small number of atoms and x-rays having wavelengths of the order of magnitude of the interatomic distances are available. These are the ideal conditions underlying studies of crystal structures.

The geometry of a crystal diffraction pattern and the absence of certain maxima immediately give the dimensions and symmetry of the small unit, the repetition of which builds up the macroscopic

[1] Address delivered before the Chemical Society of Washington on March 10, 1938 on the occasion of the award of the Hillebrand Prize for 1937. Received March 25, 1938.

crystal. This usually contains only a small number of molecules, or of atoms if molecules are not present as in ionic substances, and it can be determined for any crystal. The symmetry of this unit and the number of molecules that it contains immediately gives some knowledge of the minimum molecular symmetry. In this way we find that oxalic acid in its two anhydrous crystalline forms and in its hydrate has a center of symmetry, that is all the oxygen atoms and probably the carbon atoms are in one plane. Similarly it is found that the oxalate ion in the sodium, potassium, and rubidium acid salts and in the potassium and rubidium normal salts does not necessarily have an element of symmetry. In ammonium oxalate monohydrate it has at least a two-fold axis which, too, does not require a plane group. The question is one of possible rotation about a bond that organic chemists consider to be single.

Structure analysis goes further and from intensities of the diffraction maxima attempts to find positions of all atoms in the small unit. In principle this can be done for any crystal but in practice it is impossibly difficult for many. One not only has to find atomic positions within the molecules but simultaneously find the relationship of the molecules to each other. Only the former of these is of much interest to the chemist.

Any assistance external to the diffraction itself for simplifying the structure analysis is permissible since in the end a correct structure can be checked with absolute accuracy. The simplest assumption is that of chemical composition, a more complex one is of approximate molecular shapes and sizes. Molecules have properties that vary with direction and the amount of this variation can often be estimated from knowledge of simpler compounds and structural formulas. Some of these properties are magnetic susceptibility, optical polarization, absorption spectra, and optical activity. If they are not modified too seriously by the proximity of other molecules they can be used to gain some knowledge of molecular orientation in the crystal.

In order to test the use of optical polarization complete structure determinations were carried out for a number of oxalates and their indices of refraction and optic orientations were measured. It was found that the oxalate ion was closely planar in many oxalates and that the orientation of the ion could accurately be determined from the crystal optics. This showed that interaction between the molecules did not strongly affect their polarizabilities, which was the question at issue. Mr. Jefferson and I further demonstrated this by showing that the mean molecular refractivity of highly anisotropic molecules is approximately the same in crystals where they have definite orientations and in their melts where positions are random.

At the present time crystal structure workers are chiefly engaged in the study of those molecular compounds that have some simplifying property such as a plane benzene ring of known shape and size, or a compound having an approximately plane group of atoms with the planes of the groups parallel in its crystals. Knowledge of refractive indices for a number of such compounds permits choice of those whose structure might be determined most easily and speeds a determination on its way.

The objective in the study of the oxalates was to determine the relationship between crystal structure and crystal optics. However, it also involved us in some questions about the structures of the oxalate and carboxyl groups. Robertson[2] carried out a careful analysis of the structure of oxalic acid dihydrate, which has a plane group. He found that the carbon to carbon distance is 1.43Å which is much shorter than 1.54Å as generally found between carbon atoms joined with a single bond. It is in fact somewhat closer to 1.34Å, the characteristic double bond distance. According to theories developed chiefly by Pauling[3] and his associates, this would indicate contribution of several possible structures to the stable state of the group, that is resonance, one of which involves a double bond. Robertson indicated that a partial double bond character not only accounted for the small distance but also for the plane group.

Mr. Jefferson and I carried out an equally careful analysis of the structure of ammonium oxalate monohydrate. The separation of the carbon atoms in the oxalate ion of this salt proved to be 1.58Å which is not significantly greater than 1.54Å, the usual single bond distance. Moreover, the ion is not planar but the two $-CO_2^-$ ends are turned 28° with respect to one another. This last fact even more strongly than the first rules out the possibility of resonance involving a partial double bond character. Such a result is not unexpected since the acid and its ion are two entirely different groups. In the acid, too, the connection through hydrogen with other groups in the system must profoundly affect the group itself.

The two oxygen atoms of a carboxyl part of an oxalate ion are sensibly alike in their atomic separations and this is in entire harmony with the resonance theory. Carbon oxygen bond distances, moreover,

[2] ROBERTSON. J. Chem. Soc. **1936**: 1817.
[3] PAULING et al. J. Am. Chem. Soc. **57**: 2705. 1935.

are smaller than expected single bond values. Pauling,[4] however, has shown that a carboxylic acid, partially, and its ester, entirely, have normal carbonyl oxygen atoms. There is, therefore, less expected resonance in oxalic acid hydrate than in its salts.

A correct explanation for the shortened carbon to carbon distance in oxalic acid dihydrate is probably to be found in the work of Penney and Kynch.[5] They have shown that a single bond distance is shortened by the proximity of a double or triple bond in the case of dibenzyl, stilbene, and tolane. Thus it would appear that conjugation of the carbonyl groups in oxalic acid is really responsible for the shortened carbon to carbon distances, the plane group, and the unusual chemical properties.

I have discussed these subjects since they were in part the object of this particular award. They illustrate to some extent the type of problems studied by x-ray diffraction. There is no magic in any of this work and the confusing detail of a particular paper should never obscure the firm basis of physical theory behind it and the exactness of the final answer.

[4] GILMAN, H. "Organic Chemistry," Vol. II, p. 1871, New York (1938).
[5] PENNEY and KYNCH. Proc. Roy. Soc. **A164:** 409. 1938.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

498TH MEETING

The 498th meeting was held in the Auditorium of the Cosmos Club on Thursday, February 10, 1938, with President DRAKE in the chair. After the reading of the minutes it was announced that the Hillebrand Prize Award for 1937 was to be presented at the March meeting to STERLING B. HENDRICKS for his work in the field of crystal and molecular structure.

The Society was addressed by J. E. MAYER of the Johns Hopkins University who spoke on *peculiarities in the critical region.* It was pointed out that the long accepted view of the liquid-vapor critical phenomena is subject to reexamination in the light of recent developments both from the standpoint of experiment and of theory. Recently measured values of the densities of the coexisting liquid and vapor do not favor the view that the vapor acquires the same density as the liquid at the temperature at which the meniscus vanishes. This temperature is the point at which the interfacial tension becomes zero. Theoretical arguments speak for the existence of a range of temperature above this point, within which the pressure is not dependent upon the volume, over a limited range of volumes. This paper was discussed by MOREY, BRICKWEDDE, KRACEK and STIMSON.

A colored motion picture entitled "Scientific Tank Farming" was shown through the courtesy of the Plant Culture League of San Pedro, Calif., and the cooperation of F. G. COTTRELL.

499TH MEETING

The 499th meeting was held in the Auditorium of the Cosmos Club on Thursday, March 10, 1938, President DRAKE presiding. The meeting was held in conjunction with the annual dinner of the Society.

The Past President, B. H. NICOLET, reviewed the history and the significance of the Hillebrand Prize. President DRAKE then presented the 1937 Award to STERLING B. HENDRICKS for his contributions on the *relation of crystal optics to crystal structure* and on the *determination of molecular structures by X-ray and electron diffraction.* The recipient responded with an address which is published in this number of the JOURNAL (p. 247). Professor EDWARD TELLER of the George Washington University then gave an address of which the following is an abstract:

EDWARD TELLER: *Crystals illuminated by waves and waves illuminated by crystals.* The interaction of waves and crystals, which is the main field of Dr. Hendricks' work, presents a double interest. For the physicist it opens up the possibility of studying the nature of waves; and to the chemist it gives a tool to inquire into the molecular structure of crystals. Thus the interaction of *light* and crystals attracted the attention of Huyghens whose discovery of double refraction seemed to contradict his wave theory of light. (In those early days waves meant longitudinal waves.) In the meantime the idea of transversal light waves and Maxwell's theory not only explained Huyghens' experiments, but it made it also possible to study molecular polarizabilities and molecular form. For instance, Dr. Hendricks determined with the tool of double refraction the orientation of oxalate molecules and nitrate ions in crystals. In the case of nitrates he found the interesting phenomenon of free rotation. The accuracy of our knowledge of crystals was greatly increased by the *X-ray diffraction* discovered by v. Laue. Questions such as the one about the ionic nature of the alkali halides became settled and whole new territories such as the chemistry of silicates were disclosed. Dr. Hendricks participated in this work by his investigation of kaolins. *The electron-diffraction* demonstrated by Davisson and Germer had a revolutionary effect on physics. It made possible the understanding of the physical laws in the inside of atoms and all but abolished the boundary between physics and chemistry. In direct chemical research electron beams proved useful for investigating molecules in the gaseous state. The reason for this is that the electrons are scattered much more strongly than X-rays; therefore, on the one hand, they cannot penetrate easily into the interior of crystals but, on the other hand, they give sufficiently strong scattering in gases. Drs. Hendricks and Maxwell used these properties to determine interatomic distances in alkali halides and in the S_2 molecule. They also investigated the interesting structures of molecules like As_4, P_4, P_4O_6 and P_4O_{10}. It is hoped that these experiments will be continued. Thus the *diffraction of neutrons* (which problem has been already attacked by various investigators) promises to be of great interest in nuclear physics and may make it possible for the chemist to learn the position of a particle which has eluded both X-ray and electron bombardment, namely, the position of the hydrogen atom. There are great difficulties to be overcome. The present neutron sources are weak, and since no absorber exists which stops neutrons of all velocities, a great amount of background neutrons are present. Further complications may be caused by inelastic collisions with the crystal-lattice. But the use of focusing methods and rough mosaic crystals, as well as strongly cooled neutrons, may make these experiments (which Dr. Hendricks is planning) successful in the near future.

500TH MEETING

The 500th meeting was held in the Auditorium of the Cosmos Club on Thursday, April 14, 1938, with President DRAKE in the chair. The meeting was preceded by a buffet supper which was also served in the Auditorium.

The Secretary read the minutes of the 1st, 50th, 100th, 200th, 300th and 400th meetings of the Society, partly because they represented milestones in the Society's existence, and partly because of the points of special interest contained in them. President P. E. HOWE of the Washington Academy of Sciences then read a memorial from the Academy, felicitating the Chemical Society on this historic occasion.

The Society was addressed by C. A. BROWNE who read a paper on *Doctor Thomas Antisell and his associates in the founding of the Chemical Society of Washington,* which is published in this issue of the JOURNAL (p. 213). The paper was illustrated by early photographs of groups of chemists and of chemical laboratories, as they existed in the Department of Agriculture and in the Geological Survey in the period between 1870 and 1890 approximately. These were of very great historical interest, and were received with enthusiasm by the Society. Particularly valuable were the photographs of ANTISELL, F. W. CLARKE, H. W. WILEY, and their associates.

The 500th meeting was then adjourned, and after a period of darkness, the 1000th meeting was opened. Peculiarly, in a way, from our present point of view, President DRAKE still occupied the chair. This he explained, recalling the 500th meeting, was the result of the great progress made in the biochemical sciences, which made it possible to arrest the normal aging processes. J. F. COUCH, also well preserved, then read the minutes of the 999th meeting, which was devoted to the great advances made in the new science of Farm Chemurgy, creating great surpluses of power alcohol, and to the very ingenious ways of dealing with this problem. Madjur A. Shirt (B. H. NICOLET) reported on the photopolymer method of making practically indestructible clothing for the masses. This paper was discussed by H. C. FULLER, who in his present capacity of a shade, having lived too early to avail himself of the benefits of present scientific advances, was somewhat handicapped in making the audience see the points he raised. General Always Ponder (L. W. BUTZ) discussed a paper of great importance on the social aspects of his discoveries of *atheletone* and *esthetone,* two vital agents in the problem of proper division of labor between the male and the female sex. The meeting was concluded by a report on the remains of famous chemists whose bodies had been willed to science, by Dr. M. Wrench (S. B. HENDRICKS), who explained the results in the light of the new *keyhole theory of proteins.*

FRANK C. KRACEK, *Secretary*

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JOURNAL
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WASHINGTON ACADEMY OF SCIENCES

VOL. 28 JUNE 15, 1938 No. 6

MATHEMATICAL PHYSICS.—*Symmetry.*[1] HERMANN WEYL, Institute for Advanced Study, Princeton, N. J. (Communicated by IRVINE C. GARDNER.)

Symmetry, which is the subject of my talk tonight, plays an enormous rôle both in art and nature. I shall try to describe a little why and how this comes about, and by what concepts the mathematicians have approached this phenomenon. For, after all, symmetry is a mathematical concept.

In our everyday language and in the arts, the word symmetry is today used mostly for designating *bilateral symmetry,* the left- and

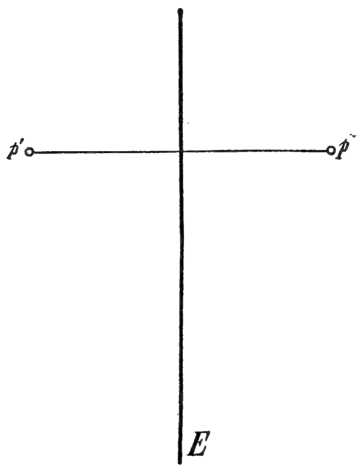

Fig. 1.—Reflection in *E*.

right-hand symmetry. Let us imagine a plane E in space and perform reflection in E; this is a mapping or transformation S of the whole space on itself $p \rightarrow p'$ by which every point p is carried over into a new point p' according to the construction indicated by Figure 1: dropping the perpendicular from p on E and prolonging it by its

[1] The eighth Joseph Henry Lecture of the Philosophical Society of Washington, delivered on March 12, 1938. The illustrating material used in the lecture could not be reproduced here. Received March 16, 1938.

own length. E acts here as a mirror. A figure is symmetric with the symmetry plane E if it goes over into itself by this transformation S.

I find it convenient to explain right at the beginning some simple general notions about mappings. Let S be a mapping carrying the arbitrary point p into $p'=pS$ and T another mapping carrying p' into $p''=p'T$; then the mapping which changes p directly into p'',

$$p''=(pS)T=p(ST)$$

shall be denoted by ST (first S, then T). The mapping which carries every point p into itself is called the *identity* J. For our reflection S in the plane E we have $SS=J$, because application of the operation S on p' changes p' back into p. The only transformations with which we shall be concerned are those that change every figure into a congruent one and thus are the result of a motion or of a motion combined with a reflection; we call them *proper* and *improper motions* respectively. The combination or "*product*" ST of any two motions S, T is again a motion, and so is the *inverse* S^{-1} of a motion S:

$$p'=pS, \quad p=p'S^{-1}.$$

These general preliminaries will become clearer by the following applications.

You all know the eminent part which bilateral symmetry plays in organic nature, in particular in the higher branches of the animal kingdom and in the structure of the human body. As a reminder I show you two pictures: a bloodhound with deep and perfectly symmetric folds in his face, and this well-known Greek statue of a praying boy, from the 4th century B.C. The noble sculpture may at the same time bear witness to the artistic value of symmetry. It is a general experience that such formal geometric principles, like that of symmetry, hold sway most strictly in archaic periods, while they are apt to soften in more mature times. Here are a few pictures of Babylonian seal stones dating between 2900 and 2650 B.C., which I owe to the kindness of my Princeton colleague, Professor Herzfeld. Particularly impressive is the second, a god fighting a lion. The lower bull-shaped part of the god's body, rendered in profile, is doubled in order to secure the symmetry of the whole composition. Similar examples are the old imperial Russian and Austro-Hungarian double eagle.

For bilateral symmetry one needs neither the three-dimensional space nor even the two-dimensional plane: reflection is essentially a *one-dimensional* operation: a straight line can be reflected at any of its points O which serves as a symmetry center. The only other motions of the one-dimensional line are *translations*, parallel displacements by an arbitrary distance a. A figure which is invariant under a translation a shows an "*infinite rapport*," i.e., repetition in a regular spatial rhythm of length a. *Rhythm*, whether in space or in time, is another esthetic principle of universal significance. Musical rhythm is its temporal form. A pattern invariant under the translation T is also invariant under its iterations

$$TT = T^2,\ TTT = T^3, \text{ etc.}$$

and under the inverse T^{-1} and its iterations. They shift the line by $1a$ $2a$, $3a$, . . . and by $-a$, $-2a$, ... All translations carrying over a given pattern on a straight line into itself are in this sense multiples

$$na\ (n = 0,\ \pm 1,\ \pm 2,\ \ldots)$$

of one basic translation a. This rhythmic symmetry may be combined with reflective. The centers of the reflections then follow each other with half the distance $\frac{1}{2}a$. Only these two types of symmetry, as illustrated by Figure 2, are possible for a one-dimensional pattern or "ornament."

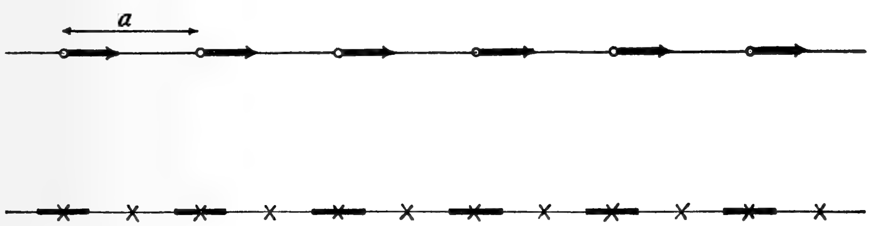

Fig. 2.—The two types of one-dimensional ornaments.

We pass from one to *two dimensions*. Here a new kind of symmetry crops up—symmetry with respect to *rotations* around a center O. The circle is in this regard the fully symmetric figure. A more limited rotary symmetry is represented by the regular polygons: All rotations around O carrying the figure into itself are the iterations of a certain aliquot part $360°/n$ of the full angle ($n = 1, 2, 3, \ldots$). We then call O an n-fold symmetry *pole*, or briefly an n-pole. The case where there is no rotary symmetry at all is included as $n = 1$. Flowers, nature's gentlest children, are charming examples of this kind of symmetry. Here is a picture of an iris with its triple pole, and here one of the quintuple flowers of hawthorn. The symmetry of 5 is most frequent among flowers. I emphasize this because, as we shall see later, it never occurs in inorganic nature, among the crystals. As a curiosity, look at this inflorescence of a composite: the arrangement emulates exactly the structure of a regular pentagon-dodecahedron, although the photograph shows it but incompletely. But I shouldn't anticipate here the study of spatial symmetry!

Very frequently rotational symmetry is combined with reflective symmetry. Reflection in a plane takes place at lines, so-called symmetry *axes*, or briefly axes. If O is an n-pole, then the axes through O form angles of $360°/2n$ with each other. For instance, a 3-pole is combined with three axes forming angles of 60° with each other. Perhaps the simplest figure with rotational symmetry is the *tripod* ($n=3$). When one wants to prevent the attending reflective symmetry one puts little flags onto the arms and obtains the *triquetrum*, an old magic symbol; the Greeks, for instance, used it, with the

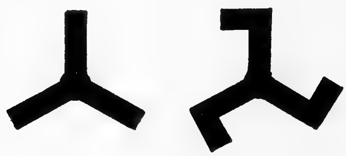

Fig. 3.—Tripod and triquetrum.

Medusa's head in the center, as a symbol for the three-cornered Sicily. The modification with four instead of three arms is the *swastika* of fylfot which I need not draw for you—one of the most primeval symbols of mankind, which we encounter in all civilizations; today it has become again for some people a symbol of magic power, for others a sign of terror like the snake-girdled Medusa's head. It seems that the origin of the magic power ascribed to these patterns lies in their startling incomplete symmetry—a center without axes. Here is the gracefully designed staircase of the pulpit of the Stephan's Dom in Vienna: a triquetrum alternates with a swastika-like wheel.

Magnificent examples of central symmetry are provided by the rose windows of the Gothic cathedrals. The richest I know is the rosette of St. Pierre in Troyes, France, which is based on the number 3 throughout. I show here one of the side portals of Notre Dame de Paris; and here a wonderful view of the Romanesque cathedral in Mainz, Germany, taken from the rear of the choir. Its severe and harmonious aspect is chiefly due to the wealth of simple symmetries: repetition in the round arcs of the friezes, octagonal central symmetry in the small rosette and the three towers, bilateral symmetry with vertical axes which rules the structure as a whole as well as almost every detail. In architecture, symmetry of 4 is prevalent. A particularly pure example is Bramante's second plan of St. Peter's in Rome. Here is a view up into the tower over the crossing of Canterbury Cathedral. The hexagon occurs occasionally; I can recall S. Ivo alla Sapienza in Rome, and the Mariahilfskirche in Innsbruck, Austria. If I am not mistaken, the Zwinger in Dresden, Germany, is a regular 12-side. A pentagon I have seen only once, in a quite inconspicuous passage in San Michele di Murano in Venice. Leonardo da Vinci engaged in systematically determining the possible symmetries of a central building and how to attach chapels or niches without destroying the symmetry of the nucleus. Let us repeat the first part of his investigation in modern terminology.

A figure invariant under the transformations S and T is also invariant under the transformation ST. A motion carrying a figure F as a whole into itself may be called an *automorphism* of the figure. The automorphisms form what the mathematicians call a *group*. A set of transformations S is a group f if any two elements S, S' of f give rise to a compound element SS' again contained in the group. Our considerations lead up to this statement: *Symmetry is described by the group of automorphisms*, and this is the only truly adequate way.

Here we study at first plane symmetries around a center O, i.e., we limit ourselves to motions leaving O fixed. We call them rotations; the proper rotations are rotations in the ordinary sense, the improper ones are reflections in axes going through O. The proper rotations D leaving a given figure invariant form a group. Let ϕ be the angles of these rotations, $D = D_\phi$. If not *all* rotations occur as in the case of a circle, we shall have a rotation of smallest positive angle $\phi = \alpha$. Every ϕ must be a multiple of α:

$$\phi = m\alpha;\ m = 0,\ \pm 1,\ \pm 2,\ \ldots .$$

Indeed, if there were a ϕ lying between two consecutive multiples, $m\alpha < \phi < (m+1)\alpha$, then $(m+1)\alpha - \phi$ would be a positive symmetry angle smaller than α, contrary to the determination of α. In particular, since the figure is left unchanged by making a full turn, 360° must be a multiple of α. Hence α is an aliquot part $360°/n$ of 360°, and the whole group of proper rotations, as we mentioned before, consists of iterations of one basic rotation of angle $360°/n$, or of the operations which a dial with n equidistant marks permits. The group is called the *cyclic group* C_n. Its order, i.e., the number of its elements, is n. n is capable of the values 1, 2, ...

In a second step we propose to include the *reflections*. Let us draw two axes 1 and 2 through O forming an angle $\alpha/2$, and let S_1, S_2 be the reflections in 1 and 2 respectively. The transformation $S_1S_2 = D_\phi$ is the proper rotation by the angle α, as shown by the simple construction in Figure 4. Hence S_2S_1 is the opposite rotation D^{-1} by $-\alpha$. In combining motions we must watch out for the order in which it is done; we see here that the result may depend on the order! From the equation $S_1S_2 = D_\alpha$ we obtain

$$S_1S_1S_2 = S_1D_\alpha \text{ or } S_2 = S_1D_\alpha.$$

Hence if the given figure F with the symmetry axis 1 permits the

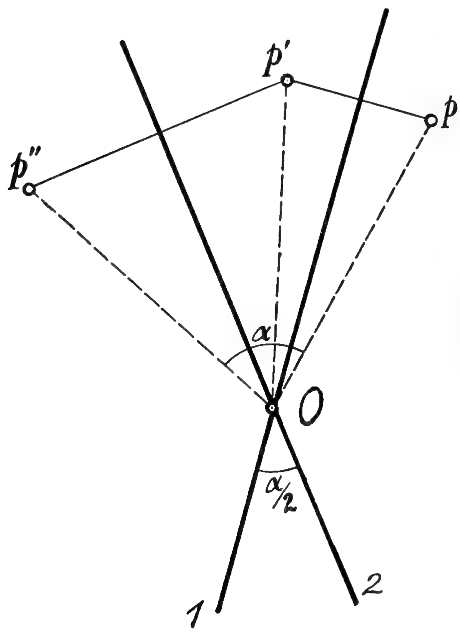

Fig. 4.—Rotation.

rotation D_α, then the line 2 forming the angle $\alpha/2$ with 1 will also be a symmetry axis. If the group C_n of proper rotations occurs together with reflections, we shall have exactly n different reflections whose consecutive axes form the angle $360°/2n$ with each other. The whole group consisting of these reflections and of the rotations by multiples of $360°/n$ is of order $2n$ and is called the *dihedral group* G_n. Thus, in agreement with Leonardo, these are the only possible central symmetries:

$$(*) \qquad \begin{array}{l} C_1, C_2, C_3, C_4, C_5, \ldots ; \\ G_1, G_2, G_3, G_4, G_5, \ldots . \end{array}$$

C_1 means no symmetry at all, G_1 means bilateral symmetry and nothing else.

When we now turn to the study of *ornaments* covering the whole plane, we have to take into account all motions, not only those leaving fixed a pre-assigned center O. A proper motion in a plane is either a translation (parallel displacement, shift, as indicated by a vector) or a rotation with a fixed point (pole) A. An improper motion is either a reflection in an axis l or such a reflection combined with a parallel displacement along l by a certain distance a; in the latter case l may be called a gliding axis. Composition of translations is commutative; it amounts to forming the resultant of two vectors according to the well-known law of the parallelogram. If the group of automorphisms of a given ornament contains translations at all there are only two possibilities:

(1) All translations or vectors are multiples of one basic vector: simple infinite rapport or band ornament.

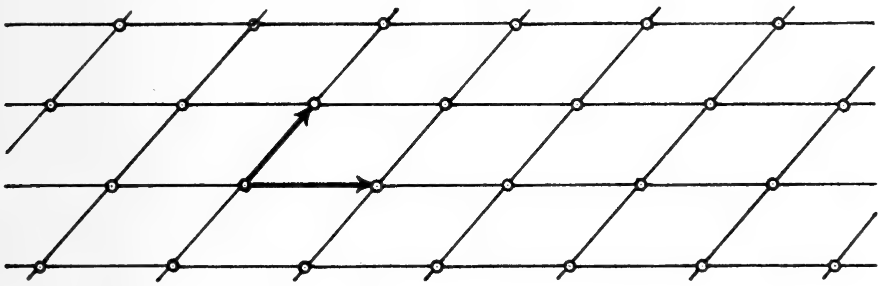

Fig. 5.—Parallelogrammatic lattice.

(2) They arise by composition from two basic vectors of different direction: double infinite rapport or surface ornament. We shall deal with this more interesting case only: Wallpapers, carpets, tiled floors and parquets, belong to this category. Once one's eyes are opened one will be surprised by the numerous symmetric patterns which surround us in our daily lives. The greatest masters of the geometric art of ornament were the Arabs, and I shall soon show you samples of their beautiful decorations. But first a little mathematics.

We choose an arbitrary point O in our plane and submit it to all the translations of our ornament. The result will be a parallelogrammatic lattice L (Fig. 5). Any motion S can be considered as a (proper or improper) rotation around O, followed by a translation. This decomposition is unique, and we call the first, the rotation part, the *reduced S*. After reduction, the motions S which the given ornament permits, form a finite group f_o of rotations; hence one of the groups in the table (*). *Its operations carry the lattice over into itself.* This relationship between the rotation group f_o and the lattice L imposes certain restrictions on both of them.

(1) As to f_o, the values $n=2$, 3, 4 and 6 only are possible because a lattice cannot have any other symmetry. Hence the rotary parts of our automorphisms must form one out of the following 10 groups:

$$C_1,\ C_2,\ C_3,\ C_4,\ C_6,$$
$$G_1,\ G_2,\ G_3,\ G_4,\ G_6.$$

In particular $n=5$ is excluded. Indeed, since the lattice permits the

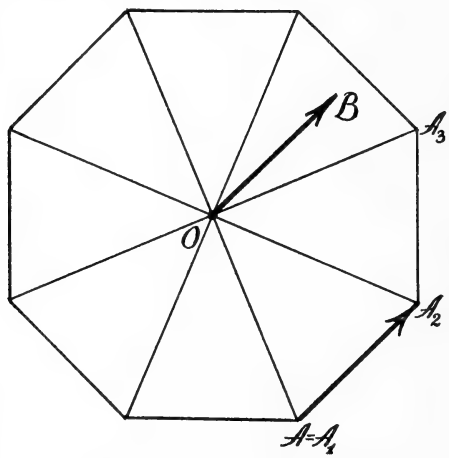

Fig. 6.—Octagon.

rotation by 180°, the smallest rotation leaving it invariant must be an aliquot part of 180°, or of the form

360° divided by 2 or 4 or 6 or 8 . . . .

We must show that the numbers from 8 on are impossible. Take the case $n=8$ and let A be one of the lattice points nearest to O. Then the whole octagon $A=A_1$, A_2, . . . consists of lattice points. The side A_1A_2 is smaller than OA just because $8>6$. Draw the vector $\overrightarrow{OB}=\overrightarrow{A_1A_2}$. O, A_1, A_2 being lattice points, B should be one too. However, this leads to a contradiction as B is nearer to O than $A=A_1$.

I beg your pardon. Did it hurt? The tooth is out now, and no such complicated geometric argument will come up again in this lecture. The rest shall be done more in the form of a narrative.

(2) How do lattices look which have one of our ten groups as their symmetry group? I enumerate the various cases.

C_1 and C_2: a perfectly arbitrary lattice L.

G_1 and G_2: either an arbitrary rectangular lattice R' or the diamond lattice R'' arising from R' by adding the centers of the rectangular meshes. R'' is the one most used for wallpapers.

C_4 and G_4: the square lattice Q.

C_3, C_6, G_3 and G_6: the hexagonal lattice H made up by equilateral triangles, which is in frequent use for tiled floors (bath rooms).

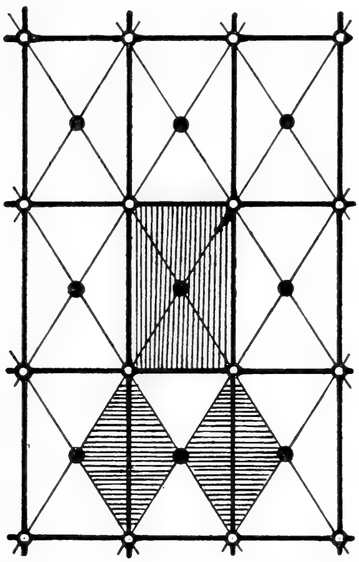

Fig. 7.—Rectangular and diamond lattice

Thus we encounter five types of lattices which differ by their symmetry. As an illustration I describe the full symmetry of the hexagonal lattice (upper half of Fig. 8). The points marked ● △ ⬡ are poles of multiplicity 2, 3, 6 respectively. The 6-poles form the lattice. All the lines are axes; the mid-lines between any two of these parallels are the gliding axes.

Finally we return from the reduced transformations, the rotary parts which form the group f_o, to the transformations proper. The translatory parts must dovetail with the lattice L of symmetry f_o. A closer investigation shows that the number 10 of possibilities is thereby increased to 17. *There are 17 essentially different kinds of symmetry possible for a two-dimensional ornament.* Examples for all 17 groups of symmetry are found among the decorative patterns of antiquity, in particular among the Egyptian ornaments. One can hardly over-estimate the depth of geometric imagination and invention reflected in these patterns; their construction is far from being mathematically trivial. The art of ornament contains in implicit form the oldest piece of higher mathematics known to us. To be sure,

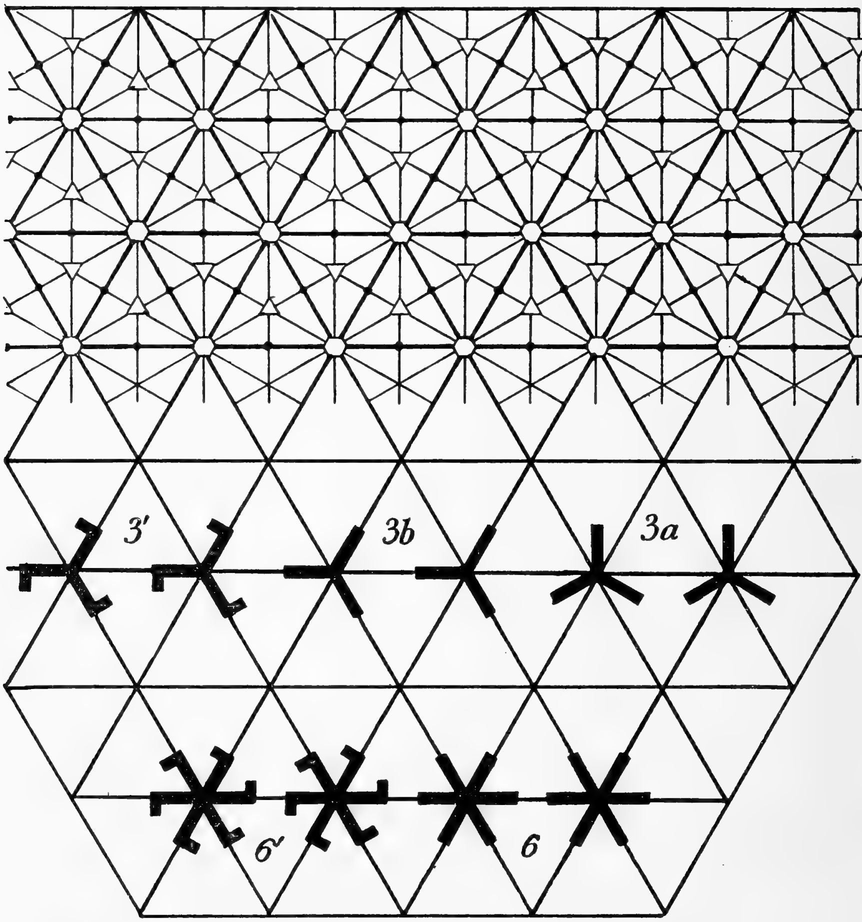

Fig. 8.—Hexagonal lattice and hexagonal symmetries.

the conceptional means for a complete abstract formulation of the underlying problem, namely the mathematical notion of a transformation group, was not provided before the 19th century; and only on this basis is one able to prove for good and all that the 17 symmetries already known to the Egyptian craftsmen more than 4000 years ago exhaust all possibilities. Strangely enough the proof was carried out only as lately as 1924 by Professor Pólya in Zürich. The Arabs fumbled around much with the number 5, but they were of course never able honestly to build in a central symmetry of 5 in their ornamental designs. They tried, however, all kinds of deceptive compromises. One might say that they proved experimentally the impossibility of the pentagon in an ornament.

I shall discuss briefly the five ornamental symmetries of the hexagonal type. I represent them by simple patterns which I obtain by fixing simple starlike figures in the lattice points, the same in the same orientation at each point (lower half of Fig. 8). Here they are: 6 has the complete symmetry of the lattice itself (reduced group or class C_6). 6′ removes the symmetry axes (class G_6). 3*a*, 3*b*, 3′ reduce the 6-poles to triple poles, 3′ without symmetry axes (class G_3) while the class C_3 now breaks up into two subcases: in 3*a* axes pass through every 3-pole, in 3*b* only through those (⅓ of the whole number) which had been sixfold before. A wonderful example of the full symmetry 6 is this window of a mosque in Cairo, of the 14th century. The elementary figure is a trefoil knot the various units of which are interlaced with superb artistry. The gliding axes are particularly conspicuous; they are the mid-lines of the tracks. Axes are absent in this azulejos ornament from the Sala de Camas of the Alhambra in Granada; the group is 3′ or 6′ according to whether or not one takes account of the colors. This is one of the finer tricks of the ornamental art, that the symmetry of the geometric pattern as expressed by a certain group *f* is reduced by the coloring to a lower symmetry expressed by a subgroup of *f*. The picture will give you at the same time some idea of the fascinating total effect of the Moorish ornamental architecture. An example of 3*b* is provided by this simple Chinese ornament. I give one case of the square class G_4, the one exhibited by the well-known design (Fig. 9) for pavements. The amusing thing about it is that no ordinary axes, only gliding axes, pass through the 4-poles (one of which is marked). Here are two more refined samples of the same symmetry from the Alhambra again. If your interest in ornaments is aroused I should recommend that you go to the library and look into the great folios edited by Owen Jones in London about the middle of the last century—his "Grammar of Ornament" and the "Plans, Elevations, Sections and Details of the Alhambra" in two volumes.

The two-dimensional case has detained us long enough; we must now pass to the *three-dimensional space*. First again, symmetry around a center. The situation here is radically different from the plane.

While in the plane we have a regular polygon for each number n of sides, there are only *five regular polyhedra* in space: tetrahedron, octahedron, cube, pentagon-dodecahedron, and icosahedron. The Greeks were familiar with the five regular bodies. They played an eminent rôle in Plato's philosophy of nature. The discovery of the icosahedron and of the dodecahedron is certainly one of the most beautiful and singular discoveries made in the whole history of mathematics. In Euclid's elements their construction is one of the chief goals of the

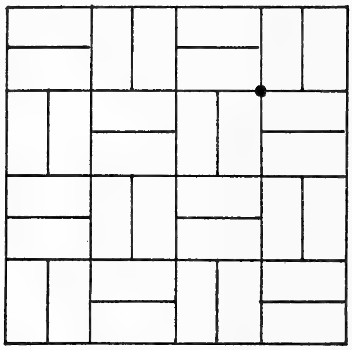

Fig. 9.—Pavement design.

whole development, perhaps *the* goal for the attainment of which all these efforts to erect a deductive system of geometry had been undertaken. It is the more surprising that the general notion of and a word for symmetry in our modern sense seems to be wanting in Greek. Euclid himself uses the word σύμμετρος in the sense of commensurable; side and diagonal of a square are ἀσύμμερτα μεγέθη. In the ancient non-mathematical literature σύμμετρος means as much as harmonious. Kepler in his Mysterium Cosmographicum, published in 1595, a long time before he discovered the three laws bearing his name today, made an attempt to reduce the distances in the planetary system to regular bodies which are alternately inscribed and circumscribed to spheres. Here is his construction by which he is convinced to have penetrated deeply into the secrets of the Creator. He proclaims his faith in prophetic words. We still hold to his belief in a mathematical harmony of the universe; it has stood ever wider and more surprising tests. But we no longer seek the harmony in static forms like the regular bodies, but in dynamical laws.

From our viewpoint the problem of the regular bodies is closely bound up with the construction of all finite groups of proper rotations around a center. First we have again C_n whose operations are now interpreted in space as rotations around an axis perpendicular to our original plane. Rotations in space have an axis, reflections have a symmetry plane. Another possibility is G_n, where the reflections in the axes l_1, l_2, . . . in the plane are now interpreted as rotations by 180° about the same axes in space. Except for these relatively trivial cases in infinite number ($n=1, 2, 3, \ldots$) already familiar to us from our study of the two-dimensional case, there are only three more quite singular possibilities:

The group T of the proper rotations carrying a tetrahedron into itself; the same group P for the octahedron or the cube (they are identical); the same group I for the icosahedron or the dodecahedron (they are again identical).

The orders of these groups are 12, 24, 60, respectively. It is not difficult to extend the table so as to include the presence of *improper* rotations. If no axes of rotation are admissible except of order 1, 2, 3, 4, and 6, we are left with 32 different groups.

They are the reduced groups or classes for a 3-dimensional ornament with a triple infinite rapport. Pasting the translatory onto the rotary parts, we obtain 230 *symmetry groups* which are divided into our 32 *classes*. The numbers we have found are collected in the following table for the dimensionalities 1, 2, 3:

Dim	No. of Classes	No. of Symmetry Groups
1	1	2
2	10	17
3	32	230

We decorate surfaces with flat ornaments; art has never gone in for *solid* ornaments. But they are found in nature. The arrangements of *atoms in a crystal* are such patterns. Unfortunately I have no models here, but I show you a photograph of two models (of calcite and rock-salt). The models consist of little balls representing the atoms and painted white, black, red, . . . according to the different sorts of atoms—hydrogen, carbon, oxygen, etc. The whole arrangement permits a group of motions with three independent translations spanning a lattice. The group describes the *microscopic symmetry of the crystal* ascertainable only by some device which allows discernment of distances of the order of the atomic distances, i.e., about 10^{-8} cm. How this has been accomplished I shall explain in a moment. The reduced group or *class*, however, describes the *macroscopic symmetry* of the crystal which rules over all its macroscopically discernible properties, and hence may be observed without penetrating into the atomic structure. Physical quantities like compressibility, index of refraction, etc., of a crystal medium, depend in general on *direction*. The variation of the optical properties with direction gives a diamond its scintillating brilliance. We represent such a quantity graphically by laying off on each ray from a center O the value of the quantity in this direction. This diagram must have the symmetry around O as described by the reduced group. Conversely, in studying the dependence of all physical properties of a crystal on direction, we find out its reduced group. Hence the division of all crystals into 32 classes. One of the properties, the speed of growth, determines under ideal conditions the outward shape of a crystal which will thus conform to its inner symmetry. All of you have probably at some time examined snowflakes closely, perhaps even under a magnifying glass, and have been thrilled by their beautiful tiny hexagonal stars. The crystallographers have carefully and thoroughly investigated the symmetry groups in space for more than a century. Nobody in science, however, had cared much about the simpler two-dimensional case so important in the art of ornament, the mathematical study of which had thus been neglected until quite recently. This two-fold application in art and physics, to ornaments and crystals, constitutes a peculiar charm of our subject.

The assumption of a lattice-like structure of the crystals had been inferred from the crystallographic laws for a long time before von Laue twenty-five years ago discovered the key that actually opens up to us the atomic pattern. We see by *light*, but light has a certain wave length, and an image traced by such light will be fairly faithful only with respect to details of considerably greater dimensions than the wave lengths, while details of much smaller dimensions will be completely leveled down. The wave length of ordinary light is about 1000 times as big as the atomic distances. However, X-rays are of the same physical nature as light, and their wave length is exactly of the desirable order 10^{-8} cm. Hence X-ray pictures of a crystalline substance betray their internal atomic structure. In this way von Laue killed two birds with one stone: he confirmed the lattice structure of crystals, and proved what had been but a tentative hypothesis at that time, that X-rays consist of short-wave light. I show you two *Laue diagrams:* one of zinc-blende from Laue's original paper, 1912;

the other of carborundum (SiC) from a paper by H. Ott, 1926. The directions in which the pictures are taken are such as to exhibit the fourfold and the threefold symmetry respectively around an axis. You must not take these portraits of the interior of a crystal too literally. By observing a slit whose width is only a few wave lengths, you obtain a somewhat contorted image of the slit made up by interference fringes. In the same sense these pictures are interference patterns of the atomic lattice. However, one is able to compute from such photographs the actual arrangement of the atoms, the scale being set by the wave length of the illuminating X-rays.

In spite of all contortion which mars our X-ray likenesses, the symmetry of the crystal is faithfully portrayed. This is a special case of the following general principle: *If conditions which uniquely determine their effect possess certain symmetries, then the effect will exhibit the same symmetries.* Thus Archimedes concluded *a priori* that equal weights balance in scales of equal arms. Indeed the whole configuration is symmetric with respect to the mid-plane of the scales, and therefore it is impossible that one scale mounts while the other sinks. For the same reason we may be sure that in casting dice, which are perfect cubes, each side has the same chance,—one-sixth. Sometimes we are thus enabled to make predictions *a priori* on account of symmetry for special cases, while the general case, as for instance the law of equilibrium for scales with arms of different lengths, can only be settled by experience or by physical principles ultimately based on experience. As far as I see, all *a priori* statements in physics have their origin in symmetry.

With this remark I shall conclude the somewhat detailed discussion of geometric symmetries dwelling in ornaments and crystals. I now take to the air and give a quick bird's eye view of other important applications of symmetry in physics and mathematics. First, *relativity theory.* Relativity is simply the most fundamental instance of symmetry. Before we studied geometric forms in space with regard to their symmetry, we should have examined *space itself*. Empty space possesses a very high grade of symmetry. On account of its homogeneity, all points are alike; there is no objective geometric property by which one may distinguish one point from any other. They can be distinguished only by a demonstrative act, by pointing with the finger and saying "*here.*" In the same sense all directions at a point are alike. The full homogeneity or symmetry of space must be described again by its group of automorphisms. A point transformation

$\left\{ \begin{matrix} p \rightarrow p' \\ p' \rightarrow p \end{matrix} \right\}$ in space is an automorphism if it leaves untouched every imaginable objective geometric relation between points. For instance, $R(p_1p_2p_3)$ being any such ternary relation like that expressed in the words: $p_1p_2p_3$ lie on a straight line, we require that any three points satisfying this relation R are turned by the automorphism into three points $p_1'p_2'p_3'$ fulfilling the same relation. Relativity is nothing else than the problem of *determining the group of automorphisms of space itself.* Two figures arising from each other by an automorphism are called "*similar*" in geometry; they are, as Leibnitz said, indiscernible when each is considered by itself and not in their mutual relation. The automorphisms of a given geometric pattern which we investigated before, may now be described in more basic terms as the *automorphisms of space carrying the given pattern into itself.* When we draw a regular hexagon around a point O in the plane, then no longer are all directions from O alike with respect to the hexagon, but merely any six directions forming a hexagonal star. The problem of relativity for the four-dimensional world including time besides the three dimensions of space, was solved in a final manner by Einstein. Felix Klein in his famous Erlanger Program, 1872, classified the various types of geometries, such as metric, affine, projective, conformal geometry, etc., by their groups of automorphisms which are either given by nature or agreed upon by convention. *Geometry*, as Klein declared, *is the study of an arbitrary set of elements called points under the viewpoint that only such relations are taken into account as are invariant under a given group of point transformations*, which then play the rôle of automorphisms.

By far the most fertile application of symmetry in the whole inorganic world has been made by *quantum physics* in studying the *atomic and molecular spectra.* An enormous amount of empiric material concerning the spectral lines, their wave lengths, and the regularities in their arrangement, had been collected before quantum physics was able to order the vast material and to show that most of the laws, whether of qualitative or quantitative nature, are independent of all dynamic peculiarities and assumptions, and a simple consequence of the inherent symmetry. Let us consider an atom consisting of a cloud of n electrons moving around a fixed nucleus at O. (By assuming the nucleus to be fixed we neglect the reaction of the electrons upon the much heavier nucleus.) The symmetry prevailing is twofold. First, rotational symmetry around O; two positions of the electrons which arise from each other by turning the whole constellation like a rigid body about O are indiscernible. This symmetry is expressed by the group of geometric *rotations* in space. Second, all electrons are alike; this symmetry is expressed by the $n!$ *permutations* among the n electrons: two constellations arising from each other by such a permutation are indiscernible. I cannot describe here in more detail how these two simple facts lead to the ordering of the atomic spectra; you must believe me on my word that nowhere else has symmetry proved the clue to a field of greater variety and importance.

Finally I turn to *mathematics*, which I must include all the more because the essential concepts, especially that of a group, were first developed from the applications in mathematics, more particularly in algebra and the theory of algebraic equations. An algebraist is a man who deals in numbers, but the only operations he is able to perform on them are the four species $+, -, \times, \div$. Hence the only relations he can grasp with his methods are the algebraic relations expressible in terms of these operations; as, for instance, the following one between two numbers α and β:

$$\{ \beta^2+\alpha(5\beta-2) \}^3-9\alpha+1+3\alpha\beta^4=0.$$

Let us consider any finite set of numbers $\alpha_1, \cdots, \alpha_n$, in particular the roots of an algebraic equation of degree n. Transformations are here permutations of the n numbers α_i; an automorphism is a permutation leaving untouched every imaginable *algebraic* relation among them. The automorphisms among the roots of an algebraic equation form the so-called *Galois group;* Galois's theory is nothing else than the relativity theory for this set which, by its discrete and finite character, is conceptually so much simpler than the infinite set of points in space dealt with by ordinary relativity theory. Galois's ideas, which for several decades remained a book with seven seals but afterwards exerted a more and more profound influence upon the whole development of mathematics, are contained in a farewell letter to a friend written on the eve of his death, which he met in a duel at the age of twenty-one. This letter is the most substantial piece of writing I know in the whole literature of mankind. I give two simple examples of Galois's theory.

The ratio $\sqrt{2}$ between diagonal and side of a square is determined by the quadratic equation

$$x^2-2=0.$$

Their incommensurability, that is, the fact that $\sqrt{2}$ is not a rational number, means that the two roots $\sqrt{2}$, $-\sqrt{2}$ are algebraically indistinguishable, or that their exchange is an automorphism. This is the instance by which the Greeks discovered the *irrational.* The deep impression which its discovery by the Pythagoreans made upon the thinkers of antiquity, is evidenced by a number of passages in Plato's Dialogues.

My other example is Gauss's construction of the regular 17-gon with ruler and compass, which he found as a young lad of nineteen. Up to then he had vacillated betweeen philology and mathematics; this success was instrumental in bringing about his final decision in favor of mathematics. When one fixes one vertex of an n-gon, all the other $n-1$ are the roots of an algebraic equation of degree $n-1$. They are algebraically indiscernible provided n is a prime number like 17, and the automorphisms then form a cyclic group of order $n-1$, i.e. a group that may be depicted by dialing a circular dial with $n-1$ equidistant marks. Since

$$17-1=16=2\times2\times2\times2$$

is a power of 2, one can cut down the cyclic group in passing from group to subgroup, by four consecutive steps, to the orders 8, 4, 2, 1. The solution of our equation of degree 16 is then obtained by means of four consecutive solutions of quadratic equations, or by four consecutive extractions of square roots. However, the four species and extraction of a square root are exactly those algebraic operations which may geometrically be carried out by *ruler and compass.* This is the reason why the regular triangle, pentagon and 17-gon,

$$3=2^1+1,\quad 5=2^2+1,\quad 17=2^4+1,$$

may be constructed by ruler and compass. ($2^3+1=9$ must be skipped because 9 is not a prime number.) During the last decades algebra has thriven more vigorously than most other branches of mathematics. For all the manifold structures it has to deal with, the quest for the group of automorphisms has always proved of cardinal importance and led straight to the core of things. One of the chief accomplishments of the late great algebraist Emmy Noether was her insistence upon this idea and the many applications she made of it in all branches of algebra.

I hope I have succeeded in giving you an impression of the deep significance of the principle of symmetry in art, nature and mathematics. Symmetry always stands for a peculiar kind of perfection. No wonder, therefore, that mystics and theologians have made use of this word and notion to describe by analogy even God's own perfection. I conclude with a short poem by Anna Wickham:

God, Thou great symmetry,
Who put a biting lust in me
From whence my sorrows spring,
For all the frittered days
That I have spent in shapeless ways
Give me one perfect thing.

PALEONTOLOGY.—*A Paleocene mammalian fauna from central Utah.*[1] C. Lewis Gazin, U. S. National Museum.

In 1935, while making geological investigations in the region of the Wasatch Plateau in central Utah, for the U. S. Geological Survey, Dr. E. M. Spieker and Dr. J. B. Reeside, Jr., discovered dinosaur and indeterminable mammalian remains in beds which had heretofore been considered as "Wasatch" in age. As a result of these discoveries a Smithsonian Institution party in 1937, under the direction of Mr. C. W. Gilmore, and with the aid of Dr. Spieker, made a more thorough investigation of the beds with highly profitable results. In addition to material representing a variety of reptilian forms the party was successful in securing a number of more or less fragmentary specimens of Paleocene mammals. The latter were discovered in beds immediately overlying the Cretaceous dinosaur levels but lithologically a part of the same sequence which Dr. Spieker has named the North Horn formation. The mammal bearing level is in variegated beds in the upper part of the formation just below the Flagstaff limestone, the localities investigated being in the vicinity of North Horn Mountain, southwest of Price, Utah.

A study of the mammalian material, which includes 16 specimens having one or more teeth, indicates that the fauna is more recent than Puerco, though apparently older than Torrejon, as the faunas of these formations are known from the San Juan Basin in New Mexico. In addition to a crocodile, six mammalian forms are distinguished in the collection. These are as follows:

Insectivora
- *Aphronorus simpsoni*, n. sp.
- Insectivore?, gen. & sp. undet.

Carnivora
- *Protogonodon*? *spiekeri*, n. sp.
- *Chriacus*? sp.

[1] Published by permission of the Secretary, Smithsonian Institution. Received March 23, 1938.

TALIGRADA
Periptychus gilmorei, n. sp.
CONDYLARTHRA
Hyopsodont, gen. & sp. undet.

The presence of *Aphronorus* and a hyopsodont, which is near *Litaletes*, in the fauna suggests a relationship with the Crazy Mountain Fort Union fauna but as these forms are known only from the Fort Union facies little can be said concerning their development or geologic range.

The principal evidence for the age of the fauna is found in the material of *Periptychus gilmorei* and *Protogonodon? spiekeri*. These forms represent better known groups whose geologic history is somewhat better understood. The periptychid is clearly intermediate in almost all characters between *Carsioptychus coarctatus* of the Puerco and *Periptychus carinidens* of the Torrejon. Similarly, the large creodont is intermediate between *Protogonodon pentacus* and *Claenodon corrugatus* (*C. ferox*) of the two San Juan horizons. This interpretation is not entirely conclusive as the relationship can be established only after a greater representation of the fauna is known, but from the material at hand an age intermediate between Puerco and Torrejon seems evident.

Inasmuch as it seems desirable to use a separate name to designate this fauna, for distinguishing it from the underlying Cretaceous dinosaurian fauna, and from other Paleocene faunas, the writer proposes the name Dragon (suggested by Dr. Spieker), from the canyon in which the fossils were found. The writer fully recognizes the difficulties which would be encountered in attempting to define on a lithologic basis the beds in which this Paleocene fauna occurs. Field work by Dr. Spieker has shown that the North Horn formation is a lithologic unit in which no disconformity or other structural evidence is apparent on which one can satisfactorily separate the two sets of beds. A marked interval of time between the two faunas is indicated, however, and similar situations are known to exist in the relations between other successive faunal zones, such as between the classic horizons, Puerco and Torrejon, in the San Juan Basin of New Mexico. Hence, it is not without precedent that a geographic name is used to designate a fauna, if only to serve as a handle for paleontological use.

The writer wishes to acknowledge the courtesy extended by Dr. G. G. Simpson in making helpful suggestions and in permitting comparisons with Paleocene materials in the American Museum.

SYSTEMATIC DESCRIPTION OF MATERIAL

INSECTIVORA

Aphronorus simpsoni, n. sp.

Holotype.—Left ramus of mandible, U.S.N.M., no. 15539, with P_4–M_3 (Fig. 1).

Locality.—N. W. ¼ sec. 8, T. 19 S., R. 6 E., Emery County, Utah.

Horizon.—Dragon, Paleocene.

Specific characters.—Ramus slightly deeper than in *Aphronorus fraudator.* Teeth relatively more slender in anterior portion. Posterior teeth relatively larger. Posterior wall of trigonid in molars directed slightly more forward externally.

Description.—*Aphronorus simpsoni* is close in size to *A. fraudator* Simpson from the Crazy Mountain Fort Union, but differs from this species in certain relative proportions which are outside the limits given by Simpson for the middle Paleocene form. The ramus is slightly deeper than in the several

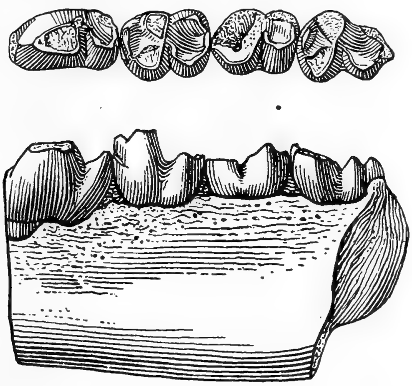

Fig. 1.—*Aphronorus simpsoni,* n. sp. Left ramus of mandible with P_4-M_3, type specimen, U.S.N.M. No. 15539. Lateral and occlusal views. ×4. Dragon Paleocene, Utah. Drawing by Sydney Prentice.

Fort Union specimens which the writer examined, a difference which is more noticeable in the posterior portion. Also, the posterior molars are relatively larger, particularly M_3, which is larger than in any of the Fort Union specimens examined. However, the teeth are relatively slender. This is most noticeable in P_4 which combines the greatest length with the least width given by Simpson for *A. fraudator.* Moreover, the posterior wall or shear of the trigonid in the molars is not so distinctly transverse, but directed slightly more forward externally. In P_4 the shear is more nearly transverse though somewhat irregular as a slight ridge extends down the posterior wall of the metaconid and unites with the hypoconid crest.

In addition to the holotype there are three isolated lower teeth, which are tentatively referred to this species.

Insectivore?, gen. & sp. undet.

A jaw fragment with only M_3 preserved may represent a second insectivore in the fauna. The tooth is about the size of that in *Aphronorus simpsoni*

TABLE 1.—MEASUREMENTS OF LOWER TEETH OF *Aphronorus simpsoni*

	P_4	M_1	M_2	M_3
Anteroposterior diameter	3.8 mm.	3.0	3.0	3.2
Transverse diameter	2.0	2.1	2.2?	2.2

but shows a somewhat different construction. The hypoconid and hypoconulid are more widely separated and a slight cingulum is present around the outer wall from about the parastylid to the hypoconulid. The tooth is not greatly different from that in the Puerco hyopsodont, *Oxyacodon priscilla,* but the paraconid is placed too far lingually and the hypoconulid is not so well developed.

CARNIVORA

Protogonodon? spiekeri, n. sp.

Holotype.—Right ramus of mandible, U.S.N.M. no. 15538, with M_1, M_2 and part of M_3 (Fig. 2).

Locality.—N. W. ¼ sec. 8, T. 19 S., R. 6 E., Emery County, Utah.

Horizon.—Dragon, Paleocene.

Specific characters.—Size about that of *Protògonodon pentacus.* Enamel on molars more rugose. Paraconid in M_1 and M_2 more lingual in position and slightly less distinct from metaconid. Entoconid apparently more distinct from hypoconulid in M_1 to M_3.

Description.—The lower molars of *Protogonodon*? *spiekeri* correspond closely in size to those of *P. pentacus* from the Puerco, but exhibit more rugose enamel. The paraconid, which is preserved in only the first two molars, is more lingual in position and not so distinct from the metaconid. However, the cusps around the talonid, though low, are somewhat more distinct from those adjacent than in *P. pentacus,* with less development of a crest and basin. The trigonid portions of the teeth are somewhat more elevated with respect to the talonids than is usual in *P. pentacus.*

In the reduction and position of the paraconid and in the rugosity of the enamel the Dragon form makes a definite approach toward the condition seen in the Torrejon specimens referred to *Claenodon corrugatus* (*C. ferox*). The paraconid in M_2, and perhaps M_1, of *Protogonodon*? *spiekeri* is better developed and more distinctly separated from the metaconid than in *C. corrugatus* although it is placed nearly as far lingually as in the Torrejon material. The union or ridge between the protoconid and metaconid is simple and not double as frequently seen in the more coarsely rugose teeth of *Claenodon corrugatus.* On the talonid the hypoconulid is more distinct from the entoconid, whereas in *Claenodon corrugatus* these two form a more conspicuous ridge which usually continues with the cingulum around the hypoconid. The cusps in general are lower and more distinct than in *Claenodon,* with a less distinctly basined talonid, with fewer accessory cuspules, and a finer quality of rugosity.

M_3, though incomplete, is much less elongate than in *C. corrugatus,* as indicated by the spacing of the metaconid, entoconid, and hypoconulid.

A maxillary fragment with part of M^3 and the root portion of M^2 shows no important characters other than a relatively great difference in size between these two teeth.

In most respects, especially in the character of the trigonid of the lower molars, *P.*? *spiekeri* stands in a relation nearly intermediate between *Protogonodon* and *Claenodon*, with perhaps a slightly greater resemblance to *Protogonodon*. It is distinct from the Fort Union *Deuterogonodon montanus*, as represented by the paratype, in the lowness of the cusps, the far less developed crest and basin of the talonid, and in the relatively greater importance of the entoconid as compared with the hypoconulid.

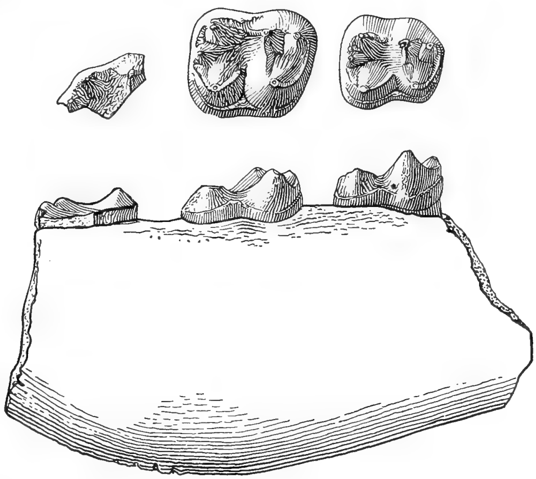

Fig. 2.—*Protogonodon*? *spiekeri*, n. sp. Right ramus of mandible with M_1, M_2, and part of M_3, type specimen, U.S.N.M. No. 15538. Lateral and occlusal views. $\times 1\frac{1}{2}$. Dragon Paleocene, Utah. Drawing by Sydney Prentice.

The anteroposterior diameters of the first and second lower molars are 10 and 11 mm respectively. The transverse diameters are 8 and 9.3 mm.

Chriacus? sp.

An isolated second upper molar and a maxillary fragment with a well worn first molar and part of the second represent an oxyclaenid carnivore, apparently near *Chriacus*. The teeth are about the size of those in *Chriacus baldwini*. The cusps are somewhat more conical than in *Chriacus* though not so rounded as in *Tricentes*. The inner portion of the isolated tooth shows a moderately developed hypocone, more lingual in position than in *Tricentes*, and a slight protostyle. The cingulum is interrupted for a very short distance between the hypocone and the protostyle. The protoconule and metaconule are less markedly joined to the paracone and metacone respectively than in *Chriacus* or *Metachriacus*. The Utah material is near that of *Metachriacus* but the cingulum is not so developed around the protocone as in the Fort Union form.

TALIGRADA

Periptychus gilmorei, n. sp.

Holotype.—Right and left maxillae, U.S.N.M. no. 15537, with cheek teeth P^2–M^3 (Fig. 3).

Locality.—N. W. $\frac{1}{4}$ sec. 8, T. 19 S., R. 6 E., Emery County, Utah.

Horizon.—Dragon, Paleocene.

Specific characters.—Size near that of *Periptychus carinidens.* Upper cheek teeth relatively wider. Lingual portion of upper premolars somewhat more constricted anteroposteriorly. Lingual wall of premolars and molars more gently sloping. External cingulum of molars better developed and cusps closer together. Inner crescent of upper premolars more fully developed than in *Carsioptychus coarctatus.* Apparently the talonids of the lower premolars (as indicated by a referred specimen) are better developed than in *C. coarctatus.*

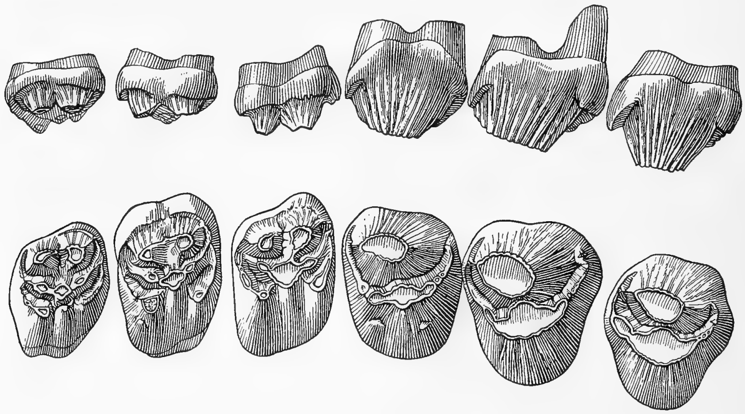

Fig. 3.—*Periptychus gilmorei,* n. sp. Right maxilla with P^2-M^3, type specimen, U.S.N.M. No. 15537. Lateral and occlusal views. ×1½. Dragon Paleocene, Utah. Drawing by Sydney Prentice.

Description.—*Periptychus gilmorei* is intermediate between *Carsioptychus coarctatus* from the Puerco and *Periptychus carinidens* from the Torrejon in almost all characters of the upper dentition. The teeth are relatively wide transversely as compared with their length and the premolars are only slightly larger than the molars. The premolars show the inner crescent developed almost as much as in *Periptychus carinidens* but the deuterocone portion is more constricted anteroposteriorly although not so much as in *Carsioptychus coarctatus.* Moreover, P^2 is much more like that in *Periptychus* than the simple condition observed in several specimens of *Carsioptychus.*

The molar teeth show a distinct resemblance to those in *Carsioptychus,* and in addition to their being relatively wide transversely, show a more distinct external cingulum than in *Periptychus.* The hypocone and protostyle have a somewhat more lingual position and the lingual walls of the molars (and premolars as well) appear to be more gently sloping than in *Periptychus.* The cusps and cuspules are somewhat less widely spaced than in *P. carinidens,* particularly the protoconule and metaconule which are located very close to the protocone.

An additional feature in *Periptychus gilmorei,* but probably of no importance is the very slight development of a "protostyle" and "hypocone" on P^4. This was not observed in any of the Puerco or Torrejon material. Also, the third molar, on the right side only, is peculiar in that the lingual wall exhibits a cuspule median to the protocone, between the protostyle and hypocone.

In an incomplete, isolated, lower premolar from the Utah locality, probably representing *Periptychus gilmorei*, the development of the cusps on the talonid is more suggestive of *Periptychus* than of *Carsioptychus.*

TABLE 2.—MEASUREMENTS OF UPPER DENTITION OF *Periptychus gilmorei*

	P^2	P^3	P^4	M^1	M^2	M^3
Anteroposterior diameter	11.6 mm.	11.7	10.5	9.2	9.5	8.8
Transverse diameter*	12.7	14.6	14.0	14.2	14.1	11.1

* The transverse diameter is taken from the external cingulum to the base of the enamel lingually and at right angles to the direction of the tooth row.

CONDYLARTHRA

Hyopsodont, gen. & sp. undet.

Four isolated lower jaw fragments with one tooth each and a fifth specimen including two upper teeth and some parts of associated (?) lower teeth represent a hyopsodont condylarth related to *Ellipsodon.* The form probably represents a new genus near *Litaletes,* but the material is too fragmentary to permit adequate description.

The two upper teeth, apparently M^1 and M^2, both exhibit a distinct hypocone, which in M^2 is markedly lingual in position. Also, in M^2 there is a slight protostyle and the cingulum is almost continuous around the inner wall of the tooth. M^1 is somewhat smaller and relatively narrower transversely, does not have a protostyle, and the cingulum does not extend around on the lingual surface. The two upper molars resemble those in *Litaletes disjunctus* but the protocone, paracone, and metacone are somewhat more widely separated. Moreover, the more lingual position of the hypocone, the extent of the cingulum, and the presence of the protostyle in M^2 distinguish it from *Litaletes.* The anteroexternal and posteroexternal angles of the two upper molars are developed more as in *Litaletes* than as in *Ellipsodon.*

In the lower molars the paraconid is lingual in position as in *Ellipsodon, Litaletes, Mioclaenus, Choeroclaenus,* and *Tiznatzinia;* not as in *Protoselene, Oxyacodon* and *others.* The lower molars are much as in *Ellipsodon lemuroides* in size and appearance but with the protoconid and metaconid farther apart and the talonid somewhat less deeply basined.

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PALEONTOLOGY.—*Descriptions of a new genus and a new species of Carboniferous brachiopods.*[1] GEORGE H. GIRTY, U. S. Geological Survey.

The contribution to paleontologic literature which follows is so insignificant that I venture a few words of explanation or perhaps of apology.

The privilege was recently given to me of sharing in the re-description and re-illustration of the Paleozoic species treated by Roemer in his *Kreidebildung von Texas.* One of these (*Productus flemingi* Roemer von Sowerby) proved to be an undescribed species of *Marginifera* to which I gave the name *Marginifera roemeri.*[2] Now it was clearly in the interest of American Paleontology to base the species not upon Roemer's specimens, but upon specimens in my own collections which could be consulted by other paleontologists of this country. At the same time it was not consonant with the project in hand to describe or figure any specimens other than Roemer's own. Consequently, *Marginifera roemeri* has remained up to now a *nomen nudum* and it seemed desirable to remove it from that status as soon as possible.

Regarding the genus *Anopliopsis* little need be said. The description might well have awaited publication in a proper setting except that I wished to refer to the genus soon in a different connection. The genus is based upon a species which has been in the literature for several years as *Chonetina subcarinata* Girty.[3] The type specimens came from the Ridgetop shale and Fort Payne formation of western Tennessee and it may be of interest to recall that *A. subcarinata* has several times been identified as a species of *Ambocoelia,* a not unpardonable error inasmuch as ventral valves with their small size, high convexity and smooth surface strongly suggest the ventral valve of that genus.

Marginifera roemeri, n. sp. Figs. 1–5

Productus flemingii. Roemer von Sowerby, Kreidebildung von Texas, p. 89, pl. 11, figs. 8a, b, 1852. Carboniferous: San Saba Valley, Texas.

Ventral valve small, strongly transverse, widest at the hinge, hemispherical. The curvature is irregular longitudinally; the highest part of the valve is posterior to the middle and the curvature is somewhat stronger at that point than it is before or behind it. Umbonal region rather inflated. Auricles large and somewhat abruptly extended. Anterior slope with a sinus, which may be rather strong, extending backward to or onto the visceral disc.

Surface marked by radial costae which are fairly high and separated by rounded striae. The costae are rather coarse for the size of the shell. The

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received February 15, 1938.
[2] GIRTY, GEORGE H. U. S. Geol. Survey Prof. Paper **186-M**: 264. 1937.
[3] GIRTY, GEORGE H. U. S. Geol. Survey Prof. Paper **146**: 27. 1926.

distance from crest to crest is commonly 1 mm and about 6 costae, also from crest to crest, come within a space of 5 millimeters. This number may be increased by 2 or 3 if the measurement is taken where some of the full-sized costae have divided to form smaller ones. The visceral disc is marked by concentric corrugations which vary in character in different specimens. They may be rather numerous, strong and regular, or on the other hand rather weak and unequal. The entire surface is crossed also by strong, fine, incremental lines. Spines are fairly large but not numerous and they are without any noticeable differential arrangement. They form neither a distinct row along the hinge-line, as in many species, nor a distinct tuft on the auricles as in others.

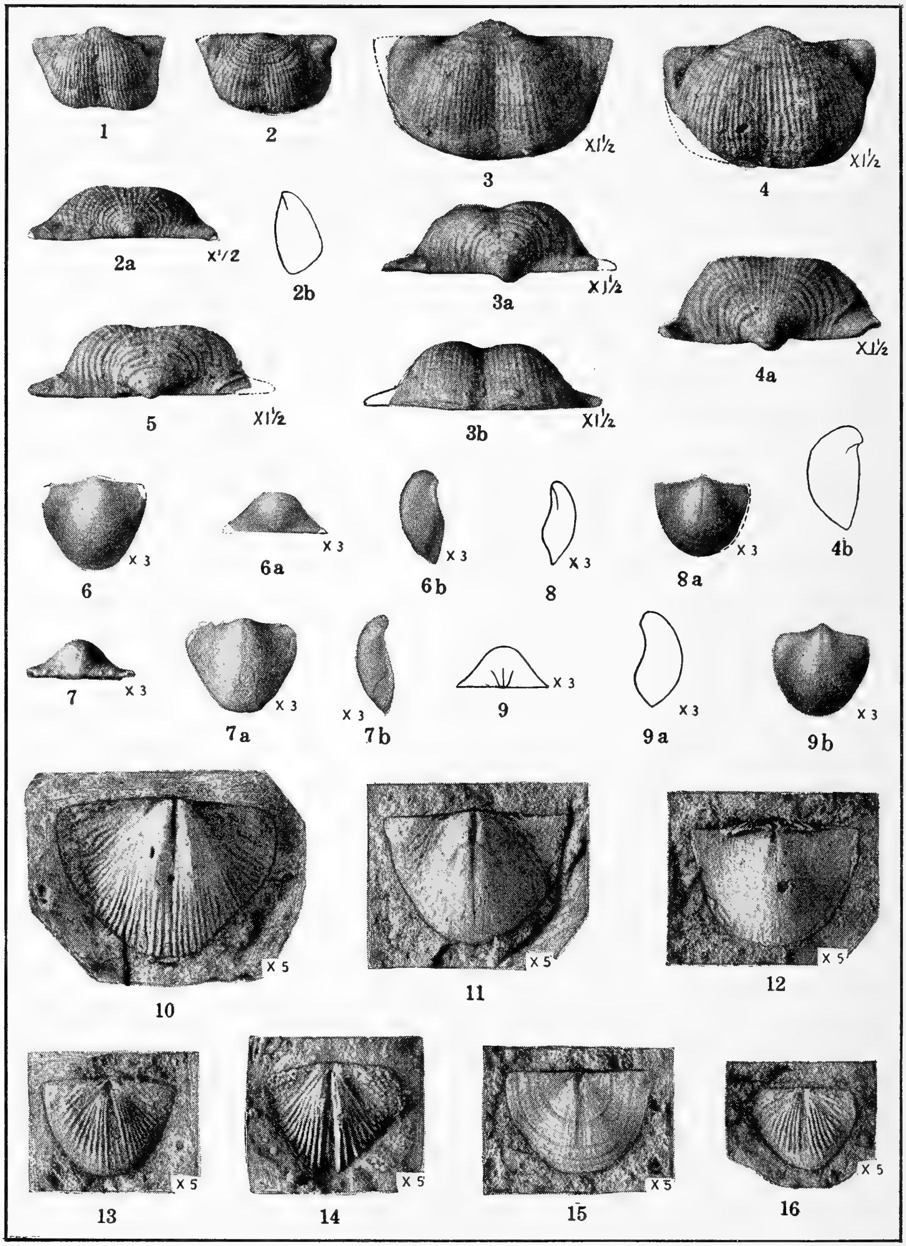
The dorsal valve, viewed as a convex object, is much less curved than the ventral valve. It consists of an extensive visceral disc and a short tail, which are in effect almost perpendicular to each other. They are gently convex and are connected by a much stronger curve. The other characters of this valve correspond to those of the ventral valve except that the surface appears to be without spines.

"*Marginifera*" structures are present, but in a rather feeble stage of development.

At first glance this species might be mistaken for *Marginifera muricatina*, somewhat more finely striated perhaps, but not materially different. If compared with characteristic specimens of that species, however, the difference in striation is conspicuous and other differences almost equally marked appear. The spines on the ventral valve of *M. roemeri* are larger and much less numerous. The dorsal valve is quasi-geniculate instead of being rather regularly concave and it is apparently devoid of spines, whereas small spines are fairly well sprinkled over the dorsal valve of *M. muricatina*. *M. roemeri* is really more closely comparable to *M. wabashensis*. Now in order to avoid creating numerous and impracticable species, *M. wabashensis* has been made to comprise a rather wide range of forms and it is difficult to select one of these as more typical than another or to name differences that will hold for all. Generally, however, it may be said that *M. roemeri* is a relatively broader species with a less convex ventral valve. The sinus is apt to be deeper than that of *M. wabashensis*, and the corrugations of the visceral disc stronger. The radial costae are also, as a rule, stronger, rising higher from wider striae. The differences last mentioned may not be so very constant, but the characters involved are found more strongly expressed in *M. roemeri* and in numerous specimens. There is one other detail which seems to be both fairly constant and not unimportant. In *M. wabashensis* there is commonly to be seen a row of spine bases passing obliquely from the beak to the lateral margins low down on each side of the vault. The spines are graduated in size, the final ones being very large. No feature really comparable to this has been observed in *M. roemeri*, though something of the sort appears sporadically.

This is the species which Roemer discussed and figured as *Productus flemingii*[4] Sowerby. There can be no doubt on this head, as I have compared my specimens with Roemer's, and as they come from the same general locality, and occur in the same faunal association. Bibliographers have commonly classed Roemer's form in the *Marginifera splendens-Wabashensis* series. Schuchert, for instance, places it under *Productus longispina* along with *M. splendens* and *M. wabashensis*. Weller also places it under *P. longispina* along with *M. splendens* but gives *M. wabashensis* separate recognition.

[4] Roemer, Ferdinand. *Kreidebildung von Texas*, p. 89, pl. 11, figs. 8a, 8b. 1852. See also, Girty, George H. Geol. Survey Prof. Paper **186-M**: 264. 1937.



Figs. 1–5.—*Marginifera roemeri*, n. sp. Fig. 1. A ventral valve with unbroken auriculations. Figs. 2, 2a, 2b. Three views of a dorsal valve preserved as an external mold partly covered by shell. Fig. 2a is enlarged $\times 1\frac{1}{2}$. Figs. 3, 3a, 3b. Three views of a large ventral valve, all $\times 1\frac{1}{2}$. Figs. 4, 4a, 4b. Three views of another ventral valve, all $\times 1\frac{1}{2}$ except fig. 4b. Fig. 5. Posterior view of a ventral valve, $\times 1\frac{1}{2}$. All the figured specimens of *Marginifera roemeri* came from the Smithwick shale (?), 11 miles west of San Saba, Texas (station 2602). (Legend continued on opposite page.)

As just stated, *M. roemeri* appears to find its nearest relative in *M. wabashensis;* it is widely unlike *M. splendens.*

Horizon and locality.—Smithwick shale (?), San Saba quadrangle, just south of highway eleven miles west of San Saba Courthouse, Texas (station 2602).

Anopliopsis, n. gen. Figs. 6–16

This genus may be summarily described as a small chonetid which has a highly arched ventral valve without a sinus and is superficially marked only by incremental lines without radial striation. Internally the ventral valve has a long and fairly strong septum; the brachial valve is covered as to the median part by a number of relatively high, thin radiating plates and as to the lateral parts by spinules.

The internal structure of the brachial valve is thought to be the main distinguishing feature of the genus. The configuration and surface characters may also prove to be diagnostic but to what extent will rest largely upon congeneric species when any are discovered. As a brief statement of its relations, *Anopliopsis* is distinguished from *Anoplia* by the presence of cardinal spines wherein it is exactly like *Chonetes.* It is distinguished from *Chonetes* by having the spinules on the interior of the brachial valve replaced over the median region by vertical plates, much as in *Chonetina.* It is distinguished from *Chonetina* by being smooth instead of striated and by having the pedicle valve strongly convex on the median line instead of deflected inward to form a deep sinus.

Genotype.—Anopliopsis subcarinata Girty.

The species which is here made the basis of a new genus was originally described under *Chonetina* Krotow.[5] The departure from that assignment does not mark so complete a reversal of opinion as it might appear to do for the reference to *Chonetina* was more or less qualified and the new genus is not proposed without some reservations.

Chonetina subcarinata was described in connection with a small fauna of Boone age from San Saba County, Texas, but the description was based upon specimens from the Ridgetop shale and the Fort Payne formation, in

[5] GIRTY, GEORGE H. U. S. Geol. Survey Prof. Paper **146**: 27, pl. 5, figs. 10a–16. 1926. By oversight the generic heading is *Chonetes* but the species is described as *Chonetina subcarinata.*

Figs. 6–16.—*Anopliopsis subcarinata* Girty. Figs. 6, 6a, 6b. Three views of a ventral valve, ×3. Figs. 7, 7a, 7b. Three views of another ventral valve, ×3. Figs. 8, 8a. Two views of another ventral valve, ×3. Figs. 9, 9a, 9b. Three views of a characteristic ventral valve, ×3. Fig. 10. Internal mold of a ventral valve in which the lamellose character is strongly developed, ×5. Fig. 11. Internal mold of a ventral valve in which the same character is faintly developed or poorly preserved, ×5. Fig. 12. External mold of a dorsal valve. The silicified fillings of the cardinal spines of the ventral valve can be seen above, ×5. Figs. 13 and 14. Squeezes made from the internal molds of two dorsal valves, ×5. Fig. 15. External mold of a dorsal valve, ×5. Fig. 16. Like figures 13 and 14, a squeeze made from an internal mold of a dorsal valve, ×5. All the specimens figured came from localities in the Waynesboro quadrangle, Tennessee, and all but the original of fig. 7 (which was collected in the Ridgetop shale) came from the basal part of the Ft. Payne chert. The specimens shown by figs. 6 and 8 came from station 1822; that shown by fig. 7 came from station 1853; those shown by figs. 9 and 14 came from station 1821; that shown by fig. 10 came from station 1830; that shown by fig. 11 came from station 1826; those shown by figs. 12, 13, 15, 16, came from station 1841. Figures 6, 6a, 6b, 8, 8a, 9, 9a, 9b, are the original figures used when the species was published as *Chonetina subcarinata.* In addition to these specimens from Tennessee on which the species was founded there were also figured at that time a specimen from the Moorefield shale of Oklahoma and 3 specimens from rocks of Boone age in Texas.

the Waynesboro quadrangle in western Tennessee; the same species occurs in the Moorefield fauna of northeastern Oklahoma. All three of the figured specimens (figs. 10–12) were ventral valves. As the internal characters of the dorsal valve are so important from a generic standpoint, I propose to figure specimens of that valve, some showing the inner, others the outer surface, and for the convenience of the reader I propose to give a resume of the characters of both valves, so far as known.

Externally the shell in certain respects agrees with *Chonetes* for it is concavo-convex, it has a cardinal area in both valves, and it has cardinal spines issuing from the ventral valve. Internally also it has certain characters in common with *Chonetes.* It is provided with dental plates and sockets and the dorsal valve has a small cardinal process, its outer surface divided by two (?) incisions. The details of this very small structure cannot be given nor has it been ascertained whether it is partly covered by a "cheilidium."

The ventral valve has a fairly long, stout, median septum in the form of a ridge more or less sharp on top but spreading downward to merge by degrees with the contour of the interior. Whether this structure should be called a septum is open to question, for it is rather an angular ridge than a thin plate such as is often designated by that term. The answer to this question would depend upon how a "septum" was defined and whether the wedge-shaped ridge was originally a thin plate which had reached its present shape through depositions of callus along its sides. The septum of *Anopliopsis* does seem to be thin and high at the tip of the beak and is probably something more than a mere accumulation of callus. It differs from the septum of *Chonetes* in length as well as in its shape, the septum in *Chonetes* being a thin plate and present, in this character, only in the umbonal region.

There is, however, a certain lack of agreement among authors regarding the presence of a septum in the valves of *Chonetes.* Hall and Clarke, for instance, credit *Chonetes* with a septum in both valves. Weller does not mention a septum as present in either valve (I mean of course in his generic diagnosis); and the same may be said of Dunbar and Condra, though they, to be sure, were writing of *Chonetes* in a restricted sense. According to my hasty observations, a septum is commonly present in the ventral valve though it is short and perhaps not very high. In the dorsal valve a septum is well developed in some species, especially in those of Pennsylvanian age; in some Mississippian species, on the other hand, I have been unable to recognize such a structure at all. In the dorsal valve of *Anopliopsis* there are several low ridges or lamellae in the median part but no real median septum.

Like *Chonetes,* again, the inner surface of the ventral valve is covered by numerous spinules arranged in radiating rows. In appearance, at least, specimens differ considerably in this regard. The internal mold (fig. 10) is partly covered by radial ridges (too completely covered in the figure) but the ridges themselves are spinose on top and are replaced by rows of spines laterally. The internal mold (fig. 11) is almost smooth, with distinct spinules only at the sides.

The ventral valve has also cardinal spines which, as in *Chonetes,* project from the angle at the upper margin of the cardinal area. The spines are of course very small and it has not been practicable to show them adequately in the illustrations. They are, in fact, broken off in most specimens though their presence is amply established. They are mostly recognized by the scars or minute perforations which they make along the upper margin of the cardinal area. This evidence, even if there was nothing more tangible would demonstrate a difference from *Anoplia* in which the homologous structures are few and do not pass completely through the shell substance.

The interior of the dorsal valve is covered as to the lateral parts with spinules, but over the median part these are replaced by continuous lamellae that have a definite and constant arrangement. The lamellae (which theoretically may be regarded as consolidated spines though actually they are thin plates and are not serrated on top) are confined to the median half of the valve, or to the more strongly arched portion, and they are divided into two groups by a relatively wide space down the middle with 6 or 7 lamellae in each group. The median space is unoccupied except as it may contain in the anterior half several lamellae which are short and conspicuously lower than the lamellae on either side. The spinules that replace the lamellae farther out on the auricles are rather large and are radially arranged. The longest and highest lamellae are those adjacent to the median area and the more lateral ones are partly replaced by spinules.

A discussion of the relationship of *Anopliopsis* to *Chonetes* and *Chonetina* is attended by some complexity because the old genus *Chonetes* has been broken up and the new genera created from the fragments have not all been distinguished on the same set of characters and have not been interpreted in the same way or given the same values by all authors.

From *Chonetes* in the broad sense *Anopliopsis* is distinguished by its internal characters especially by the thin high plates developed on the surface of the dorsal valve. In addition to this general difference, it differs from some of the chonetid "genera" in being smooth instead of striated or in being regularly arched without a fold or sinus, or in both ways, characters which have been employed for the disintegration of *Chonetes.*

Anopliopsis shows a striking resemblance to *Chonetina* in the internal characters of the dorsal valve, the characters on which Krotow relied to distinguish *Chonetina* from *Chonetes,* but it shows striking differences in every other character for it is smooth instead of striated, it is regularly arched instead of deflected into a strong fold and sinus, it was developed at the beginning of the Carboniferous period instead of toward its end, and its habitat was in the opposite hemisphere. It is true, of course, that Dunbar and Condra have referred several American species to *Chonetina* but I can see no substantial reason either why those species were distinguished from *Chonetes* s. s. or why they were included under *Chonetina.*

A consideration of *Anopliopsis* in its relation to *Anoplia* was suggested to me by G. A. Cooper, for I had overlooked that genus in canvassing the generic affinities of *A. subcarinata.* In external appearance *Anopliopsis* and *Anoplia* are much alike and each is a monotypic genus. *Anopliopsis* is a true chonetid with cardinal spines like all the rest of the tribe. *Anoplia* as described by Hall and Clarke, on the other hand, has a peculiar structure which may be compared to a single cardinal spine on each side which penetrated the cardinal area but did not reach the surface and of whose presence there is no external evidence. The absence of true cardinal spines in *Anoplia* is confirmed by Dr. Cooper from numerous excellent specimens in the National Museum. He notes points of resemblance between *Anoplia* and *Anopliopsis* in the internal structure (*Anoplia* seems to have similar but less numerous ridges in the brachial valve). He remarks also that the time relations of *Anopliopsis* would suggest a genetic affinity to the Devonian genus *Anoplia* rather than to the Permian *Chonetina,* an opinion in which all must agree (fide his letter of April 10, 1935).

As stated in the beginning, *Anopliopsis* is not proposed as a new genus without some reservations. It is possible that with increased knowledge the internal differences upon which *Anopliopsis* mainly rests will be bridged so that no satisfactory line of demarcation will be found between *Anopliopsis* and *Chonetes*. This possibility is suggested by a little known species described by Stevens as *Chonetes Michiganensis*. In its external appearance *C. Michiganensis* could be called a normal species of *Chonetes* s. s. It is a large shell, it is not highly arched, and it is marked by irregular, feeble, but quite distinguishable costae. Its internal characters, however, are analogous to those of *A. subcarinata* except that the radial plates are not so high and are obviously compacted of spinules possibly through deposits of callus. Although *Anopliopsis* is endowed with strong individuality by reason of its combination of size, configuration, and sculpture, aside from its internal characters, the fact just mentioned suggests that in its internal characters it may grade into *Chonetes*.

On the other hand, the distinction between *Anopliopsis* and *Chonetina* so far as can be determined, rests mainly upon differences in configuration and sculpture emphasized by differences in time and place of occurrence. Future discoveries may bring to light species constructed like *Anopliopsis* and *Chonetina* which are intermediate in geologic time and are gradational in shape and ornamentation.

ZOOLOGY.—*A new copepod from Japanese oysters transplanted to the Pacific coast of the United States.*[1]

CHARLES BRANCH WILSON, State Teachers College, Westfield, Massachusetts. (Communicated by WALDO L. SCHMITT.)

A few years ago some of the large Japanese oysters were transplanted to the Pacific coast of the United States and have thriven well in their new environment. During the past year some of them have been found to be infested with a copepod and specimens have been sent to the present author for identification. These specimens included both sexes and have proved to be a new species, a description and figures of which are here presented.

Mytilicola ostreae, n. sp.

Occurrence.—The copepods are found attached to the inner wall of the stomach of the oyster. There are usually but two or three specimens on one host but as many as twenty have been taken from a single oyster, in which case a considerable portion of the stomach cavity was occupied by them.

Female.—Body elongate, narrow and tapered posteriorly; head separated from the thorax, wider than long, with a small dorsal carapace which is divided longitudinally through its center. The five thoracic segments and the genital segment completely fused, with no indication of separation except the paired dorsal processes. Each thoracic segment bears a pair of these processes near its posterior corners. Each process is triangular in shape and extends diagonally outward and backward, with an acute tip which sometimes curves slightly forward. The first four pairs of processes increase in size posteriorly, the fifth pair are smaller than the fourth. The genital seg-

[1] Received March 2, 1938.

ment is enlarged at its posterior corners, but has no processes. The abdomen is considerably narrower and thinner than the genital segment and tapers a little posteriorly. It is as long as the genital segment and is apparently undivided with smooth lateral margins. The caudal rami are cylindrical, longer than wide and slightly divergent, and show no setae in any of the specimens examined.

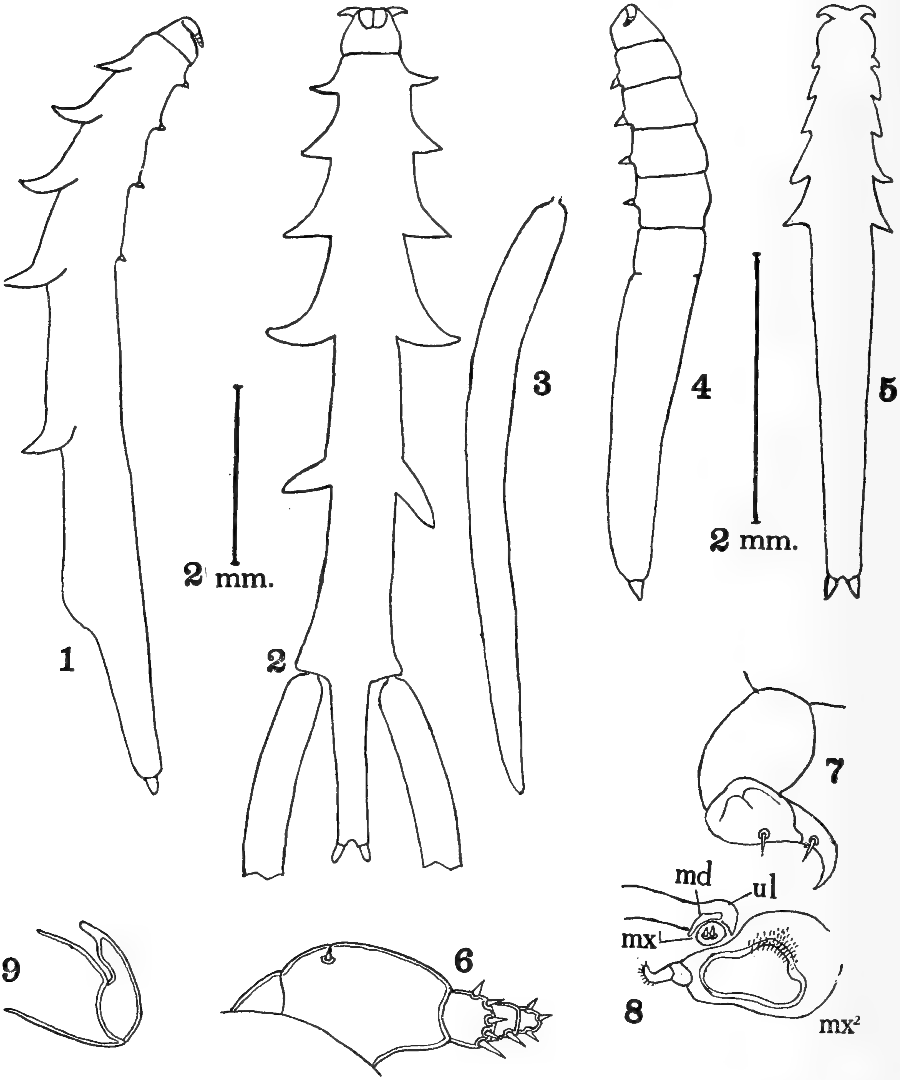
The first antennae are 4-segmented, the basal segment large and swollen, the other three segments much smaller, and all four sparsely armed with small spines. The second antennae are 2-segmented, the distal segment in the form of a stout curved claw, divided at its center and each half armed with a spine-like seta. These are the organs which attach the copepod to the stomach wall of its host and keep it from being swept out by the food current of the oyster. The mandible is attached beneath the posterior corner of the upper lip and extends inward and backward. It is cylindrical, unsegmented and so minute that it does not reach inside of the first maxilla, and so can scarcely function at all. The first maxilla is an elliptical mamma, slightly raised above the surface of the head and armed with two short spine-like setae. It is situated behind the corner of the upper lip and fits into a semicircular invagination of the latter. The second maxilla is made up of a stout basal portion attached to the surface of the head and a 2-segmented portion; the end segment is curved and fringed with fine hairs. The maxilliped is lacking in the female. There are four pairs of swimming legs, each leg uniramose and reduced to a simple pointed knob visible only in profile. The ovisacs are elongate conical, tapered to a point distally and three quarters as long as the entire body. The eggs are minute, very irregularly arranged and quite numerous, about 200 in each ovisac. Total length 10 to 12 mm. Greatest width (4th segt.) 1.33 mm. Length of ovisacs 7 mm.

Male.—Considerably smaller than the female, with the thoracic segments more or less separated by grooves. The dorsal processes are considerably reduced in size, the anterior ones almost disappearing, but the legs are relatively larger although they still remain uniramose pointed knobs. The abdomen shows no trace of segmentation; the caudal rami are enlarged and nearly parallel. The mouth parts are similar to those of the female, but there is added to them behind the second maxillae a pair of stout maxillipeds. Total length 4 mm. Greatest width 0.55 mm.

Type.—♂ & ♀, No. 69915 U.S.N.M., from *Ostrea gigas* Thunberg, from Puget Sound.

Remarks.—A new genus and species, *Mytilicola intestinalis*, was established by Steuer in 1903 upon copepods obtained from the edible mussel in the Mediterranean. The same species was reported from the same host by Dollfus in 1914 and 1927 and by Monod & Dollfus in 1932, but no other species of the genus has been proposed up to the present time. That these oyster specimens constitute such a new species can be seen by comparing the swimming legs. In *intestinalis* each leg is biramose and each ramus 2-segmented; in *ostreae* each leg is uniramose and made up of a single segment.

In 1885 Dr. Ramsay Wright described a new genus and species of copepods, *Myicola metisiensis*, found in the common long clam, *Mya arenaria*. In 1914 Dollfus added another new genus and species, *Trochicola enterica*, from certain gastropod mollusks. In 1936 Yamaguti proposed a third new genus and species, *Pseudomyicola ostreae*, from a Japanese oyster, *Ostrea* *denselamellosa.* These three are valid genera and with the present genus making a fourth they all agree in having their mouth parts arranged on the general plan found in the Ergasilidae and Bomolochidae. There is an upper



Figs. 1–9.—*Mytilicola ostreae*, n. sp. Fig. 1.—Side view of female. Fig. 2.—Dorsal view of same. Fig. 3.—Ovisac, same magnification as fig. 2. Fig. 4.—Side view of male. Fig. 5.—Dorsal view of same. Fig. 6.—First antenna. Fig. 7.—Second antenna. Fig. 8.—Mouth parts; md, mandible; mx^1, first maxilla; mx^2, second maxilla; ul, upper lip. Fig. 9.—Maxilliped of male.

lip of varying form, beneath whose posterior corners lie a pair of mandibles; behind these are the first maxillae, each consisting of a mamma armed with two or three setae. Then come the second maxillae and in the male the maxillipeds which are lacking in the female. So complete is this correspondence in all the genera that each mouth part must bear the same name in them all. And when a mouth part is missing those that are present must be named from their position in the general plan and not from their sequence to one another. For example if the mandible is lacking the mamma behind the posterior corners of the upper lip can not be called the mandible although it is the first visible mouth part. Its position tells that it is still the first maxilla.

Since the mandible was lacking in the type species of both *Mytilicola* and *Trochicola* this mamma with its setae was designated as the mandible. This name was changed by Dollfus in later publications for the genus *Trochicola,* and by Monod & Dollfus in 1932 for the genus *Mytilicola,* and this mouth part was correctly named the first maxilla.

It is misleading to designate these copepods as parasites without qualification since that word implies that they feed upon the fluids or the tissues of their host. They should be designated as commensals or at the worst as semiparasites. As can be readily seen from the preceding description the mouth parts are not suited for sucking blood or biting the body tissues of the host. In all probability these copepods subsist by appropriating a portion of the food that would otherwise serve to nourish the oyster. They are not, therefore, definitely harmful, yet their mere presence may not be considered altogether desirable. The fact that they breed prolifically in the ocean instead of in a confined body of water makes it practically impossible to eradicate them. But there is a possibility that they might be banished during the marketing of the oysters.

The digestive fluids connected with the oyster's stomach evidently contain nothing that is injurious to the copepods. Not only do these commensal copepods live and breed there but pelagic species also are often found swimming freely within the stomach. In the present instance a specimen of *Paracalanus* was found in one of the oyster stomachs along with the *Mytilicola* specimens.

Since these copepods are attached to the inner wall of the oyster's stomach even if something could be found that would kill them without injury to the oyster they would remain still attached after death and could be removed only by mechanical means.

Fortunately as stated above there is nothing in the presence of these copepods that is deleterious either to the oysters themselves or to the consumption of them. Recognition of this fact ought to remove any predjudice against their use for food just as it has done in the case of our fish. There is scarcely a single species of food fish that is not more or less infested with parasitic copepods, and these copepods are the genuine parasites feeding on the blood and fluids of the fish. The swordfish is one of those most completely parasitized, both externally and internally; it is safe to say that not a single one of them found in our markets was free from such infection at the time of its capture. And yet they still remain among the fish commanding the highest market prices and are savory to hundreds of thousands of palates including that of the author. Let the oysters join the fish and exclude all remembrance of the copepods.

ENTOMOLOGY.—*A key to the genera of chiggers (mite larvae of the subfamily Trombiculinae) with descriptions of new genera and species.*[1] H. E. EWING, Bureau of Entomology and Plant Quarantine.

When the present writer began the study of chiggers some years ago only a few species were sufficiently well known to have received names. In the United States only a single species had been named. Today there are known from the New World no less than sixty-five named species and almost as many from the Old World. Because so many species are in this economic group, and particularly because one of them is known to be a transmitter of Kedani fever, a serious disease of man, their study is assuming much importance.

HOST RELATIONSHIPS

The only genera that are here included in the subfamily Trombiculinae are those whose species are believed to have vertebrates as their natural hosts. Although several species have been reported as having both invertebrate and vertebrate hosts, such reports probably are in error. This certainly must be true of a few species with which the writer is familiar. For example, *Trombidium striaticeps* Oudemans which has been reported from both vertebrate and invertebrate hosts, occurs commonly about Washington, D. C., as a parasite of various insects, such as *Musca domestica* and *Stomoxys calcitrans;* yet from the many hundreds of vertebrate hosts from this vicinity examined for chiggers by the writer no specimens of *T. striaticeps* have been taken. In fact, among the many thousands of larvae of Trombiculinae from both North and South America examined by the writer, those of no species have been found to parasitize both invertebrates and vertebrates.

Records of chiggers of a single species from both vertebrate and invertebrate hosts have resulted in most cases, it is believed, either from misidentifications or from finding unattached chiggers wandering over a presumed host, just as they would wander over any other object in their environment. Further observations will eventually enable us to decide whether such species have either vertebrates or

[1] Received March 2, 1938.

invertebrates as hosts, and thus allocate them to their proper subfamily.

POSSIBLE VARIATIONS IN THE NUMBER OF PRONGS ON THE PALPAL CLAW

Several workers have remarked, in describing larvae of a chigger species, that the number of prongs on the palpal claw varies. It is

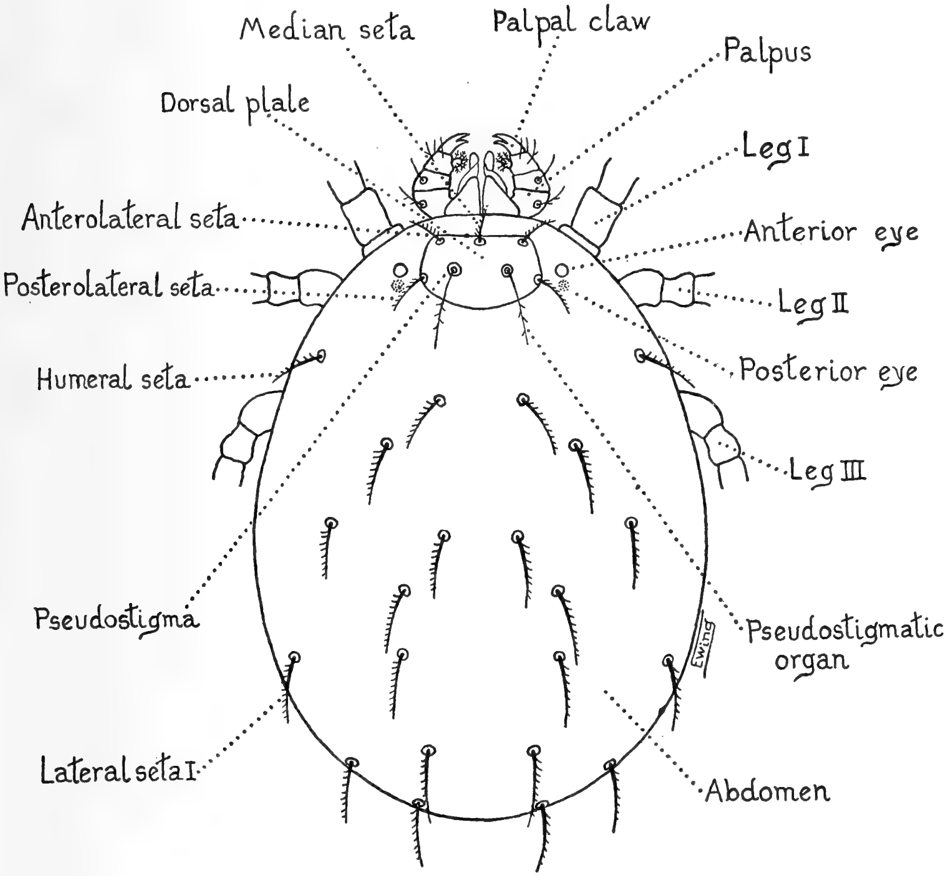


Fig. 1.—Dorsal view of the common North American chigger, *Eutrombicula alfreddugèsi* (Oudemans), with parts labeled. Greatly enlarged.

probable that most of this supposed variation is due to the fact that one prong is so small or so closely appressed to the claw proper that it has been overlooked.

The success one has in counting these prongs depends largely on two factors—the proper clearing of the specimen, and the viewing of the palpal claw from below. In poorly cleared specimens, particularly those mounted in balsam, the prongs of many species can not properly be seen. Specimens that have been partly crushed by having an insufficiency of mounting medium on the microscope slide—and there are very many such specimens in most collections—will have the palpi spread out laterally so that they occupy an unnatural, horizontal position. In such a position the palpal claw can not be seen to advantage.

When the palpal claw is observed from below in a specimen that is properly mounted, the tip of each prong may be easily detected by focusing up and down with a high-powered objective. Among the previously described chiggers from America apparently there is no species in which there is a variation in the number of prongs on the palpal claw. However, in this paper a new species, belonging to a new genus, is described in which the number of prongs is either five or seven. In this case the accessory prongs are arranged in pairs, there being either two or three of such pairs present. In another new species, being described elsewhere and belonging to the genus *Trombicula*, there may be either three or four prongs to the palpal claw.

Undoubtedly the number of prongs on the palpal claw will continue to be used as a generic character notwithstanding the difficulties mentioned. As our methods of clearing and mounting these mites improve there should be less trouble with this character as well as with certain others.

A KEY TO THE GENERA OF THROMBICULINAE, BASED ON LARVAL CHARACTERS

A. Dorsal plate with a median seta on its anterior margin.
  B. Pseudostigmatic organs strongly clavate or capitate.
    C. Anterolateral setae of dorsal plate large, barbed, similar to the posterolateral setae.
      D. Each chelicera with a row of dorsal teeth; palpal claw usually with two prongs.................... *Schöngastia* Oudemans
      DD. Each chelicera with not more than one dorsal tooth.
        E. Palpal claw with two or three prongs.. *Neoschöngastia* Ewing
        EE. Palpal claw with five or seven prongs, the accessory prongs being in two or three pairs; dorsal tooth of chelicera vestigial or absent................ *Euschöngastia*, new genus
    CC. Anterolateral setae of dorsal plate minute, simple. Parasitic on bats.................................... *Doloisia* Oudemans

BB. Pseudostigmatic organs setiform or flagelliform, frequently with barbs.

C. Each chelicera with a row of dorsal teeth; ventral tooth sometimes absent.

D. More than three subequal dorsal teeth on each chelicera; dorsal plate well developed; median seta pectinate. *Odontacarus* Ewing

DD. Three unequal dorsal teeth on each chelicera; dorsal plate vestigial; median seta simple. Living under surface of skin of amphibians.................... *Endotrombicula* Ewing

CC. Each chelicera with a single dorsal tooth; ventral tooth present.

D. Palpal claw typically divided into three prongs; dorsal abdominal setae usually more than 30............ *Trombicula* Berlese

DD. Palpal claw divided into two prongs; dorsal abdominal setae usually less than 30.............. *Eutrombicula*, new genus

AA. Dorsal plate without median seta.

B. Dorsal plate with a pair of submedian setae on anterior margin.

C. Dorsal plate with an anterior median process but without crista...................................... *Leeuwenhoekia* Oudemans

CC. Dorsal plate without anterior median process but frequently with crista; each chelicera obliquely flattened at distal end, forming a "spearhead" with teeth on its lateral margin.. *Hannemania* Oudemans

BB. Dorsal plate without a pair of submedian setae on anterior margin.

C. Each tarsus armed with two unequal claws; pseudostigmatic organs represented by a pair of simple setae; all setae, both on body and appendages, simple................. *Hemitrombicula*, new genus

CC. Each tarsus armed with three claws, the middle one usually more slender and longer than the others; pseudostigmatic organs clavate or capitate.

D. All setae on dorsal plate (exclusive of pseudostigmatic organs) marginal.

E. Dorsal plate with four or more pairs of lateral setae.................................. *Gahrliepia* Oudemans

EE. Dorsal plate with less than four pairs of lateral setae.

F. Dorsal plate with three pairs of lateral setae; eyes present....................................... *Schöngastiella* Hirst

FF. Dorsal plate with two pairs of lateral setae; eyes absent... *Walchia* Ewing

DD. Some of setae on dorsal plate not marginal; eyes usually present.................................. *Gateria*, new genus

GENERIC HOMONYM AND SYNONYMS

The name *Typhlothrombium* Oudemans (1910, Nov. 1), proposed for *T. nanus* Oudemans, was found to be preoccupied by *Typhlo-*

thrombium Berlese established earlier in the same year. In its place Oudemans proposed in 1912 the name *Gahrliepia*.

The generic name *Otonissus* Kolenati (1856)[2] comes into consideration in the subfamily Trombiculinae. Oudemans[3] has pointed out that one of the species originally included in *Otonissus*, *O. aurantiacus* Kolenati, is a larval form of Trombidiidae that would be included in Berlese's *Trombicula* as defined by Berlese. The eminent Dutch authority even lists *Trombicula* as a synonym of *Otonissus*, which he spells *Otonyssus*, following a later emendation by Kolenati. In view of the fact that *Trombicula* has become greatly restricted in recent years there can be no justification for this suggested synonymy.

The name *Leptotrombidium* Nagayo, Miyagawa, Mitamura and Imamura, proposed in 1917[4] for the Kedani mite, has been considered by subsequent workers as a synonym of *Trombicula*. Objections might well be raised against such a practice as an investigation of the use of the name *Trombicula* shows.

The generic name *Trombicula* Berlese appears to have been first applied to a larval form of the subfamily Trombiculinae in 1918 by Kitashima and Miyajima.[5] In this paper they claimed that the adult of the Kedani mite, then known as *Leptus akamushi* (Brumpt), was the same as *Trombicula coarctata* Berlese. Although subsequent investigation has shown that the Kedani mite is different from *T. coarctata* Berlese, it also has shown that this Japanese mite does belong to the genus *Trombicula*, as defined in a broad sense by Berlese.

It is very unfortunate, however, that the type species of *Trombicula*, *T. minor* Berlese, has every appearance of being established on a nymphal form. Until the larva or adult of this type species has been obtained by breeding, the status not only of the genus *Trombicula* but of all the genera of Trombiculinae will be somewhat in doubt.

Neotrombicula Hirst (1925)[6] was established as a subgenus for *Leptus autumnalis* Shaw, the common chigger of Europe. It should be regarded as a synonym of *Leptotrombidium*, since the palpal claw of the larva of the type species is trifurcate, and the other larval characters are those of the *akamushi* group of chiggers (*Trombicula*, *sensu stricto*).

[2] KOLENATI, F. A. *Die Parasiten der Chiroptern*, p. 17. Brünn, Rudolf Rohrers Erben.

[3] OUDEMANS, A. C. *Kritisch Historisch Overzicht der Acarologie*, Part III, Vol. **D**, p. 1362. 1937.

[4] NAGAYO, M., MIYAGAWA, Y., MITAMURA, T., and IMAMURA, A. Jour. Exp. Med. **25**: 255.

[5] KITASHIMA, T., and MIYAJIMA, M. Kitasato Arch. Exp. Med. **2**: Nos. 2–3. 1918.

[6] HIRST, S. Nature **116**: 609. 1925.

DESCRIPTION OF NEW GENERA AND SPECIES

Four new genera and two new species, both type species, are described in the following pages. Types are deposited in the United States National Museum.

Euschöngastia, new genus

Chelicerae each with a vestigial dorsal tooth or none. Palpal claw with five or seven prongs. Eyes present. Dorsal plate with posterolateral corners, without anterior median process, without crista. Median seta of dorsal plate present, barbed; anterolateral setae barbed; submedian setae absent; total number of setae on dorsal plate (exclusive of pseudostigmatic organs) five. Pseudostigmatic organs clavate or capitate. Dorsal abdominal setae numerous, barbed, arranged in very irregular, transverse rows. Legs and tarsal claws typical of the subfamily Trombiculinae.

Type species.—*Euschöngastia americana,* n. sp.

Only the type species is included in *Euschöngastia.* The genus is near *Neoschöngastia* Ewing, from which it differs in having the palpal claw either five-, or seven-pronged instead of two-, or three-pronged.

Euschöngastia americana, n. sp.

Palpus short, broad near base and rapidly narrowing to apex; segment II angulate laterally; first palpal seta semiplumose; second well supplied with rather slender barbs; third barbed. A single eye present on each side of cephalothorax near lateral margin. Dorsal plate over twice as broad as long; anterior margin slightly incurved; posterior margin very broadly rounded. A crescent-shaped ridge present in front of each pseudostigma. Pseudostigmatic organs strongly clavate, barbed, extending backward beyond posterior margin of dorsal plate. Dorsal abdominal setae about 40; humerals not situated in first row, which includes 12 setae; second row irregular, containing 8 setae. Other dorsal setae not arranged in rows. Legs moderate in length; tarsus I with short dorsal spine situated about twice its length from base of segment and tactile seta situated on a broad tubercle.

Length of engorged specimen, 0.58 mm; width, 0.37 mm.

Type host.—Chipmunk, *Eutamias* sp.

Type locality.—Boise, Idaho.

Type slide.—U.S.N.M. No. 1277.

Remarks.—Described from eight engorged specimens taken from type host at type locality, September 20, 1930, by S. B. Locke, and three partly engorged specimens taken from a "mouse" at San Simeon, Calif., June 7, 1931, by R. L. Boke.

Eutrombicula, new genus

Chelicerae each with a single dorsal tooth. Palpal claw bifurcate. Eyes present. Dorsal plate with posterolateral corners, without anterior median process, without crista. Median seta of dorsal plate present, barbed; anterolateral setae with barbs; submedian setae absent; total number of setae on dorsal plate (exclusive of pseudostigmatic organs) five, all marginal. Pseudostigmatic organs setiform or flagelliform, with or without barbs. Dorsal abdominal setae usually less than thirty, barbed, arranged in more or less irregular transverse rows. Legs and tarsal claws typical for the subfamily Trombiculinae.

Type species.—*Microthrombidium alfreddugèsi* Oudemans.

This new genus includes the species of the *alfreddugèsi* group of the genus *Trombicula.* The following North American species are transferred to it: *Microthrombidium alfreddugèsi* Oudemans, *Trombicula hominis* Ewing, *Trombicula flui* van Theil, *Trombicula butantanensis* Fl. da Fonseca, *Trombicula tropica* Ewing, *Trombicula insularis* Ewing, *Trombicula brasiliensis* Ewing, *Microthrombidium bruyanti* Oudemans, *Trombicula harperi* Ewing, *Trombicula ophidica* Fl. da Fonseca, *Microthrombidium göldii* Oudemans, *Microthrombidium helleri* Oudemans, *Microthrombidium tinami* Oudemans, *Trombicula dunni* Ewing, *Trombicula yorkei* Sambon, *Trombicula myotis* Ewing, *Trombicula panamensis* Ewing, *Trombicula gurneyi* Ewing, and *Trombicula cavicola* Ewing.

Doubtfully included in this genus are the South American species *Trombicula ewingi* Fl. da Fonseca and *Trombicula travassosi* Fl. da Fonseca. In both of these species the anterolateral setae of the dorsal plate are short, very stout, and peglike. The present writer has not yet seen a specimen of either species, but it appears to him that they should be put into a new genus, or at least into a new subgenus.

Some Old World species should go into *Eutrombicula,* but mounted specimens of such species are not available for study.

Hemitrombicula, new genus

Chelicerae each with a single dorsal tooth. Palpal claw bifurcate. Eyes present. Dorsal plate without posterior corners, anterior median process, or crista. Median seta of dorsal plate absent; anterolateral setae simple, similar to other setae on dorsal plate; submedian setae absent; total number of setae on dorsal plate (exclusive of pseudostigmatic organs) six, all of which are marginal. Pseudostigmatic organs simple, similar to other setae borne by dorsal plate. Dorsal abdominal setae simple, not numerous, arranged in transverse rows. Tarsi each with two unequal slender claws.

Type species.—*Hemitrombicula simplex,* new species.

Only the type species is included. This genus differs from all others of its subfamily in having only two claws to each tarsus instead of three, and in having the pseudostigmatic organs represented by a pair of simple setae.

Hemitrombicula simplex, n. sp.

Palpus slender, extending slightly beyond tips of chelicerae; second segment broadly rounded laterally; third segment long, about one and one-half times as long as second; thumb short, cone-shaped. All palpal setae simple, slightly curved. Anterior eye much larger than posterior and situated almost its diameter from latter; both eyes on sclerotized plate. Dorsal plate about as broad as long; anterior margin almost straight; posterior margin broadly rounded. Pseudostigmata absent. Pseudostigmatic organs represented by a pair of simple setae situated at about middle of dorsal plate. Dorsal abdominal setae simple, curved, each situated on a minute chitinous (? sclerotized) disc; total number about 20; humerals absent. Legs of moderate length; tarsus I without dorsal spine or specialized tactile seta.

Length of engorged specimen, 0.69 mm; width, 0.45 mm.

Type host.—Pilot black snake, *Elaphe obsoleta obsoleta* (Say).

Type locality.—Camp Bryan, Çass County, Mich.

Type slide.—U.S.N.M. No. 1278.

Remarks.—Described from two engorged specimens taken from type host at type locality during July, 1931, by P. C. Trexler. Professor Trexler wrote as follows in regard to these chiggers: "The red acarina were taken from the mouth of the snake, where they were attached so firmly that they were difficult to remove without crushing. There were ten specimens attached between the rows of teeth on the upper jaw only."

The snake from which these chiggers were taken was six feet long, and was infested also with our common chigger, *Eutrombicula alfreddugèsi* (Oudemans). The larvae of *E. alfreddugèsi* were found exclusively between the scales on the neck of the host. Of the ten specimens of *H. simplex* observed by the collector only two were seen by the present writer.

Gateria, new genus

Chelicerae each with a single dorsal tooth. Palpal claw trifurcate. Eyes reduced, vestigial or absent. Dorsal plate very large, without posterolateral corners, without anterior median process, without crista. Median seta of dorsal plate absent, anterolateral setae with barbs, similar to other setae on dorsal plate; submedian setae absent; total number of setae on dorsal plate (exclusive of pseudostigmatic organs) twelve or more, some of which are not marginal. Pseudostigmatic organs clavate. Dorsal abdominal setae with barbs and arranged in somewhat irregular transverse rows. Middle and hind legs with only six segments each. Tarsi each with three claws as in related genera.

Type species.—*Gahrliepia fletcheri* Gater.

Other species included are *Gahrliepia ciliata* Gater and *G. rutila* Gater. When Gater (1932)[7] described the type species of this genus he not only placed it in the genus *Gahrliepia,* a genus based on a species with only eight setae on the dorsal plate, but at the same time placed Hirst's genus *Schöngastiella* in the synonymy of *Gahrliepia.* His reasons for so doing he states in part as follows, "the fact that the number of scutal setae, posterior to the first two pairs, varies in different specimens of *G. fletcheri* from the same cluster, leads me to believe that the number of scutal setae is not a sound criterion for the separation of genera in this group." The present writer agrees with Gater in part only. It should be noted that individual variation in the number of setae has never been found in any species in which the total number of such setae is less than ten. In the new genus here proposed the important point about the setae on the dorsal plate is not their number, but the fact that some of them are not marginal.

[7] GATER, B. A. R. Parasitology **24**: 161.

Obituary

Maurice Crowther Hall, parasitologist, Chief, Division of Zoology, National Institute of Health, U. S. Public Health Service, died on May 1, 1938, at the Walter Reed General Hospital following an operation for gastric ulcers. He was buried May 4, in Arlington National Cemetery, with full military honors.

Dr. Hall was born July 15, 1881, at Golden, Colorado. He was graduated with the B.S. degree from Colorado College in 1905; he received the M.S. degree from the University of Nebraska in 1906, and the Ph.D. and D.V.M. degrees from the George Washington University in 1915 and 1916, respectively. After teaching in high school for one year, he came to Washington, D. C., in 1907 to join the staff of the Zoological Division of the Bureau of Animal Industry, U. S. Department of Agriculture. In 1916 he resigned from the Bureau of Animal Industry to become research parasitologist for Parke, Davis and Company. He served in the army during the world war as a lieutenant in the newly organized veterinary corps. In 1919 he returned to the Bureau of Animal Industry as assistant chief of the Zoological Division, becoming chief of that division in 1925, following the death of B. H. Ransom. In 1936 he resigned his position in the Bureau of Animal Industry to become Chief of the Division of Zoology of the National Institute of Health.

Dr. Hall's researches in the field of veterinary and medical parasitology won for him recognition as one of the world's foremost parasitologists. His most important work was in the field of anthelmintic medication. His discovery in 1921 of the value of carbon tetrachloride and in 1925 of the value of tetrachlorethylene, as effective treatments for the removal of hookworms from dogs led to the adoption of these drugs as standard treatments for the removal of hookworms from man, resulting in the saving of thousands of lives and restoring many more thousands to physical and economic usefulness. He was also responsible for the standardization of many of the anthelmintics in common use in veterinary practice. His publications in the fields of parasitology and therapeutics total more than 550 titles. In addition to papers in these fields, he published a number of papers on the philosophical and social aspects of parasitism, government, and other topics. In recognition of his contributions to science the honorary Sc.D. degree was conferred upon him in 1925 by his alma mater.

Dr. Hall was a member of the American Association for the Advancement of Science, American Society of Parasitologists (pres. 1932), American Society of Zoologists, Entomological Society of America, American Association of Economic Entomologists, American Veterinary Medical Association (pres. 1930), U. S. Livestock Sanitary Association, American Society of Tropical Medicine, American Academy of Tropical Medicine, Helminthological Society of Washington (pres. 1922), Entomological Society of Washington, Washington Academy of Sciences (v. pres. 1925), Royal Academy of Agriculture of Torino, Phi Beta Kappa and Sigma Xi.

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GEOLOGY.—*Laredo, a new name for a unit of Cook Mountain age in the Rio Grande region.*[1] Julia Gardner, U. S. Geological Survey.

I here propose the name Laredo for the part of the measured section of the Claiborne group that, in the report on the "Geology and ground-water resources of Webb County, Texas," by Lonsdale and Day, 1937,[2] is included under the name of Cook Mountain formation, and for all beds of equivalent age in the Rio Grande embayment. The area in which the name is to apply extends southwest from Frio, McMullen, and Live Oak Counties into Mexico. The Laredo formation is underlain by the Mount Selman formation, which in the upper part is dominantly clay with minor beds of sandstone and coal seams. It is overlain by the Yegua formation, which is predominantly clay and sandy clay with occasional oyster reefs.

Geologists working in south Texas have recognized for many years that the middle Eocene section differed in lithologic composition and in faunal assemblages from those displayed in central and eastern Texas. Partly through inertia and partly because it has seemed more profitable to recognize resemblances than differences, the name used to designate the upper part of the lower Claiborne in central and eastern Texas has been retained for the presumably equivalent portion of the south Texas section. However, the continued study of the section shown in the Rio Grande embayment has made increasingly inept the inclusion of the heavy sandstone section of south Texas under the name Cook Mountain formation. Our detailed knowledge rests largely upon the reports of Trowbridge[3] and that of Lonsdale and Day, to which reference has already been made. The composite section of Lonsdale and Day includes the beds lying between the top of the Mount Selman, about 5 miles above Laredo, to the base of

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received May 3, 1938.

[2] Lonsdale, J. T., and Day, J. R. *Geology and ground-water resources of Webb County, Texas.* U. S. Geol. Survey Water Supply Paper **778.** 1937.

[3] Trowbridge, A. C. *A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande.* U. S. Geol. Survey Prof. Paper **131-D.** 1923.—*Tertiary and Quaternary geology of the lower Rio Grande region, Texas.* U. S. Geol. Survey Bull. **837.** 1932.

the Yegua on the Laredo-Corpus Christi highway, 7.5 miles east of Laredo Post Office. The sections from the top of the Mount Selman on Sambarieto Creek, 5 miles north of Laredo, to that in Arroyo Chacon, about 2 miles south of Laredo Post Office, were continuous and were measured in great detail. Quoting from Lonsdale and Day, page 44:

> The thickness of the formation in the sections measured near Laredo is 630 feet. It is probably greater in the northern part of the county, and in wells east of the outcrop area the formation reaches a thickness of 875 feet. The dip is about 85 feet to the mile.

The beds include sands both soft and indurated, glauconitic sandstone, glauconitic marl and clay, and thin limestones commonly concretionary. In the Laredo district the sands and sandstones make up more than 50 percent of the formation, but farther north, in Webb County, the upper third of the formation includes more clay than sandstone. Fossil molluscan faunas are widespread both vertically and throughout the area of outcrop. A number of zones, each assemblage characterized by one or more dominant fossils, can be discriminated.

BOTANY.—*New grasses from Peiling Miao, Suiyuan Province, China.*[1] Y. L. Keng, National Central University, Chungking, China. (Communicated by Agnes Chase.)

During July and August, 1935, the writer joined the Roerich Expedition to Inner Mongolia in search of drought-resistant plants which might be introduced for forage into the great Southwest of the United States. The Expedition camped at Temur Khada, Peiling Miao, Suiyuan Province, as the center of their collections. In this arid region the grasses are the most dominant plants forming the greater part of the forage on the steppe. There were about 50 species of grasses collected during that season, among them the following 6 species appear to be unpublished and are here described.

Cleistogenes foliosa Keng, sp. nov.

Perennis 25–40 cm alta, foliosa, caespites densos formans; culmus erectus, circ. 1 mm crassus; vaginae glabrae vel oribus pilosae, internodiis longiores vel raro inferiores breviores; ligula e annulo pilorum ciliatorum circ. 0.5 mm longorum constituta; laminae planae vel in sicco involutae, 3–8 cm longae, 1.5–2.5 mm latae, praesertim versus apicem subulato-involutum scaberulae; panicula angusta, inferne inclusa, 4–7 cm longa, ramis simplicibus, ad quemvis nodum solitariis, angulatis, ut axis communis scaberulis; pedicelli rhachi adpressi, 1.5–2.5 mm vel terminales 5–7 mm longi; spiculae 3–4-florae, 6–7 mm longae (aristam brevem excludentes), pallide virides, stramineae, vel

[1] Received April 7, 1938.

ad maturitatem pauludum purpureae; glumae tenues vel scariosae, plerumque angustae, acuminatae, 1-nerves, prima (interdum acuta vel obtusiuscula, enervi) 1.5–3 mm, secunda 3.5–4.5 mm longa; lemmata superne scaberula, breviter bidentata, 5-nervia, midnervo in aristam rectam scaberulam 1.5–3 mm longam producto, prope margines scariosos plus minusve pilosa, prima circ. 6 mm longa, callo pubescente; palea bidentata, angusta, glabra vel latera prope medium sparse pilosa; antherae 3, 2.2–2.5 mm longae rhachillae articula circ. 1 mm longa, versus apicem cupularem pubescens.

Culms densely tufted, simple, leafy, 25–40 cm tall, about 1 mm thick, usually entirely enclosed by the sheaths; sheaths glabrous or pilose at the mouth, longer or rarely the lower ones shorter than the internodes; ligule composed of a ring of hairs about 0.5 mm long; blades flat or involute when dry, 3–8 cm long, 1.5–2.5 mm wide, scaberulous especially towards the subulate-involute apex; panicle narrow, included below, 4–7 cm long, the branches simple, solitary, angular, scaberulous like the main axis; pedicels appressed to the rachis, 1.5–2.5 mm, or the terminal ones 5–7 mm long; spikelets 3–4-flowered, 6–7 mm long (excluding the short awn), pale green, stramineous or somewhat purplish at maturity; glumes thin or scarious, usually narrow, glabrous, the first 1.5–3 mm, the second 3.5–4.5 mm long, acuminate, 1-nerved (the first glume sometimes acute or obtusish, nerveless); lemmas scaberulous above, shortly bidentate, 5-nerved, the midnerve prolonged into a straight scaberulous awn 1.5–3 mm long, more or less pilose near the scarious margins, the callus pubescent, the first lemma about 6 mm long; palea narrow, 0.6–0.8 mm wide between the ciliolate keels, glabrous or the sides, sparsely pilose near the middle, the keels prolonged into a short mucros; anthers 3, 2.2–2.5 mm long; rachilla joint about 1 mm long, pubescent towards the cupular apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on rocky slope, vicinity of Naran Obo, Peiling Miao, Suiyuan Province, August 21, 1935, by *Y. L. Keng no. 3538*, (*Roerich Exp. no. 886*). Other collections of this species are the following:

SUIYUAN: Peiling Miao: vicinity of Temur Khada, *Roerich Exp. 808, 814, 825* (*Keng 3460, 3466, 3477*); Payin Obo, vicinity of Olun-sumu, *Roerich Exp. 755* (*Keng 3407*); Madoni Ama, *Roerich Exp. 778* (*Keng 3430*).

This species is near *C. bulgarica* (Bornm.) Keng, from which it differs in having 3–4-flowered spikelets with narrower glumes and longer lemmas.

Cleistogenes mutica Keng, sp. nov.

Perennis 20–40 cm alta, caespites densos formans; culmus erectus, plurinodis, glaber, tenuis; vaginae glabrae vel oribus saepe villosae, inferiores aggregatae, superiores internodiis saepissime longiores, paniculae partem inferiorem attingentes vel amplectantes; ligula truncata, 0.5–0.8 mm longa, in pilos ciliatos superne divisa; laminae firmae 2–10 cm longae, 1–2 mm latae, scaberulae, planae vel versus apicem subulato-involutae; panicula diffusa, 4–8 cm longa, ramis simplicibus, puberulis, 1–2.5 cm longis; spiculae 3-10-florae, 4–10 mm longae, muticae, ad maturitatem pauludum purpureae; glumae acuminatae, saepissime scariosae, 1-nerves, inferior 2–3 mm, superior 3–4 mm longa; lemmata integra, 3-5-nervia, acuminata vel in mucronem minutum producta, in carina et prope margines plerumque adpresso-pubescentia, prima 3–4 mm longa, callo pubescente; palea 3–3.5 mm longa, in carina supra basin ciliata, versus apicem scaberula

Fig. 1.—*Cleistogenes mutica* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

vel fere leavis; antherae 1.5–2 mm longae, sufflavae vel purpureae; caryopsis (immatura) circ. 1.5 mm longa; rhachillae articula supra 1 mm longa, praesertim versus apicem cupularem pubescens.

Culms densely tufted, 20–40 cm tall, several-noded, enclosed by the sheaths or the internodes sometimes shortly exserted; sheaths glabrous or the mouth frequently villous, the lower aggregated and forming the thickened base of the culm; ligule truncate, 0.5–0.8 mm long, laciniate into hairs above; blades firm, 2–10 cm long, 1–2 mm wide, scaberulous or the lower surface nearly smooth towards the base, flat or subulate-involute towards the tip; panicle diffuse, 4–8 cm long, the branches simple, puberulent, 1–2.5 cm long; spikelets 3–10-flowered, 4–10 mm long, purplish at maturity; glumes acuminate, 1-nerved, usually scarious except the nerve, the first 2–3 mm, the second 3–4 mm long; lemmas entire, 3–5-nerved, acuminate or rarely the midnerve produced into a minute mucro, usually appressed-pubescent on the keel and near the margins, the first lemma 3–4 mm long, the callus pubescent; palea 3–3.5 mm long, the keels ciliate above the base, scaberulous or nearly smooth towards the apex; anthers 1.5–2 mm long, yellowish or purple; grain (immature) about 1.5 mm long; rachilla joint more than 1 mm long, pubescent especially towards the cupular apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on sandy steppe between Peiling Miao and Shiretu Obo, Suiyuan Province, August 6, 1935, by *Y. L. Keng no. 3378* (*Roerich Exp. no. 726*). Other collections of this species are the following:

SUIYUAN: Olun-sumu, *Roerich Exp. 576* (*Keng 3231*); Darkhan-wang, *Roerich Exp. 798* (*Keng 3450*); vicinity of Temur Khada, *Roerich Exp. 807* (*Keng 3459*), *Keng 3562*; Shara Muren, *Roerich Exp. 848* (*Keng 3500*).

This species was misidentified as *C. chinensis* Keng[2] which is based on *Diplachne serotina* var. *chinensis* Maxim. Through the kindness of Dr. N. P. Avdulov, I received last spring one of Maximowicz's type plants and found that the species here described is distinguished by the awnless spikelets, longer glumes, and shorter lemmas. The spikelets differ also in having 3 to 10 florets, Maximowicz's plant examined having spikelets with 2 to 4 florets.

Puccinellia poaeoides Keng, sp. nov.

Perennis, caespitosa; innovationes intravaginales; culmus circ. 30 cm altus, 1.2–1.6 mm crassus, inferne geniculatus, 2–3-nodis, nodo supremo in circ. $\frac{1}{4}$ inferiore sito; vaginae firmae, laeves, glaucae vel basilares stramineae, suprema 8–12 cm longa, superiore internodio demum paullo breviore; ligula firma, rotunda vel truncata, 0.5–1 mm longa; laminae caulinae circ. 3, superiores breviores, 1.5–4 cm vel eae innovationum usque 8 cm longae, plerumque involutae, expandae 2–3.5 mm latae, glaucae, erectae, subter laeves, super valide nerves puberulentaeque; panicula aperta, 8–12 cm longa, ramis binis, tenuibus, patentibus, usque 6 cm longis, inferne nudis, superne spiculiferis et leviter flexuosis; pedicelli rhachi adpressi, scaberuli vel scabri, saepissime 1–5 mm (interdum subsessiles, circ. 0.5 mm) longi; spiculae stramineae, 4–6-florae, 5–7 mm longae; rhachillae articula tenuis, glabra, circ. 0.8 mm longa; glumae obtusae vel paullo acutiusculae, glabrae vel superne minute ciliolatae, prima 1.2–1.8 mm longa, 1-nervi, secunda circ.

[2] Sinensia **5** (1 and 2): 152. 1934.

Fig. 2.—*Puccinellia poaeoides* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

2 mm longa, inferne 3-nervi; lemmata obtusa, dorso rotunda, 2.5–3.5 mm longa, obscure 5-nervia, superne scariosa, inferne adpresso-pubescentia; palea lemmato paullo brevior, emarginata, carinis superne ciliolata; antherae pallidae, circ. 1.5 mm longae; caryopsis fusiformis, circ. 2 mm longa, ad maturitatem plumbea.

Perennial with intravaginal innovations; culms tufted, geniculate below, about 30 cm tall, 1.2–1.6 mm thick, 2–3-noded, the uppermost node situated about one-fourth from the base; sheaths firm, smooth, glaucous or the basal ones stramineous, the uppermost 8–12 cm long, the next finally a little shorter than the internodes; ligule firm, rounded or truncate, 0.5–1 mm long, decurrent; blades about 3 on the culm, the upper the shorter, 1.5–4 cm, or those of the innovations up to 8 cm long, usually involute, 2–3.5 mm wide when expanded, glaucous, erect, smooth beneath, strongly nerved and puberulent above; panicle open, 8–12 cm long, the branches 2-nate, slender, spreading up to 6 cm long, naked below, spikelet bearing and somewhat flexuous above, scaberulous or scabrous the appressed pedicels similar mostly 1–5 mm long (sometimes only 0.5 mm long); spikelets stramineous, 4–6-flowered, 5–7 mm long, the rachilla joint slender, glabrous, about 0.8 mm long; glumes obtuse or slightly acute, glabrous or minutely ciliolate above, the first 1.2–1.8 mm long, 1-nerved, the second about 2 mm long, 3-nerved below; lemmas obtuse, rounded on the back, 2.5–3.5 mm long, obscurely 5-nerved, scarious above, appressed-pubescent below; palea a little shorter than its lemma, emarginate, the keels ciliolate above; anthers pale, about 1.5 mm long; caryopsis fusiform, about 2 mm long, lead-colored when ripe.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on steppe of alkali soil, Ashown Coop, about 5 miles northeast of Naran Obo, Peiling Miao, Suiyuan Province, August 8, 1935, by *Y. L. Keng no. 3395*, (*Roerich Exp. no. 743*).

This species is probably related to *Puccinellia jeholensis* Kitagawa,[3] from which it differs however, in having a smaller panicle and stramineous spikelets of 4–6 florets.

Puccinellia filiformis Keng, sp. nov.

Perennis, caespitosa; culmus 10–25 cm altus, 0.5–1 mm crassus, 2–3-nodis, nodo supremo a basi foliosa 3–7 cm remoto; vaginae striatae, glabrae, internodiis longiores vel superiores paullo breviores, suprema 2–9 cm longa (quam eius lamina longiore); ligula scariosa, 0.5–2 mm longa, ovata vel triangularis; laminae firmae, glabrae, 0.8–6 cm longae, saepissime involutae, filiformes, expandae 0.75–1 mm latae; panicula 2.5–9.5 cm longa, ramis 2–5-nis, erectis sed ad maturitatem patentibus vel reflexis, tenuibus interdum flexuosisque, scabris vel ad partem inferiorem nudum fere laevibus; pedicelli scabri, rhachi adpressi, 0.5–2 mm vel terminales 3–6 mm longi; spiculae pallide virides, 3–10-florae, 3–6 mm longae; glumae ovato-oblongae, prima 1 mm longa, 1-nervi, secunda 1.5 mm longa, inferne 3-nervi, obtusae (vel prima leviter acuta), glabrae vel marginibus superne minute ciliolatae; lemmata obovata, obtusa, scariosa et interdum superne brunnescentia, obscure inferne 5-nervia, prima circ. 2 mm longa, callo pubescente; palea lemma aequans sed angustior, emarginata, carinis superne minute scaberula;

[3] *Puccinellia jeholensis* Kitagawa, Ind. Fl. Jehol. **64**: 102. 1936.—"Prov. Hsing-an occid: Prope O-nyu-to (N.H.K. Oct. 2. 1933.—Typus); prope lacum Borden-hu (N.H.K. Sept. 30, 1933)."

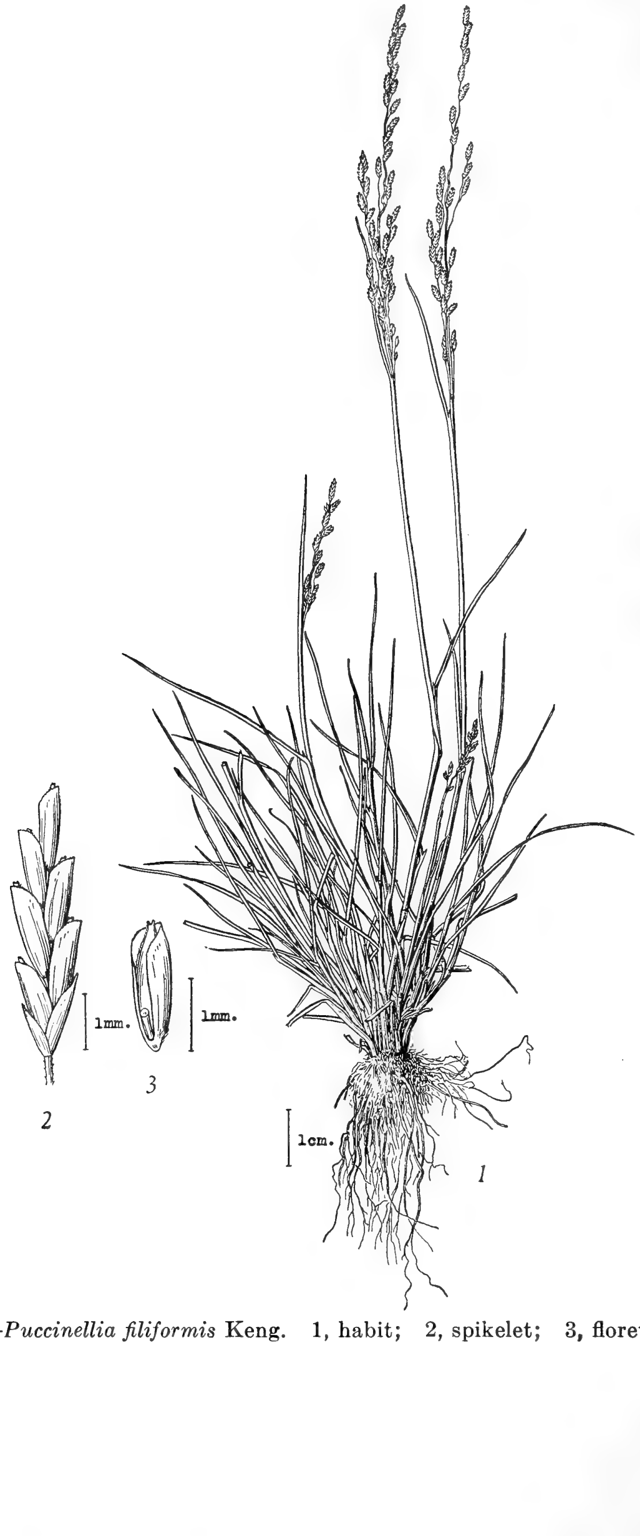

Fig. 3.—*Puccinellia filiformis* Keng. 1, habit; 2, spikelet; 3, floret. (Type)

antherae 3, 0.5–0.7 mm longae, pallidae vel sufflavae; caryopsis fusiformis, 1.2 mm longa; rhachillae articula tenuis, glabra, circ. 0.5 mm longa.

Perennial; culms tufted, 10–25 cm tall, 0.5–1 mm thick, 2-3-noded, the uppermost node 3–7 cm above the leafy base; sheaths striate, glabrous, longer, or the upper ones a little shorter, than the internodes, the uppermost 2–9 cm long (longer than its blade); ligule scarious, 0.5–2 mm long, ovate or triangular; blades firm, glabrous, 0.8–6 cm long, mostly involute, filiform, 0.75–1 mm wide when expanded; panicle 2.5–9.5 cm long, the branches 2-5-nate, erect or from spreading to reflexed at maturity, slender, sometimes flexuous, scabrous or nearly smooth on the lower naked half; pedicels scabrous, appressed, 0.5–2 mm or the terminal ones 3–5 mm long; spikelets pale green, 3-10-flowered, 3–6 mm long; glumes ovate-oblong, the first 1 mm long, 1-nerved, the second 1.5 mm long, 3-nerved below, obtuse or the first somewhat acute, glabrous or the margins minutely ciliolate above; lemmas obovate, obtuse, scarious and somtimes brownish above, obscurely 5-nerved below, the callus puberulent, the first lemma about 2 mm long; palea equaling the lemma but narrower, notched at apex, the keels minutely scaberulous above; anthers 0.5–0.7 mm long, pale or yellowish; grain fusiform, 1.2 mm long; rachilla joint slender, glabrous, about 0.5 mm long.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on the moist steppe by side of a river, Shara Muren, Suiyuan Province, August 16, 1935, by *Y. L. Keng no. 3511* (*Roerich Exp. no. 859*). Other collections of this species are the following:

SUIYUAN: Batu Khalkin Gol, vicinity of Temur Khada, Peiling Miao, *Roerich Exp. 805* (*Keng 3457*); Madoni Ama, Peiling Miao, *Roerich Exp. 535* (*Keng 3198* in part).

This species is near *Puccinellia Kobayashii* Ohwi,[4] which is, according to the original description, distinguished by the smaller lemmas (1.5–1.8 mm long) and flat blades.

Agropyron mongolicum Keng, sp. nov.

Perenne, caespitosum, ad basin vaginis emarcidis incrassatum; culmus 20–50 cm altus, 1–1.2 mm crassus, 1–3-nodis, glaber vel infra spicam pubescens, plerumque ad nodum supremum vel inferiorem geniculatus, nodo supremo in $\frac{1}{6}$–$\frac{3}{5}$ inferiore sito; vaginae arctae, glabrae, internodiis breviores, suprema 3.5–8 cm longa (quam eius lamina longiore); ligula circ. 0.5 mm longa, truncata, ciliolata; laminae firmae, involutae, 2.5–8 cm vel eae innovationum supra 10 cm longae, expandae 2–3 mm latae, durae, rectae vel falcatae, leviter glaucae, ad paginam superiorem puberulae; spica longe exserta, recta, 3.5–7 cm longa, 5–7 mm lata; rhacheos internodia 2–5 mm longa, pubescentia vel fere glabra; spiculae erectae vel adscendentes, lucide flavae, oblongo-lanceolatae vel rhombicae, 3–8-florae, 8–12 mm longae; gluma prima 4–5 mm, secunda 5–6 mm longa, ambae glabrae vel ad carinas leviter pilosulae, ovato-lanceolatae, pungentes vel aristato-acutae, lateralibus late scariosae, 3-nerves, nervis viridibus, validis; lemmata oblongo-lanceolata, glabra vel puberulo-scaberula; plerumque mucronata, prima 6–7 mm longa (mucronem 0.5–1 mm longum includente); palea lemma aequans vel in flore superiore excedens, emarginata, carinis minute scaberula;

[4] Act. Phyt. 7 Geob. 4 (1): 31. 1935.—"Hab. Manchuria: prope Dairen (M. Kobayashi n. 21)."

Fig. 4.—*Agropyron mongolicum* Keng. 1, habit; 2, part of the spike; floret. (Type)

antherae cremeae, 3 mm longae; caryopsis ellipsoidea, circ. 4 mm longa, rubido-brunnea; rhachillae articula incrassata, circ. 1 mm longa, minute puberula.

Perennial; culms tufted, thickened at the base with fibrillose sheaths, 20–50 cm tall, 1–1.2 mm thick, 1–3-noded, glabrous or pubescent below the spike, usually geniculate at the uppermost or the lower node, the uppermost node situated $\frac{1}{6}$–$\frac{3}{5}$ above the base; sheaths tight, glabrous, shorter than the internodes, the uppermost 3.5–8 cm long (longer than its blade); ligule about 0.5 mm long, truncate, ciliolate; blades firm, involute, 2.5–8 cm or those of the innovations more than 10 cm long, 2–3 mm wide when expanded, stiff, straight or falcate, somewhat glaucous, the upper surface puberulent; spike long-exserted, straight, 3.5–7 cm long, 5–7 mm wide, the rachis joint 2–5 mm long, pubescent or nearly glabrate; spikelets erect or ascending, light-yellow, oblong-lanceolate or rhombic, 3–8-flowered, 8–12 mm long; first glume 4–5 mm, second glume 5–6 mm long, both glabrous or the keel somewhat pilose, ovate-lanceolate, pungent or awn-pointed, 3-nerved, the nerves green, strong, the sides broadly scarious; lemmas oblong-lanceolate, glabrous or puberulent-scaberulous, usually mucronate, the first 6–7 mm long including the mucro, 0.5–1 mm long; palea equaling or in the upper florets exceeding the lemma, notched at the apex, the keels minutely scaberulous; anthers creamy, 3 mm long; caryopsis ellipsoid, about 4 mm long, reddish-brown; rachilla joint stout, about 1 mm long, minutely puberulent.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected on exposed sandy and rocky slope, Payin Obo, about 90 li northeast of Peiling Miao, Suiyuan Province, August 9, 1935, by *Y. L. Keng no. 3400* (*Roerich Exp. no. 748*). This species was also collected at Darkhan-wang, the same province, August 11, 1935, by *Y. L. Keng no. 3452* (*Roerich Exp. no. 800*), and from Shara Muren, August 15, 1935, by *Y. L. Keng no. 3501* (*Roerich Exp. no. 849*).

This is apparently a drought-resistant grass which may be used for forage. Although intermediate forms between it and *A. cristatum* (L.) Gaertn. are also found in this region, the above cited specimens are distinguished from *A. cristatum* by the relatively longer but narrower spikes and the pubescent or nearly glabrate rachis.

Stipa (§Lasiagrostis) **roerichii** Keng, sp. nov.

Culmi caespitosi, erecti, ubi veteres rigidi, 45–60 cm alti, 1.2–1.5 mm crassi, 3-nodes, nodo supremo prope vel infra medium eius sito; vaginae firmae, glabrae vel marginibus ciliolatae, internodiis longiores vel demum breviores; ligula scariosa, 0.5–1 mm longa, truncata vel pluri-partita; laminae firmae, erectae, setaceo-acuminatae, glaucae, 8–26 cm longae, 2–4 mm latae, planae vel sicco saepissime involutae, glabrae, praeter margines scaberulos laeves; panicula 12–25 cm longa, inferne inclusa vel demum exserta, ramis binis, tenuibus, scaberulis, erecto-adscendentibus vel ad maturitatem patentissimis, inferne nudis, supra medium aequaliter spiculiferis; spiculae 5–6.5 mm longae, lucide virides, pedicellis erectis puberulis 2–9 mm longis fultae; glumae spiculam aequans, subaequales vel prima quam secunda 0.5–1 mm brevior, oblongo-lanceolatae, 3-nerves, acutae, superne scariosae, glabrae vel minute puberulae; lemma circ. 5 mm longum, 3-nerve, omnino pubescens, callo pilis albis circ. 1 mm longis dense barbato; arista cum lemmato continua, 10–14 mm longa, superne scaberula, infra medium laxe tortuosa puberulaque; palea angusta, 4 mm longa, 2-nervis dorso adpresso-pubescens; antherae lineares, 3–3.5 mm longae, apice nudae.

Culms tufted, erect, rigid when old, 45–60 cm tall, 1.2–1.5 mm thick, 3-noded, the uppermost node situated near or below the middle of the culm; sheaths firm, glabrous or the margins ciliolate, longer or eventually shorter than the internodes, the uppermost 9–15 cm long (longer than its blade); ligule scarious, 0.5–1 mm long, truncate or frequently split; blades firm, erect, setaceous-acuminate, glaucous, 8–26 cm long, 2–4 mm wide, flat or mostly involute when dry, glabrous, smooth except the scaberulous margins; panicle 12–15 cm long, included or finally exserted, the branches binate, slender, scaberulous, erect-ascending or nearly horizontal at maturity, naked below, evenly spikelet bearing above the middle, the pedicels erect, puberulent, 2–9 mm long; spikelets light green, 5–6.5 mm long; glumes equaling the spikelet, subequal or the first 0.5–1 mm shorter than the second, oblong-lanceolate, 3-nerved, acute, scarious above, glabrous or minutely puberulent; lemma about 5 mm long, 3-nerved, pubescent throughout, the callus 0.5 mm long, densely bearded with whitish hairs about 1 mm long; awns continuous with the lemma, 10–14 mm long, scaberulous above, loosely twisted and puberulent below the middle; palea narrow, 4 mm long, 2-nerved, dorsally appressed-pubescent; anthers linear, 3–3.5 mm long, naked at the apex.

Type in the Herbarium of the National Research Institute of Biology, Academia Sinica, Nanking, China, collected in the crevice of exposed rocks near the hill top, Temur Khada, Peiling Miao, Suiyuan Province, altitude, 1500 meters, July 26, 1935, by *Y. L. Keng no. 3181* (*Roerich Exp. no. 518*). A second collection of this species was made on a moist rocky slope of the same region, August 24, 1935, by *Y. L. Keng no. 3557* (*Roerich Exp. no. 905*).

This species is probably related to *Stipa sibirica* (L.) Lam. from which it differs, in its smaller size, narrower blades, shorter spikelets, and in its glabrous anthers which are not penicillate at the apex. The species is named in honor of Professor Nicholas de Roerich, a famous painter of Russia, who was the head of our expedition to Inner Mongolia during the summer of 1935.

BOTANY.—*New species of* Elytraria *from the West Indies and Peru.*[1]

E. C. Leonard, U. S. National Museum. (Communicated by William R. Maxon.)

The genus *Elytraria*, of the family Acanthaceae, is limited in the West Indies apparently to Cuba and Hispaniola. Hitherto botanists have referred plants from these two islands either to *E. imbricata* (Vahl) Pers., of which *E. squamosa* (Jacq.) Lindau is a synonym, or to *E. Shaferi* (P. Wils.) Leonard. However, *E. imbricata*, characterized by a pair of scarious teeth on the flower bracts, has not to my knowledge been found off the mainland of tropical America except on

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 2, 1938.

Trinidad and Tobago, which after all have a flora of continental affinity.

In a recent paper on *Elytraria*[2] I erroneously treated *E. tridentata* var. *Wrightii* Gomez as a synonym of *E. squamosa*, i. e. *E. imbricata*. A careful study of type material (*Wright* 3053), which I had not seen at that time, convinces me that it consists entirely of small depauperate plants of *E. Shaferi*.

It seems expedient to classify West Indian material of this genus as representing four rather closely related species, as distinguished in the following key.

KEY TO THE WEST INDIAN SPECIES

Bracts puberulent.
- Leaves firm, usually pilose; margins of bracts floccose-ciliate; plants never proliferous . . . . 1. *E. Shaferi*.
- Leaves thin, glabrous or subglabrous; margins of bracts ciliolate; inflorescence often proliferous . . . . 2. *E. prolifera*.

Bracts glabrous.
- Leaf blades strongly crenate and rugose, firm, typically oblong-linear or narrowly oblong-obovate . . . . 3. *E. crenata*.
- Leaf blades entire or repand, rarely crenate, not rugose, thin, typically ovate . . . . 4. *E. planifolia*.

1. Elytraria Shaferi (P. Wils.) Leonard, Journ. Wash. Acad. Sci. **24**: 446. 1934.
   Elytraria tridentata var. *Wrightii* Gomez, Anal. Hist. Nat. Madrid **23**: 280. 1894.
   Tubiflora Shaferi P. Wils. Mem. Torrey Club **16**: 111. 1920.

Acaulescent; leaves oblanceolate, 1 to 5 cm long, 0.5 to 1.3 cm wide, obtuse or rounded at apex, gradually narrowed at base to a short winged petiole, firm, crenate-dentate, deep green, more or less reticulate-veined, pilose, or glabrescent except costa and basal portion; peduncles up to 6 cm long, slender, clothed with appressed, imbricate, acute scales, these 3 mm long, 1 mm wide, ciliate, puberulent or glabrescent; spikes 1 to 2 cm long; bracts oblong-ovate, 3 to 4 mm long, 1.8 to 2 mm wide, obtuse or acutish at apex, floccose-ciliate, appressed-pilose within, puberulent without; bractlets lanceolate, 3.5 mm long, 0.5 mm wide, pubescent at apex; calyx segments oblong, 4 mm long, 1 to 1.5 mm wide, acute or rounded and aristate at apex, thin, pilose at tip, the anterior segment bidentate, the teeth triangular; flowers not seen; capsules 3.5 mm long, conic, glabrous.

Type Locality: Pinelands, Sierra Nipe, near Woodfred, Oriente, Cuba.

The following specimens have been examined:

Cuba: Sierra Nipe, *Shafer* 3562 (type at New York Botanical Garden). Palm barrens west of Santa Clara, *Smith, Hodgdon, Cheadle, & Taylor* 3157. Exact locality unknown, *Wright* 3053 (type of *Elytraria tridentata* var. *Wrightii* Gomez).

[2] Journ. Wash. Acad. Sci. **24**: 444. 1934.

2. Elytraria prolifera Leonard, sp. nov.

Herba acaulis, radicibus fibrosis, folia oblongo-obovata, apice rotundata, basin versus sensim angustata et in petiolum decurrentia, integra, repanda, membranacea, glabra vel costa parce pilosa; spicae solitariae, saepe radicosae; bracteae ovatae, apice acuminatae, puberulentae, ciliolatae; flores et capsulae desunt.

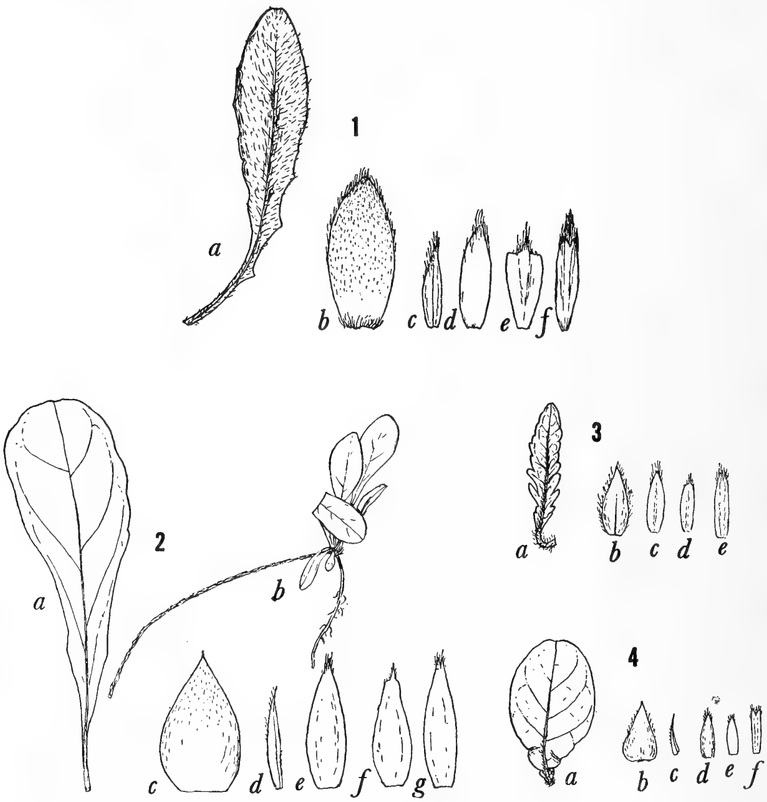

Fig. 1.—*Elytraria Shaferi* (P. Wils.) Leonard. *a*, leaf, nat size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 4 times nat. size.) Fig. 2.—*Elytraria prolifera* Leonard, sp. nov. *a*, leaf, nat. size; *b*, young plant replacing spike, nat. size; *c*, bract; *d*, one of the lateral bractlets; *e*, posterior calyx segment; *f*, one of the lateral calyx segments; *g*, anterior calyx segment. (*c*, *d*, *e*, f, *g*, about 6 times nat. size.) Fig. 3.—*Elytraria crenata* Leonard, sp. nov. *a*, leaf, nat. size; *b*, bract; *c*, posterior calyx segment; *d*, one of the lateral calyx segments; *e*, anterior calyx segment. (*b*, *c*, *d*, *e*, about 3 times nat. size.) Fig. 4.—*Elytraria planifolia* Leonard, sp. nov. *a*, leaf, nat. size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 3 times nat. size.)

An acaulescent herb, the crown densely pilose with brownish hairs about 1 mm long; leaf blades narrowly oblong-obovate, 2 to 6 cm long, rounded at apex, narrowed and decurrent on the petiole at base, entire or repand-dentate, very thin, glabrous or the costa sparingly pilose; petioles usually about 2 cm long, sparingly pilose; peduncles slender, up to 12 cm long, often rooting and producing new plants at tips, the scales firm, ovate-lanceolate, 2.5 mm long, about 1 mm wide, acuminate, ciliolate, otherwise glabrous; spikes 10 to 12 mm long, the bracts ovate, 3.5 mm long, about 2 mm wide at base, acuminate, clasping the rachis by subhyaline auricles, firm, ciliolate, both surfaces puberulent; bractlets lanceolate, 3 mm long, the keel ciliate; calyx segments about 4 mm long, lanceolate, coriaceous, pubescent at tip, and anterior segment bidentate; flowers and fruit not seen.

Type in the U. S. National Herbarium, no. 1,413,065, collected on hillside at Ennery, Haiti, by E. L. Ekman (no. H. 8407). Ekman's no. H. 8877, collected at Pointe à Raquettes, Gonave Island, Haiti, and Eyerdam's no. 267 collected at Saline Madame Doisy, Gonave Island, are of this species.

Well marked by its proliferous habit and thin leaf blades. As in *E. Shaferi* the bracts are puberulent, but differ in being ciliolate with very minute hairs instead of floccose-ciliate.

3. **Elytraria crenata** Leonard, sp. nov.

Herba acaulis, radicibus fibrosis, folia breviter petiolata, lineari-oblonga vel oblongo-obovata, apice rotundata vel obtusa, basin versus sensim angustata, crenata, rugosa, utrinque pilosa; spicae solitariae; bracteae ovatae, glabrae floccoso-ciliatae; corolla alba; capsula conica, glabra.

An acaulescent herb, the leaves flat on the ground; leaf blades oblong-linear to narrowly oblong-obovate, 1 to 3 cm long, 3 to 5 mm wide, rounded or obtuse at apex, narrowed at base to a short petiole, firm, both surfaces strongly rugose, sparingly pilose or glabrescent above, densely pilose beneath with brownish hairs, the margins deeply crenate and ruffled; peduncles up to 4 cm long, the scales narrowly ovate, 2.5 to 3 mm long, about 0.75 mm wide, acuminate, ciliate, otherwise glabrous, closely appressed; spikes 1 to 1.5 cm long; scales subtending the flowers ovate, 3.5 mm long, 1.5 mm wide, acute, ciliate with whitish matted hairs about 0.5 mm long, otherwise glabrous, firm, faintly 3-nerved, the bractlets narrowly linear, 3 mm long, pilose; calyx segments oblong, about 3 mm long, 0.5 to 1 mm wide, the anterior segment bidentate; corolla white; capsule conic, 2 to 3 mm long, glabrous.

Type in the Herbarium of the New York Botanical Garden, collected on red soil, stony hillside of barren savanna southeast of Holguin, Province of Oriente, Cuba, November 1909, by J. A. Shafer (no. 2948). Ekman's no. 15559, collected on red soil of savannas in the vicinity of Nuevitas, Province of Camaguey, Cuba, is also of this species.

Distinct from *E. Shaferi* in its usually much smaller and relatively narrower, more deeply crinkled leaf blades and its glabrous bracts. The bracts of *E. Shaferi* are always more or less finely puberulent, in addition to the marginal hairs.

4. **Elytraria planifolia** Leonard, sp. nov.

Herba acaulis, radicibus fibrosis; folia ovata vel interdum anguste oblanceolata, apice rotundata, basin versus sensim angustata et in petiolum decurrentia, membranacea, repanda vel raro crenata, glabra vel costa venisque pilosa; spicae solitariae; bracteae ovatae vel lanceolatae, apice acuminatae, glabrae, ciliatae; corolla alba; capsula conica, glabra.

Acaulescent herb; leaf blades typically ovate (sometimes narrowly oblanceolate), 1 to 5 cm long, 3 to 15 mm wide, rounded at apex, narrowed and decurrent on petiole at base, thin, flat, entire or repand-dentate, rarely crenate, glabrous or costa and occasionally the lateral veins pilose; petioles 0.3 to 3 cm long, pilose; peduncles very slender, up to 20 cm long, the scales firm, subulate, about 2 mm long and 0.5 mm wide, ending in a small white

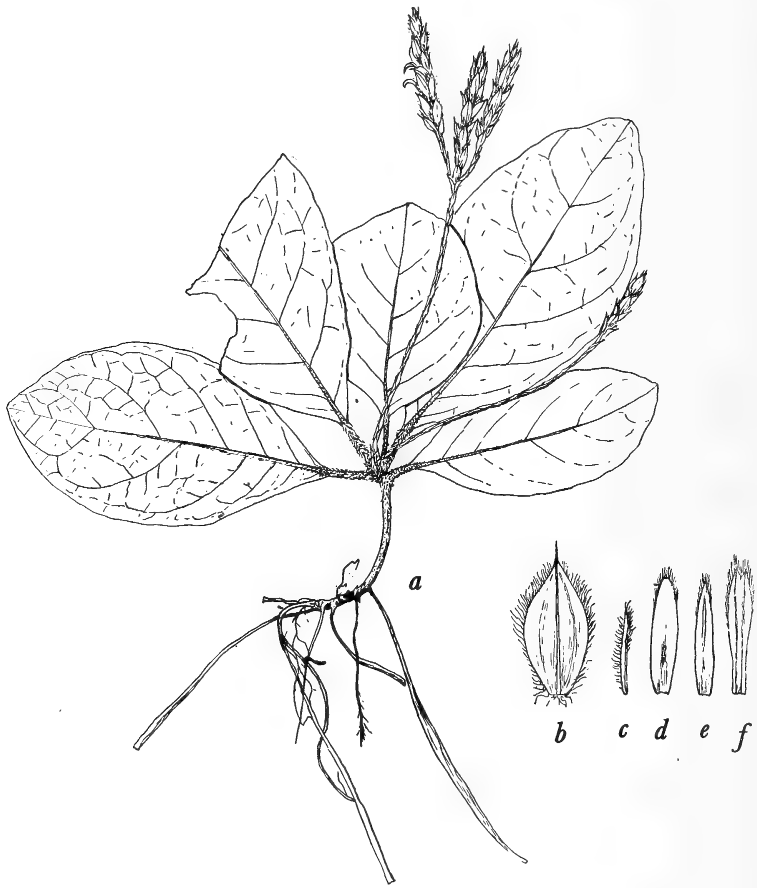

Fig. 5.—*Elytraria Klugii* Leonard, sp. nov. *a*, plant, half nat. size; *b*, bract; *c*, one of the lateral bractlets; *d*, posterior calyx segment; *e*, one of the lateral calyx segments; *f*, anterior calyx segment. (*b*, *c*, *d*, *e*, *f*, about 3 times nat. size.)

awn, spikes up to 1.5 cm long, usually about 1 cm long, the bracts ovate to lanceolate, 3 to 6 mm long, 1.5 to 2 mm wide, acuminate, ciliate, otherwise glabrous or nearly so; bractlets linear-lanceolate, 2.25 to 4 mm long, the keel ciliate; calyx segments slightly longer than the bractlets, the posterior narrowly oblong-ovate, the lateral narrowly lanceolate, the anterior linear and bidentate at apex, all pilose toward tip; corolla white; capsule conic, about 3 mm long, glabrous.

Type in the U. S. National Herbarium, no. 1,302,812, collected on steep hillside among shrubs, at Arroyo Machete, Sierra de Nipe, Province of Oriente, Cuba, Sept. 16, 1922, by E. L. Ekman (no. 15119).

The following additional specimens have been examined:

CUBA: Province of Santa Clara: Sagua, *Britton & Wilson* 385; city of Santa Clara, *Britton, Brit'on & Wilson* 6062; Sabana de San Marcos, *Leon* 9173; Placetas del Sur, *Leon & Roca* 8169. Province of Oriente: Between Taco and Nibujon, *Ekman* 3725.

5. Elytraria Klugii Leonard, sp. nov.

Herba acaulis vel caulescens, radicibus fusiformibus; folia petiolata, petiolo dense piloso, lamina elliptica, apice obtusa, basi acuta, repanda, glabra vel costa venisque hirsuta; spicae solitariae vel plures; bracteae ellipticae apice acuminatae aristatae, ciliatae; corolla alba; capsula glabra.

Caulescent or acaulescent herbs with fusiform roots; stems up to 3 cm long, retrorsely hirsute; leaf blades elliptic, 2 to 10 cm long, 1 to 5 cm wide, obtuse at apex, repand, rather thin, the costa and lateral veins (usually 5 pairs) hirsute, otherwise glabrous; petioles 1 to 1.5 cm long, densely pilose; peduncles up to 8 cm long, the scales triangular-ovate, 5 mm long, 4 mm wide at base, glabrous, ciliolate, closely clasping the peduncle; spikes 1 to 3 on each peduncle, 2 to 3 cm long, about 5 mm in diameter, bracts elliptic, 5 mm long, 3 mm wide, acuminate, ending in an awn about 1 mm long, 3-nerved (the nerves whitish), glabrous, the margins subhyaline, ciliate except at tip; bractlets linear, 3 mm long, 0.5 mm wide, acuminate, carinate, the keel and margins ciliate; calyx segments 4 mm long, thin, subhyaline, pilose at tip, the posterior segment oblong-elliptic, obtuse at apex, delicately nerved, the lateral segments lanceolate, barely 1 mm wide, acute, the anterior segment linear, 1 mm wide, bidentate at apex; corolla white, 5 to 6 mm long, glabrous; capsule 5 mm long, glabrous.

Type in the U. S. National Herbarium, no. 1,458,574, collected in forest along the Alto Río Huallaga, at Juan Jui, Department of San Martín, Peru, altitude 400–800 meters, June 1936, by G. Klug (no 4388).

A well-marked species apparently unrelated to any other South American member of the genus.

PALEOBOTANY.—*The stratigraphic significance of a southern element in later Tertiary floras of western America.*[1]

DANIEL I. AXELROD, University of California. (Communicated by ROLAND W. BROWN.)

The succession of Tertiary[2] floras in western North America gives evidence of gradual modification and restriction. In response to a trend from warm, moist climate to cooler and drier conditions during the period, homogeneous forests, at the outset extensively distributed over regions of low relief, gave place to diversified units controlled by local topography and climate.[3] These changes in distribution and composition provide a basis for determining the age of Tertiary vegetation in western North America.[4]

[1] Received April 18, 1938.

[2] The Tertiary period includes the Eocene, Oligocene, Miocene, and Pliocene epochs.

[3] CHANEY, R. W. *The succession and distribution of Cenozoic floras around the northern Pacific basin*, in *Essays in Geobotany, in honor of William Albert Setchell.* Univ. Calif. Press, 55–87. 1936.

[4] CHANEY, R. W. *Plant distribution as a guide to age determination* Jour. Wash. Acad. Sci. **26** (8): 313–324. 1936.

Table 1.—Southern Species in the Pliocene Floras of the Western United States

Fossil Species	Modern Equivalents	Nearest Modern Occurrence	Pliocene Occurrence		Oldest Fossil Occurrence
			Middle	Lower	Middle Miocene
Central California					
Celtis kansana Chaney & Elias	*C. reticulata*	Western Mohave area	Orinda		Tehachapi
Ilex sonomensis Dorf	*I. brandegeana*	Baja California		Sonoma	
Pinus kelloggi Webber	*P. cembroides*	San Rafael Mts.	Pinole		Tehachapi
Quercus bockeei Dorf	*Q. galeottii*	So. Mexico		Sonoma	
Quercus declinata Dorf	*Q. tomentella*	Insular So. Calif.		Sonoma	Tehachapi
Quercus pliopalmeri Axelrod	*Q. palmeri*	Interior So. Calif.	Orinda		Tehachapi
Quercus convexa Lesquereux	*Q. engelmanni*	Interior So. Calif.	Siesta		Tehachapi
Rhus prelaurina Axelrod	*R. laurina*	Coastal So. Calif.	Orinda		
Southern California					
Arbutus sp. Axelrod	*A. xalapensis*	Sonora	Mt. Eden		Tehachapi
Cupressus sp. Webber	*C. arizonica*	Arizona		Ricardo	Tehachapi
Palmoxylon mohavense Webber	?	Northern Mexico?		Ricardo	Tehachapi?
Robinia alexanderi Webber	*R. neo-mexicana*	Arizona		Ricardo	Tehachapi
Sapindus lamottei Axelrod	*S. drummondii*	Arizona	Mt. Eden		
Western Nevada					
Quercus turneri Knowlton	*Q. arizonica*	Arizona		Esmeralda	Tehachapi
Cupressus sp. (undescr.)	*C. arizonica?*	Arizona		Esmeralda	Tehachapi
Vaccinium ellipticum Berry	*Robinia? neo-mexicana*	Arizona		Esmeralda	Tehachapi
Southern High Plains					
Arctostaphylos prepungens Axelrod	*A. pungens*	Western Texas		Clarendon	
Condalia cf. *lycoides* Web. (=Phyllites sp. Chaney & Elias)	*C. lycoides*	Western Texas		Ogallala (Okl.)	Tehachapi
Diospyros pretexana Chaney & Elias	*D. texana*	Western Texas		Ogallala (Okl.)	
Sabal sp. (undescr.)	*S. texana*	Brownsville, Texas		Clarendon	
Ulmus moorei Chaney & Elias	*U. crassifolia*	Western Texas		Ogallala (Okl. & Kansas)	

Floras of the four epochs may be readily distinguished by this method, and the subdivisions of the three older epochs may also be satisfactorily recognized in most cases. But the task of placing a Pliocene flora in any definite part of the series has up to the present proved difficult or impossible. In the first place, the vegetation of the Pliocene has a more modern character than that of the preceding epochs, and has changed little down to the present. A second difficulty to detailed correlation is the highly localized development of Pliocene florules. They were an expression of micro-climates determined by slope exposure, altitude, position with respect to mountain ranges, and proximity to the ocean. On the other hand, Miocene and older floras inhabited regions of low or moderate relief where similar climatic conditions extended over wider areas. As a result, these floras were comparatively uniform for great distances and possessed many species in common. A third factor which has contributed to the difficulty of age determination of Pliocene florules is the absence of any climatically sensitive group of plants to afford a basis for correlation. Miocene floras, in contrast to those of the Pliocene, contain several distinct floral elements whose relative abundance in a flora assumes definite stratigraphic significance. For example, widespread occurrence of *Sequoia* on the Columbia Plateau in the early Miocene, and its poor representation there later in the epoch, suggests definite age differences within the series. Other Lower Miocene genera which are rare or absent by the end of the epoch are *Cercidiphyllum*, *Ginkgo*, and *Glyptostrobus* which make up a part of the Asiatic element, as well as *Carpinus*, *Castanea*, and *Tilia*, which are included in the broad-leaved deciduous group. While it is true that riparian species such as *Fraxinus*, *Platanus*, *Populus*, and *Salix*, occur consistently throughout most Pliocene floras in the western United States, these plants have small stratigraphic value, due to their lack of sensitivity to climatic change. Riparian species do not migrate any great distance under slightly altered climate, and hence afford little evidence of the climatic development characteristic of the Pliocene.

In the course of my studies of the Tertiary floras of southern California, an element has been found which appears to have originated in northern Mexico. This element has also been recorded at Lower Pliocene localities widely distributed to the north. Its reduction in numbers and range toward the close of the epoch appears to provide a basis for recognizing age differences. For some time it has been realized that certain species form a discordant unit in Pliocene floras. Instead of comprising part of the living flora at no great distance from the fossil locality, the modern equivalents of these species are now restricted far to the south. In his studies of the Pliocene floras of central California, Dorf[5] identified species of *Ilex, Quercus,* and *Rhus* related to plants now in Mexico and southern California. Chaney and Elias have pointed out the southern relationships of *Arctostaphylos, Bumelia, Celtis, Diospyros, Sabal,* and *Ulmus* as represented in the High Plains floras.[6] More recently, the writer has recognized a Mexican *Arbutus* in the Mount Eden flora of southern California, and has indicated the possibility of its origin in northern Mexico.[7]

The plants which form this austral element in the Pliocene floras of the western United States are listed in Table 1, together with data regarding their occurrence and that of their modern equivalents. Thirteen of the 21 species in this list first appear in the Middle Miocene Tehachapi flora of the western Mohave Desert.[8] This flora also includes such genera as *Diphysa, Dodonea, Ficus, Karwinskia, Lindleya, Pithecolobium, Robinia,* and *Sabal,* all of which are now restricted to the Southwest and to northern Mexico. Since the Tehachapi flora is considered to have had its origin in this interior southern area, it follows that the 13 Pliocene species occurring in it had a similar source. It also seems reasonable to suggest that the other 8 Pliocene species listed had a similar origin. Further collections in the earlier Miocene deposits of southeastern California and the Southwest, may be expected to add these to the list of Miocene species which first appeared in the western United States at its southern borders. The origin of this element in the south is emphasized by its rarity in the well-known floras of Miocene age to the north of the Tehachapi region. Before considering the Pliocene history of these southern plants, it is desirable to trace their distribution from the Tehachapi region northward.

More than 50 species comprise the Tehachapi flora, but only 8 have been recorded in Miocene floras farther north, as listed in Table 2. Of this list only *Quercus* (*Rhus*) *dispersa* and *Karwinskia* sp. are not also represented in the Pliocene to the north. Together with the 13 species mentioned in Table 1, there is a total of 19 species in the

[5] DORF, E. *Studies of the Pliocene palaeobotany of California.* Carnegie Inst. Wash. Pub. **412**: 30, 41–42, 100. 1930.

[6] CHANEY, R. W. and ELIAS, M. K. *Late Tertiary floras from the High Plains.* Carnegie Inst. Wash. Pub. **476** (1). 1936.

[7] AXELROD, D. I. *A Pliocene flora from the Mount Eden beds, southern California.* Carnegie Inst. Wash. Pub. **476** (3): 144–145. 1937.

[8] AXELROD, D. I. *A Miocene flora from the Tehachapi Pass region.* Proc. Geol. Soc. Amer. p. 394. 1937 (abstract).

Tehachapi flora which continued into the Pliocene. It is clear that the Tehachapi flora shows greater resemblance to Pliocene than to Miocene floras, for it has only 8 species in common with the Miocene at the north, and none of these is typically Miocene. From this relationship it may be concluded that the climatic conditions in southeastern California in Middle Miocene time resembled those of the Pliocene in northern regions. As judged from its composition, the Tehachapi flora inhabited a region characterized by an annual rainfall of approximately 20 inches, in contrast to nearly 35 inches in the Columbia Plateau at the same time. In addition, extremes of summer and winter temperature appear to have been much greater than in northern areas. The degree of continentality suggested by the flora is in harmony with its position in an interior area 800 miles south of the contemporaneous Miocene redwood flora.

TABLE 2.—TEHACHAPI SPECIES PREVIOUSLY RECORDED IN THE MIOCENE

Species	Miocene			
	Lower	Middle	Upper	Transitional
Cercocarpus antiquus Lesquereux			Blue Mts.	Table Mt.
Karwinskia sp.				Table Mt.
Platanus paucidentata Dorf		Monterey	Puente	Table Mt.
Pinus lindgreni Knowlton				Idaho
Quercus browni Brooks			Sucker Cr.	Idaho
Quercus convexa Lesquereux				Table Mt.
Quercus declinata Dorf				Idaho
Quercus (Rhus) dispersa Lesq.				Table Mt.

There are several other records of southern species in Miocene floras to the north, but they appear to be related to an older migration. Berry has suggested a relationship between fossil oaks in the Latah and Grand Coulee floras and modern Mexican species.[9] Brown has indicated that *Cedrela pteraformis* (Berry) Brown from the Miocene of the Columbia Plateau may be of southern origin.[10] LaMotte has pointed out the resemblance of *Oreopanax conditi* LaMotte to a modern species in Central America.[11] Dorf has recorded a *Celastrus* from the late Miocene Idaho flora, which is related to a living species in the mountains of central Mexico.[12] It is of further interest that MacGinitie has recognized species of *Cedrela*, *Oreopanax*, and *Sapin-*

[9] BERRY, E. W. *A Miocene flora from Grand Coulee, Washington*, U. S. Geol. Survey Prof. Paper **170c**: 36. 1931; *Miocene plants from Idaho.* U. S. Geol. Survey Prof. Paper **185e**: 110. 1934.

[10] BROWN, R. W. *Miocene leaves, fruits, and seeds from Idaho, Oregon, and Washington.* Jour. Paleon. **9** (7): 585. 1935.

[11] LAMOTTE, R. S. *The Upper Cedarville flora of northwestern Nevada and adjacent California.* Carnegie Inst. Wash. Pub. **455**: 139–140. 1936.

[12] DORF, E. *A late Tertiary flora from southwestern Idaho.* Carnegie Inst. Wash. Pub. **476** (2): 120. 1936.

dus in the Florissant flora of Colorado which appear to have originated in the south.[13]

A consideration of the Eocene floras of western America[14] suggests that most of the species mentioned above may have moved northward from low latitudes during the migration which took place early in the Tertiary. Represented in these early Tertiary floras are many low latitude warm-temperate and subtropical plants including *Anona. Aralia, Calyptranthes, Cinnamomum, Drimys, Ficus,* and *Meliosma,* In addition, there are such genera as *Quercus, Rhamnus, Sophora,* and *Ulmus* whose modern representatives are now in the uplands of central and southern Mexico. It may be pointed out that an Eocene flora from the Mohave formation in the western Mohave Desert is dominated by such genera as *Celastrus, Hicoria, Juglans,* and *Myrica,* rather than by lowland genera such as characterized the windward slopes of the Pacific coast; the Mohave species also have their living representatives in central and southern Mexico. This suggests that all of these plants were migrating northward along cooler interior areas in Eocene time, and were not involved in the Middle Tertiary migration of the arid southern element.

The rarity or absence of this element in Miocene floras to the north, appears to be due to the fact that it was restricted to drier upland habitats along mountain ranges. From such situations there was little chance of leaves and other structures entering the fossil record. As lowland conditions became drier and warmer in the early Pliocene, and as the mesic forest was eliminated, these upland plants became established in lowland habitats where they entered accumulating deposits. This is clearly illustrated by the paleobotanical sequence in central California. Here the lowlands were occupied by a mesic *Taxodium-Nyssa* forest in Miocene time.[15] During the early Pliocene this flora was replaced by a more xeric type of vegetation. This included live oaks, shrubs, and riparian species which closely resemble plants still living in the region, together with species of *Celtis, Ilex, Pinus, Quercus,* and *Rhus,* which seem to have had a southern origin. That the upland flora in central California in late Miocene time contained certain of these "Pliocene" species is shown by the general character of the Table Mountain flora in the foothills of the central

[13] Oral communication, April 2, 1938.

[14] Chaney, R. W. *The Goshen flora of west-central Oregon.* Carnegie Inst. Wash. Pub. **439.** 1933; Sanborn, E. I. *The Comstock flora of west-central Oregon.* Carnegie Inst. Wash. Pub. **465** (1). 1935; Potsbury, S. S. *The La Porte flora of Plumas County California.* Ibid., pt. 2. 1935.

[15] Condit, C. *The San Pablo flora of west-central California.* Carnegie Inst. Wash. Pub. **476** (5). 1938.

Sierra Nevada.[16] Represented in it are 6 species which have been recorded in the Pliocene of central California, and all of these have modern equivalents in the region today. These are listed below, along with their modern representatives.

TABLE MOUNTAIN SPECIES RECORDED IN THE PLIOCENE

Table Mountain Species	Modern Representatives
Arbutus matthesii Chaney	*A. menziesii*
Cercocarpus antiquus Lesquereux	*C. betuloides*
Platanus dissecta Lesquereux	*P. racemosa*
Quercus browni Brooks	*Q. chrysolepis*
Salix californica Lesquereux	*S. lasiolepis*
Umbellularia sp.	*U. californica*

In addition to these, there are other California species in the Table Mountain flora which have not been recorded in Pliocene deposits in central California: *Cornus ovalis* Lesquereux, and *Quercus* (*Rhus*) *dispersa* Lesquereux. Also contained in the flora are plants whose modern representatives are now limited farther south in present distribution: *Arbutus idahoensis* (Knowlton)Brown (in the Southwest and northern Mexico), *Karwinskia sp.* (in northern Mexico), and *Quercus convexa* Lesquereux (in interior southern California and the Southwest). It seems clear that the drier and warmer conditions of the early Pliocene shifted these species, which in late Miocene time had lived in drier uplands, into lowland habitats where they could enter accumulating deposits.

The later Pliocene floras in central California show indications of cooler and moister climate, and this is in harmony with the approaching Pleistocene epoch. The redwood forest, restricted in distribution during the Lower Pliocene, gradually extended its range in coast-central California. It was at this time that the southern element was limited to the south, for it has not been recorded in the late Middle or Upper Pliocene floras of central California. The southern plants represented in early Pliocene floras, therefore have stratigraphic value. They are distinctive in these floras whose other constituents are related to modern vegetation at no great distance from the fossil locality. Unlike the dominant riparian element, they are responsive to climatic change. Regularly present in early Pliocene floras, they disappeared to the north in the later portion of the epoch due to the cooler and moister conditions.

[16] LESQUEREUX, LEO. *Report on the fossil plants of the auriferous gravels deposits of the Sierra Nevada.* Mus. Comp. Zool. **6** (2). 1878; KNOWLTON, F. H. *Flora of the auriferous gravels of California.* U. S. Geol. Survey Prof. Paper **73**: 57–64. 1911; CHANEY, R. W. *The Mascall flora—its distribution and climatic relation.* Carnegie Inst. Wash. Pub. **349** (2).

Taking into account the general climatic trend from warm and dry to cooler and moister conditions during the Pliocene, and considering the occurrence of these floras with respect to mountain ranges, proximity to the ocean, latitude, and botanical provinces, the following general floral succession in the Pliocene of California may be indicated:

Upper Pliocene floras.—(1) Southern element absent in central California, and possibly in southern California; (2) species closely related to modern California plants still living near at hand; (3) species related to other California plants now limited to cooler habitats.

Middle Pliocene floras.—(1) Southern element with living representatives not as far south in present distribution as those of the Lower Pliocene; (2) plants resembling modern vegetation growing in the same general region.

Lower Pliocene floras.—(1) Southern element well developed, with modern descendants now mostly limited to Mexico and the Southwest; (2) species whose living representatives still exist at no great distance from the fossil locality.

Note.—The gradual reduction and elimination of the northern Miocene element from Pliocene floras may serve as a further basis for determining their position in the Pliocene when there are more floras known from central California and adjacent areas.

In addition to their California occurrence, southern plants are also represented in early Pliocene floras in two other regions in the western United States—in the Esmeralda flora of west-central Nevada[17] and in the Ogallala formation of Beaver County, Oklahoma, and near Clarendon, northern Texas.[18] The floristic relationships in these areas are not as clear as they are in California, where a greater number of Pliocene floras are available.

Additional collections must be obtained before the Esmeralda flora can be thoroughly analyzed. This is no place to evaluate the determinations suggested for all the species in the flora, but several suggestions are pertinent to the present discussion. The oak, *Quercus turneri* Knowlton, is certainly a southern species in its modern relationships, and shows resemblance to the living *Q. arizonica;* in addition, one of the species figured as *Cinchonidium? turneri* Knowlton[19] is assignable to *Q. turneri*. The oak leaf figured as *Quercus simulata* var. *truncata* Berry resembles the foliage of several modern oaks of northern Mexico, but is too poorly illustrated to suggest a definite relationship. The ovate leaf determined as *Vaccinium ellipticum* Berry

[17] Knowlton, F. H. *Fossil plants of the Esmeralda formation.* U. S. Geol. Survey 19th Ann. Rept. pt. 2, 209–220. 1900; Berry, E. W. *The flora of the Esmeralda formation in western Nevada.* Proc. U. S. Nat. Mus. **72** (23). 1928.

[18] Chaney, R. W. and Elias, M. K. *Late Tertiary floras from the High Plains.* Carnegie Inst. Wash. Pub. **476** (1). 1936.

[19] Knowlton, F. H. op. cit., pl. 30, fig. 11. 1900.

resembles the leaflets of several leguminous genera which are abundant throughout the Southwest and northern Mexico, and cannot be separated from the ovate leaflets of *Robinia neo-mexicana*. In addition to these leaf impressions, wood of *Cupressus* has been reported from the Esmeralda formation.[20] This genus is absent from Nevada today and is interpreted as a member of the southern element. Perhaps it is the Pliocene equivalent of the modern *C. arizonica*, a species with equivalents in both the Ricardo and Tehachapi floras.

There is a southern element in the Esmeralda flora, but a lower percentage of southern species are in it as compared with the Ricardo 200 miles farther south. This is explainable on the basis of the occurrence of the Esmeralda flora in a different climatic and floristic area where more of the northern genera (*Cercis, Trapa*) had survived.

Several florules have recently been described from the Ogallala formation of Nebraska, Kansas, Oklahoma, and northern Texas. It has been possible to identify southern plants in them and, as might be expected, the southernmost floras show a closer resemblance to vegetation farther south. The Clarendon florule of northern Texas is of interest because it is distinct from the other floras of the High Plains. It contains seeds of a *Sabal* palm, apparently representing the Pliocene equivalent of the modern *S. texana*, fruits of *Arctostaphylos* resembling the living *A. pungens*, and wood of *Fraxinus*. The Clarendon assemblage clearly suggests warmer and drier conditions than existed in the areas to the north. The distinctness of the Clarendon from the Beaver County flora 135 miles farther north, shows that they are not related, for its affinities are to the south rather than to the east, from which area the Beaver County flora derived several of its species.

The following species from the Lower Pliocene Beaver County flora of Oklahoma have also been recorded in the Middle Miocene Tehachapi flora, 1200 miles to the west: *Celtis kansana, Condalia* cf. *lycoides* (=*Phyllites* sp.), *Populus lamottei, Salix coalingensis, Typha lesquereuxi* and *Bumelia florissanti*. Disregarding the cat-tail and willow, a consideration of the modern distribution of the remaining species, as well as their presence in the Tehachapi flora, suggests that they represent an element which was developing in the Southwest and northern Mexico during the Middle Tertiary. To this group may perhaps be added the *Sapindus* and *Diospyros* of the Beaver County flora.

[20] GIANELLA, V. P. and WHEELER, H. E. *Tertiary gold-bearing fossil wood in Nevada.* Proc. Geol. Soc. Amer. p. 301. 1936 (abstract).

Condalia, *Diospyros*, and *Ulmus* represent the southern element in this flora, for their modern descendants are now in southwestern Texas. In addition, there is a legume[21] represented in the flora whose general shape, venation, and thickened petiole suggests an affinity with several arborescent genera now in the Southwest and northern Mexico. A more complete evaluation of the southern element in this area awaits the discovery of additional florules. It is believed that their recognition in early Pliocene floras of the southern High Plains may have stratigraphic value. As in California, a late Pliocene flora in this region would be expected to show the indications of a cooler and moister climate, and hence an absence of southern species.

Summary.—A distinct group of plants whose modern descendants are restricted southward, has been identified in Pliocene floras whose dominant element resembles living vegetation near at hand. A study of the Miocene floras in the western United States, and especially the middle Miocene Tehachapi flora, shows that this austral element had its origin in the Southwest and northern Mexico. These plants migrated northward along drier upland habitats during the Miocene and entered lowland deposits to the north in great abundance in early Pliocene time, when lowland conditions became drier and warmer. These species disappeared from areas of their former distribution in the north by the later Pliocene, in response to the lowered temperatures and increased rainfall which preceded the Pleistocene. Present evidence suggests that the occurrence of this southern element in a northern Pliocene flora establishes its early Pliocene age.

[21] CHANEY, R. W. and ELIAS, M. K. op. cit. 1936. The leaf figured as *Diospyros pretexana* Chaney and Elias, pl. 7, fig. 8, is considered to be a legume.

PALEOBOTANY.—*Protophycean Algae in the Ordovician of Nevada.*[1]

CHARLES W. MERRIAM, Cornell University, and LYMAN H. DAUGHERTY, San Jose State College, California. (Communicated by C. LEWIS GAZIN.)

During the progress of stratigraphic work in the Roberts Mountains of central Nevada under a grant from the Penrose Fund of the Geological Society of America, a nodule-bearing horizon was encountered in bituminous graptolite shales of Ordovician age. Thin-sections of the nodular bodies disclosed a variety of organic remains among whch are microscopic algal aggregates showing original cellular structure.

The exposures which yielded the nodules lie slightly over three

[1] Received May 13, 1938.

miles east of the summit of Roberts Creek Mountain (Roberts Mountains quadrangle), on the east side of Vinini Creek canyon and about seven-tenths of a mile northwest of the canyon mouth. The nodules are most abundant in the wall of an old tunnel driven eastward on the east side of the canyon. The entire outcrop of the graptolitic shale is extensive, occupying several square miles along Vinini Creek. The shales in the vicinity of the tunnel are finely laminated and black when fresh, but weather to very light gray tones. The sediments contain a great deal of bituminous matter. When heated in a Bunsen flame they burn readily and yield a tarry odor. Graptolite rhabdosomes are very abundant and unusually well preserved. The genera recognized include *Climacograptus*, *Diplograptus*, and *Glossograptus*. At Garden Pass (formerly called Summit, Nevada), five and one half miles southeast of the tunnel locality another graptolite fauna is found. This assemblage has been discussed by Gurley,[2] Ruedemann[3] and Kirk[4] and is regarded by the last author as early Chazyan. In the fauna Gurley reports *Phyllograptus*, and *Didymograptus;* these have not been recognized in the Vinini Creek locality which may represent a somewhat higher horizon.

In addition to plant remains the nodules themselves contain much undistorted and apparently little altered graptolitic material such as spines and entire siculae. Several genera of radiolaria are also present.

The nodules are small, averaging the size of walnuts. They occur in definite layers, are distributed parallel to the bedding and are disposed in such manner that the contiguous laminae of the shale seem to pass around rather than into the small rounded bodies. Evidently a good deal of compaction has taken place subsequent to formation and induration of the nodules. They do not have the appearance of wholly concretionary segregations of mineral matter forming long after deposition of the surrounding muds.

The nodules possess an outer coating of black tarry material. Under the microscope in thin-section this is seen to be of deep golden brown color and is laminated concentrically. It may have a thickness of at least one and a half millimeters. The bodies are impregnated throughout with bituminous matter having a similar golden brown color. While the masses have not been studied mineralogically they are known to contain a moderate amount of pyrite. Only a small proportion of the substance was dissolved on prolonged

[2] Gurley, R. R. Jour. Geol. **4**: 294–302. 1896.

[3] Ruedemann, R. *Graptolites of New York*, Pt. 2. New York State Museum Memoir No. **2**: 89, 382, 383, 440. 1908.

[4] Kirk, E. Am. Jour. Sci. **26**: 31. 1933.

treatment with dilute hydrochloric acid, indicating a limited percentage of carbonate. Tests for phosphate gave but a slight trace.

The minute algae occur as colonies of cells, frequently forming almost perfect spheres, though in the largest individuals they may be slightly flattened and appear oblong in section. The colonies vary in

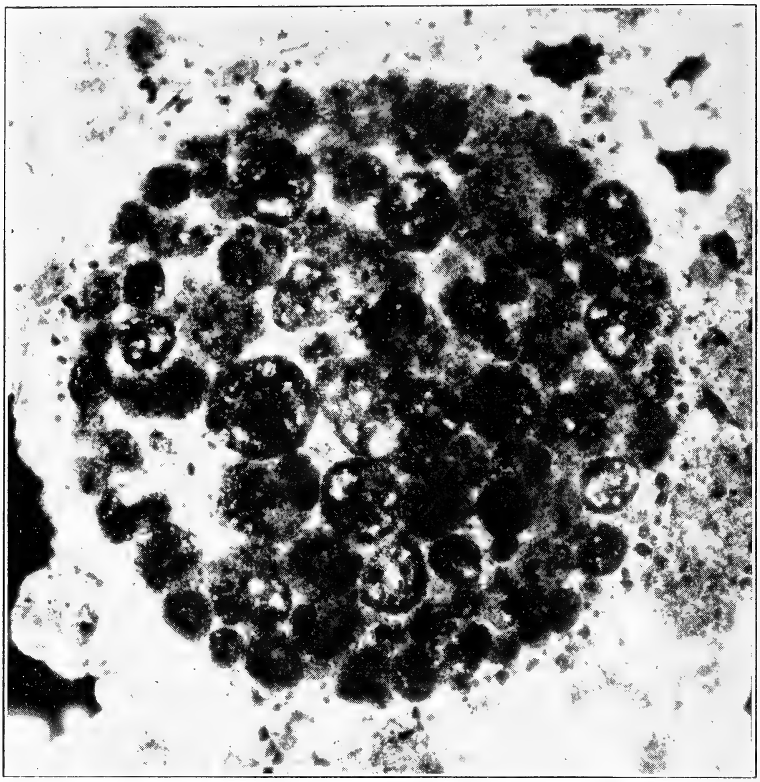

Fig. 1.—Photophycean algae, Ordovician, Roberts Mountains, Nevada. Spherical colony in thin-section, ×170 diameters. Occur in bituminous nodules resembling small coal balls.

diameter from 117 microns to 770 microns. There is evidently some differentiation of cells within the spherical groups. Individual cells are spherical to slightly angulated and range from 18 microns to 45 microns in diameter. Most of the larger clearly defined units lie well within the colony, while those on the outer border are inclined to be the smaller ones.

Whether the forms represent spore capsules or mature individual algal colonies has not been determined. Among described fossil algae they possess some of the characters of *Gloeocapsomorpha* from the

Ordovician Kukersite deposits of Esthonia. This interesting plant form played an important role in formation of the Kukersite, a variable Ordovician shaly sediment containing a high percentage of sapropelic debris. (Lindenbein, op. cit., pp. 381–382.) The Kukersite bears remains of trilobites, bryozoa and brachiopods, evidence that conditions may have been suitable for benthonic life. Lindenbein has reached the conclusion that *Gloeocapsomorpha* was itself a bottom-dwelling rather than a planktonic type. In the case of the Nevada graptolite shales the fauna is that of a "pure graptolite shale,"[5] all of the animal remains representing types which were in all probability members of the plankton (graptolites, radiolaria, small neotremate brachiopods with horny or phosphatic shells).

Gleocapsomorpha has been studied by Zalessky[6] and by Lindenbein.[7] Zalessky compares the form with the living blue-green alga *Gloeocapsa*. In the fossil *Gloeocapsomorpha* the individual cells are more or less irregular in form, are of yellowish color and occur as aggregates of varying shape within a supposed mucilaginous matrix. According to Lindenbein the cells ("cellules") have diameters ranging from 2 to 10 microns, while the colonies ("thalles") rarely exceed 0.1 millimeter.

The Nevada form appears to differ from the Esthonian type in the clearly spherical shape of many colonies and in the much greater number of cellular elements. The Esthonian form frequently shows an irregularly radiate arrangement of the less numerous cellular units in the individual colony or thallus and does not exhibit the peripheral layer of smaller cells, which last appears to be a characteristic of the Nevada genus.

For want of more specific terminology the harmless general term Protophyceae, applied to the ancient *Gloeocapsomorpha* by Lindenbein is adopted provisionally for the Nevada form figured herein.

It is likely that the small alga of the graptolite deposits constituted an important element in the Ordovician planktonic marine algal flora and may have been the source of much of the organic matter in the shales. A record of morphological character with preservation of such delicate structure would be expected only where deposition went on in relatively quiet waters below wave and violent current action. It is not, however, implied that these partially sapropelic muds were

[5] Ruedemann, R. Jour. Pal. **9** (1): 83. 1935.

[6] Zalessky, M. D. Soc. Paleont. Russie, for November. 1918.

[7] Lindenbein, H. A. R. Archieves Sciences Physiques et Naturelles, 5th periode **3**: 393, figs. 1, 2. 1921.—Supplement to above: Compte Rendu des Seances, Société de Physique et D'Histoire Naturelle **38** (2): 60–63.

of bathyal or abyssal origin. In any case the algae and radiolaria inhabited the photic zone, but in view of presumed allochthanous origin of the organic matter, no clear-cut case can be made here for shallow water (neritic) accumulation of the shales.

The character of the nodules and unusual preservation of their organic contents calls to mind the remarkable coal balls of the Carboniferous, though processes involved in formation of the latter may be quite different.

ZOOLOGY.—*Two new species of amphipod crustaceans from the east coast of the United States.*[1] CLARENCE R. SHOEMAKER, United States National Museum. (Communicated by MARY J. RATHBUN.)

In November, 1937, a collection of amphipods taken at the Isles of Shoals, New Hampshire, by Mr. James A. Williams, was sent by him to the U. S. National Museum for identification. The collection for the most part contained only well known New England forms, but two, *Pontharpinia epistoma* and *Gammarus greenfieldi*, were recognized as being new to science. A number of specimens of *Pontharpinia epistoma* are in the National Museum collection, but these whenever identified, had been assigned to *Paraphoxus spinosus* Holmes, which they superficially much resemble. *Gammarus greenfieldi* is a very abundant littoral form occurring on the coast of Massachusetts and extending northward at least as far as Frenchmans Bay, Maine. It is surprising that such a conspicuous common littoral New England form should have remained unnoticed for so long a time.

Pontharpinia epistoma n. sp. Fig. 1

Diagnosis.—Gnathopods with sixth joint distally very broad and palms only slightly oblique. Fourth side-plate with hind excavation very shallow. Fifth peraeopod with hind margin of second joint plainly serrate. Third metasome segment with lower margin evenly convex and with a scarcely perceptible hind angle, hind margin with only a few long, closely set spines on lower part, above which it is convex.

Male.—Head, rostrum reaching to about the middle of the second peduncular joint of antenna 1, apex broadly rounding. Eye large, oval, brownish, Antenna 1, first and second peduncular joints equal in length, third joint very short; flagellum shorter than peduncle and composed of about nine joints which bear calceoli; accessory flagellum not much shorter than the primary and composed of about eight joints. Antenna 2 as long as the entire body, fourth and fifth peduncular joints equal in length; flagellum very long and slender and bearing a calceolus on every other joint. Epistome project-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 20, 1938.

ing forward, prominent, conical, and rather sharply pointed. In many specimens the epistome is not so prominent as in the specimen figured. Mandible with apparently five spines in spine-row; second and third joints of palp about equal in length. Maxilla 1, inner plate very well developed, with perhaps three short apical spines and a few marginal setules; outer plate with eleven spine-teeth which may be slightly serrate; palp two-jointed and bearing six apical spines. Maxilla 2 with inner and outer plates about equal in size and shape. Maxillipeds, inner plate broader than outer and bearing distally one spine and several spinules; outer plate short, reaching to about the end of first joint of palp and bearing a few spines on inner margin; fourth joint of palp very slender, curved and bearing a minute spinule on inner margin near apex.

Side-plates 1 to 4 bearing a few setae on lower margin, fourth very slightly excavate behind, fifth bilobed with front lobe shallower than hind lobe. Gnathopods about alike in size and shape; sixth joint rather short, and widening very much distally; palm only slightly oblique, and defined by a rounding projection of the hind margin of sixth joint. First and second peraeopods about alike in size and shape; the form and armature of these, as also of peraeopod 3, 4, and 5, are accurately shown in the accompanying figures of these appendages.

Pleon segment 1 rather evenly rounding below. Segment 2 broader below than either 1 or 3, a row of plumose setae near lower margin which is slightly concave toward the rear margin. Segment 3 with very slight lower hind angle, lower margin convex and bearing a row of slender marginal spines above which in the largest specimens are a few scattered spines, lower hind margin straight for a short distance and bearing a row of long slender closely-set spines above which the margin is convex. This hind margin is subject to considerable variation; in some specimens the convexity is very pronounced, while in others it is scarcely perceptible. Urosome slender. Uropods slender and rather sparsely spinose; but in the largest specimens they are stouter and more spinose. Uropod 1, peduncle bearing a few spines on the upper inner and outer margins, and a conspicuous spine on the inside distal end; outer ramus with three marginal spines and inner with two above and one slender spine projecting down from lower margin. In the largest specimens there are fewer peduncular spines, the large inside spine is absent and the spines of the rami are grouped closer together and are nearer the peduncle. Uropod 2, peduncle with a few marginal spines; outer ramus with two marginal spines and inner with one. In the largest specimens the peduncular spines are longer and the two or three proximal ones are conspicuously long and slender, the outer ramus with three spines and the inner with two. The spination of the pleon segments and the uropods is thus seen to vary with age, and even in the largest specimens the number of spines is not constant. Telson bearing two setae on either lateral margin, and two small spines on the apex of either lobe. Length of the largest males about 6 mm.

Type.—A male specimen taken by the U. S. Fisheries steamer *Albatross* at the surface off Block Island, Rhode Island, July 8, 1883, U. S. Nat. Mus. no. 75671.

Female.—The female is stouter and much broader than the male. The eyes are small, nearly round, and brownish. Antenna 2 not much longer than 1. The remaining appendages are very much like those of the male, except the third uropods, which show the sexual modification usual in the genus *Pontharpinia.* Uropod 3 of the female is shown in fig. *1 r.* Length of the largest females about 7 mm.

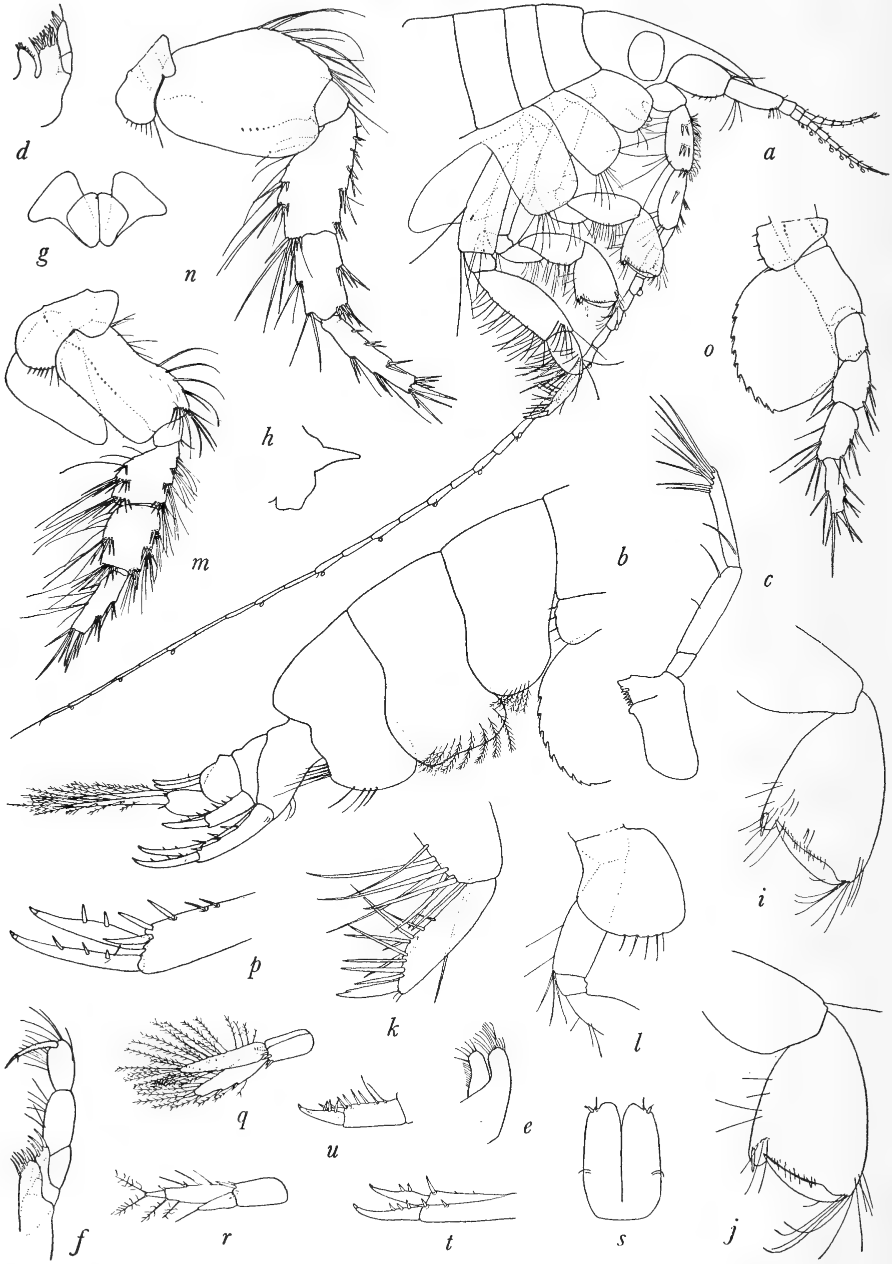

Fig. 1.—*Pontharpinia epistoma*, new species, male. *a*, Anterior end; *b*, posterior end; *c*, mandible; *d*, maxilla 1; *e*, maxilla 2; *f*, maxilliped; *g*, lower lip; *h*, epistome and upper lip; *i*, *j*, gnathopods 1 and 2; *k*, end of peraeopod 1; *l*, peraeopod 2; *m*, *n*, *o*, peraeopods 3, 4, and 5; *p*, uropod 1, inside; *q*, uropod 3; *r*, uropod 3, female; *s*, telson; *t*, *u*, uropods 1 and 2 of a larger male.

This species has been confused with Holmes' species *Paraphoxus spinosus* which it superficially resembles. I have examined the mouth-parts of *Paraphoxus spinosus* and find that the first maxilla has a two-jointed palp, so this character, together with the strongly expanded fourth joint of peraeopods 3 and 4, places it in the genus *Pontharpinia*. *P. epistoma* can be distinguished from *P. spinosa* by the more expanded sixth joint of the gnathopods and the less oblique palms. In *P. epistoma* the serrations on the rear margin of the second joint of the fifth peraeopod are very prominent, while in *P. spinosa* they are scarcely perceptible. In *P. epistoma* the lower margin of the third pleon segment is convex and bears marginal spines, but in *P. spinosus* this margin is straight or slightly concave and is without spines.

Stebbing, in his diagnosis of the family Phoxocephalidae (Das Tierreich, I. Gammaridea, p. 133) says, "epistome not projecting," but *P. epistoma* has a well-developed forward-projecting epistome, fig. 1 *h*.

There are specimens of *Pontharpinia epistoma* in the U. S. National Museum collection from Isles of Shoals, New Hampshire; Narragansett Bay, Rhode Island; Block Island, Rhode Island; Long Island Sound, and Gardiner's Bay, Long Island; off Martha's Vineyard, Massachusetts; off Broadkill, Delaware; *Albatross* station 2312, off Charleston, South Carolina; and west end of Skull Creek, South Carolina.

Gammarus (Marinogammarus) greenfieldi, n. sp. Fig. 2

Diagnosis.—The corners of the side lobes of head rounding. The lower hind corner of the second joint of peraeopods 3–5 forming a prominent angle which is rounding in peraeopod 3 and square in 4 and 5. Third metasome segment with lower hind angle square and not produced. Uropod 3 with inner ramus well developed and nearly half the length of the outer which is one-jointed and very setose. Telson bearing a conspicuous group of spines on lateral margins.

Male.—Head about as long as the first plus one-half of the second mesosome segment; side-lobes not much protruding, with upper and lower corners rounding. Eye reniform, rather long and narrow, black. Antenna 1 longer than 2; first joint about one-fourth longer than second, which is nearly twice as long as third; flagellum composed of about forty joints. Antenna 2, fourth joint slightly shorter than fifth; flagellum about equal in length to the peduncle; upper and lower margins of peduncle and flagellum furnished with groups of setae, a few of which are sparsely plumose.

Upper lip evenly convex on lower margin, and lateral lobe on right side rather prominent. Right mandible, molar prominent and bearing a seta on hind margin; cutting-edge narrow and bearing three teeth; accessory plate with double serrate cutting edge; five spines in spine-row; second joint of palp longest and bearing spines on outer edge; third joint about three-fourths as long as second and bearing a comb of very fine spines on outer margin, and a group of spines on inner and outer surface. Maxilla 1, right, inner plate with lateral margin spinose throughout; outer plate bearing eleven serrate spine-teeth; palp with the obliquely truncate distal margin bearing five short teeth and two setae. Maxilla 2, outer plate with distal spines only; inner plate with spines on inner margin and apex, and an oblique row of plumose spines near inner margin. Lower lip with inner lobes

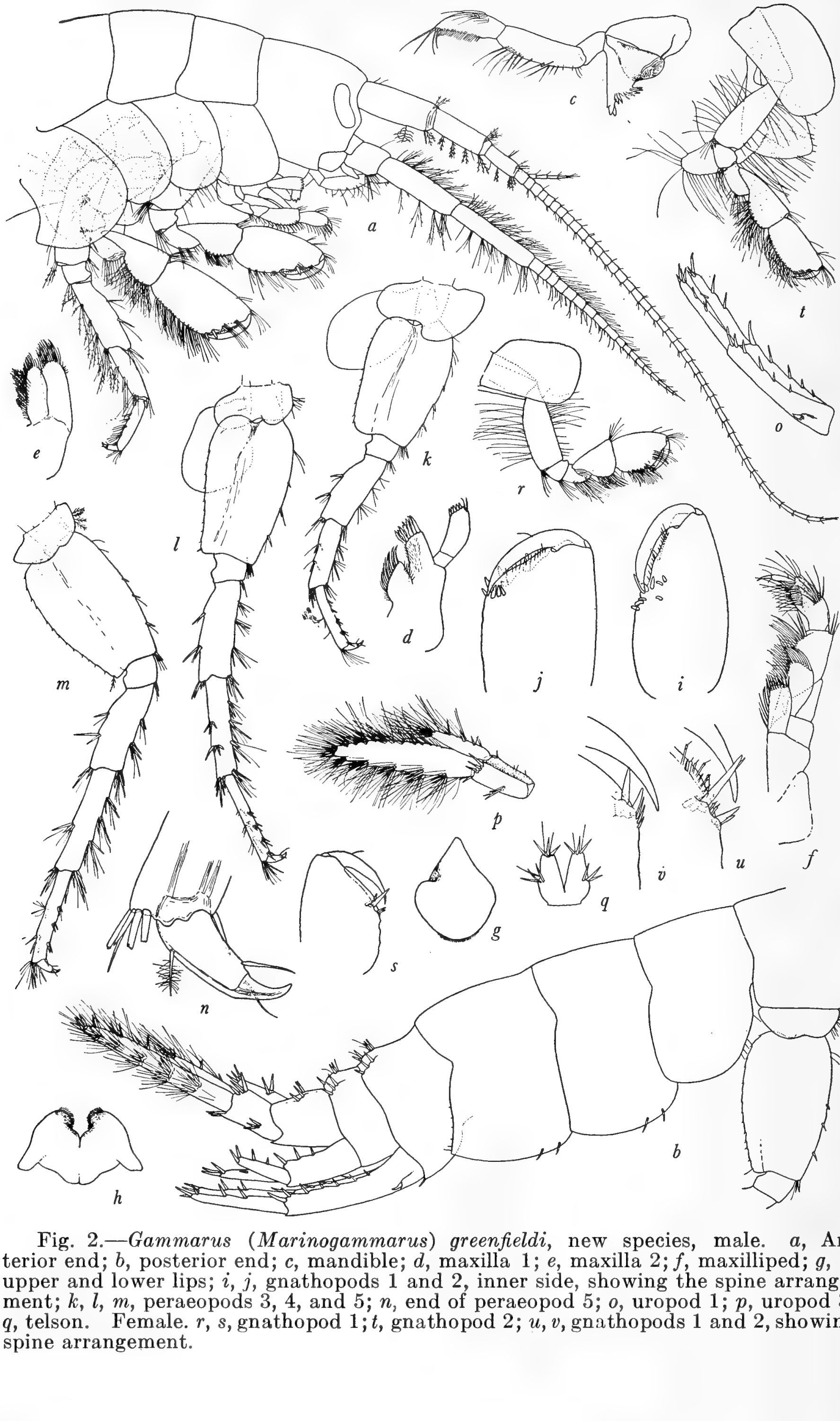

Fig. 2.—*Gammarus* (*Marinogammarus*) *greenfieldi*, new species, male. *a*, Anterior end; *b*, posterior end; *c*, mandible; *d*, maxilla 1; *e*, maxilla 2; *f*, maxilliped; *g*, *h*, upper and lower lips; *i*, *j*, gnathopods 1 and 2, inner side, showing the spine arrangement; *k*, *l*, *m*, peraeopods 3, 4, and 5; *n*, end of peraeopod 5; *o*, uropod 1; *p*, uropod 3; *q*, telson. Female. *r*, *s*, gnathopod 1; *t*, gnathopod 2; *u*, *v*, gnathopods 1 and 2, showing spine arrangement.

not perceptible. Maxilliped with inner plate reaching to about the middle of first joint of palp, armed distally with three spine-teeth and a row of spines which is continued down the inner margin; outer plate reaching to about the middle of the second joint of the palp, armed distally with long, curved spines and along the upper half of the inner edge with spine-teeth; palp well developed, outer margin of third joint produced into a short lobe whose inner margin extends obliquely down the inside of the joint and is furnished with a row of long setae; dactyl well developed and bearing a sharp nail at the base of which is a short setule.

Side-plates 1–3 deeper than broad, lower margin broadly rounding, and bearing a spinule at the junction with the hind margin; side-plate 4 as broad as deep, rear margin excavate, rear lobe without spinules; side-plates 5 and 6 with shallow front lobe. Gnathopod 1, fifth joint four-fifths as long as sixth, sixth joint with palm very oblique and passing imperceptibly into the hind margin, but defined by one long and one short spine against which the dactyl closes, a stout spine in center of palm, and several short, blunt spines, some of which are curved, situated on inside of joint in the vicinity of the defining spines; dactyl curved, not fitting palm, but apex only resting against palm. Gnathopod 2 larger than gnathopod 1, fifth joint three-fourths as long and not as wide as sixth, sixth joint widest distally, palm oblique and passing into the hind margin by a rounding curve, but defined by a long spine just beyond which is a shorter one, a stout spine on the outside at the center of the palm and another on the outside near the defining spine, three spines on inside opposite the defining spine.

Peraeopods 1 and 2 about equal in length; dactyls rather short and stout, and bearing a well-defined nail, inside margin bearing a seta just before the nail, and the nail bearing a seta on the outside at its base. Peraeopods 3–5 increasing in length consecutively, though 5 is only slightly longer than 4, second joints moderately expanded with lower hind corner forming a decided angle, which is rounding in peraeopod 3 and square in 4 and 5; dactyls like those of peraeopods 1 and 2 except that the seta at the base of the nail is on the inside, owing to the turning forward of the limb.

Metasome segments 2 and 3 with lower hind corner quadrate, not produced, lower margin with two spines, but frequently with only one or none at all. Urosome segments 1 and 2 very slightly raised dorsally. The dorsal spine arrangement of the ural segments is quite variable, but the most frequent arrangement appears to be: segment 1, a pair of spines on either side of the median line near the center and one spine on either side of the median line at the rear margin, and three lateral spines obliquely placed on either side; segment 2, a pair of spines on either side of the median line near the center, one spine centrally placed on rear margin and three lateral spines obliquely placed on either side; segment 3, one spine on either side of the median line near rear margin and two lateral spines on either side, no rear marginal spines. Segment 1 has also a spine at the lower lateral corner at the base of uropod 1.

Uropod 1 extending farther back than 2; peduncle, besides the upper marginal and distal spines, has a prominent spine at the lower margin near its base; rami subequal and about two-thirds the length of the peduncle. Uropod 2, peduncle with three or four spines on upper, outer margin, inner ramus longer than outer and about equal in length to the peduncle. Uropod 3 extending much beyond 1 and 2; outer ramus about two and one-half times the length of the peduncle and consisting of only one joint; inner ramus very nearly one-half the length of the outer; outer ramus bearing groups of spines and setae on outer and inner margins and apex, but the spines on inner margin confined to the upper half; apex bearing four spines; inner ramus bearing spines and setae only on the inner margin and apex. All the setae of uropod 3 are simple and not plumose. Telson as broad as long, cleft nearly to base and reaching to about the end of the peduncle of uropod 3, a group of three spines at the center of the lateral margins and three spines and a few setae on the apex of each lobe. Length, 19 mm.

Type.—A male collected by Mr. Ray Greenfield from a small pool at Pebbly Beach, near Gloucester, Massachusetts, June 20, 1929. U. S. Nat. Mus. no. 75670.

Female.—Like the male in general, but smaller, Gnathopod 1 with fifth and sixth joints shorter than in the male, palm oblique, passing into the hind margin by a rounding curve, and defined on the outside by a spine beyond which are two smaller spines; on the inside, opposite the longer defining spine, is a spine at the base of which are two smaller ones. Gnathopod 2 slenderer than in the male; fifth joint as long as or a little longer than sixth; sixth joint widest in the middle, at which point it is as wide as the fifth, palm less oblique than in the male, evenly convex and passing into the hind margin by a rounding curve, defined by a spine beyond which is a shorter spine and several slender spinules, a pair of spines on inside of palm opposite the shorter outer spine, no spine in center of palm. Length, 15 mm.

This species belongs to the new subgenus *Marinogammarus,* recently created by Dr. A. Schellenberg.[2] This subgenus contained only two species, *G. marinus,* known from Europe as far north as the White Sea, British Isles, Faröe Islands, and the northeast coast of the United States, and *G. locustoides,* known from the northwest coast of North America and the northeast coast of Asia. The present species differs from the other two by the absence of the second joint to the outer ramus of uropod 3, and by the presence of a very well defined lower anterior angle to the second joint of peraeopods 3–5. In *G. marinus* the outer ramus of uropod 3 possesses a very well developed second joint, and in *G. locustoides* the second joint is very small and inconspicuous, but in *G. greenfieldi* the second joint is entirely absent.

Mr. Ray Greenfield, while visiting the Massachusetts coast near Gloucester during the summer of 1929, found this amphipod to be a very abundant inhabitant of the intertidal zone and rock pools left by the receding tide. He made a very fine collection, including individuals of all sizes, for the the National Museum, and I am therefore naming this species for him.

There are in the National Museum collection specimens of *Gammarus greenfieldi* from Frenchman's Bay, and Heron Island, Lincoln County, Maine; Rye Beach and Isles of Shoals, New Hampshire; Gloucester and Cohasset, Massachusetts.

[2] Zoologischer Anzeiger, Bd. 117, heft 11/12, p. 270. 1937.

MAMMALOGY.—*New pocket gophers of the genus* Thomomys *from Arizona and Utah.*[1] E. A. GOLDMAN, Bureau of Biological Survey.

Resumed studies of the pocket gophers of the genus *Thomomys* in Arizona have led to the decision that several additional subspecies of widely dispersed, and extremely plastic, *Thomomys bottae* group must be recognized. It has also become evident that several well-marked geographic races have hitherto been included in the territory assigned to *Thomomys fossor*, west of the Colorado River in Arizona and Utah. These conclusions are based on studies of numerous specimens recently acquired by the Bureau of Biological Survey, supplemented by the examination of pertinent material in other museums, thus affording a clearer concept of many complex regional relationships. Many gaps in our knowledge of the forms of the genus in Arizona alone still remain, however, to be filled by coördinated field and laboratory investigations.

I am especially indebted to Laurence M. Huey, Curator of Mammals and Birds, Natural History Museum, San Diego, California, and to Dr. Joseph Grinnell, Director, Museum of Vertebrate Zoology, Berkeley, California, for the privilege of reviewing material in their charge. Mr. Huey has conducted several expeditions to Arizona; and under direction of Dr. Grinnell, extensive mammal collections, including pocket gophers, were made by Miss Annie M. Alexander and Dr. Seth B. Benson in many parts of the State.

Thomomys fossor kaibabensis, subsp. nov.

Kaibab Pocket Gopher

Type.—From DeMotte Park, Kaibab Plateau, Coconino County, Arizona (altitude 9,000 feet). No. 262891, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, September 10, 1937. Original number 443.

Distribution.—Apparently restricted to the Kaibab Plateau.

General characters.—A large, comparatively light-colored subspecies of the *Thomomys talpoides-fossor-quadratus* group. Resembling typical *Thomomys fossor* of southwestern Colorado, but larger, color less rufescent, near sayal brown instead of mikado brownish; skull differing in detail, especially the smaller interparietal. Similar to *Thomomys uinta* of the Uinta Mountains, northern Utah, in color over dorsum, but sides of body and under parts more buffy, less grayish; skull larger, more elongated and presenting other differential features. Not very unlike *Thomomys quadratus fisheri* of northeastern California and northern Nevada, but very much larger and color darker, the dorsum more profusely mixed with black; cranial details distinctive.

[1] Received April 30, 1938.

Color.—*Type* (worn pelage): Upper parts near "sayal brown" (Ridgway, 1912), moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; anterior part of body irregularly flecked with white, a character appearing sporadically in the group and with little or no taxonomic significance; under parts overlaid with pinkish buff, the dark under color showing through; muzzle blackish; ears black, flecked with white; postauricular areas deep black; feet white; tail brownish above on basal two-thirds, white below, becoming white all around toward tip.

Skull.—Similar to that of *fossor* but larger; zygomata more widely spreading; interparietal smaller; posterior border of palate more extended and shelf-like; auditory bullae larger; molariform teeth similar, but upper incisors broader, less recurved. Somewhat like that of *uinta,* but larger, less flattened, more convex in upper outline; rostrum and nasals longer, the nasals usually truncate or slightly rounded instead of deeply emarginate posteriorly; premaxillae less prolonged beyond nasals posteriorly; interparietal relatively smaller; posterior border of palate more extended and shelf-like; auditory bullae much larger; molariform teeth similar; upper incisors broader, less procumbent. Somewhat similar in general form to that of *fisheri,* but contrasting strongly in much greater size; premaxillae relatively narrower, less prolonged beyond ends of nasals posteriorly; palatal shelves more extended posteriorly; auditory bullae larger; dentition similar.

Measurements.—*Type:* Total length, 238 mm; tail vertebrae, 58; hind foot, 31. An adult male topotype: 225; 64; 31. Average of four adult female topotypes: 223 (215–230); 59 (57–64); 30 (29–31). *Skull* (type [♂], and an adult female topotype): Occipitonasal length, 41.7, 39.5; zygomatic breadth, 25.1, 22.9; breadth across squamosals (over mastoids), 20.6, 19.5; interorbital constriction, 5.7, 6.4; length of nasals, 16.6 15.2; interparietal, 7×5.6, 8.9×5.3; maxillary toothrow (alveoli), 7.7, 7.6.

Remarks.—General comparisons indicate that numerous forms, including *fossor* and *quadratus,* differ only subspecifically from *talpoides,* but a new group alignment should be based on more complete studies than I have made. *Thomomys fossor* has, hitherto, been accorded an extensive range west of the Colorado and Green rivers in southern Utah and northwestern Arizona. Additional material, recently collected, now indicates that specimens from the region mentioned must be assigned to other subspecies. *T. f. kaibabensis* is readily distinguished from *fossor* by the combination of large size and well-marked cranial features, but exhibits a similarity in pattern of characters indicating close alliance.

Specimens examined.—Total number, 23, all from Kaibab Plateau, Arizona, as follows: Bright Angel Spring, 3; DeMotte Park (type locality), 18; Greenland Spring, 1; Jacob Lake, 1.

Thomomys fossor parowanensis, subsp. nov.

Parowan Mountains Pocket Gopher

Type.—From Brian Head, Parowan Mountains, Iron County, Utah (altitude 11,000 feet). No. 158072, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by W. H. Osgood, September 8, 1908. Original number 3483.

Distribution.—High mountains of southwestern Utah.

General characters.—Closely resembling *Thomomys fossor kaibabensis* of northwestern Arizona externally; color about the same, but decidedly smaller, the difference in size most obvious in the skull; cranial details different. Similar to *Thomomys uinta* of the Uinta Mountains in size, and in color over dorsum, but sides of body more buffy, less grayish; rostrum much longer. Much larger and darker than *Thomomys quadratus fisheri* of northeastern California; skull differing in proportions.

Color.—*Type* (acquiring winter pelage): Upper parts in general near "sayal brown" (Ridgway, 1912), brightest and approaching "cinnamon" on top of head, moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; under parts evenly overlaid with pinkish buff; muzzle blackish; ears and postauricular areas deep black; feet white; tail light brownish above and below on basal two-thirds, becoming white all around toward tip.

Skull.—Very similar in general to that of *kaibabensis* in general form, but distinctly smaller; rostrum and nasals long, the nasals truncate or slightly rounded posteriorly as in *kaibabensis;* auditory bullae relatively smaller; maloriform teeth similar, but incisors narrower. Similar in size to that of *uinta,* but rostrum and nasals longer, the nasals truncate or slightly rounded posteriorly, instead of deeply emarginate as usual in *unita;* premaxillae less extended posteriorly beyond ends of nasals; interparietal smaller; dentition lighter, the upper incisors curved more directly downward (slightly procumbent in *uinta*). Compared with that of *T. q. fisheri* the skull is larger, with longer rostrum and nasals; auditory bullae relatively larger; dentition similar, but molariform teeth comparatively light.

Measurements.—*Type:* Total length, 228 mm; tail vertebrae, 64; hind foot, 29. An adult male topotype: 228; 74; 31. An adult female topotype: 206; 58; 29. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 38.1, 36.5; zygomatic breadth, 21, 19.7; breadth across squamosals (over mastoids), 18.4, 17; interorbital constriction, 5.8, 5.7; length of nasals, 14.5, 12.8; interparietal, 7.8×4.8, 7.8×4.9; maxillary toothrow (alveoli), 7.7, 6.8.

Remarks.—*Thomomys fossor parowanensis* is more closely allied to *kaibabensis* than to any other known form, but the smaller size and cranial features pointed out are separative. It requires no close comparison with *fossor, uinta,* or *fisheri.*

Specimens examined.—Total number, 16, all from Utah, as follows: Beaver (or Tushar) Mountains, 10; Buckskin Valley, Iron County, 1; Panguitch Lake, 1; Parowan Mountains (type locality), 4.

Thomomys fossor moorei, subsp. nov.

Type.—From one mile south of Fairview, Sanpete County, Utah (altitude 6,000 feet). No. 248222, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by A. W. Moore, February 19, 1928. X-catalog number 24799.

Distribution.—San Pete Valley and adjoining mountains of central Utah.

General characters.—Approaching *Thomomys uinta* of the Uinta Mountains; size similar but color paler, the upper parts less mixed with black; skull differing in greater length of rostrum and other features. Similar in size to *Thomomys fossor parowanensis* of the Parowan Mountains, but color brighter, more rufescent, the dorsum less modified by black; skull broader, with nasals deeply emarginate posteriorly.

Color.—*Type* (winter pelage): Upper parts in general between "cinnamon" and "sayal brown" (Ridgway, 1912), the top of head and back finely overlaid with dusky hairs that scarcely alter the general tone; flanks, forearms, thighs, and under parts "pale pinkish buff"; muzzle brownish, except a small white patch on top of nose; chin whitish; ears and postauricular patches deep black; feet white; tail very light brownish above, white below. The summer pelage is distinctly darker, near "mikado brown," slightly mixed with black.

Skull.—Most closely resembling that of *uinta*, but rostrum and nasals longer, the nasals deeply emarginate posteriorly as in *uinta;* braincase slightly broader; interparietal smaller; dentition usually lighter, the upper incisors longer and curving more directly downward (curving slightly forward in *uinta*). Compared with that of *parowanensis* the skull is straighter in upper profile, more depressed across anterior roots of zygomata; nasals deeply emarginate instead of rounded posteriorly; upper incisors longer.

Measurements.—*Type:* Total length, 220 mm; tail vertebrae, 67; hind foot, 29. Average of five adult male topotypes: 217 (203–236); 64 (52–72); 29 (28–31). Average of five adult female topotypes: 205 (198–207); 60 (55–64); 26 (25–27). *Skull* (type and an adult female topotype): Occipitonasal length, 37.7, 35.4; zygomatic breadth, 22, 22.5; breadth across squamosals (over mastoids), 18.6, 18.8; interorbital constriction, 6.5, 6.5; length of nasals, 14.6, 12.6; interparietal, 5.9×3.9, 6.2×3.9; maxillary toothrow (alveoli), 7.3, 7.2.

Remarks.—*Thomomys fossor moorei* is more closely allied to *T. uinta* than to any of the other forms of the group but, as shown by cranial details, it tends to bridge a rather wide gap between *uinta* and *parowanensis.* Specimens from 10,000 feet altitude near Ephraim are darker in color, but agree closely in cranial details, and it seems best to refer them to *moorei.* This new form is based upon a fine series of specimens taken at the type locality by A. W. Moore for whom it is named.

Specimens examined.—Total number, 32, all from central Utah, as follows: Ephraim, 5; Fairview (type locality), 27.

Thomomys fossor levis, subsp. nov.

Fish Lake Plateau Pocket Gopher

Type.—From Seven Mile Flat, five miles north of Fish Lake, Fish Lake Plateau, Sevier County, Utah (altitude 10,000 feet). No. 158079, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by W. H. Osgood, October 1, 1908. Original number 3616.

Distribution.—Known only from the type locality.

General characters.—Similar in general to *Thomomys fossor parowanensis* of the Parowan Mountains; size and color about the same; skull differing in detail, notably the reduction of the interparietal in antero-posterior dimension. Similar in size to *T. f. moorei* of central Utah, but color darker, upper parts more mixed with black and under parts a deeper buffy tone in winter pelage; cranial features, especially the shortness of the interparietal and the rounded posterior ends of the nasals, distinctive.

Color.—*Type* (acquiring winter pelage): Upper parts near "sayal brown" (Ridgway, 1912), deepest on top of head, moderately mixed with black, paling gradually to "pinkish buff" along lower part of flanks and on forearms and thighs; under parts overlaid with pinkish buff, except a patch on chin which is pure white to roots of hairs; muzzle blackish; ears and postauricular spots deep black; feet white; tail light brownish on basal half above and below, white all around thence to tip.

Skull.—Rather closely resembling that of *parowanensis*, but interparietal less extended antero-posteriorly, laterally pointed elliptical instead of triangular, there being little trace of the anterior angle usually well developed in the group; ascending branches of premaxillae usually less projecting beyond posterior ends of nasals; dentition similar, but upper incisors shorter. Compared with that of *moorei* the skull is similar in general size, but more convex in upper outline and it differs in form of interparietal as from *parowanensis;* nasals rounded posteriorly, instead of deeply emarginate; zygomata less widely spreading; ascending branches of premaxillae less prolonged beyond posterior ends of nasals; upper incisors shorter, more strongly recurved.

Measurements.—*Type:* Total length, 208 mm; tail vertebrae, 55; hind foot, 28. *Skull* (type): Occipitonasal length, 35.7; zygomatic breadth, 20; breadth across squamosals (over mastoids), 18.7; interorbital constriction, 6.1; length of nasals, 13.3; interparietal, 8.2×3.1; maxillary toothrow (alveoli), 7.

Remarks.—*Thomomys fossor levis* is closely allied to *T. f. parowanensis*, but the peculiar form of the interparietal readily separates it from any of the subspecies of the group.

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

Thomomys bottae nicholi, subsp. nov.

Shivwits Plateau Pocket Gopher

Type.—From 20 miles south of Wolf Hole (road to Parashouts), Shivwits Plateau, Mohave County, Arizona (altitude 5,000 feet). No. 262864, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, August 6, 1937. Original number 363.

Distribution.—Shivwits Plateau region, on the terrace between the Hurricane Ledge and Grand Wash Cliffs, north of the Grand Canyon, northwestern Arizona; north to St. George, Utah.

General characters.—A light buff-colored subspecies of medium size. Closely allied to *Thomomys bottae trumbullensis* of the neighboring Mount Trumbull lava area, but much paler buff, the dorsum much less mixed with black; cranial characters nearly identical. Similar in general to *Thomomys bottae virgineus* of the Virgin River Valley below the break through the Beaverdam Mountains, but usually somewhat darker, and cranial details, notably the more widely and evenly spreading zygomata distinctive. Differing from *Thomomys bottae planirostris* of Zion National Park, Utah, in smaller size, less tawny coloration, and less massive skull.

Color.—*Type* (acquiring fresh pelage): Upper parts near "cinnamon buff" (Ridgway, 1912), thinly mixed with black on head and over back, paling gradually to "pinkish buff" on flanks, forearms and thighs; under parts overlaid with "pale pinkish buff," palest on inguinal region, varying to near "cinnamon buff" on throat and chest; muzzle blackish; feet white; tail thinly clothed all around with whitish hairs. In some other specimens the tail is cinnamon buffy on basal half above.

Skull.—Very closely resembling that of *trumbullensis*. Similar in size to that of *virgineus*, but frontal region broader; zygomata more widely spreading, the sides more nearly parallel, and the jugals not distinctly bowed inward as in *virgineus;* dentition about the same. Compared with that of *planirostris* the skull is less massive; rostrum and nasals decidedly narrower; dentition lighter.

Measurements.—*Type:* Total length, 228 mm: tail vertebrae, 67; hind foot, 29. Two adult male topotypes: 229, 208; 65, 59; 27.5, 28. *Skull* (type): Occipitonasal length, 39.5; zygomatic breadth, 23.9; width across squamosals (over mastoids), 29.7; interorbital constriction, 6.4; length of nasals, 14; interparietal, 5.9×4.4; maxillary toothrow (alveoli). 7.5.

Remarks.—*Thomomys bottae nicholi* occupies the broad terrace along the base of the Hurricane Ledge, extending westward toward the top of the Grand Wash Cliffs. Both of these topographic features mark great "fault" lines extending north and south across the Grand Canyon.

T. b. nicholi agrees closely in cranial characters with *trumbullensis* which inhabits the lava area surrounding Mount Trumbull, on the higher plateau, but is readily distinguished by paler coloration. Specimens from St. George, Utah, are more tawny in tone and suggest gradation toward *planirostris.*

This new subspecies is dedicated to Andrew A. Nichol of the University of Arizona, botanist, zoologist, master workman in Nature's laboratory, who assisted in the collection of specimens.

Specimens examined.—Total number, 19, as follows:

Arizona: Diamond Butte (3 miles northwest), 1; Wolf Hole, 6 (20 miles south, 4; 6 miles north, 2).

Utah: St. George, 12.

Thomomys bottae alienus, subsp. nov.

Upper Gila Valley Pocket Gopher

Type.—From Mammoth, San Pedro River, Pinal County, Arizona (altitude 2,400 feet). No. 261926, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by E. A. Goldman, November 4, 1936. Original number 23746.

Distribution.—San Pedro River Valley, and upper part of Gila River Valley in southeastern Arizona and southwestern New Mexico.

General characters.—A large, rich rufescent subspecies of the *Thomomys bottae* group; mammae, pectoral two pairs, inguinal two pairs. Similar in general to *Thomomys bottae cervinus* of the Salt River Valley, but smaller; upper parts near "cinnamon" (Ridgway, 1912), instead of "vinaceous buff"; skull smaller, less angular. Approaching *Thomomys bottae opulentus* of the Rio Grande Valley, southern New Mexico, in size and coloration; cranial characters, especially the more slender rostrum and less recurved upper incisors, distinctive. Similar to *Thomomys bottae toltecus* of the Casas Grandes River Valley, northwestern Chihuahua, but color more vivid; contrasting also in cranial details notably the lower braincase and less procumbent upper incisors. Decidedly larger, less distinctly tawny than *Thomomys bottae* *mutabilis*, of the Verde River Valley. Differing from *Thomomys bottae extenuatus* of the Sulphur Springs Valley region, mainly in decidedly larger size.

Color.—*Type* (acquiring winter pelage): Upper parts near "cinnamon" (Ridgway, 1912), moderately mixed with black over top of head and back, becoming lighter, the dark hairs thinning out, and near "cinnamon buff" on flanks, forearms and thighs; under parts overlaid with "pinkish buff," varying to cinnamon buff on the median area from throat to chest; muzzle blackish; feet white; tail blackish above, on basal three-fourths, becoming whitish below, and white all around near tip. Color varying over dorsum in other specimens from "cinnamon" heavily mixed with black to nearly clear "tawny."

Skull.—Similar to that of *cervinus*, but smaller, less angular; auditory bullae smaller, less inflated; dentition lighter. Resembling that of *opulentus*, but flatter, less convex in upper outline, the nasals less depressed anteriorly; rostrum narrower; bullae usually smaller; upper incisors narrower less recurved. Compared with that of *toltecus* the skull is similar in size, but braincase broader, lower, and flatter; supraoccipital region more deeply concave; upper incisors less procumbent, curving nearly directly downward. Not very unlike that of *mutabilis*, but considerably larger and heavier. Differing from that of *extenuatus* mainly in larger size, and less inflated auditory bullae.

Measurements.—*Type:* Total length, 247 mm; tail vertebrae, 75; hind foot, 33. Average of four adult male topotypes: 240 (230–254); 68 (58–80); 32 (30–33.5). Average of four adult female topotypes: 212 (207–218); 58 (57–59); 28 (27.5–28.5). *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 41.4, 37.9; zygomatic breadth, 27, 24.8; width across squamosals (over mastoids), 21.4, 20.2; interorbital constriction, 6.9, 7.3; length of nasals, 14.2, 13.5; maxillary toothrow (alveoli), 8.3, 8.1.

Remarks.—*Thomomys bottae alienus* appears to be restricted to the valleys of the upper part of the Gila River and some of its affluents. It undoubtedly intergrades with obviously related forms inhabiting the higher neighboring areas. In specimens from Duncan, Arizona, the upper incisors tend to project forward and suggest gradation toward *toltecus*, but in cranial details, and in coloration agree closely with *alienus*.

Specimens examined.—Total number, 52, as follows:

Arizona: Duncan, 9; Mammoth (type locality), 9; Safford, 31.

New Mexico: Redrock, 3.

Thomomys bottae parvulus, subsp. nov.

Intermountain Pocket Gopher

Type.—From pass between Santa Catalina and Rincon Mountains, Pima County, Arizona (altitude 4,500 feet). No. 262813, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Luther C. Goldman, June 5, 1937. Original number 213.

Distribution.—Known only from the vicinity of the type locality.

General characters.—A very small, tawny subspecies; mammae, pectoral two pairs, inguinal two pairs. Allied to *Thomomys bottae catalinae* of the upper slopes of the closely adjoining Santa Catalina Mountains, but much smaller, and color lighter, more inclining toward tawny. Somewhat similar to *T. b. extenuatus* of the Sulphur Springs Valley, and to *T. b. modicus* of the lower elevations to the west in color, but contrasting strongly in diminutive size with both.

Color.—*Type* (summer pelage): Upper parts near "cinnamon" (Ridgway, 1912), darkened on forehead and median line of rump by black-tipped hairs, paling through "pinkish cinnamon" to "cinnamon buff" along lower part of flanks, and on forearms and thighs; under parts overlaid with cinnamon buff; muzzle blackish; ears and small postauricular patches deep black; feet white; tail light brownish above, whitish below. Upper parts varying in other specimens from a more profuse admixture of black to nearly pure cinnamon. In one individual most of the body is irregularly flecked with white.

Skull.—Similar in general to that of *catalinae*, but much smaller; rostrum and nasals relatively shorter. Not very unlike those of *extenuatus* and *modicus* in general form, but so much smaller that close comparison is not required.

Measurements.—*Type:* Total length, 200 mm; tail vertebrae, 45; hind foot, 26. Two adult male topotypes: 203, 211; 60, 57; 27, 25. Two adult female topotypes: 190, 188; 56, 55; 25, 25. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 35.9, 34.1; zygomatic breadth, 22.9, 20.8; width across squamosals (over mastoids), 18.4, 17.4; interorbital constriction, 6.3. 6.3, length of nasals, 11.9, 11.1; maxillary toothrow (alveoli), 7, 6.8.

Remarks.—*Thomomys bottae parvulus* is a diminutive form apparently restricted in range to gravelly pockets in the granitic formation in the pass between the Santa Catalina and Rincon Mountains. Rock exposures in the vicinity may be effective barriers limiting distribution. Close alliance with the neighboring forms is evident, but the departure in size is remarkable.

Specimens examined.—Thirteen, all from the type locality.

Thomomys bottae hueyi, subsp. nov.

Rincon Mountains Pocket Gopher

Type.—From Spud Rock Ranger Station, Rincon Mountains, Pima County, Arizona (altitude 7,400 feet). No. 10088, ♂ adult, skin and skull collection San Diego Society of Natural History; collected by Laurence M. Huey, June 17, 1932.

Distribution.—Known only from the upper slopes (7,400 to 7,900 feet) of the Rincon Mountain.

General characters.—Closely allied to *Thomomys bottae catalinae,* of the adjoining Santa Catalina Mountains; size and cranial features about the same; color decidedly paler, the upper parts less profusely mixed with black and the under parts a lighter buff tone. Similar in general to *Thomomys bottae parvulus* of the pass, only a few miles away, between the Rincon Mountains and the Santa Catalina Mountains, but decidedly larger and usually darker in color. Very similar in color to *Thomomys bottae grahamensis* of the Graham Mountains; differing in slight but appreciable cranial details, including the narrower interorbital region. Color less inclined toward tawny, and skull less massive than in *Thomomys bottae extenuatus* of the Sulphur Springs Valley.

Color.—*Type* (summer pelage): Upper parts near "cinnamon" (Ridgway, 1912), thinly and inconspicuously mixed with black, paling gradually to "cinnamon buff" along lower part of sides, and on forearms and thighs; under parts overlaid with cinnamon buff: muzzle blackish; ears and postauricular patches black; feet white; tail thinly clothed with dull whitish hairs above and below. Upper parts varying in other specimens to a heavier admixture of black.

Skull.—About as in *catalinae.* Distinctly larger than that of *parvulus.* Very similar to that of *grahamensis,* but frontals narrower, supraorbital region rising less steeply, more inclined forward, instead of bulging posteriorly over foramen magnum. Compared with *extenuatus* the skull is slenderer in proportions; braincase narrower; auditory bullae smaller.

Measurements.—*Type:* Total length, 215 mm; tail vertebrae, 64; hind foot, 27. Two adult male topotypes: 220, 220; 62, 66; 30, 29. Two adult female topotypes: 198, 196; 60, 60; 26, 27. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 37, 38; zygomatic breadth, 22.5, 22.9; width across squamosals (over mastoids), 18.7, 23; interorbital constriction, 6.5, 6.4; length of nasals, 13.4, 13.6; maxillary toothrow (alveoli), 7.7, 7.9.

Remarks.—*Thomomys bottae hueyi* is not very unlike *catalinae,* but appears to be isolated by the interposed range of *parvulus,* and the difference in color is distinctive. It is named for the collector of the fine series of specimens, Laurence M. Huey, curator of mammals and birds, Natural History Museum, San Diego, in recognition of his important contributions to knowledge of the fauna of the Southwest.

Specimens examined.—Total number, 37, all from the Rincon Mountains, Arizona, as follows: Spud Rock Ranger Station (7,400 feet), 20; Manning Camp (7,900 feet), 17.

Thomomys bottae patulus, subsp. nov.

Hassayampa Valley Pocket Gopher

Type.—From bottomland along Hassayampa River, two miles below Wickenburg, Maricopa County, Arizona (altitude, 2,000 feet). No. 262899, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Luther C. Goldman, September 16, 1937. Original number 460.

Distribution.—Known only from the type locality, but probably has an extensive range along the valley of the Hassayampa River.

General characters.—A large cinnamon or cinnamon buff subspecies; mammae, pectoral two pairs, inguinal two pairs. Somewhat similar to *Thomomys bottae cervinus* of the Salt River Valley, but smaller; upper parts more vivid in color, near "cinnamon" or "cinnamon buff" (Ridgway, 1912), instead of "vinaceous buff" or "avellaneous"; skull less angular. Similar to *Thomomys bottae mutabilis* of the Verde River Valley, and *Thomomys bottae desitus* of the Big Sandy River Valley, but size larger and color much paler than either. Similar in size to *Thomomys harquahalae* of the Ranegras Plain to the westward, but color richer buff; cranial characters indicating no very close relationship.

Color.—*Type* (acquiring fresh pelage): Upper parts near "cinnamon" (Ridgway, 1912), mixed with black on top of head, but only slightly darkened by black-tipped hairs over dorsum, passing gradually through "cinnamon buff" to "pinkish buff" along lower part of sides, and on forearms and thighs; under parts overlaid with pinkish buff, varying to near "pinkish cinnamon" on chest and throat; muzzle blackish; ears encircled with black; feet white; tail light brownish above, dull whitish below.

Skull.—Similar in general to that of *cervinus*, but smaller, less angular, relatively shorter and broader; temporal ridges less upturned; premaxillae less prolonged posteriorly beyond nasals; interparietal relatively shorter and broader; mastoid and auditory bullae smaller, the auditory bullae more rounded anteriorly (somewhat angular or truncated anteriorly in *cervinus*). Resembling that of *mutabilis*, but larger. Compared with that of *desitus* the skull is larger, relatively broader and heavier. Similar in size to *harquahalae*, but zygomata less widely spreading; nasals and frontals less depressed along the median line between posterior ends of premaxillae (tending toward concavity in transverse section in adult males of *harquahalae*); upper incisors more abruptly decurved, instead of strongly procumbent.

Measurements.—*Type:* Total length, 245 mm; tail vertebrae, 64; hind foot, 30. An adult male and an adult female topotype: 240, 215; 80, 60; 31, 29. *Skull* (type [♂] and an adult female topotype): Occipitonasal length, 40.8, 36.5; zygomatic breadth, 27.4, 23.3; width across squamosals (over mastoids), 22, 18.5; interorbital constriction, 7, 6.8; length of nasals, 14.3, 12.8; maxillary toothrow (alveoli), 8.3, 8.2.

Remarks.—*Thomomys bottae patulus* may be restricted to the alluvial soil along the Hassayampa River Valley, as the distribution of pocket gophers appears to be discontinuous in the adjoining arid areas. The alliance of this subspecies to the neighboring geographic races is shown, but it differs from all in combination of size, color, and cranial details.

Specimens examined.—Sixteen, all from the type locality.

Thomomys bottae pinalensis, subsp. nov.

Pinal Mountains Pocket Gopher

Type.—From Oak Flat, 5 miles east of Superior, Pinal Mountains, Arizona. No. 245709, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Walter P. Taylor, May 22, 1924. Original number 1667.

Distribution.—Known only from the Pinal Mountains, but may have a wider range in the mountain mass between the Gila and Salt rivers.

General characters.—A very small dark-colored subspecies, with a narrow, weakly developed skull; mammae, pectoral two pairs, inguinal two pairs. Most closely allied to *Thomomys bottae mutabilis* of the adjoining region to the north, but much smaller and darker than usual in that form; skull much smaller, narrower, less massive. Resembling *Thomomys bottae fulvus* of the Mogollon Plateau region in color, but much smaller, and skull presenting about the same differences as from *mutabilis*.

Color.—*Type* (acquiring fresh pelage): Upper parts near "cinnamon" (Ridgway, 1912), mixed with black, the black tending to become predominant along a narrow median line from top of head to rump, becoming gradually lighter and near "cinnamon-buff" on forearms, flanks, and thighs; under parts thinly overlaid with a mixture of "pinkish-buff" and gray, the darker basal color showing through; muzzle blackish, ears encircled with black; feet white; tail light brownish above, whitish below, becoming white all around at tip.

Skull.—Similar in general to those of *mutabilis* and *fulvus*, but much smaller and relatively narrower and slenderer than either; zygomata more strongly convergent anteriorly; maxillary arm of zygoma relatively heavy, but jugal more slender; palate very narrow; auditory bullae small, much as in *fulvus*.

Measurements.—Types: Total length, 195 mm; tail vertebrae, 56; hind foot, 24; weight, 81.6 grams. *Skull* (type): Occipitonasal length, 33; zygomatic breadth, 19.7; width across squamosals (over mastoids), 16.9; interorbital constriction, 6.3; length of nasals, 11.5; maxillary toothrow (alveoli), 6.9.

Remarks.—T. b. pinalensis is based on a single specimen exhibiting characters that along with geographic considerations seem to warrant the recognition of a new subspecies. It requires no close comparison with the much larger, "vinaceous buff" or light fawn-colored animal, *Thomomys bottae cervinus*, inhabiting the Salt River Valley not far to the west.

Obituary

George Bird Grinnell, ethnologist, author and explorer, died at his home, 238 E. 15th Street, New York, on April 11, 1938. Dr. Grinnell was born in Brooklyn, N. Y. Sept. 20, 1849. He received the A.B. degree from Yale University in 1870, the Ph.D. in 1880, and in 1921 was awarded the honorary degree of Litt.D. In the summer of 1870 he accompanied Prof. O. C. Marsh of Peabody Museum on his first expedition to the Far West. Two years later Grinnell accompanied the Pawnee Indians on a buffalo hunt and on these and subsequent expeditions he developed his life long interest in the Indians themselves, and in the conservation of western wild life. From 1874 to 1880 he was assistant in osteology at the Peabody Museum. In the summer of 1874 he went as naturalist with Gen. George A. Custer's first expedition to the Black Hills, and the following summer accompanied Col. William Ludlow on his reconnaissance of Yellowstone Park. In 1885 he discovered Grinnell Glacier in Montana, and it was largely due to his long continued efforts that legislation was later enacted for the establishment of Glacier National Park and for the protection of its wild life and that of the Yellowstone Park. In 1895, at the request of the Blackfoot and Fort Belknap Indians, Dr. Grinnell was appointed United States Commissioner to treat with them for the cession of part of their lands. In 1899 he was a member of the Harriman Expedition to Alaska.

With Col. Theodore Roosevelt he was one of the founders of the Boone and Crockett Club, an organization of sportsmen and game conservationists, whose members later organized the New York Zoological Society. As joint editor with Col. Roosevelt of the Boone and Crockett Club publications, and later as editor and owner of the magazine *Forest and Stream*, Dr. Grinnell exercised a wide influence among sportsmen and naturalists. He was active in various conservation organizations, including the American Game Association of which he was a founder and director; he was chairman of the Council on National Parks, Forests and Wild Life, and president of the National Parks Association. In recognition of his efforts in the cause of conservation he was selected in 1925 as one of the recipients of the Roosevelt Gold Medal for Distinguished Service, presented by Roosevelt Memorial Association.

Dr. Grinnell was the author of a number of popular books on Indian life and on the West. His scientific books and papers, dealing mainly with the Cheyenne, Blackfoot, and Pawnee, have provided valuable information on the customs, traditions, and history of those tribes.

Dr. Grinnell was a member of the Anthropological and Biological Societies of Washington, the Washington Academy of Sciences, American Anthropological Association, and the Archeological Institute of America. He was a fellow of the American Association for the Advancement of Science, American Ethnological Society, American Ornithologists Union, American Society of Mammalogists, and the New York Academy of Sciences. He was also a trustee of Hispanic Society of America, the National Association of Audubon Societies and the New York Zoological Society.

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CRYSTALLOGRAPHY.—*The ray-surface, the optical indicatrix, and their interrelation: a correction.*[1] G. Tunell, Geophysical Laboratory, Carnegie Institution of Washington.

The application of the construction stated by the writer[2] (under Problem I′) for finding the two wave-normals associated with a given ray in a biaxial crystal is limited to the case in which the given ray lies in one of the three principal sections of the indicatrix;[3] the general construction given by Pockels[4] and by Fletcher[5] reduces to the first in this case. The construction stated by the writer (under Problem II′) for finding the two rays associated with a given wave-normal is applicable in the general case as well as in the case of a wave-normal lying in a principal section.

[1] Received June 11, 1938.
[2] Jour. Wash. Acad. Sci., **23**: 332–333. 1933.
[3] It has been pointed out by Wooster (*A text-book on crystal physics*, Cambridge, 1938, p. 131.) that, in general (that is, in the case of a ray not lying in a principal section), the four points on the intersection of the indicatrix and the plane conjugate to the given ray-direction (as a diameter of the indicatrix) from which lines drawn normal to the indicatrix intersect the given ray do not coincide with the ends of the major and minor diameters of the conjugate section, though they are near to them.
[4] *Lehrbuch der Kristalloptik*, Leipzig, 1906, p. 54.
[5] *The optical indicatrix*, London, 1892.

GEOLOGY.—*New formation names used on the geologic map of Frederick County, Maryland.*[1] A. I. Jonas and G. W. Stose, U. S. Geological Survey.

New names have been given to crystalline schists and limestones which will appear on a geologic map of Frederick County and parts of Washington and Carroll Counties, Maryland, to be published by the Maryland Geological Survey as a separate map in advance of the complete report. It is thought desirable, therefore, to publish a brief description of the new formations and their stratigraphic relations. Some of these new names are used also for the same formations in York County, Pennsylvania, in forthcoming reports by the same authors on York County and the Hanover-York district, Pennsylvania.

[1] Published with the permission of the State Geologist of Md. and the Director, Geological Survey, United States Department of the Interior. Received May 14, 1938.

The formations described occur in a belt of crystalline schists, largely argillaceous and arenaceous, which include mica schists, phyllites, marble, and quartzite, together with volcanic flows and tuffs. Their extent and a generalized description of their lithology and their structure were given in a recent paper,[2] but formation names were not used.

Wakefield marble.—This name is applied to a white, finely crystalline marble which underlies and is interbedded with volcanic flows in the western Piedmont of Maryland and York County, Pennsylvania, and in part of this area is beneath and infolded with the albite-chlorite schist facies of the Wissahickon formation. It is named from Wakefield Valley, Carroll County, Maryland. It occurs on the northwestern side of the Peach Bottom syncline. The Cockeysville marble underlies the Wissahickon formation on the southeastern side of that syncline but since the equivalency of the two marbles is not established a new name, Wakefield marble, is given to the marble of the western Piedmont area where it is associated with volcanic rocks not present southeast of the Peach Bottom syncline.

Silver Run limestone.—This is a blue, thin-bedded, argillaceous banded, finely crystalline limestone in which the argillaceous material forms slaty or muscovite partings. It is named from the valley of Silver Run, Carroll County, Maryland, and occurs also in Frederick County, Maryland, and in York County, Pennsylvania. It occurs largely northwest of the Wakefield marble, and in places seems to grade into the marble and may be equivalent to it. It is infolded with and underlies Marburg schist and Ijamsville phyllite, to be described later.

Ijamsville phyllite.—This rock is a blue, green, or purple phyllitic slate probably of tuffaceous origin, named from Ijamsville, Frederick County, Maryland, where it has been quarried for roofing slate because of its well developed cleavage. It is widespread in Frederick County and occurs also in Carroll County, Maryland, where it is part of a volcanic series including green metabasalt, blue metaandesite, and purplish-red aporhyolite flows. In part it contains flattened amygaloidal blebs, but in many places close folding and metamorphism have obscured its volcanic character. It is composed of finely crystalline muscovite, chlorite or chloritoid, and quartz, and is banded with ilmenite or iron oxide dust, visible only under the microscope. It contains purplish-red or purplish-blue quartzite layers and blue slate banded with thin quartzose layers, thought to be pyroclastics.

Urbana phyllite.—The Urbana phyllite is a green, ferruginous, quartzose, chlorite phyllite with green slaty layers, and is probably a pyroclastic facies of the associated metabasalt. It contains many sericitic quartzite layers, some thin calcareous layers, and infolded quartzite similar to that associated with the Ijamsville phyllite. It has been mapped in a belt 4 miles wide adjacent to Sugarloaf Mountain and has been traced a maximum of 12 miles northeastward in narrow tongues, where it apparently interfingers with the metabasalt. It is named from Urbana, Frederick County, Maryland. It is overlain by the Sugarloaf Mountain quartzite on Sugarloaf Mountain.

Marburg schist.—Lying northeast, east, and southeast of the area of Ijamsville phyllite, volcanic flows, and Wakefield marble is a formation

[2] JONAS, A. I. *Tectonic studies in the crystalline schists of southeastern Pennsylvania nd Maryland.* Amer. Jour. Sci. **34**: 364–367, 376–383. 1937.

similar to the Ijamsville phyllite and here called the Marburg schist. It is probably in part equivalent to the Ijamsville phyllite, but is injected along the layers by quartz and is closely folded and volcanic textures that it may have contained are destroyed by this folding and metamorphism. It is a blue and green muscovite-chlorite schist and chloritoid schist with infolded quartzite beds. It is named from Marburg, York County, Pennsylvania, and is stratigraphically continuous from Pennsylvania into Carroll County, Maryland. In York County[3] the Marburg schist lies northwest of the albite-chlorite schist facies of the Wissahickon, and extends northeastward into the area of the McCalls Ferry quadrangle where it is much coarser in grain and contains abundant muscovite and was included with the Wissahickon formation in an earlier report.[4] The Marburg schist has been separated from the Wissahickon formation which lies southeast of it because it is finer in grain, and in southern York County and in Maryland it resembles the Ijamsville phyllite and apparently is derived also from volcanic tuff. It may be in part equivalent to the more coarsely crystalline albite-chlorite schist facies of the Wissahickon formation which lies to the southeast.

Sugarloaf Mountain quartzite.—This quartzite caps Sugarloaf Mountain in Frederick County, Maryland. It consists of massive white quartzite, about 200 feet thick, which caps Sugarloaf Peak, lower massive quartzite, 100–150 feet thick, which makes prominent cliffs and ledges on the upper slopes of the peak and forms the summits of most of the lower peaks and ridges, and thinner-bedded quartzites about 150 feet thick between the two massive ledges. The quartzite is composed of densely packed white or blue, small, rounded quartz grains in a fine siliceous matrix with scanty argillaceous material now crystallized as muscovite. The oolitic-like sand grains are probably wind blown and the formation may be terrestrial. It overlies poorly exposed Urbana phyllite, a green ferruginous quartzose, chlorite phyllite, which contains many thinner quartzite beds.

This formation was named Sugarloaf sandstone by Keyes.[5] Because the name Sugarloaf arkose, of Triassic age, has become established as a formation name in Massachusetts it is thought advisable, therefore, to use the name Sugarloaf Mountain quartzite for the formation in Frederick County, Maryland.

This quartzite is believed to be of Cambrian age, but in the absence of fossils and of any comparable Cambrian sequence with which it can be compared, the age assigned is Cambrian (?).

The formations named and briefly described above are, with the exception of the Sugarloaf Mountain quartzite, a part of the Glenarm series.[6] From relations established in Virgina,[7] it is known that the Peters Creek formation, and hence the Glenarm series, is pre-Cincinnatian in age.

[3] Op. cit. p. 366.

[4] KNOPF, E. B., and JONAS, A. I. *Geology of the McCalls Ferry-Quarryville district, Pennsylvania.* U. S. Geol. Survey Bull. **799**: 25–33. 1929.

[5] KEYES, C. R. *A geological section across the Piedmont Plateau in Maryland.* Geol. Soc. Amer. Bull. **2**: 320–322. 1891.

[6] KNOPF, E. B. and JONAS, A. I. *Stratigraphy of the crystalline schists of Pennsylvania and Maryland.* Am. Jour. of Sci. **5**: 43–49. 1923.

[7] TABER, STEPHEN. *Geology of the Gold Belt in the James River basin.* Virginia Geol. Survey, Bull. **7**: 39–42, pl. 6. 1913.—DARTON, N. H. *Fossils in the Archean rocks of Central Piedmont.* Amer. Jour. Sci. **44**: 50–52. 1892.—JONAS, A. I. *Geological reconnaissance in the Piedmont of Virginia.* Geol. Soc. Amer. Bull. **38**: 841–842. 1927.

The age of the Sugarloaf Mountain quartzite, which overlies rocks of the Glenarm series in Frederick County, Maryland, is thought to be Lower Cambrian but in the absence of known fossils this age is not proved. For this reason the Glenarm series is designated as pre-Cambrian (?) on the map of Frederick County, Maryland and in forthcoming reports on York County, Pennsylvania.

BOTANY.—*Notes on* Cremosperma.[1] C. V. MORTON, National Museum.

In 1935 the writer published a revision[2] of the small genus *Cremosperma* (Gesneriaceae), in which ten species were recognized, all natives of Colombia and Ecuador. At that time no specimen of *C. hirsutissimum* Benth., the type of the genus, was available, but recently the actual type has been studied on loan from Kew. A second specimen of this species is now known, viz., *Kjell von Sneidern* 483, from La Costa, Department of El Cauca, Colombia, Oct. 5, 1935.

In the previous treatment one species, *C. cinnabarinum* (Fritsch) Morton, was referred to *Cremosperma* on the authority of Fritsch, but was regarded as an anomalous element. The type of this has now been studied, through the courtesy of the Botanisches Museum, Berlin, and the writer finds that it may by no means be referred to *Cremosperma* belonging rather to the closely related genus *Besleria*.

An examination of the type of *Besleria cestroides* Fritsch shows that this species must be referred to *Cremosperma*.[3] In the paper above mentioned it would key to *C. album* Morton, from which it is at once distinguished by the lanceolate, long-acuminate leaves; those of *C. album* are orbicular and rounded.

For the privilege of studying the two following new species, the writer is under obligation to the Royal Botanic Gardens, Kew, the New York Botanical Garden, and the Naturhistoriska Rijksmuseet, Stockholm.

Cremosperma sylvaticum Morton, sp. nov.

Herbae 15–30 cm altae, caulibus non ramosis, densissime sericeis, subcrassis; folia opposita subaequalia, longe petiolata, petiolo 1.2–2.8 cm longo, sericeo; lamina foliorum late elliptica, 5.5–9 cm longa, 3.2–5 cm lata, apice obtusa, basi obliqua subrotundata, membranacea pellucido-punctata, crenata, supra pilis paucis flaccidis instructa, subtus in venis subtomentosa, venis primariis

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 14, 1938.

[2] This Journal **25**: 284–291.

[3] **Cremosperma cestroides** (Fritsch) Morton, comb. nov. (*Besleria cestroides* Fritsch, Notizbl. Bot. Gart. Berlin **11**: 962. 1934.)

6–8-jugis; pedunculus communis 3–4 cm longus, glaberrimus, floribus numerosis, racemoso-capitatis, pedicellis brevissimis; calyx 4–4.5 mm longus, tubo campanulato, ca 2.2 mm longo, 10-costato, subglabro, lobis latis oblongis rotundatis eciliatis; corolla ca. 7 mm longa, externe fere glabra, tubo sursum paullo ampliato, lobis patulis rotundatis; androeceum glabrum; ovarium et stylus glabri; discus in glandulam triangularem glabram reductus.

Type in the Naturhistoriska Rijksmuseet, Stockholm, collected at La Costa, District of El Tambo, Department of El Cauca, Colombia, altitude 1500 meters, Oct. 10, 1935, by Kjell von Sneidern (no. 488). An additional specimen was collected at the same locality by Sneidern (no. 480).

Most closely related to *Cremosperma ignotum* Morton, from which it may be distinguished as follows:

Disk annular; corolla much exceeding calyx; calyx lobes 1 mm. long; leaf blades entire or with a few remote serrulations .... *C. ignotum*

Disk reduced to a solitary gland; corolla only slightly longer than calyx; calyx lobes 2 mm long or more; leaf blades regularly crenate .... *C. sylvaticum.*

Cremosperma auriculatum Morton, sp. nov.

Fruticuli parvi, usque ad 16 cm alti, caulibus basi ramosis, subhirsutis; folia opposita, valde inaequalia, majora breviter petiolata (petiolo usque ad 8 mm longo), elliptica vel oblonga, 2.5–4.5 cm longa, 1–2.3 cm lata, apice rotundata, basi cuneata vel subrotundata, chartacea, remote serrata, supra glabra, subtus in venis subtomentosa, folia minora auriculiformia sessilia orbicularia, 7–8 mm longa et lata; pedunculus communis 15–18 mm longus, tenuis, glaber, floribus subcapitatis, pedicellis usque ad 7 mm longis, puberulis; calyx 4.5 mm longus, perspicue strigosus, tubo ca. 3 mm longo, 10-costato, lobis 1.5 mm longis, rotundatis, eciliatis; corolla alba, 10–13 mm longa, tubo cylindrico, non ampliato, externe piloso, lobis patulis, 2.5–3.5 mm longis; androeceum glabrum; ovarium glabrum; placentae lamellae intus solum ovuliferae; discus semiannularis glaber, plus quam 1 mm altus.

Type in the herbarium of the Royal Botanic Gardens, Kew, collected on Mt. Abitagua, Ecuador, October, 1857, by R. Spruce (no. 5072). Duplicate in the New York Botanical Garden.

The relationship of the present species to *C. pusillum* Morton is doubtless close, but that species may be distinguished by the leaves all being equal and usually ternate or quaternate in arrangement. In *C. auriculatum* the leaves are opposite and strongly unequal, the smaller of a pair being orbicular and auriculiform. In this respect it resembles *C. congruens* Morton, but in that species the smaller leaves are lanceolate and acute.

BOTANY.—*Emendations to the descriptions of* Taphrina lethifera *and* T. aceris *on maple* (Acer).[1] ANNA E. JENKINS, Bureau of Plant Industry. (Communicated by JOHN A. STEVENSON.)

Taphrina lethifera (Peck) Sacc. (*Ascomyces lethifer* Peck) (5) and *T. aceris* (Dearn. and Barth.) Mix (3) (*Exoascus aceris* Dearn. and Barth.) (1) are the only two species of *Taphrina* described on maple in the United States, as previously noted (2). The first species was discovered on mountain maple (*Acer spicatum* Lam.) at Elizabethtown, N. Y., by Charles H. Peck, about 50 years ago (Fig. 1, A).

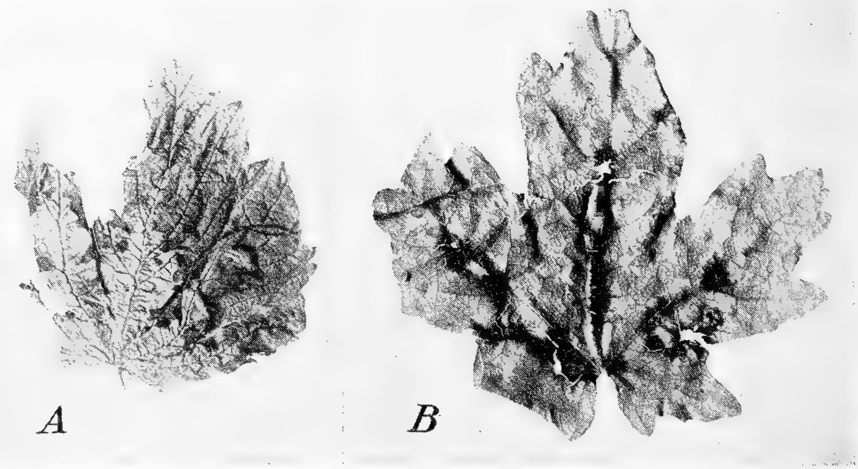

Fig. 1.—*A*. *Taphrina lethifera* on mountain maple, Elizabethtown, Essex County, N. Y., C. H. Peck, June 1886 (part of type, contributed by H. D. House). ×1. *B*. *T. aceris* on Rocky Mountain hard maple, Bear Lake, Utah, July 6, 1908, L. H. Pammel. ×1.

The other species occurs on Rocky Mountain hard maple (*A. grandidentatum* Nutt.) in Utah and was described in 1917 from specimens collected in Parley's Canyon by E. Bartholomew and A. O. Garrett. Further study of these two species reveals that each possesses certain characters not mentioned in the original descriptions. In particular, each possesses a stalk cell (Fig. 2) and this is not mentioned in the diagnosis of either species. The descriptions of these two little known fungi are accordingly here emended. Additional historical information at hand relative to *T. aceris* is given.

Taphrina lethifera (Peck) Sacc.

Ascomyces lethifer Peck.

Indefinite, occupying part or all of the leaf causing wrinkling, (on dry

[1] Received July 7, 1938.

specimen) "amber brown" to "Brussel's brown," and darker;[2] asci often occupying the whole lower surface of the leaf, and suffusing it with a glaucus bloom, cylindrical, obtuse, or subtruncate, 36–50×14–20μ; stalk cell 14–20×17–25; spores often elliptical 4–5×3–7μ; conidia numerous subglobose to elliptical, of various sizes, often 2–4×3–5μ.

On living leaves of mountain maple (*Acer spicatum*). Elizabethtown, Essex Coounty, N. Y., June, 1886, C. H. Peck.

Peck made the following remarks relative to his new species:

"This species is very distinct from *A. polyspora*," (now known as *Taphrina polyspora* (Sorok.) Johans), "which forms definite spots. The attacked leaves soon turn black, wither and die. Sometimes all the leaves on a branch are affected and the fungus then causes a veritable blight."

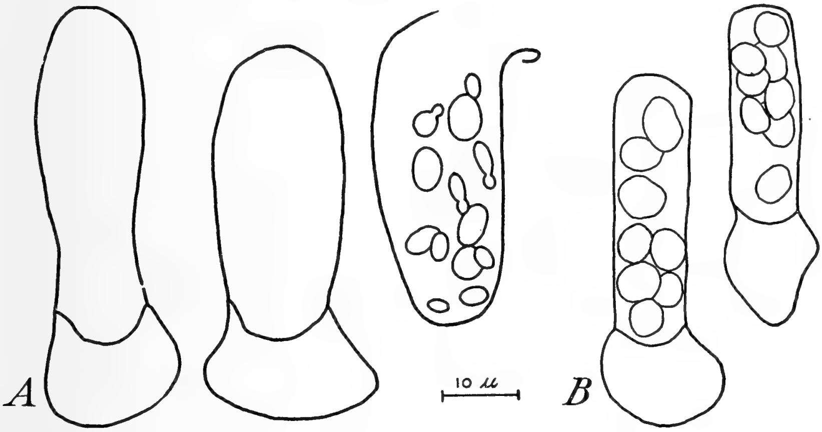

Fig. 2—Asci of *Taphrina lethifera* (*A*) and *T. aceris* (*B*).

The writer has found this species, as well as *Taphrina aceris*, to be distinct from *T. polyspora* of Europe, which also has a large ascus, but for which no stalk cell is known. The *Taphrina* reported a number of years ago under the name of *T. lethifera* (7), on red maple (*Acer rubrum* L.), is not this species but the undescribed *Taphrina* noted by the writer on this host (2).

Although not referred to in the original description, *Taphrina aceris* was actually first discovered in 1908 by L. H. Pammel (4), who stated that he found the fungus abundant in the "Wasatch Mountains near Logan, especially in Logan Canon, and along the adjacent streams emptying into the Logan River" (fig. 1, *B*). He stated also that "in some cases the trees were entirely defoliated, in others a majority of the leaves were attacked."

Pammel did not name the fungus, but he made a detailed study of it, comparing it with two European species, specimens of which were sent him by W. G. Farlow.[3] Illustrating all three species, Pammel represented for the

[2] The color readings given in quotations are based on Ridgway's Color Standards (6)

[3] These specimens were transmitted with Farlow's letter of May 10, 1911 to Pammel. This letter had the two specimens, together with a second letter of May 23, 1911, to be referred to presently, are attached to the herbarium sheet bearing the Pammel specimens from Utah, lent from the Herbarium of the Iowa State College.

western species an ascus with a basal cell, and in the asci, from 9 to 14 spores or conidia of more or less uniform size. He did not make comparisons with *T. lethifera*, which he indicated was apparently different, and which Farlow also found evidently to be different after comparing the two. His communication of May 23, 1911,[4] to Pammel following the receipt and examination of a specimen of the *Taphrina* from Utah, is quoted as follows:

Your specimen of Taphrina on *Acer grandidentatum* reached me safely, and is very interesting. I have compared" it "with *T. lethifer* but it does not seem to be that species which has spores of different shape. Your fungus is perplexing for the reason that it has asci with 8 spores and others which are myriasporic. The described species on *Acer* are generally given as having some 8, some ∞ spores, but in Giessenhagen the remark is made that when generally found, it has only ∞ spores. From this one can infer that it sometimes has only 8 spores. As a matter of fact all the ∞ sporic species have only 8 spores when young enough.

Taphrina aceris (Dearn. and Barth.) Mix.

Exoascus aceris Dearn. and Barth.

Spots often located on veins sub-circular, irregular, .5–1.5 cm, or extending a greater or less distance along veins or leaf margins and spreading to at least 1 cm in width, "cinnamon buff," "cinnamon," to "snuff brown" or "bister"; asci amphigenous, usually hypophyllous, numerous, short clavate or cylindric, 23–40×8–13μ (or after Pammel rounded 20–18×12–18μ); stalk cell 8–16×8–16; spores 3–5×4–6μ globose, subglobose or elliptical.

On living leaves of *Acer grandidentatum* Nutt., not causing deformation, but sometimes causing complete defoliation. BEAR LAKE (Wasatch Mts. near Logan, Utah, July 6, 1908, L. H. Pammel (68580 Myc. Coll. B.P.I.); PARLEY'S CANYON, Salt Lake Co., Utah, June 29, 1915. E. Bartholomew and A. O. Garrett. (E. Barth. Fungi Columbiani 5018. Type).

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[4] See footnote 3.

BOTANY.—*A new species of* Taphrina *on sugar maple and black maple.*[1] Anna E. Jenkins, Bureau of Plant Industry. (Communicated by John A. Stevenson.)

In May and June, 1922, specimens of a leaf spot on sugar maple (*Acer saccharum* Marsh.) and on black maple (*A. nigrum* Michx.) from Yellow Springs, Ohio, were received from O. L. Inman, Antioch College, who asked for information concerning the cause of this dis-

Fig. 1.—*Taphrina* on black maple. Antioch, Ohio, June 1922. Collected by O. L. Inman. ×1.

ease then appearing in destructive form on these two native maples. He wrote that he had compared the fungus present on the lesions with *Gloeosporium apocryptum* Ell. and Ev. (2), but that from the description he was not certain that it was this species. At about the same time a specimen of sugar maple, affected in the same way, was received from W. T. Morse, of the Maine Agricultural Experiment Station. The specimen had come from Rockport, Morse wrote that

[1] Received July 8, 1938.

the disease was unfamiliar to him, but that, although he had found no fungus fruiting on the leaf spot, it appeared to be of fungus origin. From Pennsylvania a specimen was also sent for identification by L. O. Overholz.

Taphrina, with small, inconspicuous asci, mostly overmature and with spores and conidia lying free on the substrata, was found on all these specimens, which at first sight had not suggested a disease of this etiology (Fig. 1).

In the attempt to learn more of the history and distribution of the newly discovered *Taphrina*, phanerogamic herbarium specimens were examined for the presence of the leafspot. This search revealed that the fungus was not new, but that it had been present in this country for many years. The *Taphrina* was found on specimens of *Acer saccharum* collected as far west as Missouri and as far south as Georgia. The earliest was dated 1894.

The *Taphrina* was also present on maple leaves, evidently those of sugar maple, gathered in June 1922, in New Hampshire, New York, and Indiana. This material was received at the Branch Laboratory of the Division of Forest Pathology, then located at Providence, R. I., and was examined for asci of the *Taphrina* in March, 1923, by Alma M. Waterman and the writer. It appears that Collins' (2) report in 1922 of *Gloeosporium apocryptum* on a maple leaf spot from New York and Indiana may have been based on the specimens just cited. The disease was apparently epiphytotic in 1922, as previously indicated in the Plant Disease Reporter (4). During the past three years this Reporter has recorded additional more or less severe occurrences of *Taphrina* maple leaf blister, which in some instances definitely concern sugar maple.

The specimens had originally been sent from Indiana to the Department for examination by entomologists, because it was thought that the trouble might be of insect origin. All three specimens were evidently from valued shade trees. The specimens from New Hampshire were received with the following comment:

> The leaves of our fine trees show dark spots on them, then shrivel up, turn black and die, leaving the limbs entirely bare.

Likewise, the correspondent from New York wrote:

> We have one tree which is dying from some disease. Last year one tree died in the same manner. The tree leaves out and looks perfectly healthy, then after the leaves are partly grown they turn black and fall off. Two trees near this one are partly affected.

In August, 1922, and in succeeding years until at least 1931, the

Fig. 2.—*Taphrina* on sugar maple, Walton, Del. Co., N. Y., August 1, 1923. $\times\frac{1}{2}$.

Taphrina was more or less prevalent in a certain locality at Walton, New York, as indicated by specimens to be cited later (Fig. 2). It was here found on both shade and forest trees. However, in 1929, sugar maples in a nearby locality, Northfield, were examined and no evidence of the disease was found. The fungus was easily culturable and was isolated from fresh specimens collected at Walton both in July, 1924, and in June, 1929.

This *Taphrina* possesses much smaller asci than the two American species, *T. lethifera* or *T. aceris,* discussed in a recent article (5). They are also not so large as in the two unnamed American species attacking *Acer* first reported by the writer in 1925 (4), and now being measured for description. On the other hand the fungus in question appears to be nearer to *T. acericola* Massal. (6), known only on *Acer campestre* L. in Italy. Specimens were exchanged with Massalongo, and at first it was thought that the American *Taphrina* on sugar maple and black maple (Fig. 3) might be this species, despite slight differences in measurements and the evidently more evanescent

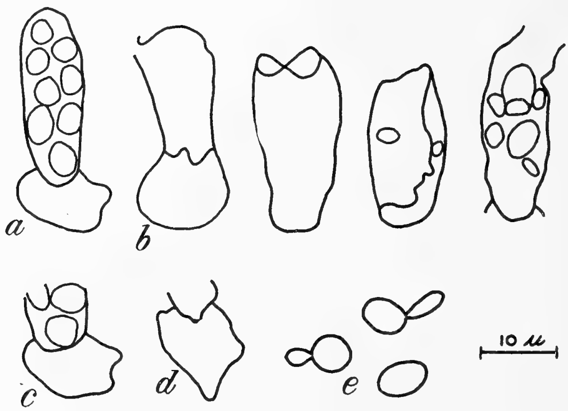

Fig. 3.—*Taphrina sacchari.* Asci or fragment of asci, *a* and *b*, showing basal cells, *a* containing 8 ascospores, *c* and *d*, lower part of two asci showing basal cells, *e*, ascospores two of which are sprouting.

asci of the American fungus. In 1924, a few trees of *Acer campestre* were planted near affected trees of sugar maple at Walton, but these have never become infected. The other species on *Acer campestre* is *T. jaczewski* Palm (*Exoascus confusus* Jacz. non Atk. (3)), also with comparatively small asci, of which specimens were kindly sent by Jaczewski. This fungus forms witches' brooms and appears to be entirely distinct. For the American species on sugar and black maples the name *Taphrina sacchari* is proposed, and it is described as follows:

Taphrina sacchari n. sp.

Spots few to numerous, scattered, sometimes near the veins, deciduous, sometimes causing the lobes of the leaf to bend or roll toward the center of the leaf above, circular, subcircular, or irregular, reaching 1.5 cm diam, larger by confluence, often circular to subcircular and less than 1 cm in diam, (on dry specimen) "pinkish buff"[2] below and "ochraceous tawny" above, to "cinnamon buff," "snuff brown," "clove brown," "bister" or blackish brown; asci hypophyllous, cylindric-clavate, rounded or truncate, 16–24 (of sometimes 28)$\times$6.7–10μ, stalk cell variable, exceeding the diameter of the ascus, 5–10μ high $\times$10–16μ wide, 8-spored; spores subglobose to elliptical, 4–5$\times$6–7μ.

Near *Taphrina acericola* Massal.

Hypophylla, maculas, 1 cm. usque 1.5 cm in diam efficiens; asci cylindrico-clavati, saepe 16–24, interdum 28$\times$6.7–10μ; cellulae basilares 5–10$\times$10–16μ; sporidia subglobosa vel elliptica, 4–5$\times$6–7μ.

DISTRIBUTION AND SPECIMENS EXAMINED

On *Acer nigrum*

OHIO, Yellow Springs (Antioch College), June 68550[3] *Type*, and May 68552, 1922, O. L. Inman.[3]

On *Acer saccharum*

ARKANSAS, Fayetteville, May 5 (69587) and May 24 (69877) 1935, E. H. Young.

GEORGIA, Gap of Dick's Ridge, Whitfield Co., July 27, 1900, R. Harper (68562). Fragment of phanerogamic specimen in U. S. National Herbarium, No. 38467.

INDIANA, Centerville, June, 1922, Ellen Ranch. Comm. Frederick J. Haskins Information Bureau (68556).

MAINE, Rockport, June 1922 (68553 *Type*) and June 26, 1922 (68554), J. Achorn. Comm. W. J. Morse.

MICHIGAN, Lansing "near President's house," July 7, 1894 (68561). Fragment of No. 26 ex Herb. Mich. Agr. Coll. in U. S. National Herbarium No. 201687.

MISSOURI, Galena, Stone Co., May 25, 1914, Coll. E. J. Palmer (68563). Fragment of phanerogamic herbarium specimen in U. S. National Herbarium No. 588420.

NEW HAMPSHIRE, Center Conway, June, 1922, Charles Baird (68557).

NEW YORK, Andover, June 9, 1922, Bernice Nye (68558); vic. Ithaca (Dr. Bull's Woods) July 9, 1927 (67979) and June 14, 1931 (67880) A. E. Jenkins, Walton (Mountain Home Farm), Aug. 20, 1922 (72869) and July 11 (68325), Aug. 1 (68548 and 68549); and Aug. 11 (72870), 1923, A. E. Jenkins; Sept. 25, 1923, M. Taylor (72871); July 10 (68547) and July 14, 1924 (68536), F. A. Jenkins; July 18, 1924, O. R. Taylor (68525) June 20, 1925, E. J. House (68573); July 17 (72872) and July 22 (72873), 1927; June 18, 1929 (69298), July 26, 1930 (72874), A. E. Jenkins; June 1 (72875), and June 6 (72876), 1931, M. K. Jenkins; Sept. 15, 1931 (69080), A. E. Jenkins.

OHIO, Yellow Springs (Antioch College), June, 1922, O. L. Inman (68551). Vic. Oxford, May 24, 1922, Bruce Fink (identified as *Gloeosporium saccharini* E. and E.).

[2] Color readings given in quotations are based on Ridgway's Color Standards (7).
[3] Accession number in Mycological Collections of the Bureau of Plant Industry.

PENNSYLVANIA, Elk Lake, June 28, 1922, G. E. Young, Comm. L. O. Overholts (68555).

TENNESSEE, Knoxville, May 27, 1934 (67781), and June 7, 1935 (70371) P. R. Miller.

WEST VIRGINIA, Rainelle, Sept. 20, 1928, W. A. Archer (U. S. Dept. Agr. and West Va., Agr. Exp. Sta. Plant Disease Survey 3033, labelled *Gloeosporium saccharinum* E. & E.).

WISCONSIN, Madison, Univ. Drive, June, 1894, labelled *Gleosporium saccharinum* E .& E.

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ANTHROPOLOGY.—*Aconite arrow poison in the Old and New World.*[1]

ROBERT F. HEIZER, University of California. (Communicated by HENRY B. COLLINS, JR.)

This short discussion is intended primarily to call attention to the distribution of the use of various species of *Aconitum* plants for arrow poison, and to indicate the possible significance of these occurrences. *Aconitum* is a genus of plants belonging to the Ranunculaceae, the buttercup family, embracing about 60 species. Aconite contains quantities of an alkaloid, pseudaconitine, a very deadly poison. The pharmacology and toxicology of aconite are not dealt with here. Santesson (1936) and Lewin (1923) have much data on these.

H. B. Collins (1937, pp. 280, 345, 373–378) and F. de Laguna (1934, pp. 217–220) present evidence indicating an Asiatic-American culture connection *via* the Aleutian islands, basing their conclusion on the distribution of such elements as the oval stone lamp, roof entrance, labret, refuge island, notched and grooved stones, stone with hole, hunter's lamp with ring, bone arrowhead with blade but no barbs, etc. For the most part these elements seem to be explainable as having an American provenience, the Asiatic littoral being the recipient. The occurrence of the use of the extract of pounded aconite

[1] Received May 13, 1938.

roots for poisoning weapon points may be another of these Asiatic-American elements—the distribution map would indicate the tenability of this interpretation since the practice is unknown among the Asiatics north of Kamchatka and the Eskimo north of the Alaskan Peninsula.

The following presentation is in the order of the numbers on the distribution map.

1. *Kodiak Island.*—Sauer (1802, p. 177) gives a very specific account of the use of pounded aconite roots for poison among the Koniag. He says:

> They [the Koniag] also use poison to their arrows, and the Aconite is the drug adopted for this purpose. Selecting the roots of such plants as grow alone, these roots are dried and pounded, or grated; water is then poured upon them, and they are kept in a warm place till fermented: when in this state, the men anoint the points of their arrows, or lances, which makes the wound that may be inflicted mortal.

Sauer also states (p. 180) that sea lion are hunted with poisoned arrows. He remarks (p. 181) that:

> Whales are in amazing numbers about the straits of the islands, and in the vicinity of Kadiak; the natives pursue them in their small boats, and kill numbers with a poisoned slate-pointed lance.[2]

2. *Aleutian Islands.*—It is not known whether the Aleuts used aconite to poison their weapon points. They hunted whales, however, in the Kodiak fashion, with a detachable slate lance head. Miss Margaret Lantis tells me that her Aleut informants from the island of Atka remembered that in former times a deadly plant poison was made from the juice of roots. The possibility is that aconite was used, yet we cannot be sure. I am indebted to Mr. H. B. Collins for calling my attention to the following references. Petroff (1884, pp. 154–155), translating from Veniaminof, says of the Aleuts:

> The pursuit of whales was encumbered with many observances and superstitions. The spear-heads used in hunting the whale were greased with human fat, or portions of human bodies were tied to them, obtained from corpses found in burial caves, or portions of a widow's garments, or some poisoned roots or weed. . . . Then, taking with him a companion, he proceeded to the shore where he presumed the whale had lodged, and if

[2] Associated, particularly on Kodiak, with actual whale hunting by means of a poisoned slate lance head was a great complex of observances, ceremonials and taboos regarding whalers and whaling. Lisiansky (1814, p. 174) describes a magical substance, or we might say, a ceremonial poison. He states that: "These bodies [of deceased whalers] are said by some to be stolen, from the idea that the possession of them conduces to render the fishing season prosperous; and by others, that a juice or fat is extracted from them, into which if an arrow be dipped, the whale, when wounded by it, dies the sooner." Weyer (1932, p. 309) describes the same thing, using de Laguna's information from Athabascan informants of Cook Inlet who knew of Koniag whaling. Weyer believes this to be a fetish substance and not an actual poison. Miss Lantis is now publishing a full account of the whale cult in the northern hemisphere which has further data on this aspect.

the animal was dead he commenced at once to cut out the place where the death-wound had been inflicted.

For hunting the sea-otter such poisoned spears were not used . . .

Dall (1877, p. 75) gives an incomplete note which would lead one to believe that the Aleuts knew the use of poison:

> The later whale harpoons were always slate-tipped, the modern Aleuts ascribing some poisonous quality to that stone, which they assert will invariably kill the whale in a few days, providing the slate-tip remains in the wound, even if the dart has penetrated but slightly.

3. *Kamchatka.*—The Kamchadal use a poison made from the expressed roots of plants. Krasheninnikov (1764, pp. 92–93) says:

> The zgate [footnote reads: Anemonoides et ranunculus] must not be omitted, whose dreadful qualities are but too well known in all this part of the world. They anoint the points of their darts and arrows with the juice which is squeezed from the roots of this plant, and the wounds which they give are incurable unless the poison be sucked out. This is certainly the only method, and, if this be neglected, the wound immediately turns blue and swells, and in two days the patient dies. The very largest whales, when they have received a slight wound from such a poisoned weapon, cannot bear the sea for any considerable time; but throwing themselves on the shore, expire most miserably, with terrible groans and bellowing.

The Kamchadal shoot sea lions, when they are found asleep at sea, with poisoned arrows. Death follows in 24 hours (Krasheninnikov 1764, p. 121). Kamchadal arrows, about four feet long, tipped with flint or bone and poisoned, are used for war. The person wounded by such an arrow dies in about 24 hours, unless the poison is sucked out, the only remedy known (Ibid. p. 202). Lewin (1923 pp. 174–75) identifies this as *Anenome ranunculoides* L., and notes that it is a rather weak poison. His statement that a root poison of *Cicuta virosa* was used is also an alternative. Although this is not aconite, I feel that the Kamchadal use is so similar in other respects, that this is not a very important difference. Their whaling lance is apparently the detachable slate pointed variety noted for the Aleut and Koniag. It is of interest to note that the Kamchadal, like the Aleut, Koniag and northern Ainu all poisoned their whaling lance heads.

4. *Sakhalin Island.*—The Ainu of this island, according to Lewin (1923, p. 173) used aconite roots for arrow poison, particularly in the southern section about Karafuto.

5. *Kurile Islands.*—Krasheninnikov (1764) states that:

> . . . poisonous herbs, whose roots are yellow as saffron and as thick as rhubarb, and are well known to the inhabitants of the first *Kurilskoy* island, for they [?] formerly bought them from the natives of those islands, and used to poison their arrows with the juice.

He further states (p. 138) that the *Kuriles* throw poisoned darts to kill whales. Lewin (1923, p. 173) says that apparently aconite poison was known in the Kurile islands. These people, at least in the southern islands, were Ainu.

6. *Yezo Island.*—There are numerous accounts of the use of aconite arrow poison among the Ainu. Lewin (1923, pp. 170–173) notes that the roots were collected in summer and dried till fall in the shade. The roots were then ground fine between two stones. The poison could be used immediately or sometimes was mixed with fat and buried in the earth for several days, whereupon it assumed a red-brown color. Another method of preparation was to take the pulverized and dried aconite roots, mix tobacco and Capsicum in water and fox gall all together. This was sometimes, though, not always buried in the ground for a few days. Arrows were dipped in fir resin and then the poison was laid on. The poison would remain fresh and potent for about five months. Von Siebold (1878) describes Ainu arrows poisoned with aconite and used for deer and bear hunting. Aldridge (1876) reports on the Ainu use, saying:

> The root [of *Aconitum ferox* or *A. japonicum*] is prepared by maceration and pounding till it forms a pulp: this is mixed with other ingredients . . . and the resulting mass is buried for a time in the earth.

These poisoned arrows were used for hunting bears. There is, Eldridge claims, no antidote known. The flesh surrounding the wound is cut away.

I can find no certain evidence that the Ainu hunted whales regularly with poisoned lances. Kishinouye (1911, pl. 27, fig. 105) illustrates a carved bone, depicting what is presumably an ancient Ainu whale hunt.

7, 8. *Southwest China* (*Yunnan and Szechwan*).—Handel-Mazetti (1927, p. 73) describes the use of the roots of *Aconitum delavayi* by the Nahsi near Chungtien in northwest Yunnan, for poisoning arrowpoints. These are shot at bears. The flesh around the wound is quickly cut out. Lewin (1923, p. 169) notes the use of *Aconitum ferox* on the Lan-Tsan Kiang in western Yunnan and Szechwan. The poison is applied to crossbow arrows; spears and knives are not poisoned. Santesson (1936, pp. 12–14) gives further evidence from Handel-Mazetti's specimens. Davies (1909, pp. 392–393) mentions aconite arrow poison among the Lahu; Metford (1935, pp. 137–138) for the Lisu; Clarke (1911, pp. 124–125) and Davies (1909, pp. 370–371) for the Miao; and Baber (1882, p. 39) for the Lolo.

9. *Assam.*—Lewin (1923) notes the use of *Aconitum ferox* in eastern and southeastern Assam. Waddell (1895, p. 57) describes arrows poisoned with aconite roots used in warfare and for large game by the Akas of the hill country north of the Brahmaputra.

10. *Bhutan.*—Lewin (1923, pp. 45, 47.)

11. *Sikkim.*—Lewin (1923, p. 44) notes the use of *Aconitum ferox* among the Lepcha (Rong).

12. *Nepal.*—Lewin (1923, pp. 44,47) describes the use of *Aconitum napellus* Eldridge (1876, p. 80) lists *A. ferox* as used by the Gurkhas.

13. *Padam.*—Lewin (1923, pp. 45–47) records the use of arrow poison of

Fig. 1.—Showing distribution of the use of aconite arrow poison. Numbers refer to areas described in the text. ▪ Present. ● Reported, or location indefinite.

the Abor on the Dibong river, near the source of the Brahamputra. The plant used is *Aconitum ferox*.

14. *Orissa.*—The Khond (Khand, Kodu, Ku) use *Aconitum ferox* for poisoning their arrows according to Lewin (1923, p. 44).

15. *Burma.*—Santesson (1936, pp. 5–12) gives excellent information on the use of aconite arrow poison in this region. Lewin (1923, p. 53) notes the use of *Acontium ferox* among the Katschin of northern Burma.

16. *North China.*—Eldridge (1876, p. 81) cites an account of the use of *Aconitum japonicum* in northern China for arrow poison. He, as well as I, could find no further reference to the location, preparation, etc. of this. Lewin (1923, p. 169) mentions seven kinds of arrow poisons in Chinese antiquity.

The distribution of various species of *Aconitum* whose roots are used as arrow poison is fairly continuous. It is regrettable that there are not more specific data on the Aleut, yet a fair presumption may be raised that they too used aconite. The Kamchadal occurrence is so nearly comparable to the Ainu and Kurilian in use and preparation that a connection can hardly be doubted. The bare mention of aconite poison in northern China is to be accepted with caution.

Lewin (1923, pp. 23–27) gives evidence of the former use of aconite poison in Europe. He also states (p. 175) that the Koryak, Yukaghir and Chukchi use arrow poisons, but does not state what these poisons are. Lewin also thinks it "Wholly unproven and more than improbable is the statement that the Koryak use an aconite extract for arrow poison."

Weyer (1932, p. 330) states that the Eskimo have developed no processes for deriving poisons useful in hunting or fighting. Lewin (1923, p. 409) is definite in stating that the Eskimo do not have poison for weapons, and, furthermore, is certain that they did *not* use aconite.

In view of the above evidence, I suggest that the use of weapon poison made from the roots of various *Aconitum* species seems to have a distributional center in the Himalaya region, extending from there northeasterly to Yezo, Sakhalin and Kurile Islands of Kamchatka and with a further extension across the Aleutian islands to Kodiak. In the light of the present evidence I suggest that here is another cultural element common to Asia and America,[3] and that in this case the route of transmission was *via* Aleutian chain to America from Asia.

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[3] Plant poisons are rather rare or not fully reported in North America. Teit, H. J. (*The Thompson Indians of British Columbia.* Am. Mus. of Nat. Hist. Memoirs **2** (4): 263, 1900.) notes the use of arrow poison made of the juice of the flowers of some species of *Ranunculus.* Hoffman, W. J. (*Poisoned arrows.* Amer. Anthrop. o.s. **4**: 70, 1891.) states that the Pit River Indians use arrow poison of dogs liver mixed with the juice of the wild parsnip. Kelly, I. T. (*Ethnography of the Surprise Valley Paiute.* Univ. of Calif. Publ. in Amer. Arch. and Ethnol. **31**: 145, 1932.) states that an arrow would be stuck into the root of the wild parsnip to poison the tip. These few instances do not to me seem comparable to the plant poison described in this paper.

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ZOOLOGY.—*Notes on Chinese spiders chiefly of the family Argiopidae.*[1]

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In the following pages is continued a report on Chinese spiders loaned through the courtesy of the authorities of the United States National Museum. This material, unless otherwise indicated, was collected by Dr. D. C. Graham in Szechwan Province during the years 1923 to 1930, and is deposited in the United States National Museum.

Family Argiopidae

Argiope amoena L. Koch

Argiope amoena L. Koch, Verh. Zool.-Bot. Ges. Wien. **27**: 735, Pl. XV, Fig. 1. 1877.

Records.—China: Szechwan Province, Gongshien, August 1–4, 1934, female; near Shiao Shiang Lin Pass, 6500 ft., July 22, 1928, female; Queichou, Shih Men Kan, July 1, 1934, 3 females. Soochow, female (N. Gist Gee, collector). Himan Province, September 15, 1920, female (J. R. Thompson, collector).

Argiope bruennichi (Scopoli)[2]

Aranea bruennichi Scopoli, Obs. Zool. in Ann. V. Hist.-Nat., p. 125, 1772.

Records.—China: Szechwan Province, Suifu, near Yunnan Border, 2000 ft., October 10, 1924, female; Tseo Jia Geo, 2000 ft., August 30, 1929, female.

Argiope ocula, n. sp. Fig. 6

Female.—Total length, 23 mm. Carapace, 7.6 mm long, 6.8 mm at the widest place, 2.88 mm wide in front. Carapace light brown above with distinct dark lines radiating from the transverse thoracic groove. Clypeus and chelicerae dark brown, much darker than the dorsum of the carapace. Sternum dark brown, with a large median light lanceolate design, labium and endites dark brown, with yellowish distal borders, coxae dark brown,

[1] Received May 12, 1938.

[2] For synonymy see Reimoser's catalogue in Abh. Zoo. Bot. Ges. Wien, **10**: 42. 1919.

each with an irregular median yellow patch. Legs reddish brown, somewhat darker distally. Dorsum of the abdomen with a grayish brown ground color, the anterior end with two light yellowish transverse bands; at a place about one-third the length of the abdomen from the anterior end are two yellowish spots with black shadows posteriorly. A short median dark line below these spots sends out two branches on each side. The general design of the dorsum bears a rather close likeness to Bösenberg and Strand's figure of the species described by them as *Aranea ikomonsanus*.[3] Sides of the abdomen irregular gray and brown; venter dark brown, enclosed by a light longitudinal band on each side.

Anterior row of eyes recurved, slightly narrower than the procurved posterior row. Anterior median eyes two-thirds as large as the anterior lateral, separated from each other by slightly more than a diameter. Posterior lateral eyes seven-eighths as large as the posterior median, contiguous with the anterior lateral eyes. Posterior median eyes separated from each other by less than a diameter, from the anterior median by slightly more than a diameter. Median ocular quadrangle wider than long (23/18), slightly wider in front than behind. Clypeus equal in height to about one-half the diameter of an anterior median eye. Upper cheliceral margin armed with four teeth of which the third from the claw is the largest, lower cheliceral margin armed with three teeth increasing in size, the third from the claw being the largest. Tibia and patella IV, 10 mm long, tibia and patella I lacking. For the structure of the epigynum see Fig. 6.

Type locality.—China: Female holotype from Shin-Kai-Si, Mt. Omei, Szechwan Province, 4000 ft., August 7, 1929 in the United States Museum (U.S.N.M. Cat. No. 1299).

This new species may be readily distinguished from the other Chinese members of its genus by the coloration and design of the abdomen. In this respect and in the structure of the epigynum, it does not seem to be closely related to any described Chinese species.

Gasteracantha kuhlii C. L. Koch

Gasteracantha kuhlii C. L. Koch, Arachn. **4**: 20, Fig. 262. 1838.

Gasteracantha leucomelas Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 239, Pl. 3, Fig. 18, Pl. 15, Fig. 395. 1906.

Gasteracantha nabona Chamberlin, Proc. United States Nat. Mus. **63**: 22, 1924 (New Synonym.)[4]

Records.—This species is represented in the United States National Museum by Chamberlin's female holotype from Soochow, China (N. Gist Gee), and by two females from Kiang Su, China (M. McDade). A single female from Mupin, Szechwan Province, 4500 ft., July 24, 1929 (D. C. Graham) is in the American Museum of Natural History.

Meta doenitzi Bösenberg and Strand

Meta doenitzi Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**:180, Pl. 11, Figs. 238, 239. 1906.

Record.—China: Szechwan Province, Suifu, two females.

[3] Bösenberg, W. and Strand, E. Abh. Senckenb. Naturf. Ges., **30**: 234, Pl. 11, Fig. 224. 1906.

[4] For further synonymy see Dahl in Mitteil. Zoo. Mus. Berlin **7**: 262, 1914.

Meta kompirensis Bösenberg and Strand

Meta kompirensis Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 181, Pl. 3, Fig. 6, Pl. 11, Fig. 242. 1906.

Record.—China: Szechwan Province between Suifu and Yachow, 1000 ft., June 5, 1929, female.

Cyclosa argenteo-alba Bösenberg and Strand

Cyclose argenteo-alba Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 202, Pl. 4, Fig. 38, Pl. 15, Fig. 419. 1906.

Record.—China: Szechwan Province, Suifu, female.

Cyclosa atrata Bösenberg and Strand

Cyclosa atrata Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 204, Pl. 4, Fig. 28, Pl. 15, Fig. 417. 1906.

Record.—China: Szechwan Province, Suifu, October, 1930, female.

Cyclosa monticola Bösenberg and Strand

Cyclosa monticola Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 210, Pl. 15, Fig. 413. 1906.

Record.—China: Szechwan Province, Suifu, 1000 ft., April 25, 1930, female.

Eucta caudicula (Karsch)

Eugnatha caudicula Karsch, Verh. Ver. Rheinl. **36**: 66, Pl. i, Fig. 4. 1879.

Tetragnatha (*Eucta*) *caudicula* Bösenberg and Strand, Abh. Senckenb. Natuf. Ges. **30**: 179, Pl. 15, Fig. 408. 1906.

Record.—China: Szechwan Province, South of Suifu, 1000 ft., March 25, 1930, female; Suifu, October, 1930, three females.

Tetragnatha japonica Bösenberg and Strand

Tetragnatha japonica Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 177, Pl. 15, Fig. 409. 1906.

Records.—China: Szechwan Province, Tseo-Jia-Geo, 2000 ft., August 30, 1929, male and female; Chengtu, 1700 ft., August 5, 1933, female; Chungking, 2000 ft., May 6, 1930, male; between Suifu and Kiating, June 26, 1930, male and female.

Tetragnatha recurva Schenkel

Tetragnatha recurva Schenkel, Arkiv. för Zoologi **29**: 85, Fig. 29. 1936.

Record.—China: Szechwan, Suifu, 1000 ft., April 25, 1930, two males, two females.

Leucauge blanda (L. Koch)

Meta blanda L. Koch, Verh. Zool.-Bot. Ges. Wien. **27**: 743, Pl. 15, Fig. 5. 1877.

Leucauge blanda Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 182, Pl. 3, Fig. 8, Pl. 15. Fig. 394. 1906.

Records.—China: Szechwan, Mupin, 4500 ft., July 24, 1929, twelve females; between Chengtu and Kuan Shien, July, 1924, two females; Shin-Kai-Shi, July 6, 1924, 4000 ft., seven females; Chungking, 2000 ft., May 6, 1930, female.

Poecilopachys bufo Bösenberg and Strand

Poecilopachys bufo Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 241, Pl. 3, Fig. 12, Pl. 11, Fig. 219. 1906.

Record.—China: Szechwan Province, Ningyuen Fu, 6200 ft., July 31, 1928.

Aranea scylla (Karsch)

Epeira scylla Karsch, Verh. Ver. Rheinl. **36**: 71. 1879.
Aranea scylla Bösenberg and Strand, abh. Senckenb. Naturf. Ges., **30**: 215, Pl. 11, Figs. 202, 220. 1906.

Records.—China: Szechwan, Suifu, 1000 ft., June, 1925, five females, one male; Chungking, 2000 ft., May 6, 1930, three females; Shin-Kai-Shi, 4500 ft., July 6, 1934, two females.

Aranea pentagrammica (Karsch)

Miranda pentagrammica Karsch, Verh. Ver. Rheinl. **36**: 72, Pl. i, Fig. 6. 1879.
Aranea pentagrammica Bösenberg and Strand, Abh. Senkenb. Naturf. Ges. **30**: 219, Pl. 4, Fig. 35, Pl. 11, Fig. 211. 1906.

Record.—China: Szechwan, Suifu, April, 1925, female.

Aranea sia Strand

Aranea (*Zilla*) *sia* Strand, Abh. Senkenb. Naturf. Ges. **30**: 237, Pl. 4, Fig. 24. 1906.

Record.—China: Szechwan Province, 2000 ft., June, 1923, two males, two females.

Aranea ventricosa (L. Koch)

Epeira ventricosa L. Koch, Verh. Zool.-Bot. Ges. Wien. **27**: 739, Pl. 15, Fig. 2. 1877.
Aranea ventricosa Bösenberg and Strand, Abh. Senckenb. Naturf. Ges. **30**: 213, Pl. 3, Fig. 15, Pl. 11, Figs. 198, 199, Text fig. 3. 1906.

Records.—China: Szechwan, Yoa Gi, 7400 ft., July 3, 1929, 2 females; Tseo Jia Geo, 2000 ft., Aug. 30, 1929, female; Suifu, 1000 ft., October 20, 1925, female; Ningyuen Fu, 6200 ft., July 31, 1928, female; near Yunnan Border, 3500 ft., May 1, 1928, two females; Gongshien, August 1, 1934, male; Lu Ding Chiao, 5000 ft., August 8, 1923, female; Tatsientu, July 20, 1923, female. Soochow, female (N. Gist Gee, collector). Himan Province, September 15, 1920, two females (L. R. Thompson, collector).

Aranea boesenbergi, n. sp. Fig. 7

Female.—Total length, 7.5 mm. Carapace, 1.44 mm long, 1.35 mm at the widest place, .9 mm wide in front. Carapace brown above without distinct dark markings, somewhat darker at the sides. Chelicerae lighter than the carapace. Sternum dark brown contrasting strongly with the lighter coxae. Labium and endites dark brown with lighter distal borders. Legs irregular dark and light brown without distinct annulations. Dorsum of the abdomen with a broad transverse brown band at the base; posterior to this is a triangular white patch within which a median dark line gives off branches on each side. (Among the paratypes are specimens in which this design is partially or wholly lacking.) Sides of the abdomen and venter grayish brown, the latter outlined by an irregular white stripe on each side.

Anterior and posterior rows of eyes recurved, the former narrower than the latter. Eyes of the anterior row subequal, somewhat closer to each other than to the anterior lateral, removed from the posterior median eyes by about one diameter. Eyes of the posterior row subequal, the posterior median closer to each other than to the posterior lateral. The lateral eyes of each row contiguous. Median ocular quadrangle wider than long (15/11), as wide in front as behind. Clypeus slightly higher than the diameter of an anterior median eye. Lower cheliceral margin armed with three subequal teeth, upper cheliceral margin armed with four teeth of which the first and third, counting from the claw, are largest. Tibia and patella I, 1.76 mm; metatarsus and tarsus I, 1.6 mm long. Tibia and patella IV, 1.44 mm; metatarsus and tarsus IV, 1.36 mm long. Epigynum wider than long, with a broad scape flanked on each side by a circular atrium. For further details of the structure of the epigynum see Fig. 7.

Type locality.—China: Female holotype and seven female paratypes from Mupin, Szechwan Province, 3500 ft., July, 1927 in the United States National Museum (U.S.N.M. Cat. No. 1300).

The epigynum of this species resembles that of *A. pentagrammica* (Karsch) in general structure. It differs, however, in that the scape is shorter and broader. This new species also differs in the design of the abdomen and in being much smaller.

Aranea triangula, n. sp. Figs. 4 and 5

Female.—Total length, 21 mm. Carapace, 10.5 mm long, 7.4 mm at the widest place, 4.4 mm wide in front. Carapace and chelicerae reddish brown without distinct dark markings. Sternum and coxae dark brown, the latter lighter medially. Labium and endites dark brown with pale distal borders. Legs reddish brown, darker at the distal ends of the joints. Abdomen more or less triangular in shape, basally with a pair of prominent humps followed by two more humps on each side; narrowing posteriorly and bifurcate at the termination. The distinct design consists of a dark median triangular portion outlined irregularly by whitish bands. Sides of the abdomen and venter grayish brown.

Anterior and posterior rows of eyes slightly recurved, the former narrower than the latter. Anterior median eyes much larger than the anterior lateral (11/7), much closer to each other than to the anterior lateral, removed from each other by about a diameter, from the posterior median eyes by slightly less than a diameter. Posterior median eyes smaller than the anterior median, about as large as the posterior lateral eyes, much closer to each other than to the latter, separated from each other by slightly more than a diameter. Lateral eyes of both rows subequal situated very close together beneath a heavily sclerotized prominence on each side. Median ocular quadrangle much wider than long (25/15), wider in front than behind (25/20). The median eyes situated on a horny prominence. Clypeus equal in height to one and one-half times the diameter of an anterior median eye. Lower cheliceral margin armed with three subequal teeth, upper margin armed with four teeth of which the third from the claw is the largest. Tibia and patella I equaling tibia and patella IV in length (9.76 mm), metatarsus and tarsus I equaling metatarsus and tarsus II in length (8 mm). Epigynum relatively small, wider than long (excluding the scape) with a subtriangular scape more sclerotized medially than at the sides. For further details regarding the structure of the epigynum see Fig. 4.

Type locality.—China: Female holotype from Ningyuen Fu, Szechwan Province, July 31, 1928, in the United States National Museum (U.S.N.M. Cat. No. 1301).

This new species does not seem to be closely allied to any described mem-

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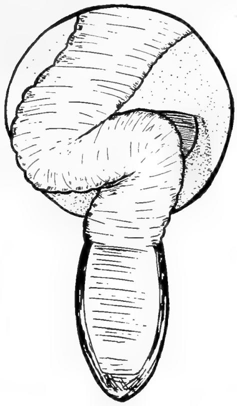

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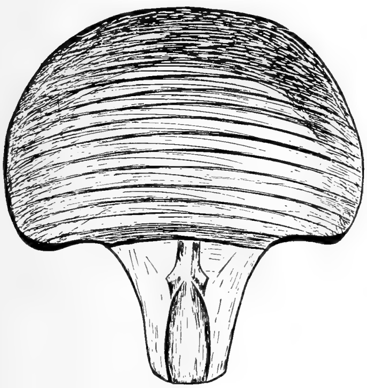

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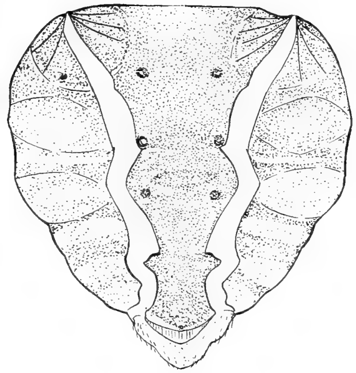

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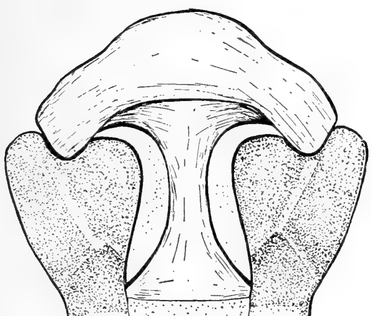

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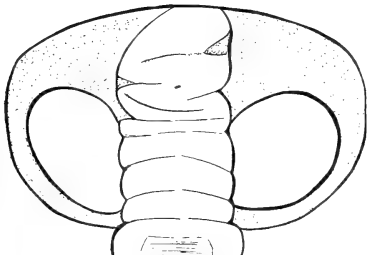

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Fig. 1.—*Heteropoda exigua*, n. sp., male, right palpus, lateral view. Fig. 2.—*Aranea virga*, n. sp., epigynum. Fig. 3.—*Heteropoda exigua*, n. sp., male, right palpus, ventral view. Fig. 4.—*Aranea triangula*, n. sp., epigynum. Fig. 5.—*A. triangula*, n. sp., female, dorsal view of abdomen. Fig. 6.—*Argiope ocula*, n. sp., epigynum. Fig. 7.—*Aranea boesenbergi*, n. sp., epigynum.

ber of its genus. It may be readily recognized by the design on the dorsum of the abdomen (Fig. 5) and by the epigynum.

Aranea virga, n. sp. Fig. 2

Female.—Total length, 12.5 mm. Carapace, 5.6 mm long, 4.4 mm at the widest place, 2.08 mm wide in front. Carapace reddish brown above with irregular dark brown spots and a large dark brown triangular mark which encloses the thoracic groove and extends anteriorly in the form of two dark longitudinal lines. Sternum and coxae dark brown without lighter markings; labium and endites concolorus with the sternum except for the distal edges which are light yellow. Chelicerae and clypeus dark, contrasting strongly with the pars cephalica. Femora and patellae of the legs dark brown, lighter basally; tibiae light yellow with dark annulations at the proximal and distal ends of the joint; metatarsi yellow with a dark distal annulation; tarsi dark brown with a basal yellow annulation. Dorsum of the abdomen with evidences of a pair of shoulder humps and a distinct dark brown folium within which is a broken median white band. The dark folium is outlined with dirty white. Sides and venter black.

Anterior and posterior rows of eyes slightly recurved, the former somewhat narrower than the latter. Anterior median eyes slightly larger than the anterior lateral, much closer to each other than to the latter, removed from each other by one and one-half times a diameter, from the posterior median eyes by about a diameter. Posterior median eyes about two-thirds as large as the anterior median, separated from each other by less than a diameter, much further from the posterior lateral eyes and somewhat larger than the latter. Lateral eyes close together, situated beneath a sclerotized prominence on each side. Median ocular quadrangle wider than long (17/10), wider in front than behind (17/13). Clypeus equal in height to about one and one-half times the diameter of an anterior median eye. Lower cheliceral margin armed with three teeth, upper margin armed with four teeth of which the first and third from the claw are the largest. Tibia and patella I, 7.6 mm long, metatarsi and tarsi I, 6.8 mm; tibia and patella IV, 5.68 mm; metatarsi and tarsi IV, 5.2 mm. For details regarding the structure of the epigynum see Fig. 2.

Type locality.—China: Female holotype from Mupin, Szechwan Province, July, 1929, in the United States National Museum (U.S.N.M. Cat. No. 1302).

This new species may be easily distinguished from the other Chinese members of its genus by the structure of the epigynum whose scape is rather long and basally convoluted.

Family SPARASSIDAE[5]

Heteropoda exigua, n. sp. Figs. 1 and 3

Male.—Total length, 8 mm. Carapace, 3.6 mm long, 3.44 mm at the widest place, 1.84 mm wide in front. Dorsum of the carapace reddish brown with darker streaks radiating from the dorsal groove; sides and clypeus lighter. Sternum and coxae light yellow, labium and endites somewhat

[5] I wish to express my appreciation to Dr. B. J. Kaston who has pointed out that the name Sparassidae was not first proposed by Simon in 1874 but by Bertkau in 1872 (Arch. F. Nat. **38**: 232), hence it has priority over Heteropodidae Thorell 1873, which I had regarded as the earliest family denomination (Jour. Washington Acad. Sci. **27**: 461. 1937).

darker. Legs concolorous with the dorsum of the carapace, with dark punctations. Abdomen reddish brown above lighter at the base than at the distal end. Venter clear yellow proximally, with reddish spots distally.

Anterior and posterior rows of eyes slightly recurved, the former less than three-fourths as wide as the latter. Anterior median eyes about one-half as large as the anterior lateral, closer to each other than to the latter, removed from each other by about one diameter. Posterior median eyes about three-fourths as large as the posterior lateral, closer to each other than to the latter, removed from each other by about one diameter, from the latter by about one and one-half diameters. Lateral eyes of each row situated on chitinized protuberances. Median ocular quadrangle slightly longer than wide (20/19), narrower in front than behind (12/19). Clypeus equal in height to one and one-half times the diameter of an anterior median eye. Chelicerae with four teeth on the lower margin and three teeth on the upper of which the middle one is the largest. Anterior tibiae with 2–2–2–2 spines below, anterior metatarsi with 2–2 spines below. Posterior tibiae with 2–2–2 spines below, posterior metatarsi with 2–2 spines below. Patella and tibia I, 6 mm long, patella and tibia IV, 5.6 mm. The palpus of this species resembles that of *H. hamata* I. Fox in the tibial process which is simple, unbranched, and lacks an associated shorter process. It differs, however, in that the process is not curved, and in other details illustrated in Figs. 1 and 2.

Type locality.—China: Yunnan Border, South of Suifu, Szechwan Province, China, 6000 ft., October, 1928, in the United States National Museum (U.S.N.M. Cat. No. 1303).

This new species finds a place in the group whose members bear a close resemblance in general appearance to *H. venatoria* (Linn.). It is somewhat smaller than the other species, but is nevertheless characteristic in coloration. It may be specifically separated from the other Chinese species of the genus by the palpal organ.

Family Urocteidae

Uroctea compactilis L. Koch

Uroctea compactilis L. Koch, Verh. Zool. Bot. Ges. Wien, **27**: 749, Pl. 15, Fig. 11. 1877.

Records.—China: Szechwan, Suifu, April 23, 1935, three females; June, 1925, 1000 ft., two females, male.

Family Oxyopidae

Oxyopes sertatus L. Koch

Oxyopes sertatus L. Koch, Verh. Ver. Zool.-Bot. Ges. Wien, **27**: 779. 1877.

Records.—China: Szechwan Province, between Suifu and Kiating, June 26, 1930, eight females, three males; Suifu, September 1929, female; Chungking, 2000 ft., May 6, 1930, three females.

ORNITHOLOGY.—*A new subspecies of the European nuthatch from North Siam.*[1] H. G. Deignan. (Communicated by Herbert Friedmann.)

The race of *Sitta europæa* resident upon the higher mountains of

[1] Received June 27, 1938.

northern Siam proves to be separable from all other named forms of this species. In honor of M. Jean Delacour, the authority on Indo-chinese ornithology, I propose that it be called

Sitta europæa delacouri, subsp. nov.

Diagnosis.—Nearest to *Sitta europæa nebulosa* La Touche, of South-west China, with which it agrees perfectly in coloration, but distinguishable therefrom by its much shorter wing. 22 males and 19 females from Yunnan and Szechwan (*nebulosa*) have a wing-length from 77 to 85.6 mm; 8 males and 3 females from north-western Siam and the South Shan State of Kengtung (*delacouri*) have a wing-length from 71 to 76 mm.

Range.—The pine-forests of Doi Angka, Doi Suthep, and Doi Chiengdao, in north-western Siam; Kyu Loi, in the State of Kengtung; probably on other high peaks of the district; not known below 4,500 feet.

Type.—Adult female, United States National Museum, No. 335604; collected at the summit of Doi Suthep, Chiengmai Province, North-west Siam, 14 July, 1935, by the author.

Remarks.—This bird has been identified in the past with *Sitta europæa nagaensis,* which has the under-parts gray and not dirty buff. It has no connection with *Sitta castanea neglecta,* which is common in the deciduous forest of the plains and the foothills to about 2,000 feet, in the same parts of Siam.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

RECENTLY ELECTED TO RESIDENT MEMBERSHIP IN THE ACADEMY

A. K. Balls, principal chemist, Bureau of Chemistry and Soils, U. S. Dept. of Agr., in recognition of his contributions to biochemistry, especially in the field of enzymes.

Howard P. Barss, principal botanist, Office of Experiment Stations, U. S. Dept. of Agr., in recognition of his leadership in the broad field of agricultural science, especially his contributions to pathological and physiological plant science.

A. E. Brandt, senior mathematical statistical analyst, Soil Conservation Service, U. S. Dept. of Agr., in recognition of his contributions to statistical analytical methods in evaluation of experimental results.

Sara E. Branham, senior bacteriologist, National Institute of Health, in recognition of her work on public health aspects of bacteriology, especially her studies on the meningoccocus in which she has given special attention to the epidemiological significance of serological types and to the improvement of therapeutic serum.

Cornelius J. Connolly, professor of physical anthropology, Catholic University of America, in recognition of his contributions to physical anthropology and biology.

Paul R. Dawson, senior biochemist, Bureau of Plant Industry, U. S. Dept. of Agr., in recognition of his work in biochemistry, especially on the chemistry of soil organic matter, the relation of trace elements to soil fertility and the relation of soil fertility to occurrence and control of cotton root rot.

J. Charles Miller, senior geologist and assistant chief of Mineral Classification Division, U. S. Geological Survey, in recognition of his services in the field of geology and in particular his investigations on the occurrence of petroleum and natural gas and on the origin, occurrence and use of carbon dioxide.

Conrad V. Morton, Division of Plants, Smithsonian Institution, in recognition of his contributions to systematic botany, mainly studies of the flowering plants of the western United States and of tropical North America.

George W. Musgrave, in charge of the Section of Soil and Water Conservation Experiment Stations, U. S. Dept. of Agr., in recognition of his studies of infiltration rates and moisture movement in soils.

Paul Albert Smith, hydrographic and geodetic engineer, U. S. Coast and Geodetic Survey, in recognition of his contributions to the knowledge of sound transmission through sea-water and to the study of subaerial erosion patterns on the sea bottom.

John G. Thompson, senior metallurgist, National Bureau of Standards, in recognition of his contributions to theoretical metallurgy, in particular, studies on the properties and uses of bismuth, the determination of gases in metals, and the preparation of high purity iron.

C. Warren Thornthwaite, in charge of the Section of Climatic and Physiographic Factors of Erosion, U. S. Dept. of Agr., in recognition of his contributions to climatology and geomorphology.

Waldo R. Wedel, assistant curator of archaeology, U. S. National Museum, in recognition of his work in reconstructing the prehistory of Nebraska and Kansas, as well as showing cultural developments in the Great Plains area.

Harry Ardell Allard, senior physiologist, Bureau of Plant Industry, in recognition of his work in plant physiology, plant pathology, taxonomic botany, ornithology, entomology and animal and plant ecology.

Alfred Edward Fivaz, senior forester, Soil Conservation Service, U.S.D.A., in recognition of his investigations of *Ribes* ecology, and forest protection and management.

Deane Brewster Judd, senior physicist, National Bureau of Standards, in recognition of his contributions to the theory and practice of colorimetry.

Melvin Clarence Merrill, chief, Division of Publications, Office of Information, U.S.D.A., in recognition of his researches in plant physiology and in the presentation of technical data.

Oliver Scott Reading, hydrographic and geodetic engineer, U. S. Coast and Geodetic Survey, in recognition of his work in aerial photography, especially his design of the nine-lens aerial camera, giant precision camera, transforming printer and the projection ruling machine.

William Norwood Sparhawk, senior forest economist, U. S. Forest Service, in recognition of his contributions to land economics, especially forest economics.

RECENTLY ELECTED TO NON-RESIDENT MEMBERSHIP IN THE ACADEMY

Andrew Thompson, physicist, Meterological Service of Canada, Toronto, Canada, in recognition of his contributions to the science of meterology.

PHILOSOPHICAL SOCIETY

1122nd MEETING

The 1122nd meeting was held in the Cosmos Club Auditorium, Saturday, October 9, 1937, President Wenner presiding.

Program: E. R. Shepard: *Electrical resistivity and seismic exploration for road beds and other engineering structures.*—Simple, compact and portable electrical resistivity and seismic instruments, suitable for relatively shallow sub-surface explorations, have been designed and built by the Bureau of Public Roads. For determining the presence and location of solid rock and for classifying soils and other underlying strata with respect to their relative degrees of compaction, the seismic method is more accurate and dependable than the electrical resistivity method. The seismic method has been found to be of practical use in highway design and construction for classifying materials of excavation, determining bridge foundation conditions and for locating suitable materials for fills and road surfacing. It has been shown to be of even greater value in connection with large engineering structures such as locks, dams, and reservoirs. On such projects a large amount of preliminary core boring can be dispensed with where preliminary seismic tests are made. (*Author's Abstract.*)

L. B. Tuckerman: *Pseudofrictionless undamped vibration.*—The friction of two solid surfaces sliding on each other obeys approximately Coulomb's law which states that the friction is independent of the velocity and depends solely on the character of the surfaces. Experiment shows that in most cases the friction decreases slightly with increasing velocity. If a vibratory motion of one of the surfaces is superimposed upon a steady relative motion so small that the direction of relative motion does not change, the major effect of the friction is merely to displace the center of the vibration. It produces no damping effect upon the vibration and even may increase it.

About 1898 the late Professor Frank P. Whitman of Western Reserve University was giving a simple demonstration of this phenomenon of pseudofrictionless undamped vibration to his physics classes which is duplicated in the demonstration shown tonight.

Only two references to it have been found in the literature. In Rayleigh "The Theory of Sound," 2nd edition, MacMillian & Co., London, 1894, p. 212, the statement is made: "A curious effect of the same peculiarity of solid friction has been observed by W. Froude, who found that the vibrations of a pendulum swinging from a shaft might be maintained or even increased by causing the shaft to rotate." On December 15, 1928, one leaf of the Strauss Bascule Bridge over the Hackensack River on the Lincoln Highway fell into the river. In the report it was stated: "It was observed at the bridge during the motion of the operating leaf that the initial oscillation of the inverted counterweight pendulum persisted, undamped by friction of the supporting trunnion."

Professor C. H. Willis of Princeton (Eng. News Record **103**: 426. 1929) and Professor P. W. Ott of Ohio State University (Eng. News Record **103**: 784–785. 1929) apparently independently ascribed this to pseudofrictionless behavior of a rotating shaft in its effect on vibrations, and confirmed it by experiments duplicating those ascribed by Rayleigh to Froude, and demonstrated by Professor Whitman.

This same phenomenon was recently found to be responsible for unduly large vibrations in an airplane tachometer. It seems probable that it is partly responsible for the severity of crank shaft vibrations in some airplane engines, and it is probably an unrecognized factor in other vibration problems in rotating machinery. (*Author's Abstract.*)

The first paper was discussed by Messrs. Page and McNish; the second one by Messrs. Goldberg, Wenner, McNish, Dickenson, and White.

An informal communication by L. B. Tuckerman was entitled "A Simple Theorem in Statics."

1123rd MEETING

The 1123rd meeting was held in the Cosmos Club Auditorium, Saturday, October 23, 1937, President Wenner presiding.

Program: E. D. McAlister, Smithsonian Institution: *The induction period in photosynthesis.*—The induction period is the time required for a plant to reach a steady rate of photosynthesis upon illumination. Using a spectrophotometric method of carbon dioxide measurement this phenomenon has been studied in a higher plant, wheat of the variety Marquis.

The present paper reports direct experimental evidence strongly indicating that a simple compound of carbon dioxide and chlorophyll operates in the actual photosynthetic process. The ratio of carbon dioxide to chlorophyll in this compound is of the order of unity. This finding is opposed to the current view that there is a chlorophyll unit of some thousand chlorophyll molecules acting per molecule of carbon dioxide. It was found that the number of carbon dioxide molecules "lost to photosynthesis" (not photosynthesized) during the induction phase is approximately equal to the number of chlorophyll molecules present in the plant. A similar simple number relationship is postulated by Franck in his new theory of photosynthesis (Jour. Chem. Phys. **5**: 237–251. 1937) in which the conception of a large chlorophyll unit is avoided. (*Author's Abstract.*)

E. O. Hulburt: *Observations of a searchlight beam at great altitudes.*—The beam of a high intensity searchlight directed over an observing station 18.4 km. distant at angles of 30 degrees and 45 degrees to the horizontal was visible to a vertical altitude of about 20 km. and was photographed to 28 km. on clear nights. The intensity of the beam measured from the photographs was of the same order of magnitude as that calculated from the Rayleigh theory of molecular scattering using standard tables of stratospheric densities. At 5 km. the observed intensity was greater than the theoretical intensity by a factor of about 7, the factor decreasing to about unity above 10 km., as would be accounted for by a small number of haze particles at 5 km. which decreased to an imperceptible amount above 10 km. (*Author's Abstract.*)

R. E. Gibson: *The influence of pressure on the refractive index of benzene.*—This communication gives a description of an apparatus and method of estimating the effects of high hydrostatic pressure on the refractive index of liquids and gives the results for benzene. The apparatus consists of a heavy steel vessel provided with two windows in line. The whole is contained in a thermostat. Inside this bomb benzene is sealed over mercury in a glass vessel with parallel sides, and different optical glasses whose refractive indices are higher than those of the liquid are immersed in the benzene. At constant temperature the pressure is adjusted so that the boundaries between a piece of glass and the liquid just disappear. With monochromatic light the pressure at which the indices of the liquid and glass match may be determined to 1 bar, which for benzene corresponds to 0.00004 in the refractive index. The refractive index of glass under the conditions of match is computed from its index at ordinary pressure and temperature and its expansibility and compressibility. A given rise of pressure changes the indices of benzene and optical glass in the ratio 1:0.025. Results are given for benzene from 25 to 45 degrees Cent. and from 1 to 1200 bars. The effects of pressure and temperature changes on the refractive index of benzene are represented with great precision by the Eykmann formula

$$v(n_D^2-1)/(n_D+0.4)=0.7506$$

where n_D is the refractive index for the sodium D lines and v is the specific volume of the liquid. The refractive indices for the mercury blue line (436 $m\mu$) are given by the formula

$$v(n^2-1)/(n+0.4)=0.7813.$$

It was also found that the dispersion of benzene is a pure volume function. (*Author's Abstract.*)

The first paper was discussed by Messrs. ABBOTT, HAWKESWORTH, STEVENS, and HUMPHREYS; the second one by Messrs. HUMPHREYS, TUVE, TUCKERMAN, ABBOTT, GISH, and MCNISH; the third by Messrs. MOHLER and HULBURT.

1124TH MEETING

The 1124th meeting was held in the Cosmos Club Auditorium Saturday, November 6, 1937, President WENNER presiding.

Program: S. E. FORBUSH: *Interpretation of observations with continuously recording meters.*—Instruments used in the Carnegie Institution of Washington's program for continuously recording cosmic-ray intensity at several stations were described and sample records shown. The statistical technique which established the reality of the 24-hour wave in the solar diurnal variation was reviewed. It was shown that statistical evidence is still inadequate to establish the reality of the 24-hour sidereal wave in cosmic-ray intensity predicted by the theory of Compton and Getting.

Changes in cosmic-ray intensity observed during the magnetic storm of April, 1937, were shown and an hypothesis to explain them was advanced. (*Author's Abstract.*)

S. A. KORFF: *Cosmic ray investigations in the upper atmosphere.*—The instruments used in upper air observations of cosmic rays consisted of Geiger counters connected to 5-meter wireless transmitters. A recording barograph signalled the altitude. The entire unit weighs about five pounds, including batteries. With this equipment a series of five flights was made in Washington during February and March 1937, an altitude of 65,000 feet being attained. Five flights were made in Peru up to 70,000 feet. The cosmic ray intensity in the Peruvian stratosphere is about half that above Washington. This is interpreted as indicating the effect of the earth's magnetic field on the incoming rays. The intensity reaches a maximum at roughly 50,000 feet, above which elevation it drops off. This is taken to indicate that the incoming rays are powerful producers of secondary rays in the upper atmosphere, and that these secondary rays contribute a large part of the ionization which we measure with any cosmic ray recorder.

The determination of the large amount of this secondary effect is perhaps the most important contribution of this work. Cooperation of the National Bureau of Standards, the Weather Bureau, and the Peruvian Meterological Service is acknowledged. (*Author's Abstract.*)

The first paper was discussed by Messrs. McNISH and PAWLING; the second one by Messrs. HAFSTAD, HECK, HAWKESWORTH, HUMPHREYS, and MORSE.

W. J. HUMPHREYS presented three informal communications. One was on "fox fire"; the other two concerned inaccuracies in published statements.

1125TH MEETING

The 1125th meeting was held in the Cosmos Club Auditorium, Saturday, November 20, 1937, President WENNER presiding.

Program: H. S. RAPPLEYE: *Use of leveling in determining ground movements.*—This paper discussed briefly the general problem of determining earth movement by means of precise spirit leveling and also covered briefly the cases in the United States where precision leveling has been used in the actual determination of earth movement.

Quantitative data were presented, giving the results of releveling in the vicinity of Kosmo, Utah; in Los Angeles-Long Beach area, California; and in the region surrounding Brawley, California, as typical cases of earth movement resulting from earthquake activity and measured by spirit leveling. The settlement of the region surrounding San Jose, California, which is *probably* due to the compacting of considerable depths of loose material and which has been studied by repeated relevelings, was also covered briefly in this paper. (*Author's Abstract.*)

A. J. HOSKINSON: *Gravity in the Empire State Building.*—The purpose of this work was to test the vertical gradient of gravitational attraction. The Empire State Building was selected on account of its height. The instrument used for the work was the *Mienesz three pendulum apparatus*, which has been used with great success for sea observations and would, therefore, measure gravity in a tall building with the required accuracy, the sway of the building being taken care of by the construction of the instrument. The time interval was determined from a crystal chronometer designed and constructed by the Bell Telephone Laboratories, for the gravity at sea expedition in the West Indies during the winter of 1936–37. The indicated accuracy of the chronometer was one part in ten million. Twenty gravity observations were made in the building spaced about ten floors apart. No value was more than 1 milligal from the mean curve of the series. The indicated accuracy of the observations is about plus or minus 1 milligal. *The tests checked the theoretical law within one milligal or about 1%.* This is also about the accuracy of the observations, so that the difference may be either a real difference or observational errors. (*Author's Abstracts.*)

The first paper was discussed by Messrs. PAWLING, BENNET, HECK, and NEUMANN.

An informal communication on "A Modification of a Problem in Statics" was presented by A. G. McNISH and discussed by Messrs. TUCKERMAN and WENNER. L. B. TUCKERMAN presented an informal communication on "The Paradox of a Flexure Beam." W. J. HUMPHREYS presented one on "The Phenomenon Known as a Lawrence."

1126TH MEETING

The 1126th meeting, constituting the 67th annual meeting, was held

Saturday, December 4, 1937, in the Cosmos Club Auditorium; President WENNER presiding.

The Treasurer reported that, except for a deposit of $163.03 with the Perpetual Building & Loan Association and the sale of $11\frac{1}{4}$ shares of Duluth Superior Transit Co. common stock, there was no change in the investments of the Society during the year. The ordinary income of the Society during the year was $1384.25 and the ordinary expenditures $1418.82, leaving a deficit of $34.57. The expenditures were at the rate of $4.55 per member.

The Secretaries' joint report showed an active membership as of December 1, 1937, of 305, of whom the following were elected during the year: ALBERT K. LUDY, W. W. STEVENS, E. M. DAWSON. LANCASTER LOWRY, W. E. HARTGEN, JESSE A. KINGSBURY, HARRY DIAMOND, WM. F. STEINER, HARRY W. WELLS, IRVIN MICHAELSON, ALFRED H. MIKESELL, HAROLD B. REX, PRESCOTT N. ARNOLD, GEORGE IRWIN, ALBERT LONDON, and LAWRENCE A. WOOD.

The President reported for the General Committee that, in accordance with the by-laws of the General Committee, nine members who have been active in the Society for twenty years or more and who have been retired from the remunerative practice of their professions, have been made life members as of January 1, 1938. The President also reported that a change in the by-laws of the General Committee providing that, in case a member is nominated for two or more offices in the Society, he shall be consulted by the Committee on Elections and his wishes respected in preparing the printed ballots.

The following officers were declared elected for the year 1938: President, N. H. HECK; Vice-Presidents, R. E. GIBSON and F. G. BRICKWEDDE; Corresponding Secretary, W. G. BROMBACHER; Treasurer, H. F. STIMSON; Members-at-Large of the General Committee, W. E. DEMING and E. O. HULBURT.

On March 13, 1937, JAMES FRANCK, Professor of Physics, Johns Hopkins University, delivered the seventh Joseph Henry lecture on "Fundamentals of Photosynthesis."

At the conclusion of the business meeting a paper entitled, "The skeptical Physicist," was presented by PAUL R. HEYL. The paper was discussed by Messrs. McNISH, BLAKE, HERZFELD, TUCKERMAN, and GOLDBERG.

1127TH MEETING

The 1127th meeting was held in the Cosmos Club Auditorium Saturday, December 18, 1937, President HECK presiding.

Program: L. T. SAMUELS: *Radiometeorograph program of the Weather Bureau.*—Just as airplanes have supplanted kites in upper-air observations in this country, it now is believed that radiometeorographs attached to sounding balloons will soon replace airplanes in this work. The Weather Bureau began daily radiometeorograph observations at Burbank, Calif., on September 1, 1937; at Boston, Mass., on October 1, 1937; and at Fairbanks, Alaska, on October 7, 1937. Three different types of instruments are being used at these stations, with a view to determine the advantages of each. The results are being compared with airplane observations made at, or near, the same place. Generally good agreement was found between the two sets of temperature data, although further improvement is expected during the remainder of this fiscal year, as experience is gained in the technique of this new work. The Weather Bureau contemplates expanding this work to include daily observations at probably six stations next fiscal year.

To do this, it will be necessary to discontinue airplane observations at some stations since additional funds were not made available. The large percentage of returned instruments during sounding balloon series in past years, when the non-radio type of meteorograph was used, indicates that the cost of these observations at favorably located stations will be materially reduced. (*Author's Abstract.*)

L. F. Curtiss and A. V. Astin: *Precision radiometeorography and cosmic ray studies.*—This paper deals with a dual program which has been developed by the authors during the past 3 years and which involves two phases of upper air observations. Taking up first the work in cooperation with the U. S. Weather Bureau aimed at the development of a successful system of radiometeorography, it should be pointed out that at the present time a thoroughly reliable and sufficiently precise instrument is still lacking. Consequently, the authors have concentrated on the design and construction of such an Olland type instrument which has shown itself both in laboratory tests and in the air to give an accuracy of $\pm 1°$ C in temperature readings, and humidity readings that depend for accuracy only on the response of the active material used. This instrument is used with a light but powerful transmitter. The receiving equipment is of extreme simplicity and with little additional expense a curve drawing recorder can be added so that all curves are automatically plotted when the balloon has reached its maximum altitude.

Special equipment for cosmic-ray investigations also have been designed in connection with this work and 24 cosmic-ray flights have been made. A special radio-barograph designed on the same principle as the radiometeorograph mentioned above has proven thoroughly satisfactory. Geiger-Muller counters requiring less than 500 volts for operation are also an essential part of the equipment. Several of the ascensions have gone to new altitudes for cosmic-ray observations, the highest to a pressure of 5 millibars represents a new altitude record of approximately 116,000 feet for any type of upper air equipment.

The cosmic-ray data obtained, averaged for the 12 highest flights, show a marked decrease in cosmic-ray intensity at pressures below 100 millibars. These new data seem to confirm the view that practically all observed cosmic-ray effects are secondary phenomena generated within our own atmosphere.

The second paper was presented by L. F. Curtiss.

An informal communication on "The Need for Radiometeorograph Observations in Meteorological Studies" was presented by H. R. Byers.

The various papers were discussed by Messrs. Pawling, McNish, Hawkesworth, Brombacher, Tuckerman, Johnson, Astin, Berkner, and Heck.

1128th meeting

The 1128th meeting was held Saturday, January 15, 1938, in the Cosmos Club Auditorium, President Heck presiding.

The Retiring President, Frank Wenner, gave an address on "Time Measurements."

1129th meeting

The 1129th meeting was held Saturday, January 29, 1938, in the Cosmos Club Auditorium, President Heck presiding.

Program: H. Diamond, W. F. Hinman, Jr., and F. W. Dunmore: *A method in radiometeorography.*—Experimental work conducted for the U. S.

Navy Department on the development of a radio meteorograph for sending down from unmanned balloons information on upper air pressures, temperatures, and humidities, has led to radio methods applicable to the study of a large class of upper-air phenomena. The miniature transmitter sent aloft on the small balloon employs an ultra-high-frequency oscillator and a modulating oscillator; the frequency of the latter is controlled by resistors connected in its grid circuit. These may be ordinary resistors mechanically varied by instruments responding to the phenomena being investigated, or special devices the electrical resistances of which vary with the phenomena. The modulation frequency is thus a measure of the phenomenon studied. Several phenomena may be measured successively, the corresponding resistors being switched into circuit in sequency by an air-pressure-driven switching unit. This unit also serves for indicating the balloon altitude. At the ground receiving station, a graphical frequency recorder, connected in the receiving set output, provides an automatic chart of the variation of the phenomena with altitude. The availability of a modulated carrier wave during the complete ascent allows of tracking the balloon for determining its azimuthal direction and distance from the receiving station; data required in measuring upper-air wind conditions. (*Authors' Abstract.*)

R. Stair and W. W. Coblentz: *Ultraviolet intensities in the stratosphere.*—A photoelectric filter type of ultraviolet intensity meter coupled with a relaxation oscillator and radio transmitter are transported into the stratosphere by unmanned balloons.

The intensity of the ultraviolet solar rays on the photoelectric cell modulates the radio frequency wave. A barograph gives altitude indications at intervals. The total intensity, the intensities through the three filters, and the altitude indications are received and recorded graphically at a ground station.

Six balloon ascensions were made during June and July 1937, in which ultraviolet intensities to a height of 19 km were obtained.

Below 14 km but little change occurred in the filter transmissions, indicating but little change in the spectral quality of the short wave lengths. Between 14 and 19 km, a decrease in filter transmissions occurred, indicating a decrease in ozone absorption, estimated at 15 to 30 per cent of the superposed layer, the lower value being in good agreement with previous determinations.

At the highest altitudes attained the total untraviolet intensity of wave lengths less than 3132 was about 3 times the value observed at sea level. (*Authors' Abstract.*)

The first paper was presented by H. Diamond and discussed by Messrs. Brombacher, Smith, Mohler, Brickwedde, and Wenner. The second paper was presented by R. Stair and discussed by Messrs. Maris, Mohler, Diamond, McNish, and Smith.

An informal communication on "The Blind Landing of a Commerical Air-Liner near Pittsburgh" was presented by H. Diamond.

1130th meeting

The 1130th meeting was held Saturday, February 12, 1938, in the Cosmos Club Auditorium, President Heck presiding.

Program: I. C. Gardner: *The eclipse of 1937 in the South Seas.*—At the meeting of the Washington Philosophical Society April 10, 1937, a corona camera specially designed and constructed at the National Bureau of Standards was described and the results obtained with it in Asiatic Russia at the total eclipse of June 19, 1936, were discussed. This same equipment was used to photograph the eclipse of June 8, 1937, from Canton Island as a part of the work of the National Geographic-U. S. Navy Eclipse Expedition. Black and white photographs, color separation negatives and Kodachrome positives in color were obtained. The results were presented by lantern slides, followed by a general discussion of the equipment used and of the more interesting characteristics of Canton Island. (*Author's Abstract.*)

C. Bittinger: *Colored motion pictures of the eclipse of 1937.*

The lectures were discussed by Messrs. Hawkesworth, Tuckerman, Humphreys, Morse, Smith, Howe, and Heck.

1131st meeting

The 1131st meeting was held Saturday, February 26, 1938, in the Cosmos Club Auditorium, President Heck presiding.

Program: W. A. Shewhart, Bell Telephone Laboratories: *Observational significance of accuracy and precision.*—Two of the most common terms used in pure and applied science are accuracy and precision. When such terms are used, as in the specification of quality of manufactured products, it is desirable that they have definite and, in so far as possible, experimentally verifiable meanings. It is, therefore, important to determine how far one can go towards attaining this end by applying with rigor the principle that *only that which is observable is significant.* In the application of the concepts of accuracy and precision, it is customarily assumed that the available data constitute a random sample. Hence, the first step in attaining experimentally verifiable meaning of these terms is to choose an operationally verifiable criterion of randomness. One such criterion is the quality control chart. In order to give experimental definiteness to any *measure* of either accuracy or precision derived from a random sample, it is also necessary to specify the way any statement involving the measure may be experimentally verified. To do this it is necessary to make at least four empirical choices as to the details of taking and analyzing the data in the process of verification. Hence, it appears that the meaning of either precision or accuracy is verifiable only in a limited sense subject in any specific case to the choice of empirical criteria of verification.

There was discussion by Messrs. McNish, Pawling, Curtis, Wertheimer, Baecher, Astin, and Wright.

1132nd meeting

The 1132nd meeting was held in the Cosmos Club Auditorium Saturday, March 12, 1938, President Heck presiding.

The eighth Joseph Henry Lecture entitled "Symmetry" was delivered by Prof. Hermann Weyl of the Institute for Advanced Study, which is at Princeton. It has been published in this Journal **28,** 253–271. 1938.

1133rd meeting

The 1133rd meeting was held Saturday, March 26, 1938, in the Cosmos Club Auditorium, Vice-President Brickwedde presiding. (Corresponding Secretary Brombacher presiding during the presentation of the first paper.)

Program: F. G. Brickwedde: *The scattering of slow neutrons by liquid normal and para hydrogen.*—The experiment which was carried out with Dr. H. J. Hoge at the National Bureau of Standards in cooperation with Dr. J. R. Dunning and Dr. J. H. Manley of Columbia University was suggested by Prof. E. Teller as a direct test of the spin dependence of the force of interaction between protons and neutrons.

A beam of slow neutrons having a distribution of velocities approximately a Maxwellian distribution characteristic of room temperatures in some cases and liquid air temperatures in others, was passed through layers of liquid normal and liquid para hydrogen of various thicknesses, and the transmission of the neutron beam was measured. In this way the difference between the scattering of slow neutrons by liquid ortho and parahydrogen was investigated. From the differences in the scattering we were able to show, upon the basis of the calculations of Schwinger and Teller that; (1) the force of interaction between protons and neutrons is spin dependent; (2) that the energy of the singlet state (spins of proton and neutron anti-parallel) of the deuteron is greater than the energy of these particles when far separated; and (3) that the spin (angular momentum) of the neutron is $\frac{1}{2}h/2\pi$. A full description of the experiment will be published in the Physical Review. (*Author's Abstract.*)

F. D. Rossini: *Thermochemistry of simple organic molecules.*—The evaluation of bond energies in organic molecules is discussed. It is shown that, within the accuracy with which measurements can be made today, the energies of formation of even the simplest organic molecules cannot be expressed as the sum of various constant terms assigned to represent the energies of the atomic linkages in the molecules. It appears that any accurate representation of the energies of the atomic linkages in organic molecules must consider the following points: (a) the simple and direct energy of binding; (b) the various interaction energies between all atoms twice removed from one another; (c) the energy of excitation of the carbon atoms to the appropriate valence state; (d) the correction of the calorimetric data to the absolute zero of temperature to eliminate the translational, rotational, and ordinary vibrational energy; (e) the zero-point energy. The older thermochemical data are compared with the new data obtained at the National Bureau of Standards. The new data are analyzed and found to yield simple relations for the energies of formation of the various members of homologous series consisting of molecules of the form $Y-C_nH_{2n+1}$, where Y is any atom or combination of atoms forming a radical and C_nH_{2n+1} is a normal (straight chain) alkyl radical. In the equation $\Delta H = A + Bn + \Delta$, ΔH is the heat of formation, A is a constant depending on the nature of the radical Y, B is a universal constant for all such series and is independent of Y, and Δ is the deviation from linearity and is zero for n greater than about 5. The importance of these data and relationships is discussed. (*Author's Abstract.*)

The first paper was discussed by Messrs. Mohler and Roller, the second one by Messrs. Seeger, Kracek, Tuckerman, and Brickwedde.

1134th meeting

The 1134th meeting was held Saturday, April 9, 1938, in the Cosmos Club Auditorium, President Heck presiding.

Program: O. S. Reading: *A nine-lens camera for aerial mapping.*—Many sections of the coast, such as rocky irregular shores exposed to the open ocean, mangrove swamps, and marshes with complicated waterways, are difficult to survey on the ground but are as readily photographed as any other region from the air. Coast surveys must maintain high accuracy of geographic position. Unlike the automobilist using a poor map, the navigator of a vessel usually cannot see when he is running into danger in time to avoid it, but must depend on the accuracy of the chart for safety.

A rather close network of ground measurements is necessary to maintain high accuracy of geographic position when mapping from single lens air photographs, but the amount and cost of such control can be much reduced with a nine-lens camera recently developed by the Coast and Geodetic Survey. One photograph from this camera includes the same area as eight to twenty single lens photographs.

This air camera simultaneously exposes nine separate views on a single film. The central view is taken vertically and the eight marginal ones are tilted outward by means of steel mirrors coated with evaporated aluminum. This film is transformed into a single continuous composite 35 inches square in a special transforming printer. Micrometer adjustments on the printer to compensate for film shrinkage and other errors make it possible to keep the residual errors of the composite photograph within plus or minus 0.01 inch, 0.25 mm.

The main problem of design was to hold the adjustment of the many elements of the air camera in the wide range of temperatures of aerial photography (sometimes as great as 100° F.). The mirrors, their supporting cone, the plate holding the lenses, the lens barrels and all fastenings were made from the same billet of Grade A stainless steel (chromium 13.5% with only a trace of nickel) and are all screwed firmly together. The air camera with this construction has held its adjustment through seven flights made thus far, four of which were to 20,000 feet and minus 10° F. The camera is capable of photographing an area of 5,000 square miles on a single flight. (*Author's Abstract.*)

G. Gamow: *The fourth Washington Conference on Theoretical Physics.*—The fourth Washington Conference (held on March 21–23) was, as usual, organized jointly by the Carnegie Institution of Washington and the George Washington University and had the aim of bringing together the group of astronomers studying the internal constitution of stars (Drs. Chadrasekhar, Menzel, Sterne and Strömgren) and the physicists studying, theoretically and experimentally, the structure of atomic nuclei (Drs. Bethe, Breit, Gamow, Hafstad, Neumann, Teller, and Tuve) for discussions on the problem of nuclear transformations in stars as sources of stellar energy. These discussions may be divided into four main groups:

A. *The nuclear reactions or the chains of nuclear reactions which could be held responsible for the energy liberation in stars and building up of heavy elements.* On this subject the conference arrived at the conclusion that the so-called Weizsacker's chain must be excluded because of experimental indication of non-existence of isotope He^5 playing an important role in this chain. The same must be said about the chain based on Be^8-nucleus due to recent experimental evidence of instability of such nucleus. The new chain proposed on the Conference is based on the hypothesis of triple collision and existence of Be^6-nucleus. Such nucleus can be obtained by bombarding lithium with 4-million-volt-protons and the experimental investigation of its properties has been planned.

B. *The possibility of resonance-phenomena in stellar nuclear reactions.* It was indicated that the existence of selective resonance-effect for the nuclear reaction responsible for innerstellar energy production will considerably change the present model of the star (the shell-source-model has been suggested) and will permit better understanding of the stellar evolution

C. *Super-dense state of matter in stellar interior.* The recently proposed stellar model with super-dense nuclear core has been discussed. It turns out that in such a model the temperature and density in the center would reach the value several hundred times higher than that usually accepted. Under such conditions, the rate of nuclear reactions will increase so considerably that the total energy liberation will be millions of times larger than observed. The only possible way out of this difficulty would be to suppose that the stellar interiors are completely filled up with very heavy elements (lead!) which seems to be in contradiction with all present evidence on this subject.

D. At the end of the Conference the joint meeting with the Washington Physical Colloquium was held, at which Dr. Strömgren reported his recent investigation about the double star "E. Aurigae," one component of which, according to his calculation, is transparent, so that the other component could be seen through it. The possible reasons for such transparency gave rise to animated discussions. (*Author's Abstract.*)

The first paper was discussed by Messrs, GARDNER, TUCKERMAN, BROMBACHER, and HECK; the second one by Messrs. MOHLER, TUCKERMAN, BRICKWEDDE, MCNISH, and ROLLER.

1135TH MEETING

The 1135th meeting was held Saturday, April 23, 1938, in the Cosmos Club Auditorium, President HECK presiding.

Program: P. S. ROLLER: *The plastic flow of dispersions.*—When a soft, amorphous substance such as grease, fat, cream, mineral paste of clay or lime, or cement mortar is subjected to a principal compressive stress, it flows out rapidly to a final state of deformation that is determined by the stress. The deformation of the substance constitutes its plastic flow. The amorphous materials enumerated are a dispersion of solid and liquid in which the bonds between the dispersed particles are weak. This constitution explains the softness and the very rapid yielding under stress.

A law has been found to underlie the plastic deformation, which may be stated as follows:

$$(1)\quad \kappa=\frac{dp}{p}\bigg/\frac{dv}{v}$$

In this equation p is the unilateral pressure, v is the volume of specimen, and dv is the extent of plastic flow. κ is a constant which is called the coefficient of renitence since it is a measure of the increase in resistance to plastic flow with increase in flow itself.

Integration of (1) results in the following equation:

$$(2)\quad \kappa=\frac{\log p/p_0}{\log h_0/h}$$

In equation (2) h is the height of specimen at pressure p, and h_0 is the initial height. p_0 is a constant that is evidently the pressure under which the substance just begins to deform under stress, and so is the yield value.

Plastic materials have been found to have a coefficient of renitence between .05 and about 1. When the coefficient exceeds 1 the substances show an increasing tendency to rupture during plastic flow under stress. The coefficient of renitence is therefore a measure of so-called plasticity of these materials. An important property of κ is that it is independent of the amount of liquid phase.

The yield value was observed to indicate the apparent stiffness. It varied from 0.4 for liquid-like substance to over 100 for stiff materials.

The magnitude of the coefficient of renitence and yield value has been found to be but little affected by rate of application of stress. (*Author's Abstract.*)

H. E. MCCOMB, *Recording Secretary*

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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.

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ETHNOLOGY.—*The modern growth of the totem pole on the Northwest Coast.*[1] MARIUS BARBEAU, Dominion Ethnologist, National Museum, Ottawa, Canada. (Communicated by H. B. HUMPHREY.)

Totem poles were once a characteristic form of plastic art among the tribes of the Northwest Coast, in British Columbia and southern Alaska. The natives took pride in them and strained every nerve to make them worthy symbols of their own social standing and achievements.

But the carvers were not artists in our present acception of the term; they were not permitted to give free rein to their imagination or fancy. They had little or nothing to do with the choice of the cedar tree they were to carve, nor the spot in the village where it was to be erected after it was carved, nor even the selection or the number of the figures they were hired to execute. Their art was not considered aesthetic; it was useful. Regulated by custom, it fulfilled a social purpose and was the chief vehicle of a system of heraldry which in a short time grew to abnormal proportions. Hence its vital importance in the life of the natives.

The totems, what they were.—The totems whose figures appear on the poles were not, as often misrepresented, pagan gods or fetishes, nor did they stand for clan ancestors. Their spiritual significance was quite secondary; they were not worshipped or even revered for their own sake. First of all they were symbols in the nature of European coat-of-arms or badges of ownership, and they usually illustrated historic events either true or fictitious.

When a new totemic emblem was introduced—this happened only seldom—an explanation of its origin and significance was usually furnished; this was purely stereotyped. The people were not credulous enough to believe their own tales, nor presumably the other folk at large.

The Raven, the Wolf, the Eagle and the Thunderbird were four

[1] Address before the Washington Academy of Sciences, delivered April 21, 1938. Received June 27, 1938.

of the outstanding totems of the Northwest Coast. They were used in most places from Alaska to the Strait of Georgia. Yet hardly any effort was made to explain how they had become the exclusive badges of definite families. They were hereditary and taken for granted. Nor was a Raven or a Wolf god supposed to exist in that country. At best the Raven was a culture hero of ancient folk tales, quite apart from heraldry. And I wonder whether the Eagle emblem, admittedly recent, is not a mere imitation of the Russian imperial crest. Like it, it often appears as a double-headed eagle, and it originated in the country occupied by the Russians, about the time of their occupation.

When a stereotyped explanation is given of the origin of an emblem it runs like this:

> A man named Small-frogs long ago was starving with his family, up the Nass. As he stood at the edge of the lake, a monster emerged from the water —Large-eyes, with a huge human face. Assisted by his human family, he cut this being in half and succeeded in pulling the outer part of its body out of the water. Later he gave a feast to the people, and adopted Large-eyes as an emblem. It was represented pictorially with a large human face and a body without legs—just a trunk.

A story of this kind was of little importance to the people. What mattered was the feast given and the presents distributed to confer prestige upon the emblem which was supposed to illustrate it. Without this consecration no emblem ever came into existence, for it would have had no status, no social recognition. It would have been an object of ridicule.

The figures or totems most commonly used, besides the above-mentioned, were those of familiar animals: the Frog, the Killer-whale, the Bear, the Owl, the Halibut and the Starfish. A number of other themes, localized, were derived from the fauna, the flora and the traditions of the country. Such phenomena as the Rainbow, the Stars, the Earthquake, the Glacier, casually appeared in the list of clan and personal badges. Among them we find even the White-man's dog, the Palisade and the Waggon-road.

The totem poles, where and how they stood.—There were carved house poles and totem poles proper, detached, that stood in front of the houses. Smaller poles with grave-boxes were also found among some of the tribes, mostly in the southern districts. House-front paintings, carved house-posts and graveyard structures were more ancient than detached poles. The detached totem poles as a fashion were fairly recent.

The village houses almost always stood in a row along the water


FIG. 1.—The row of totem poles at Kitwanga, on the upper Skeena river. This village on the Canadian National Railway line to Prince Rupert is often visited by tourists in the summer. FIG. 2.—The Salmon pole of Angeedaw, now at the Royal Scottish Museum, Edinburgh, Scotland; one of the finest poles of the Nass river type.

front, quite close to the edge of the water, either in the coves or along the rivers. The Tsimsyan were the only people of the true West Coast nations whose habitat consisted of rivers as well as of the adjacent sea coast. The villages of two of their sub-nations (the Niskae and the Gitksan) dotted the whole length of two rivers—the Nass and the Skeena, close to the Alaskan boundary. It is only there that we find totem poles away from the coast, up the rivers, as far as two hundred miles away from the tide-waters.

The detached poles stood in a row, in front of the owners' houses —a few feet away, and quite close to the waterfront. They extended the whole length of the village, in an impressive, though irregular, row of tall carved columns sometimes surmounted by detached figures of birds, animals and people.

Totem poles until recently stood along the village fronts of only a few nations in the north: the Haidas of Queen Charlotte Islands, the Nass River people and the southern Tlingit, of Alaska. Elsewhere

Fig. 3.—Totem poles at Skidegate, Queen Charlotte Islands.

they were either non-existent or very few. The only way of showing the owner's crests, when this was done, was by means of painted designs on the house fronts, or a few carved portals.

A pole was left to stand as many years as nature would permit. Sometimes two or three poles belonged to the same family, but had been erected at different times as memorials to chiefs after their death, one generation apart from the other. They stood side by side, and were part of the village cluster. Some of the poles leaned to one side, ready to fall, sometimes supported by props. It was not the custom to mend or transplant a pole, however precarious its condition. Once fallen, it was pushed aside, if it were in the way; it decayed gradually or was cut up and burnt as firewood.

The totem poles of the Haidas of the Queen Charlotte Island and of the Niskae of the Nass River, have mostly fallen and disappeared, or they have been removed to museums abroad. Some of the Tlingit poles, on the Alaskan coast, are being preserved where they stand. The only collection that is still fairly intact is that of the Gitksan tribes, on the upper Skeena River, in northern British Columbia. It consists of over one hundred poles, in isolated village groups of from a few to about thirty, in the eight tribal villages of the upper Skeena. Some of these are also being preserved by the Canadian Government and Railways.

The natives abandoned their old villages and moved to new quarters, many years ago. The old village sites are now deserted; the plank houses have fallen in, and the totem poles were forsaken in those former abodes of native life. They fall down and decay, while others lean precariously or totter in the wind, soon to come down with a crash. A few of the finest clusters, among the Tsimsyan, were wilfully destroyed in recent years. They reminded the modern villagers too much of their breech-clout ancestors whom they were anxious to deny and forget, in their haste to ape the white people.

The art of totem pole carving now wholly belongs to the past. As it is not really ancient, it has covered altogether less than a hundred years, mostly from 1840 to 1880. For the Haidas and the Niskae it came to an end about 1880. Elsewhere it actively survived till after 1900. The Gitksan near Hazelton have erected a few poor specimens in the past ten years.

The age of totem poles.—It is a mistake to say that totem poles are hundreds of years old. They could not be. A green tree, cut down, carved and planted without preservative cannot stand very long, as it is highly perishable. It rots at the base, and its weight together with the wind brings it down within a fairly definite span of years—often less than fifty years on the coast, where the moisture is intense and the muskeg foundation is corrosive. Up the rivers, where the climate is drier and the soil is sandy, some of the poles, the oldest, have stood as long as 70 or perhaps 80 years. They are the most archaic specimens of the kind. A minute examination of each one of them on the upper Skeena has made it clear that the art of totem pole carving evolved out of humble beginnings mostly after 1840. In a short period of intensive development it passed through two or three phases or styles.

Practically all the poles of the Haidas and the Tlingit as we know

FIG. 4.—Totem poles at Gitwinklkool, a Gitksan village on the Grease trail between the Skeena and the Nass rivers. FIG. 5.—The Woman and Lizard pole of Gitlarhdamks, upper Nass, now at the Royal Ontario Museum, Toronto; a fine carving in a state of decay. It was part of a totem pole, one of the oldest.

them were carved between 1860 and 1880, at the time when the fur trade on the Northwest Coast and at Victoria was at its height and native ambition had not yet been ruined by the introduction of Christianity.

The growth of the system of native heraldry.—The growth of heraldry on the Northwest Coast coincides with that of the art which served it as a vehicle. On the whole it can hardly be said to be very ancient or prehistoric.

Archaeologists so far have failed to unearth anything like the present totems, even in miniature form. The small stone or bone carvings and rock engravings that have been found in many places, when they are old, are of a different type—rather formless and naturistic. They have very little in common with the highly stylized art of such tribes as the Haidas, the Tsimsyan and the Tlingit.

The generation of wood-carvers that worked from 1860 to 1880 is acknowledged by the natives as the best. The names of the craftsmen have been partly compiled; their work can often be identified. They belonged almost exclusively to the Niskae, the Haida and the Southern Tlingit tribes.

One of the two best-known carvers of the Haidas, of Queen Charlotte Islands, was Edenshaw. This name is hereditary, as are the personal names. Out of three generations of Edenshaws, the second, from 1840 to 1880, was that of the best wood-carver of that name. The earliest of the three was an expert metal worker, evidently sometime after the introduction of metals by European sea traders.

The older tribes of the Tsimsyan still remember a time when their ancestors were not totemistic, had few if any emblems, and did not observe the rule of exogamic marriage, which is the outstanding feature of totemic organization. Yet the Tsimsyan are now one of the only three totemistic nations of the Coast.

If this type of social organization and its counterpart in heraldry existed at all before the coming of the Russians, at the end of the seventeenth century, no evidence can be found to prove it, whereas every indication points to its spread and development since.

The early mariners and discoverers, from 1779 to 1800, failed to observe any real detached totem poles, among the Haidas, the Tsimsyan or the Tlingit. Only a very few house posts and portals, roughly carved, crude masks and carved objects, were seen in various places and, in one village, house-front paintings. Some drawings of these were made by the visitors at the time. They are the only evidence that is left of native art at the end of the eighteenth century.

From one or two of those records, it is clear that the typical stylization of West Coast art already existed in the neighborhood of the present Alaskan frontier. But it must have been fairly restricted in scope, at the time, and also in the area of its diffusion. Was this stylization aboriginal or derivative?

It had every chance of being derivative. Yet it is difficult to say from where, for the lack of sufficient comparative data. Advanced stylization can be the result only of intense cultural development,

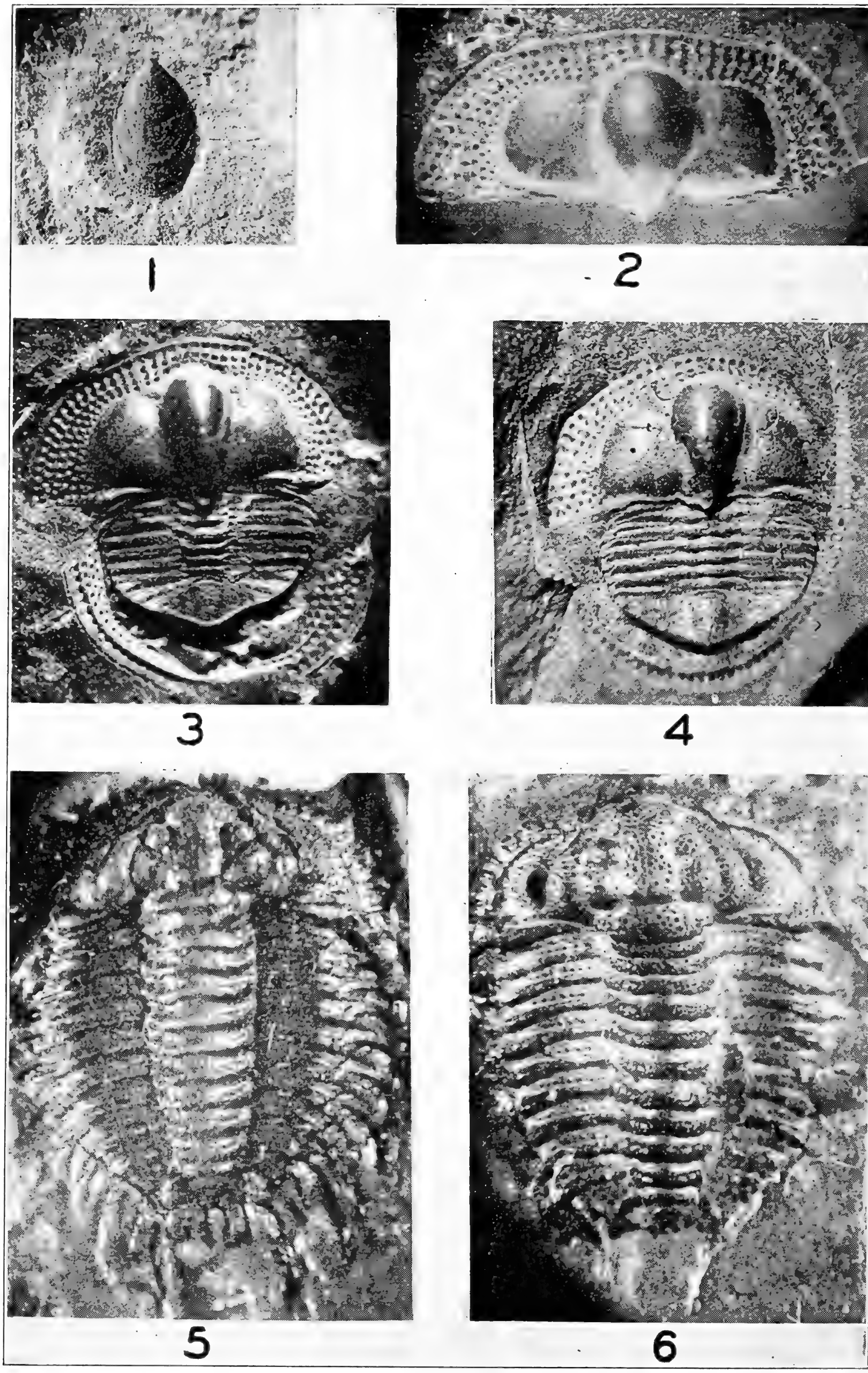
FIG. 6.—The Eagle's Nest pole, of Gitiks on the lower Nass. It now stands, sixty-six feet high, in the provincial park at Charlesbourg, near Quebec. FIG. 7.—The Mountain Eagle pole (to the right), now at the Royal Ontario Museum, Toronto. It is 81 feet high—the tallest and perhaps the finest in existence. From the lower Nass.

such as never had happened on the Northwest Coast in prehistoric times.

From distant resemblances, it seems that some of the Northwest Coast designs, like the culture itself, are of an Asiatic type. The use of masks is modern among the northernmost nations of the coast, but it seems to have been common on Vancouver Island at the time of the discovery. Masks are also commonly used in Asia. The Tlingit patterns on Chilkat blankets, among other things, resemble those of the garments of the Ainus in northern Japan. The West Coast people are not the only ones at the edge of the Pacific to have erected tall carved memorials or totems. These are also known under various forms in Japan, Korea, and in the South Seas. Some of the New Zealand carved poles so closely resemble the older poles on the Nass River, in British Columbia, that the ones might easily be mistaken for the others. The technique of erecting them, besides, was identical. It is quite possible that the Kanakas of the South Seas, brought over to the British Columbia coast by the earliest circumnavigators, may have had something to do with the development of this local art in America. Indeed, the carvings of the South Seas and Asia have many points in common with those that were executed in the mid-nineteenth century on the Northwest Coast—their sea-shell incrustations in particular.

Where the detached totem poles first appeared.—It is probable that the custom of erecting detached poles as memorial columns to the dead originated among the Tsimsyan of the lower Nass River, close to the present Alaskan frontier on the coast. But if it is more ancient there than elsewhere, it does not date back very far. The old people have heard of the time when two out of three of the Tsimsyan nations had no totem poles. One of those nations along the coast in fact never quite adopted that custom, as it passed under the banner of Christianity about 1850, a decade or so before totem poles became the fashion in the north.

It is far more likely that the Haidas and the Tlingit imitated the Nass River people than the reverse. Candlefish or *ulaken* fishing made of the estuary of the Nass the most important thoroughfare of native life in the north. *Ulaken* was a universal and indispensable staple. Tribes of several nations gathered every spring for the *ulaken* run in the neighborhood of the present Fishery Bay. During several weeks, exchanges of all kinds, barter, social contacts and quarrels were normal. Cultural features of the Nass as a result were observed by the strangers and imitated, wood carving in particular. The Nass River carvers are known to this day to have been about the best in that whole country. And their totem poles were the finest and the tallest seen anywhere. The twenty that stood there until recently were on the whole the tallest, and the best on the sea coast. They were also the oldest.



Figs. 1–6.—For explanation see opposite page.

PALEONTOLOGY.—*New data on upper Martinsburg fauna.*[1] MARK H. SECRIST, Department of Geology, The Johns Hopkins University. (Communicated by EDWARD W. BERRY.)

This paper presents a preliminary account of an exposure of upper Martinsburg shale at its contact with the overlying Oswego sandstone. The section, revealed by recent highway construction, is at the Water Gap in Blue (First) Mountain, along the west bank of the Susquehanna River, on Pennsylvania Highway Route 14, about seven miles north of Harrisburg.[2]

The section has been visited from time to time during the fall and winter of 1937–1938. Since the fauna listed in this paper seems to be unusually varied, the author wishes to call attention to the locality. Systematic study will be carried on during the field season of 1938.

The upper Ordovician section (generalized) follows:

Silurian: Tuscarora Formation

Massive, grayish-white sandstone. Makes the crest of Blue Mt. N75E75S at the contact with the Juniata sandstone.

Ordovician: Juniata Formation

Predominantly red sandstone, cross-bedded, with conglomerate lenses in the lower portion. A few conglomerate lenses and thin shale beds are scattered through the formation. The contact with the overlying Tuscarora formation is taken where there is a decided change in color, from red to grayish-white. The contact with the Oswego is fairly sharp. N80E66S at the contact with the Oswego sandstone....100 ft.

Oswego Formation

Mostly massive gray to reddish-brown conglomerate with scattered shaly beds. The contact with the underlying Martinsburg shale is sharp, showing a slight angular unconformity of about 3°. N85E80S at contact with the Martinsburg shale..........................79 ft.

[1] Received June 18, 1938.

[2] WILLARD, B. and CLEAVES, A. B. *A Paleozoic section in south-central Pennsylvania.* Pa. Top. & Geol. Sur. Bull. **G8**: 5–8. 1938.

FIG. 1.—*Lingula riciniformis* (Hall). Mold of ventral valve, ×4. FIG. 2.—*Cryptolithus bellulus* (Ulrich). Top view of well-preserved cranidium, ×5, showing the relative breadth of the species as well as the straightness of the anterior and posterior margins. FIG. 3.—*Cryptolithus tesselatus* (Green). Dorsal view of a nearly complete specimen, ×5. A portion of the inverted anterior brim of a second specimen is looped around the pygidium. FIG. 4.—*Cryptolithus tesselatus* (Green). Dorsal view of the mold of a nearly complete specimen almost encircled by the inverted buckler of a second specimen of equal size, showing the length of the genal spines, ×5. FIG. 5.—*Odontopleura* sp. Dorsal view of an entire individual, ×7, showing details of cephalon lobation and marginal ornamentation. FIG. 6.—The mold of the same specimen as FIG. 5, showing additional details of surface ornamentation and sculpture.

Martinsburg Formation

Dark blue-gray to brown, thin bedded, hackly shale which weathers rusty. N80E77S at the contact with the Oswego ss. Owing to its soft, unresistant nature, the shale is crumbling rapidly into soil. Observed in place.. 25 ft.

All the formations are overturned to the south.

The exposed Martinsburg shale is fairly fossiliferous up to the Oswego contact.

The following fossils were collected from the Martinsburg:

Crinoidea, columnals; *Cornulites* sp.; *Bryozoa* sp.; *Lingula riciniformis; L. curta; L.* sp. ind.; *Pholidops* cf. *cincinnatiensis; Plectorthis plicatella; Dalmanella testudinaria; Parastrophia hemiplicata; Sowerbyella rugosus; Rafinesquina alternata* var.; *R. squamula; Leptaena* sp.; *Cuneamya elliptica; C. aff. neglecta; C.* sp.; *Ctenodonta* sp.; *Clidophorus* cf. *scitulus; Colpomya faba-pusilla; C. faba* mut. *intermedia; Psiloconcha subovalis; Sinuites cancellatus; S. granistriatus; S.* sp.; *Plethospira quadricarinata; Eccyliomphalus* (?) sp.; *Holopea* sp.; *Hyolithes* sp.; *Geisonoceras amplicameratum; G. tenuitextum; Cryptolithus bellulus; C. tesselatus; Triarthus eatoni; Odontopleura* sp.; *Lepidocoleus jamesi.*

The above faunal assemblage, including 36 species distributed among 26 genera, corresponds very closely to the Lorraine fauna[3] of New York and also to the Eden fauna of the Ohio basin.

A few forms apparently have a range which is more extensive than either the Eden or the Lorraine. It is hoped that additional work may clarify their significance.

PALEOBOTANY.—*The age of the Carboniferous strata of the Paracas Peninsula, Peru.*[1] CHARLES B. READ, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, Jr.)

The succession of Paleozoic floras in the Southern Hemisphere has for many years been of interest to geologists. The distribution of these floras both in time and in space and their contrasts with the northern floras of apparently similar ages lead into problems of paleogeography and of geographic distribution of organisms which are still largely unsolved. The general nature of the succession of strata and the contained floras is too well known to require review here. However, a fact perhaps not so well known is the building up in recent years of evidence suggesting an intermingling of boreal and austral floral ele-

[3] Ruedemann, R. *The Utica and Lorraine formations of New York*, Pt. I, *Stratigraphy*, N. Y. State Mus. Bull. **258**: 1925. Pt. II, *Systematic Paleontology*, N. Y. State Mus. Bull. **262**: 1925 and **272**: 1926.

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received June 9, 1938.

ments at a few localities. Likewise, a few "outpost" or "relict" floras, depending on the interpretation, have been described. The evidence in most cases seems adequate. The Permian Kousnetzk floras in Siberia are cases of this sort in the Northern Hemisphere. An intermingling of a rather different sort has been indicated in the Wankie coal field in Rhodesia, where a so-called *Glossopteris* flora contains a few northern fernlike types (16). In South America in Brazil, and to a certain extent in Argentina (9, 10, 18), there are known floras which appear to be similar to those of the Wankie region.

From the Paracas Peninsula on the coast of Peru (lat. 13°55′ S., long. 76°33′ W.) one of the most interesting of these northern relict or outpost floras has been described (1, 2, 8, 13). There, according to Berry's published accounts, a fault block of continental Carboniferous strata carries a flora which is Westphalian in age. This is of particular interest inasmuch as it is one of the very few if not the only known occurrence of such strata on the west coast of South America. Likewise, Berry's list, published in 1922, of the species present in the largest collection described from Paracas indicates that the flora is completely boreal in type.

More recently it has been suggested by both Gothan (8) and Seward (13) that the flora is lower Carboniferous. Even before Berry's paper there was some difference of opinion. Fuchs (7) in 1900 referred the flora to the upper Carboniferous. A little later Steinmann (14) indicated the age should more properly be regarded as lower Carboniferous. Identifications by Zeiller (19) in 1917 suggest Westphalian age.

Schuchert (12) in 1932 stated that "the occurrence at Paracas, Peru, is lower Carboniferous in age or at most oldest Pennsylvanian." Du Toit (6) in his recent book seems to be somewhat uncertain. And in his volume on "*Plant life through the ages*," Seward also seems hesitant to pronounce final judgment. Thus there has been in the past some difference of opinion regarding the age and interpretation of the flora. If it is upper Carboniferous (Westphalian) it is exceedingly interesting as an outpost of the northern flora far in the Southern Hemisphere. On the other hand, if it is lower Carboniferous it is typical of the floras of that age already known from several localities in the Southern Hemisphere and in consequence raises no particularly important phytogeographic problems.

Accordingly, it was with a great deal of interest that the writer recently began the examination of a collection made from the Paracas Peninsula in 1922 by Harvey Bassler. This study was in connection with a review of South American Paleozoic floras preliminary to a detailed report on collections of fossils from Brazil.

Bassler's statement regarding the occurrence of the fossils is as follows: "My small collection was made as a pleasant incident of a very busy day, from the rock debris which had been hauled up during the excavation of a shallow shaft in the sag at the neck of the peninsula. This debris had already been rather thoroughly broken up and doubtless furnished some of the plant material of which mention has been made in the several papers concerning this locality."[2]

Although the collection was made very hurriedly and from debris picked over on several previous occasions by other collectors, Bassler was particularly fortunate in that he obtained several species belonging to genera which definitely determine the age of the deposit and also relate it to other occurrences in South America as well as elsewhere in the Southern Hemisphere. The determinable forms are as follows:

Sphenopteris parasica Gothan; *Adiantites whitei* (Berry), n. comb.; *Adiantites peruianus* (Berry), n. comb.; *Adiantites bassleri*, n. sp.; *Rhacopteris ovata* (McCoy) Walkom; *Rhacopteris* sp. cf. *R. cuneata* Walkom; *Aphlebia australis*, n. sp.; *Lepidodendron peruvianum* Gothan; *Lepidophyllum* sp. Gothan; *Calamites peruvianus* Gothan.

This flora is clearly lower Carboniferous and cannot be regarded as Westphalian. It is, in fact, late Dinantian, or at the latest, early Namurian in age. This is shown by the presence in abundance of *Rhacopteris ovata* and by the several species of *Adiantites*, a genus common in the lower Carboniferous. The first mentioned species, *R. ovata*, is perhaps the most common species present in the so-called *Rhacopteris* flora characteristic of the lower Carboniferous of the Gondwana province.

It is probable that this flora is of about the same age as that known in western Argentina in the general region of Barreal and San Juan, where occur *Rhacopteris ovata* (McCoy) Walkom (= *R. inaequalatera* Goeppert), *Adiantites antiquus* Ettingshausen, *Cardiopteris polymorpha* Goeppert, *Archaeopteris argentinae* Kurtz, and *Lepidodendron veltheimianum* Sternberg among other forms (10). These plants are from stage 1 of the Paganzo "system" of Bodenbender (3), which is regarded as ranging in age from late lower to upper Carboniferous.

Similarly the flora is correlative with that of the Kuttung series of

[2] Bassler, Harvey, personal communication, February 16, 1938.

New South Wales. That series, according to the Australian geologists, is late lower and early upper Carboniferous (4, 15).

It is difficult to place precisely the Paracas flora in the North American Carboniferous. In a general way, however, the flora corresponds to certain floras known, but undescribed, from the lower portion of the Mauch Chunk and from the upper part of the Pocono.

The appended remarks on the species present in the Bassler collection are brief diagnoses and discussions of the important elements in the flora necessary to support the remarks made concerning the age of the strata in question.

Adiantites bassleri, n. sp. Fig. 7

Frond unknown but presumably compound. Ultimata pinna slightly sinuose angularly, rather narrow, striate longitudinally, bearing widely spaced pinnules which are deeply divided into 3, 4, or 5 narrow, elongate cuneate lobes. Pinnules alternate, attached at the base by a very short foot-stalk. Nervation unknown.

This species is known from only a few fragments, the most complete being seen in the figure. It suggests *Adiantites antiquus* Stur, from which it is clearly distinct, differing in the larger size of the pinnules and their more elongate outlines.

As is indicated above, the venation is unknown in the specimen which is preserved in a dark sandy matrix. A sketch of the plant has been prepared from the photograph originally made, and this drawing is reproduced in figure 7. The relatively large size of the pinnules and their rather elongate shape are features of distinction, although the form does approach an undescribed species from the Mississippian of the Appalachian trough.

Sphenopteris parasica Gothan Fig. 2

Palmatopteris furcata (Brongniart) Potonié. Berry, Johns Hopkins Univ. Studies in Geology **4**: 15–17, pl. 1, figs. 1–3. 1922.

Sphenopteris parasica Gothan, Neues Jahrb. **59** (B): 293, pl. 13, fig. 1. 1928.

Fronds of unknown size, pinnae open, inclined to be irregularly flexuose, the ultimate pinnae rather distant. Ultimate pinnae set at open angles on the pinnae of the next lowest order, similar in flexuose nature, the pinnules rather distant. Pinnules cuneate or triangular in gross outline, deeply incised into cuneate segments, each of which bears from two to four veins originating from a single basal vein supplying all segments of the pinnule.

To some extent this species suggests *Rhodea tenuis* Gothan and *R. smithi* Kidston, both of which are lower Carboniferous forms. In fact, on the basis of the highly divided nature of the pinnules, this plant should perhaps be placed in *Rhodea* rather than *Sphenopteris*. From *R. smithi* the plant here described differs in its somewhat larger size as well as in the somewhat broader laminae, which are rounded apically rather than acutely round pointed. *R. tenuis* is a somewhat smaller, more compact type.

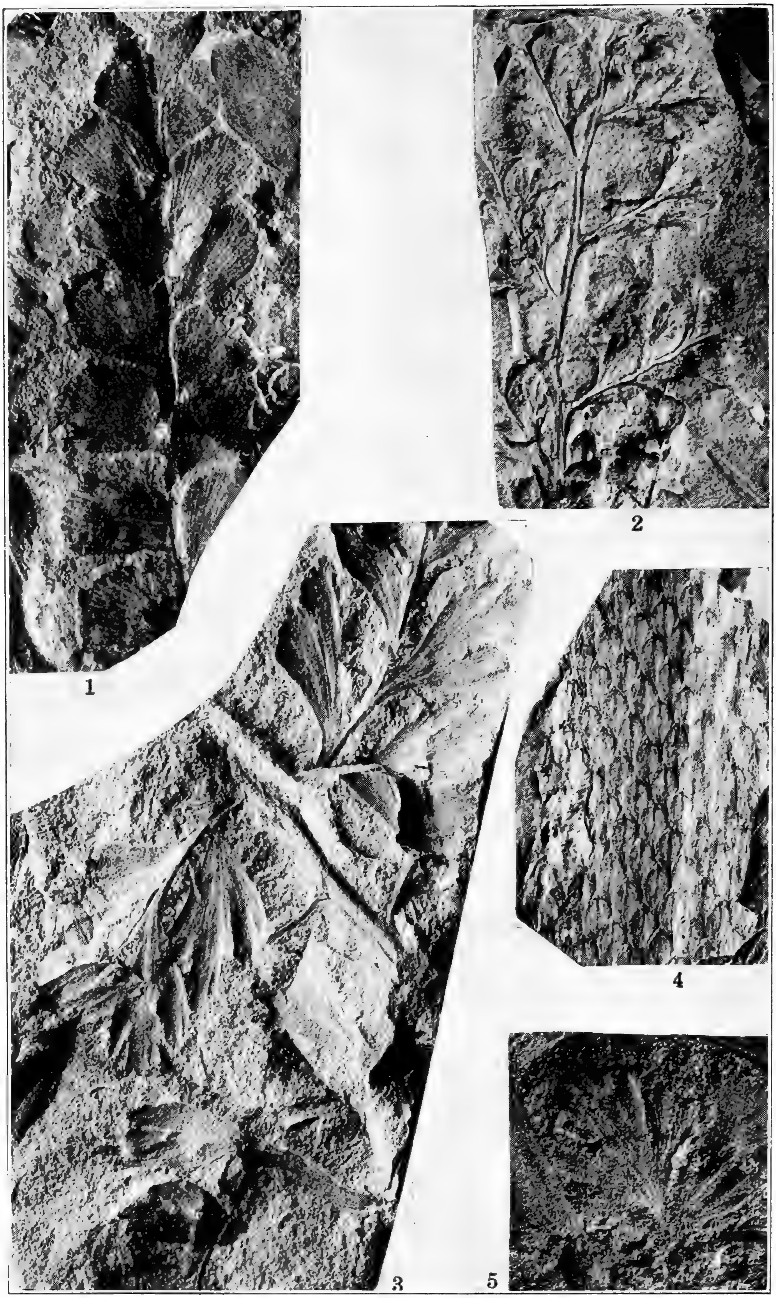


FIG. 1.—*Rhacopteris ovata* (McCoy) Walkom. FIG. 2.—*Sphenopteris parasica* Gothan. FIG. 3.—*Adiantites peruianus* (Berry), n. comb. FIG. 4.—*Lepidodendron peruvianum* Gothan. FIG. 5.—*Rhacopteris* sp. cf. *R. cuneata* Walkom.

Adiantites whitei (Berry), n. comb.

Eremopteris whitei Berry, Johns Hopkins Univ. Studies in Geology **4**: 20–21, pl. 4. 1922.

This species has already been described in considerable detail, and the present writer has nothing to add to the description. However, the species appears to be more properly referable to the genus *Adiantites* than to *Eremopteris*.

Very little of this material is present in the Bassler collection and that poor. In consequence these remarks are based in part on Berry's illustration and description. The pinnules are, when lobed, apparently arranged fasciculately. The pinnule outlines appear rather typically *Adiantites*-like but are smaller than *A. peruvianus* and do not show the erose apices characteristic of that species.

Adiantites peruianus (Berry), n. comb. Fig. 3

Eremopteris peruianus Berry, Johns Hopkins Univ. Studies in Geology **4**: 19–20, pls. 2–3. 1922.

This species appears to be referable to *Adiantites* rather than to *Eremopteris*.

In the grouping of the pinnules into fasciculate bundles and in the general form of the divisions this species is rather typical of *Adiantites*. However, in the rather erose and sometimes denticulate pinnule apices there are features which are not commonly seen in the genus. It is, in fact, very distinct and should not be confused with any other known species.

Rhacopteris ovata (McCoy) Walkom Fig. 1

Otopteris ovata McCoy, Annals and Mag. Nat. History **20**: 148, pl. 9, fig. 2. 1847.

Rhacopteris inaequalatera Feistmantel, New South Wales Geol. Survey, Mem., Paleontology **3**: 97. 1890.

Rhacopteris ovata (McCoy) Walkom, Linnean Soc. New South Wales, Proc. **59** (5–6): 431–432. 1934

The Paracas collection made by Bassler includes a number of specimens of this important species. It must be borne in mind that this form is one of the index fossils to the lower Carboniferous strata of the Southern Hemisphere. Hence its presence in the Paracas flora points conclusively to the early Carboniferous age of the strata exposed at that locality.

The specimen figured is rather typical of the species and is the best preserved fragment in the collection. However, the species is abundantly represented, being perhaps the most common form present.

Rhacopteris sp. cf. **R. cuneata** Walkom Fig. 5

The single fragment which is referred with considerable hesitation to Walkom's species (16) appears to also resemble the specimen of *Rhacopteris circularis* Walton figured by Gothan (8) from Vichaicoto, south Huanuco. The material at hand is insufficient to determine clearly the specific position of the form. However, it almost certainly belongs to *Rhacopteris*.

Walkom's species, it will be recalled, was described as ?*Sphenopteridium cuneatum*. In his discussion Walkom pointed out that there were resemblances to *Rhacopteris* and indicated that the plant might be included in that genus. To the present writer the assignment to *Rhacopteris* is preferable.

Walkom's plant seems to be characterized by a slightly more compactly lobed pinnule than the Paracas fragment. The features of both are rather vague, however, and do not permit more than a very superficial comparison which does suggest close similarity, if not identity.

Aphlebia australis, n. sp. Fig. 6

Lamina apparently membranaceous, lax, flabellate, showing abundant dichotomies to form a highly divided leafy organ, base unknown. Venation not very distinct, apparently consisting of a single broad vein which forks

Fig. 6.—Sketch of *Aphlebia australis*, n. sp., showing the highly dichotomous and lax structure of the organ. Traced from photograph. Fig. 7.—Sketch of *Adiantites bassleri*, n. sp., slightly restored.

following the division of the lamina, each lobe carrying but a single vascular strand. Apices of the lobes apparently pointed, very acute.

The single specimen known of this form is a fragment revealing only the highly dichotomous lamina and shows little of either the base or of the ultimate divisions. As has been indicated above, the organ is a highly dichotomous one, very lax in its aspect, and traversed by a very simple system of a single vascular strand. Its relationship to the fern and fernlike elements of the Paracas floras is, at best, quite speculative.

Lepidodendron peruvianum Gothan Fig. 4

Lepidodendron rimosum Sternberg. Berry, Johns Hopkins Univ. Studies in Geology **4**: 24–26, pl. 8. 1922.

Lepidodendron obovatum Brongniart. Berry, Johns Hopkins Univ. Studies in Geology **4**: 26–27, pl. 1, fig. 5. 1922.

Lepidodendron peruvianus Gothan, Neues Jahrb. **59** (B): 294–295, pl. 13, fig. 2. 1928.

The material referred by Berry to *Lepidodendron rimosum* Sternberg and *L. obovatum* Sternberg appears to be more properly referable to Gothan's *L. peruvianum.* Both the specimens figured by Berry as *L. obovatum* and *L. rimosum* do not seem very close to those species as the writer understands them. The specimen in figure 2, plate 8, of Berry's paper is simply partly decorticated and is almost certainly referable to the same species as that in plate 1, figure 5. The proportions of the bolsters in all these Paracas specimens differ markedly from those of *L. obovatum.* The latter has a very symmetrical rhomb-shaped bolster, while the South American specimens show the widest point plainly above the middle. Likewise the leaf scars are higher in the latter than in the former.

The resemblances to *Lepidodendron rimosum*, with its elongate, slightly sinuous bolsters, are slight. None of the Paracas specimens examined by the writer seems close.

Calamites peruvianus Gothan

Calamites suckowi Brongniart. Berry, Johns Hopkins Univ. Studies in Geology **4**: 21–23, pls. 5–7. 1922.

Calamites peruvianus Gothan, Neues Jahrb. **59** (B): 294, pl. 14, fig. 1. 1928.

Material referable to *Calamites* is quite rare in the collection made by Bassler. However, the few specimens seen appear to be nearer to Gothan's *C. peruvianus* than to *C. suckowi* Brongniart.

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ZOOLOGY.—*A new* Liolaemus *and two new* Syrrhopus *from Peru.*[1] BENJAMIN SHREVE, Harvard University. (Communicated by THOMAS BARBOUR.)

This paper deals with some novelties found in a collection of Peruvian reptiles and amphibians made by Warren F. Walker, Jr. Mr. Walker intended to work out this collection himself but due to the pressure of college studies he was unable to complete the task. Hence it became my lot to finish identifying the collection and to publish the descriptions of the new forms found therein.

Liolaemus walkeri sp. nov.

Type:—Museum of Comparative Zoology no. 43770, a male, from Lloclapampa, circa 10,000 feet altitude, Department of Junin, Peru, collected by Warren F. Walker, Jr., June 26 to July 3, 1936.

Paratypes:—Museum of Comparative Zoology nos. 43771–9 and ten uncatalogued specimens with the same data as the type. Many paratypes are gravid females.

Diagnosis:—Allied to *Liolaemus gracilis* and *bibronii;* from the former it differs in possessing a larger scale count around the middle of the body, an antehumeral fold, hind limbs averaging shorter, and in coloration; from the latter it differs in not having mucronate dorsal scales, a larger average number of anal pores, and in coloration. This new form is also allied to *Liolaemus alticolor* from which it differs in having smooth temporal scales, and in not having mucronate dorsal scales, and in coloration.

Description:—Nostril lateral; upper head scales rather large, smooth; an azygos frontal separated from the interparietal by a pair of frontoparietals, the right frontoparietal being divided more or less longitudinally (in the paratypes, frontoparietals variously fused or split); interparietal as large as, or larger than, parietals (also, smaller than parietals in many paratypes); a series of about three enlarged supraoculars (about three or four in paratypes); a single series of scales between the labials and infraorbital (in some paratypes, part of one labial is actually in contact with infraorbital); temporal scales smooth; ear opening with indistinct denticulation in front (fairly distinct in some paratypes); sides of neck covered with very small scales, with an irregular, longitudinal fold; a short, curved antehumeral fold; dorsal scales moderate, more or less rhomboidal, strongly keeled, pointed, although not mucronate; ventral scales slightly larger or about the same size, rounded, hexagonal, or rhomboidal, smooth; about 58 scales around the middle of the body (about 50–62 in paratypes); about 63 scales from occiput to rear of hind limb (about 55–68 in paratypes); the adpressed hind limb reaches the axilla (from the axilla, or a little further, to well behind the

[1] Received July 2, 1938.

axilla in paratypes); hinder side of thighs uniformly granular; 4 anal pores (4–6 pores in five paratypes, the rest with none; apparently present in males only, as in other members of the genus); caudals as large as, or larger than, dorsals.

Coloration in alcohol:—Above, brown (gray where outer epidermis has peeled off), a narrow, dark brown or black vertebral stripe extending from the neck almost to the end of the tail, rather broken on the tail; a light grayish stripe about two scale rows wide beginning at the upper posterior border of the eye extending on to the tail where it becomes obsolete; below this stripe, on the side, another narrower and more obscure beginning at the lower posterior border of the eye and extending to the hind limb, almost obsolete in front of the ear; dark brown or black spots on the dorsum and head, on the dorsum extending as far as the lowest stripe; also, below the upper grayish stripe, sides speckled with whitish; below, gray, rear of hind limbs, belly, and chest overlaid with black; throat and underside of head marked with black; chin blackish gray; therefore, it is seen that the ground color is largely obscured; underside of tail grayish, spotted with blackish.

The five paratypes with anal pores, which are all males, differ somewhat from the type in coloration. In no. 43772, the largest of these, the dark vertebral stripe and the lower light stripe are absent, the stripe that is present being ill defined, and there are no dorsal spots on this individual; in the smaller examples, the dorsal and lateral stripes are much more distinct even than in the type, the beginnings at the eye being plainly visible; below, in the smaller individuals, the black of the belly extends not at all or but little onto chest; in no. 43775, the smallest of these five, the body is uniform blackish gray below, without black markings. Males of this species, as they become older, become more indistinctly striped above and more extensively black below.

The female coloration is like that of what are apparently juvenile males, with the stripes perfectly distinct and the underside of the body light gray to blackish gray, darker on chin, with the black being absent.

Underside of tail in all paratypes is grayish or whitish brown, marked, or unmarked with dark brown; also the vertebral stripe may be margined with grayish and may be unbroken on tail; light stripes may be whitish brown as well as grayish; dorsal spots are sometimes lacking as also spots on the head.

Measurements:—

	Length head and body	Tail[1]	Total length	Hind limb	Hind foot
Type no. 43770	54 mm	69 mm	123 mm	27 mm	14 mm
Paratypes nos. 43771–9 and ten uncatalogued specimens	60–30 mm	67–42 mm	127–72 mm	28–16 mm	15–8 mm

[1] The tail of type and largest paratype regenerated.

This species is named for Warren F. Walker, Jr., the collector of a valuable Peruvian herpetological collection which he has kindly presented to the Museum of Comparative Zoology.

Remarks:—Specimens of this species in the Museum of Comparative Zoology from Ticlio, circa 15,600 feet altitude, Department of Lima, and Janchiscochas Mine, 40 kilometers north of Jauja, Department of Junin, present certain small differences from the type series which may or may not entitle them to separate recognition. For example, one of the Ticlio series, the only one with any pores, has but three. Therefore, these specimens were not included as paratypes.

Syrrhopus montium sp. nov.

Type:—Museum of Comparative Zoology no. 22858 from Cascas, near Huasahuasi, Department of Junin, Peru, collected by Warren F. Walker, Jr., August 31, 1936.

Paratypes:—Museum of Comparative Zoology nos. 22859–61 with the same data as the type.

Diagnosis:—Allied to *Syrrhopus simonsii* from which it differs in having shorter hind limbs, no dorsal warts forming longitudinal folds, and in coloration.

Description:—Tongue suboval, entire; vomerine teeth none; snout rounded, longer than the diameter of the eye; loreal region concave and oblique; canthus rostralis distinct, curved; nostril a little nearer the tip of the snout than the eye; interorbital space slightly broader than upper eyelid; no tympanum, tips of digits not or but extremely feebly swollen; digits short; first finger slightly shorter than second; first toe shorter than second; inner metatarsal tubercle rather large but ill defined, outer virtually indistinguishable from many surrounding poorly defined tubercles; the tibiotarsal articulation of the adpressed hind-limb does not reach the axilla (it does in two paratypes); granulate above, especially posteriorly; sides very coarsely granulate; belly, chest, throat, and lower surface of thighs also very coarsely granulate.

Coloration in alcohol:—Above, dark purplish brown, limbs obscurely crossbanded with darker; the inner side of hand and the two inner fingers, inner side of foot and the three inner toes white, both above and below, this white also marked in places with dark purplish brown; below whitish, belly slightly suffused and marked with purplish brown, underside of limbs, except outer part of lower side of thighs, and on the hands and feet as previously noted, colored like dorsum.

The coloration of the paratypes is essentially similar to that of the type except the crossbands on limbs may be absent; below, there may be extensive white areas on limbs, and below the dark suffusion may be a bit more pronounced than in type.

Measurements:—

	Length of head and body	Head	Hind limb	Fourth toe
Type no. 22858	29 mm	10 mm	30 mm	6 mm
Paratypes nos. 22859–61	26–21 mm	10–7 mm	30–27 mm	7–6 mm

Syrrhopus juninensis sp. nov.

Type:—Museum of Comparative Zoology, no. 22851, a male from Cascas near Huasahuasi, Department of Junin, Peru, collected by Warren F. Walker, Jr. August 31, 1936.

Paratypes:—Museum of Comparative Zoology nos. 22852–7 with the same data as the type.

Diagnosis:—Allied to the preceding species from which it differs in being smooth below, in having a more distinct outer metatarsal tubercle, a distinct fold above the spot where the tympanum should be, and in coloration.

Description:—Tongue suboval, entire (very slightly nicked in some paratypes); vomerine teeth none; snout rounded, longer than the diameter of the eye (about the same length in some paratypes); loreal region concave and oblique, canthus rostralis distinct, curved, nostril slightly nearer the tip of the snout than the eye; interorbital space about as broad as upper eyelid or a bit narrower; no tympanum, a distinct fold over the tympanic area; tips of digits very feebly swollen or not swollen at all; digits fairly short; first finger slightly shorter than second; first toe shorter than second; toes unwebbed at base; inner metatarsal tubercle rather large, outer decidedly smaller; the tibio-tarsal articulation of the adpressed hind limb reaches the axilla (a bit beyond the axilla in two paratypes); above with low, rather indistinct warts, especially posteriorly (warts more distinct in some paratypes, in others almost obsolete); smooth below.

Coloration in alcohol:—Above, dark gray, decidedly lighter on sides and on limbs, an obscure blackish crossband between the eyes, a similar band from the nostril to the eye and from the posterior corner of the eye along the "supratympanic" fold; dorsum obscurely marked with blackish; below, brownish white, suffused with light gray.

In some paratypes the obscure band anterior to the eye starts at the tip of the snout; also the "supratympanic" blackish marking may be absent. In addition, the limbs above may be obscurely crossbanded; while in some the middle of the back is not darker than the sides; markings above quite distinct in one paratype.

Measurements:—

	Length head and body	Head	Hind limb	Fourth toe
Type no. 22851	31 mm	10 mm	44 mm	9 mm
Paratypes nos. 22852–7	30–23 mm	10–8 mm	39–29 mm	8–6 mm

Remarks:—Both of these frogs have been found on dissection to have a broad cartilaginous sternum and more or less T-shaped terminal phalanges. These characters, in addition to the absence of vomerine teeth, would indicate membership in the genus *Syrrhopus.*

The terminal phalanges appear to be more T-shaped than in *Eusophus* hence these are not considered members of that genus without vomerine teeth. It appears likely that *Syrrhopus, Eleutherodactylus* and *Eusophus* may eventually be merged. See H. W. Parker, Ann. Mag. Nat. Hist. **10** (10): 344. 1932.

ICHTHYOLOGY.—*Status of the Asiatic fish genus* Culter.[1] HUGH M. SMITH, United States National Museum.

In 1855 Stephan Basilewsky published a paper in which were described various new genera and new species of Chinese fishes. None of the generic names except *Culter* has survived to the present time, all the others having long ago been discarded as synonyms.

The characters given in the definition of the genus were mostly applicable to several other cyprinoid genera, and scarcely a single distinctive feature was noted. One outstanding character was a dorsal fin situated over the space between the ventral and anal fins, with its second simple ray very robust and osseous. Included under the

[1] Received July 6, 1938.

genus was the well-known European fish *Cyprinus cultratus* Linnaeus, and six new species were described, of which the first three (*alburnus, erythropterus,* and *mongolicus*) had the abdomen compressed and carinate and the second three had the abdomen non-compressed. In two of the first three the natatory vesicle was noted as trilobed; in all of the last three it was given as bilobed.

The genus, obviously composite, has now been split up into at least four genera, *Hemiculter* (Bleeker, 1859), *Pseudoculter* (Bleeker, 1859), *Erythroculter* (Berg, 1909), and *Pseudohemiculter* (Nichols and Pope, 1927), while *Culter* proper has been retained for a few species of China, Formosa, and Siam in which the entire abdominal edge is trenchant (Berg; Nichols, 1928), or in which the abdominal edge is either trenchant throughout or trenchant only posterior to the ventral fins (Günther, 1868; Oshima, 1917).

If there were no other points involved, the status of *Culter* could be left here, but the case is not so simple.

In 1863 Bleeker designated *alburnus* as the type species of the genus *Culter,* putting it in a section of his general synopsis and key to cyprinoid fishes characterized by having the abdomen cultrate anterior to the ventral fins. In this course he was followed by Günther (1868) who, however, placed *alburnus* in the synonymy of *recurviceps* (Richardson, 1846), and in his description of the species said: "Abdominal edge trenchant from behind the ventrals, flattened between the ventrals and pectorals." Berg (1909) on the other hand recognized *alburnus* as a species in which the abdominal keel exists anterior to the ventrals and established his *Erythroculter* to accommodate Basilewsky's *erythropterus* with a trenchant abdominal edge only posterior to the ventrals. The position taken by Nichols and Pope (1927) was that "Whereas we suspect that Basilewsky's *alburnus* was actually a species with posterior keel only, quite likely identical with his *erythropterus,* one opinion is as good as another as to this and we follow Berg's ruling."

As a contribution to this phase of the present discussion, it is possible to quote from a letter dated April 29, 1937, from Mr. J. R. Norman, Assistant Keeper, Department of Zoology (Fishes), in the British Museum who had been requested to indicate just what undoubted specimens of *alburnus* and *erythropterus* in that institution actually showed as regards the abdominal edge. Mr. Norman courteously wrote:

We have several specimens identified by Günther as *Culter recurviceps* (= *alburnus*) and *C. erythropterus* respectively and I have no reason to doubt the correctness of these identifications. Both have the abdominal edge trenchant only posterior to the ventral fins.

In setting up *Culter alburnus* as the type of *Culter*, Bleeker and various writers who agreed with him in this course entirely ignored the fact that Basilewsky himself adopted or considered *Cyprinus cultratus* Linnaeus as the type of *Culter*. No other interpretation can be placed on the circumstance that, immediately after the first use of the name *Culter*, Basilewsky devoted an entire line to the words "Cypr. cultratus Linn." The case is clearly covered by the International Rules of Zoological Nomenclature, reference being made particularly to article 30, paragraph *g*, reading:

> If an author, in publishing a genus with more than one valid species, fails to designate or to indicate its type, any subsequent author may select the type.

That Basilewsky did select a type species by "indication" seems to be fully established by the international rules and the opinions thereunder, and Bleeker's action was void.

Although the point is not of vital importance, it may be noted that the original definition of the genus *Culter* fitted fairly well the species *cultratus* and that in the few particulars in which it did not apply it would have been subject to future emendation, correction, or amplification, as was done by Günther (1868) to make it fit the species he assigned to it.

In passing on the name *Culter* and its genotype, Jordan (1919) expressed the following opinion:

> *Culter* Basilewsky; logotype *C. alburnus* Basilewsky, as restricted by Bleeker and Günther. Under the head of *Culter* Basilewsky mentions especially *Cyprinus cultratus* L. . . . although he does not exactly specify this as type. He then proceeds to describe certain Chinese species. For some of these the name *Culter* has been kept, although Basilewsky plainly intended to make his type *Cyprinus cultratus*. At present we follow the authority of Bleeker and Günther.

If it were established that *Cyprinus cultratus* was not designated or indicated by Basilewsky as the type of *Culter*, that species would automatically have become the type under another provision of the International Rules of Zoological Nomenclature. Thus, paragraph *i* of article 30, which appears as a recommendation of the International Commission on Zoological Nomenclature, reads:

> If a genus, without designated type, contains among its original species one possessing as a specific or subspecific name, either as valid name or synonym, a name which is virtually the same as the generic name, or of the same origin or same meaning, preference should be shown to that species

in designating the type, unless such preference is strongly contraindicated by other factors. (Type by virtual tautonymy.)

The foregoing review has been intended to prepare the way for another aspect of this case.

The genus *Pelecus* was established by Louis Agassiz (1835) for the accommodation of *Cyprinus cultratus* Linnaeus, and the fish has ever since borne the name of *Pelecus cultratus*.

It therefore follows that Basilewsky's *Culter*, proposed twenty years later, was a synonym and that this name is not available for any of the various species which have from time to time been so designated, many of which, however, have already been placed in newly-established genera.

It now remains to provide for forms that are still carried under the name of *Culter*. These fall into two closely related genera which are named and diagnosed as follows:

Cultrops n. g. (Cyprinidae)

Body and head strongly compressed, with abdominal edge trenchant throughout; dorsal profile nearly straight and horizontal, ventral profile strongly and evenly decurved; eye in anterior half of head, postorbital region long; mouth subvertical; lower jaw with a strongly developed symphysial hook which fits into a corresponding depression in the upper jaw; no barbels; pharyngeal teeth triserial, with 4 uncinate teeth in each of the two outer rows and 2 shorter blunt teeth in the innermost row; gill openings wide; gill membranes narrowly united to isthmus; gill rakers numerous, long, setiform; natatory vesicle tripartite; scales small; lateral line slightly decurved, often consisting of 2 or 3 disconnected overlapping sections, and running in lower half of caudal peduncle; dorsal fin placed over the space between ventral and anal fins, with 7 branched rays and with last simple ray slender, weak, and non-osseous; caudal fin forked; anal fin with 23 to 25 branched rays; pectoral fins long.

Genotype.—*Culter siamensis* Hora, inhabiting Siam.

The genus *Paralaubuca* established by Bleeker in 1863 (Atlas Ichthyologique, III) for a common Siamese species (*typus*) is close to *Cultrops* (rather than to *Laubuca* with which Bleeker compared it) but seems to be sufficiently differentiated.

Cultrichthys n. g. (Cyprinidae)

Body and head strongly compressed, with abdominal edge trenchant from pectoral base to vent; dorsal and ventral outlines similar; eye in anterior half of head, postorbital region long; mouth subvertical; no postsymphysial knob or hook on lower jaw; no barbels; pharyngeal teeth slender, triserial, 5,4,2—2,3(or 4),4, or 4,3,1—1,3,4; gill openings wide; gill membranes narrowly united to isthmus; gill rakers numerous, long, setiform; natatory vesicle tripartite; scales small; lateral line with slight downward curvature; dorsal fin placed over the space between ventrals and anal or slightly overlapping origin of anal, with 7 branched rays and with the last simple ray smooth, stout, and osseous; caudal fin forked; anal fin with 28 to 30 branched rays; pectoral fins long.

Genotype.—*Cultur brevicauda* Günther, inhabiting Formosa and China.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1135TH MEETING continued

J. W. MCBURNEY: *Freezing and thawing of brick.*—Freezing and thawing tests are rarely used as acceptance tests for building brick because of the length of time required to obtain results. The principal use of such tests in recent years has been in the evaluation of weathering classification of building brick. The classifications are based upon certain physical properties that can be readily measured in the laboratory. The most important of these properties is the C/B ratio which can be defined as the ratio of easily filled pore space to total fillable pore space. Twelve samples of 20 bricks each were selected from each of 5 large samples representing 5 different types of bricks so that the distribution of the physical properties of each small sample closely resembled each other small sample. These comparable small samples were frozen and thawed up to 75 cycles using 7 different techniques of freezing and thawing. Three types of exposure to weather were used on others of these small samples. The action of both laboratory freezing methods and natural exposures can be summed up by stating that the greater the degree of saturation at the time of freezing, the more effective was the method in producing disintegration. (*Author's Abstract.*)

The first paper was discussed by Messrs. KRACEK, HERSCHEL, MCNISH, and HECK; the second one by Messrs. TUCKERMAN, HECK, KRACEK, and STEVENSON.

An informal communication on the bisection of a horn angle was presented by A. S. Hawkesworth and discussed by Messrs. Goldberg and McNish.

1136th meeting

The 1136th meeting was held Saturday, May 7, 1938, in the Cosmos Club Auditorium, President Heck presiding.

Program: H. L. Dryden: *Liveliness of baseballs.*—At the request of Clark Griffith, President of the Washington Nationals, representing a committee of American League officials concerned with standardization of baseballs, and because of the considerable public interest in the matter, the National Bureau of Standards undertook to study methods of measuring the liveliness of baseballs and to determine whether the ball to be used by the American and International Leagues next season is livelier than that to be used by the National League.

The "liveliness" or in scientific language the resilience of a body is commonly determined by allowing it to fall and rebound from a suitable hard surface. A lively ball rebounds more than a dead ball. This method is, however, not at all satisfactory for baseballs. The principal reason is that the pitcher bounces the baseball off the bat in a home run hit with relative speeds far greater than can be obtained by dropping from any reasonable height. The impact of a ball dropped from the top of the Washington Monument or higher on to the pavement below is probably not as great as that of the bat hitting a fast ball. The falling ball is retarded by the resistance of the air and soon approaches a constant speed at which the air resistance equals the weight. This speed has not been accurately determined but is probably of the order of 120 feet per second. The relative speed at which the bat meets a fast ball is probably greater. In any case large corrections would have to be made for the effects of air resistance in the measurement of liveliness by dropping tests.

It is necessary to secure impacts comparable with those of a batted ball, since the liveliness decreases as the severity of the impact and the consequent deformation of the ball increases. The Bureau has constructed a machine which gives relative speeds of the right order of magnitude. The machine is an adaptation of apparatus developed by Professor H. A. Thomas of the Carnegie Institute of Technology for measuring the liveliness of golf balls. It consists of an air gun which shoots a one-pound hard-wood projectile representing the bat at speeds up to 200 ft/sec against the ball which is "teed" like a golf ball. After impact, the projectile and ball are caught in ballistic pendulums, by means of which their speeds can be determined. The resilience or "liveliness" is measured by the ratio of the relative speed after impact to the relative speed before impact.

Since balls of the same lot vary somewhat in weight, size, and physical properties, it was necessary to take a large number of measurements on a fair number of balls of any given type to obtain reliable average values. The measurements of the liveliness of the American and National League baseballs showed no difference of any practical significance. Some National League balls are more lively than some American League balls, and some are less lively. There are slight variations in liveliness of balls of either league, just as there are slight variations in weight within the official limits of 5 to $5\frac{1}{4}$ ounces and slight variations in circumference within the official limits of 9 to $9\frac{1}{4}$ inches. The differences between averages of three measurements on six balls of each type are small in comparison with variations in the individual measurements and would probably disappear if a very large number of balls were tested.

As a check on the laboratory measurements (and of greater interest to most people) the gun was taken to the ball park and used as a robot batter to drive out home runs. It was easily possible to knock the ball over the fence. Numerous measurements of distance were made under the same conditions in so far as possible. The average distance was the same for the American and National League balls within one foot, namely, 367 feet for the conditions used. Individual shots went from 320 to 410 feet, this scatter and lateral deflections up to 30 feet either way being largely due to the effect of the variable wind. (*Author's Abstract.*)

O. H. GISH and K. L. SHERMAN: *Electrical resistance of the atmosphere.*

The first paper was discussed by Messrs. ROLLER, TUCKERMAN, BUCKINGHAM, and HAWKESWORTH; the second one, which was presented by Mr. GISH, was discussed by Messrs. HAWKESWORTH and TUCKERMAN.

An informal communication on "Fibonacci Redivivus" or "The Fecund Rabbits" was presented by Mr. L. B. TUCKERMAN. This was discussed by Messrs. McNISH, HUMPHREYS, and GOLDBERG.

1137TH MEETING

The 1137th meeting was held Saturday, May 21, 1938, in the Cosmos Club Auditorium, President HECK presiding.

Program: W. C. LOWDERMILK: *The recent floods in southern California.*—The flood of March 1938 in Southern California was the most disastrous since the historical record began in the founding of the San Gabriel Mission in 1771. Because of highly developed culture and density of population, flood waters were more destructive to the interests of human inhabitants than ever before. Eighty-three persons lost their lives and 116 were injured and nearly 5,000 families required assistance and rehabilitation. The losses in property destroyed and damaged approximated 83 millions of dollars. The flood affected principally the four drainage basins of the Los Angeles, San Gabriel, Santa Ana and Santa Clara Rivers. Highway and railway bridges were washed out. Highways and roads were cut through; stream channels were deepened and widened under cutting banks; densely populated communities were overwhelmed by overwash and extensive areas of agricultural lands were damaged or ruined by the overwash of sands, gravels and boulders and cultivated fields on sloping lands suffered serious erosion throughout the area. The total rainfall of two storms coming one close upon the other varied from 7 inches in the coastal plains to 30 inches above 7000 feet in the mountains. Melting of winter snows above the 6,000 feet level added to the flood runoff. Rain intensities equalled as much as 3 inches per hour per 15 minutes and there was as much as 11 inches of fall in 12 hours at the higher elevations. But greater rainfall has occurred in the past, such as in the winters of 1861–62, 1884–85 and in 1889. Such storms may be expected to occur from time to time in the future. Important lessons in the interests of flood control and water conservation may be learned from this flood.

The flood control dams were effective in reducing runoff peaks up to 50 percent and plans for construction of additional flood control reservoirs appear to be fully justified.

Debris in the flood currents presents the greatest problem in the control of flood waters for this area. The 16 debris basins constructed along the mountain front were effective in unloading heavily charged runoff and mud flows. Cleaning out of the debris basins represents a heavy cost of flood protection. The flood control reservoirs, moreover, were filled to surprising degree by debris washed out of tributary mountain streams. The capacities of reservoirs were reduced from 5 to 77 per cent by this one storm.

The importance of maintaining the sloping lands of the agricultural areas in cover crop vegetation and of the mountain slopes with grass or chaparral forests was demonstrated in this storm. It is also apparent that such safeguards in runoff control must be supplemented by engineering structures to secure a reasonable control of flood runoff. (*Author's Abstract.*)

This address was discussed by Messrs. Heck, Curtis, Tuckerman, Gregg, Bernard, and Wenner.

Mr. P. R. Heyl presented an informal communication on "The Law of Anomalous Numbers." Mr. M. Goldberg presented an informal demonstration of "Polyhedral Chain Linkages." The latter was discussed by Mr. L. B. Tuckerman.

H. E. McComb, *Recording Secretary*

GEOLOGICAL SOCIETY

554th meeting

The 554th meeting was held at the Cosmos Club October 27, 1937, President R. C. Wells presiding.

Program: Gordon Rittenhouse: *Criteria used in recognizing modern fluvial sediments.*—Those fluvial deposits formed by accelerated sedimentation resulting from agricultural use of uplands are defined as Modern sediments. Methods used to recognize and determine the thickness and lateral extent of such deposits fall in two classes, (1) those which give reasonably accurate determination of the total amount of modern aggradation, and (2) those which indicate the minimum amount of aggradation or the amount of aggradation during a known period of time.

The first of these methods involves identification of the premodern soil by (a) darker color, (b) presence of ferruginous concretions, or (c) "bleached" colors. Texture probably cannot be used as a criterion to differentiate between modern and pre-modern sediments.

The minimum amount of aggradation or the amount of aggradation during a known period of time may be determined (a) by comparison of new and old instrumental surveys or (b) by the use of natural or artificial gages.

The use, as criteria, of geomorphic changes resulting from accelerated sedimentation is not discussed.

H. D. Miser and R. E. Stevens: *Taeniolite, a rare lithium-magnesium mica from Magnet Cove, Arkansas.*

Taisia Stadnichenko: *Organic sediments as indices of regional metamorphism.*

555th meeting

The 555th meeting was held at the Cosmos Club November 10, 1937, President R. C. Wells presiding.

Informal communication.—Charles Milton stated that a sample submitted by the Park Naturalist of the Yosemite National Park to the Geological Survey for determination turned out to be copiapite, a hydrous ferric sulphate, forming a crust on a weathered siliceous rock. A letter received subsequently from Mr. Matthes of the Survey states that the deer in the Yosemite seek it avidly, and consume it in place of salt which is extremely scarce in the region. On enquiring at the Biological Survey of the Department of Agriculture concerning this, it was learned that this was a very unusual thing, and the expert consulted said he had never heard of it before; he added, however, that deer sometimes show a craving for other things of bitter taste, such as the bark of willow trees.

Program: G. W. RITCHEY: *Lava flows on the moon.*

F. E. WRIGHT: *Progress in the study of surface features of the moon.*

P. B. KING: *Tectonics of the Guadalupe Mountain region.*

556TH MEETING

The 556th meeting was held at the Cosmos Club November 24, 1937, President R. C. WELLS presiding.

Program: J. C. MILLER: *The occurrence and commercial use of carbon dioxide.*

B. E. JONES: *Advantages of resistivity measurements in the examination of dam sites.*

C. P. ROSS: *Erosion in the Lost River Range, Idaho.*—The sharp contrast between the high, rugged Lost River Range with its moderate rainfall and the wide, alluvium-filled, semi-arid valleys on either side emphasizes some features of erosion. The mountains are being actively carved by streams, frost, and wind but the lowlands, partly because of exceptionally abundant alluvium, show comparatively few permanent stream channels. Even within the mountains, few of the larger valleys contain streams that flow at the surface during most of the year. Land sculpture and the transportation of waste are accomplished by sporadic floods that spread and shift rather than by the orderly extension of established drainage channels. Here, as elsewhere, streams tend to entrench themselves and to extend such trenches headward wherever possible. High in the mountains this is the most effective method of erosion but on the valley borders only the master streams are able to establish relatively permanent and continuous channels. In extreme instances mountain valleys end in funnel-like depressions in the alluvium at the valley border. The comparatively important role played by short, vigorous floods from upstream has resulted locally in the formation of conspicuous, embanked gullies and gulches in which walls are formed by the pushing aside of material loosed by the rushing water in excess of the amount it can carry downstream.

557TH MEETING

The 557th meeting was held at the Cosmos Club December 8, 1937, President R. C. WELLS presiding.

Program: Presidential Address by R. C. WELLS: *Present trends in geochemistry.*—Geochemistry is chemistry applied to geology, petrology and mineralogy. It considers where each chemical element is found and how much there is of it. Isotopes must also be considered. The major problem is to explain the origin of natural products. The sizes of the different atoms, as well as their arrangement, affect the physical properties of minerals. Rocks may be classified from their chemical analyses. Phase rule studies help to generalize knowledge concerning the formation and associations of minerals. Ores and the weathering products of rocks are continuously being explored by geochemical methods. The study of radioactive changes is yielding information relating to the origin of certain elements, to geologic time, and even to problems in cosmogony.

45TH ANNUAL MEETING

The 45th annual meeting of the Society was held at the Cosmos Club, December 8, 1937, President R. C. WELLS presiding.

The annual reports of secretaries and treasurer were read and approved.
The Society elected the following officers for 1938:
President: H. D. MISER.
Vice Presidents: J. B. REESIDE and W. P. WOODRING.
Treasurer: A. H. KOSCHMANN.
Secretary: J. W. GREIG.
Members-at-Large-of-the-Council: C. G. BROWN, E. P. HENDERSON, K. E. LOHMAN, A. N. SAYRE, and E. A. TRAGER.

558TH MEETING

The 558th meeting was held at the Cosmos Club January 12, 1938, President H. D. MISER presiding.

Program: L. W. STEPHENSON and W. H. MONROE: *Stratigraphy of the Upper Cretaceous of Mississippi and Alabama.*

A. K. BREWER: *Age of matter as determined by the radioactivity of potassium and rubidium.*—Potassium and rubidium have long been known to emit beta rays. In consequence these elements may be used to determine the age of matter provided the following facts are known: (1) the abundance of the isotopes responsible for the emissivity; (2) the amount of end products formed, and (3) the rates of conversion. It has recently been shown that isotopes ${}_{19}K^{40}$ and ${}_{37}Rb^{87}$ are responsible for the entire radioactivity. Mass spectrographic measurements give the ratio of total potassium to K^{40} as 9000, while the ratio of total rubidium to Rb^{87} is 3.59. The end products of the disintegration have been found to be ${}_{20}Ca^{40}$ and ${}_{38}Sr^{87}$. The ratios in the earth's crust of the end products to the radioactive isotopes are $Ca^{40}/K^{40}=1.24\times10^4$, and $Sr^{87}/Rb^{87}=0.29$.

The radioactive constants for potassium and rubidium have been measured by means of a Geiger Counter, using a thin aluminum window to admit the rays. The disintegration constants so obtained are for K^{40}, $\lambda=9.1\times10^{-10}$ yrs.$^{-1}$ and for Rb^{87}, $\lambda=1.35\times10^{-11}$ yrs.$^{-1}$. These values depend for their accuracy on the absorption coefficients given by Klumperer, Proc. Roy. Soc. **148**: 630. 1935.

An upper limit for the age of matter is given by the time required for K^{40} and Rb^{87} to be increased by the amount of Ca^{40} and Sr^{87} in existence today. This may be computed from the equation $1/N_0=e^{-\lambda t}$, where $N_0=1+Ca^{40}/K^{40}$ and Sr^{87}/Rb^{87}. The values for the age of matter so computed are $K=1.06\times10^{10}$ yrs. and $Rb=1.5\times10^{10}$ yrs.

A. C. SPENCER and K. J. MURATA: *Base exchange as a factor in estimating the age of the ocean.*

559TH MEETING

The 559th meeting was held at the Cosmos Club January 26, 1938, President H. D. MISER presiding.

Program: Symposium on the relation of some volcanoes to geologic structure.

E. G. ZIES: *Santa Maria dome, Guatemala.*—In 1902 a series of violent explosions blew out a crater on the S. W. flank of the supposedly extinct volcano of Santa Maria in Guatemala. Karl Sapper (Neues Jahrbuch f. Min. Geol. Pal. 1904, I, 39) estimated that about 5½ cubic kilometers of clastic material were ejected during the eruption. No further activity was observed until August of 1922 (Sapper, Zeit. f. Vulkanologie IX, 158) when a series of eruptions initiated the building of an andesitic volcanic dome which within a period of about 3 years reached a height of about 900 feet above the present floor of the crater. In 1929 a series of glowing clouds emerged from the base of the dome. Intense thermal and chemical activity are still in evidence. The carefully recorded history of the dome and its continuing activity provide the student of volcanology with an exceptional opportunity for study.

E. Callaghan: *Volcanoes of the Cascade Range.*

C. S. Ross: *Valles Volcano, New Mexico.*—The Valles volcanic crater is situated west of Santa Fe, and north of Albuquerque, New Mexico. This is an explosive vent or rather group of vents, that have built up a crater of elliptical shape, about 13 by 17 miles in extent. This makes it the largest crater ever reported. The materials ejected are almost exclusively tuffs which reach a thickness of at least 1,000 feet on the east flank. Paleozoic sedimentary rocks underlie the volcanics on both the north and south flanks, and are also exposed in the crater floor. Thus it occupies a gentle dome, and is not a crater of subsidence. The underlying rocks dip off to the east at about the same rate, but in the Rio Grande canyon 3 to 4 miles farther east no Paleozoics are exposed. Thus a fault zone may lie not far west of the Rio Grande, but from there to the crest of the granite mass about 38 miles farther west, there is no observable faulting.

A. H. Koschmann: *The Relationship of the Cripple Creek Volcano to Regional Structure.*—The Cripple Creek district lies in the central part of Colorado 17 miles in a straight line southwest of Colorado Springs and 9 miles southwest of Pikes Peak. The district consists of a denuded composite volcano which lies on a gently undulating plateau between 9,500 and 11,000 feet in altitude, deeply cut by canyons. The region surrounding this volcano consists chiefly of pre-Cambrian granite capped in places by sandstone, conglomerate and some volcanic rocks.

Structurally the Cripple Creek volcano lies on the southwest end of the Front Range which represents an anticlinal uplift of Laramide age. The Range has been truncated and almost stripped of its cover of Paleozoic and later rocks and consists chiefly of pre-Cambrian rocks excepting small synclinal remnants or graben of sedimentary rocks. Such remnants of sedimentary rocks in the Pikes Peak quadrangle are sufficient to outline the regional structure and show that the Cripple Creek volcano lies on a structural high. Major faults of the area apparently had not had any influence in determining the location of the volcano.

Locally, a group of prominent fractures undoubtedly influenced the immediate location and outline of the volcano. A study of the surface outline of the volcano's neck shows it to be extremely irregular but the influences of prominent pre-volcanic fissures is seen in its angular outlines. Subsequent influence of these fissures is seen in the parallelism of many dikes and veins to the straight stretches of the surface outline of the neck. General vertical uplift during and following the Laramide revolution apparently produced major fissures, in part parallel to pre-Cambrian dike-filled fissures, which thus guided the rising magma and the escaping gases.

W. S. Burbank: *Silverton caldera, San Juan County, Colorado.*—The Silverton caldera is located in the San Juan Mountains of southwestern Colorado near the western edge of the Tertiary volcanic field that covers an area of over 3,000 square miles in the State of Colorado.

The Silverton volcanic series with which the caldera is associated is one of the older series of the San Juan volcanic field, and is of Miocene age. The series has a maximum thickness of at least 3,000 feet, covers an area of about 1,000 square miles, and has a volume of about 250 cubic miles.

Structurally, the caldera is located near the edges of two ancestral uplifts of the San Juan Mountains. The uplift as it now exists was first outlined in late Paleozoic time. After renewal of sedimentation in the Mesozoic, this uplift was rejuvenated and much enlarged during late Cretaceous and early Tertiary time.

The Silverton caldera, which appears to be one of the eruptive centers of the Silverton series, is a downfaulted or collapsed block of volcanic rocks about 8 miles in diameter. The central collapsed block is surrounded by radial fissures and dikes, and by radial and concentric intrusive axes.

As seen in plan, the structure of the caldera presents a remarkable symmetry, not only in the shape of the central collapsed block, but also in the focal concentration of the dikes and fracture systems towards this center. The pattern of this structure obviously is not inherited, but was produced by some igneous bodies acting over a large area of the crust and probably from considerable depth, as otherwise the lack of homogeneity in the shallow crust would have caused greater distortion of the fracture pattern.

The caldera is located on the northwest flank of the compound pre-Tertiary uplift without apparent relation to, or without control inherited from, the structural framework of the pre-Tertiary formations. The fact that the radial intrusive axes extend much farther towards the west than towards the east, and also the fact that the dikes and fissures are much more continuous westward, suggests that the magma lay shallower in the crust in this direction. Hence the magma may have risen obliquely from great depth beneath the more central parts of the San Juan mountain block and migrated toward the plateaus. Finally at a certain critical level the pressure of the magma became sufficient to fracture the overlying crust or to permit invasion by stoping. The flanks of the two ancestral uplifts may have provided zones of weakness or of shearing that assisted in the upward migration of the magma.

This widespread melting of the deep crustal zones was more or less coincident with the continental uplift of the mountain and plateau country as a whole, which was initiated during early Tertiary but which was much accelerated during middle and later Tertiary time. It is interesting to note that throughout the entire range of Paleozoic and Mesozoic time, this region, except for local mountain groups, lay beneath or close to sea level, and that there had been very little igneous activity prior to the end of Cretaceous time.

H. D. Miser: *Volcanoes of the Gulf Coastal plain.*—Volcanoes that were active in Upper Cretaceous time were numerous in the Gulf Coastal Plain. The igneous rocks forming their cones and occupying their necks are found in Texas, Arkansas, Louisiana, and Mississippi. Many of the occurrences of such rocks are exposed and many others have been revealed in deep wells. The known occurrences are confined to a winding belt with arcuate bends extending northeastward from southern Texas into Arkansas and thence southeastward into Louisiana and Mississippi. This belt coincides with the belt of deformed Paleozoic rocks of the Ouachita geosyncline. Although the belt is now largely concealed by Cretaceous and Tertiary rocks, the structural features of the superjacent Cretaceous and Tertiary rocks bear a relation in origin to movement in the basement rocks.

A volcanic cone underlies a part of the Monroe gas field of Louisiana and volcanic rocks underlie the Jackson gas field of Mississippi. The origin of the structural features of the gas-bearing strata in these two areas is probably related to the igneous rocks of Cretaceous age lying underneath them. Igneous rocks—some of them occupying volcanic necks—have been found in deep wells that have been drilled on geophysical highs elsewhere in Louisiana, Mississippi, and southern Arkansas.

In central and southwestern Arkansas nephelite syenites and many other kinds of igneous rocks are exposed. The diamond-bearing peridotite near Murfreesboro in that State occupies the necks of Upper Cretaceous volcanoes. The character and distribution of water-laid volcanic tuff and ash in the Woodbine and Tokio formations of the Upper Cretaceous in Arkansas, Oklahoma, and Texas indicate that the tuff and ash were derived from old volcanics now concealed in southwestern Arkansas—one near Nashville and another near Lockesburg.

The Chapman and Lytton Springs oil fields, which are here briefly mentioned, are two of the many fields in central Texas yielding oil from serpentine which is altered from volcanic rocks of Upper Cretaceous age. The serpentine in the Chapman field occurs as a flattened ovate mass about one square mile in extent and lies within, but close to the base of, the Taylor marl of Upper Cretaceous age. Presumably the lava that was later transformed to serpentine was extruded on the floor of the Upper Cretaceous sea. The serpentine mass of the Lytton Springs field is an ovate-shaped mass measuring about 9,000 by 9,500 feet. It underlies the Taylor marl and occurs in part in the Austin chalk. A slight structural dome at the surface overlies the serpentine. Presumably the lava and ash later changing to serpentine were erupted into the sea in early Taylor time. The igneous rocks in the Coastal Plain in Texas lie in a belt 200 miles long. They are all of Upper Cretaceous age except some occurrences near Uvalde of Tertiary age. Within this belt is the Balcones fault zone and along its southeast side is the Mexia fault zone in or near which the oil-bearing serpentine occurs. The close correspondence of igneous activity and faulting in the Balcones and Mexia zones shows that a genetic relation exists between them.

The igneous activity in early Upper Cretaceous time in the Gulf Coastal Plain in Texas, Arkansas, Louisiana, and Mississippi was contemporaneous with the initial downwarping of the Mississippi embayment, as well as downwarping elsewhere in the Gulf Coastal Plain. The igneous activity doubtless accompanied deep-seated adjustments in molten material under the subsiding area. The Ouachita belt in which the igneous rocks reached the surface apparently contained zones of structural weakness in the deformed Paleozoic rocks whence the molten and fragmental material could move upward most readily.

Besides the volcanic rocks that have been described above, bentonites derived from volcanic ash are extensive in the Gulf Coastal Plain from Texas to Florida. Some of them are of Upper Cretaceous age and their sources probably have been, at least in part, from the volcanoes here described, but other unexposed centers of the same age may also have contributed pyroclastic materials. Other beds of bentonite occur at many horizons in the Tertiary; their source is not known.

560TH MEETING

The 560th meeting was held at the Cosmos Club February 9, 1938, President H. D. MISER presiding.

Informal communications.—D. G. Thompson drew the attention of the Society to a series of papers on "The Archeology of Pleistocene Lake Mohave" published as number eleven of South West Museum Papers, Los Angeles, describing artifacts suggesting that man had lived along the shores of this lake which was in existence some 15,000 years ago.

Program: V. H. Jones: *Sedimentation in Herrin Reservoir No. 2, Illinois, from 1926 to 1935.*—During a program of reservoir study in Illinois through the summer of 1936, the writer with D. Hoye Eargle of the Section of Sedimentation Studies, had opportunity to visit the drained municipal reservoir of Herrin, Williamson County, Illinois. Since the failure of the dam on June 20, 1935, the lake had been empty and the silt deposits were accessible for measurement and study on May 12 and 13, 1936. Reconstruction of the dam was nearly complete at that time and water was again beginning to accumulate in the basin.

Unusually accurate interpretation of the lake's history was possible because an accumulation of leaves or seeds had been included in each year's deposit. A brief outline of the construction and history of the lake follows.

In February 1926, the earthen dam and concrete spillway were completed and storage of water was begun in the narrow valley of Wolf Creek above the dam. The resulting lake was 12 miles south of Herrin in the west half of Section 20, T. 10 S., R. 2 E., Williamson County, Illinois. The dam was 18.5 feet high with spillway crest at 479 feet above sea level.[1] For 10 years the impounded water of the lake, which was nearly 1 mile long, 1,000 feet wide, and contained an estimated quantity of 350,000,000 gallons at crest level, furnished an adequate supply of water to the city.

Early June of 1935 brought a period of unusually heavy rains which continued for 13 days. On the 20th this was climaxed by a precipitation of 6 inches over the watershed within 6 hours. Overflow water gorged the spillway, and mounted high enough to flow over the top of the dam, and resulting erosion cut through the dam early in the morning of June 21. Although some silt was removed by flushing action of the flood and subsequent escape of the lake water, only a small proportion of the accumulated silt was affected. The small delta, nearly 600 feet long and about 150 feet wide, was completely truncated by reestablishment of Wolf Creek channel through it. At one locality the beds thus revealed tell the complete sedimentary history of the lake.

At and near crest level the delta was more than 200 feet long and ranged from 150 feet in width at the lower end to zero at the head. The deposit had ponded the water of a small tributary. In the lower lake near the dam the sediment had an average thickness of nearly 2 feet which had been compacted an unknown amount by drying. Where the delta deposit was thickest the average yearly deposition was 1.2 feet, measured after a year of exposure to the atmosphere.

L. W. Stephenson and J. B. Reeside, Jr.: *A comparison of the Upper Cretaceous deposits of the Gulf region and western interior.*

561st meeting

The 561st meeting was held at the Cosmos Club February 23, 1938, President H. D. Miser presiding.

Informal communications.—W. P. Woodring spoke on the terms *synclinorium* and *anticlinorium.* Walter E. Warren read a note on the age of the Guy Formation, Cascade region, State of Washington.

Program: R. E. Stevens: *The constitution of lepidolite.*

A. F. Buddington: *Some problems of Adirondack geology of general significance.*—The author is engaged in a general study of the geology of the igneous rocks of the Adirondacks. Three problems of general significance were discussed.

[1] Data given by A. S. Misker, Supt. of Herrin Water Dept.

The anorthosite of the Adirondacks is interpreted as a differentiate of a gabbroic anorthosite magma of a composition consisting of about 80 per cent normative plagioclase ($Ab_{46}An_{51}$), 12 per cent femic molecules and the remainder of salic molecules. This is based in part on the composition of the border facies assumed to represent a relatively undifferentiated facies. The intrusive nature of this magma is based on the local sill structure, associated profound metasomatic replacement skarns of a peculiar and characteristic type, formation of igneous breccias, assimilation and nebulitic structures, etc. The general arrangement of layers in thick gabbroic stratiform sheets was discussed and taken as suggestive of the arrangement of layers in the outer part of the earth. A bytownite anorthosite horizon is therefore postulated to exist somewhere above the peridotite zone. Partial melting of such a calcic anorthosite layer will yield the type of magma postulated. Field evidence indicates a noteworthy volatile content in the magma so that no abnormally high temperatures need be assumed for it.

The major gabbro bodies of the Adirondacks have been variously interpreted as older than the quartz syenite and granites, younger than the quartz syenite and granites, and those within the anorthosite either as intrusive or as early crystal accumulates from a magma of much different composition. The younger age of the gabbros with respect to the granitic rocks has in large part been based on fine-grained border zones. These are now interpreted by the author as "pseudo-chill" zones, a product of contact metamorphic recrystallization by the granite which is younger. The tabular olivine gabbro bodies within the anorthosite have in many cases been proven to be dikes athwart the foliation of the anorthosite and are therefore younger intrusives and not crystal accumulates.

Three-fourths of the igneous rocks of the Adirondacks show a granoblastic structure and evidence is presented that their regional foliation and linear structure are a product of plastic or solid flow. There is a systematic regional variation in the size of grain of similar rocks, and concomitantly a consistent variation in the mineralogic facies developed by reconstitution in each type of rock within different metamorphic zones. In particular, gabbros of the same chemical composition are found to show a regional variation from a hornblende-labradorite facies through a hornblende-augite-hypersthene labradorite type, to rocks consisting of oligoclase, hypersthene, and garnet, or of hornblende, oligoclase, and pyrope-almandite garnet. Hypotheses which assume the foliation and linear structure of the border facies of the anorthosite massif and the surrounding rocks to be a magmatic flow structure are believed by the author to be based on an untenable foundation.

562ND MEETING

The 562nd meeting was held at the Cosmos Club March 9, 1938, President H. D. MISER presiding.

Informal communications.—A. C. SPENCER showed two slides giving in graphic and tabular form the data of the paper on Base exchange. (See regular program January 12, 1938.)

Program: H. G. FERGUSON and S. W. MULLER: *Structural geology of the Hawthorne and Tonopah Quadrangles, Nevada.*

ROLAND W. BROWN: *The Cretaceous-Eocene boundary in Montana and North Dakota.*—The paleontologists who first studied the fossil plants and animals collected from the lignite-bearing strata of western North Dakota and eastern Montana could not agree on a boundary between the Mesozoic and Cenozoic in that area. The paleobotanists held that the Hell Creek strata with *Triceratops* dinosaurs also carried a flora that was identical with the recognized Fort Union flora and should be classed as Cenozoic. The paleozoologists insisted that not only was the Hell Creek with its dinosaurs Mesozoic but that the overlying marine Cannonball and its continental equivalents, carrying a fauna having a close affinity to preceding Cretaceous faunas, should also be included in the Mesozoic. Evidence accumulated by the speaker during the past eight years of field and office study now shows that some of the early contenders in this boundary dispute were mistaken both as to the distribution of the strata and in the identifications of some important species of fossils involved in this controversy. Carefully measured sections checking and supplementing those given in the coal reports and other publications, together with identifications of new collections of fossil plants and animals from critical points on or adjacent to the disputed boundary, indicate that the strata overlying the Hell Creek formation and underlying the Wasatch constitute a recognizable, measurable, and mappable unit, carrying a distinctive flora and fauna differing significantly from those of the Hell Creek and Wasatch. The *Triceratops dinosaurs,* ammonites, a species of cycad, and some species of dicotyledons, according to the most reliable records from this region, became extinct before or at the close of Hell Creek time. On the other hand, a flora and fauna of distinctly modern cast began to emerge from the body of Cretaceous life at that time. Paleontologists almost universally have accepted the term Paleocene as a period designation of equal rank with Eocene, Oligocene, Miocene, etc., to include the transitional strata here in controversy as well as similarly situated, disputed strata in other parts of the world. In the speaker's opinion the new evidence seconds the acceptance of this practice for it indicates more clearly than ever that the thin zone of interfingering beds at the upper limit of the Hell Creek formation and the base of the immediately overlying Fort Union in its emended sense, marks the boundary between the Mesozoic and the Cenozoic.

EARL INGERSON: *Albite trends in the Piedmont.*

563RD MEETING

The 563rd meeting was held at the Cosmos Club March 23, 1938, President H. D. MISER presiding.

Informal communications.—J. W. GREIG reported that he had made a series of melting experiments on material produced by the melting of overlying beds by a burning coal seam and that the experiments showed that a temperature of about 1,200° had been produced.

Program: MARLAND BILLINGS: *The Geology of western and central New Hampshire.*—Our knowledge of the bed-rock geology of New Hampshire has been greatly increased by investigations carried on during the last ten years by a dozen geologists representing Harvard, Wellesley, Dartmouth, Radcliffe, Brown, Bryn Mawr, and the University of Minnesota. The mapping of about 2,000 square miles has been completed, but less than half the maps have been published.

The metamorphosed sedimentary and volcanic rocks of western and central New Hampshire are dated from a few Silurian and Devonian fossil localities around Littleton, New Hampshire, and Ordovician fossil localities around Montpelier, Vermont. The Ordovician (?) rocks of New Hampshire, 12,000 feet thick, were initially shale, sandstone, and volcanic tuff. The Silurian rocks are composed of an underlying quartzite and quartz conglomerate, 0 to 1,200 feet thick, and an overlying calcareous series from 400 to 700 feet thick. The lower Devonian rocks, originally shale, sandstone, and volcanic tuff, are 5,000 feet thick. These stratified rocks show varying grades of metamorphism, those in westernmost New Hampshire belonging to the low-grade zone or epizone of Grubenmann and Niggli; to the southeast is the middle-grade zone or mesozone; and further southeast is the high-grade zone or katazone.

The stratified rocks are intruded by four magma series: the subalkaline Highlandcroft series, probably late Ordovician; the subalkaline Oliverian magma series, probably late Devonian; the somewhat younger subalkaline New Hampshire magma series, probably late Devonian; and the alkaline White Mountain magma series, probably Mississippian. A recently published lead-uranium ratio seems to confirm the late Devonian age of the New Hampshire magma series. Each of these magma series has its own peculiar mechanism of intrusion. No particular study has been made of the Highlandcroft magma series, but during the late Devonian (?) orogeny these bodies, having consolidated in the late Ordovician (?), behaved as passive plutons. The Oliverian magma series forms large, injected domes, with roofs similar to laccoliths. The New Hampshire magma series occurs as injected, concordant sheets, lenses, and stocks. The White Mountain magma series is in ring-dikes and stocks, the latter presumably having attained their position by some stoping mechanism.

New Hampshire is an unusually favorable state in which to study certain geological features, notably progressive metamorphism, shape of plutonic bodies, relation of plutonic rocks to orogeny and stress conditions in the crust of the earth, and mechanics of intrusion. Moreover, before the Appalachian Highlands are fully understood we must know the geological history of New England and the Piedmont. It is hazardous to speculate on the origin of mountain-built areas without a knowledge of their history.

In addition to the subjects mentioned above, one of the major projects now being pressed is the completion of the mapping of the area between the Ordovician of the Montpelier, Vermont, region and the Carboniferous along the Atlantic coast at Portsmouth, New Hampshire. A second project being actively pursued is the tracing of the Silurian of western New Hampshire southward to Massachusetts and northeasterly to Maine.

R. W. STONE: *Some problems in geology in Pennsylvania.*

564TH MEETING

The 564th meeting was held at the Cosmos Club April 13, 1938, President H. D. MISER presiding.

Program: J. B. MERTIE, Jr.: *Platinum placers of the Goodnews Bay district, Alaska.*

R. W. GORANSON: *Silicate-water systems: orthoclase-water and albite-water equilibrium relations.*

OLIVER BOWLES: *Geologic and economic problems of the asbestos industry.*

565TH MEETING

The 565th meeting was held at the Cosmos Club April 27, 1938, President H. D. MISER presiding.

The Standing Rules were amended to read as follows:

Sec. 2. *Officers:*—Last sentence—"In his absence the Treasurer, with the approval of the President, is authorized to appoint an Acting-treasurer."

Sec. 3. *Dues:*—Last sentence, first paragraph—"Any member, whether active or corresponding, who has been a member in good standing for at least ten years and has been retired from service shall no longer pay dues."

Program: A. I. LEVORSEN: *Some new trends in petroleum geology.*—The dominant geological methods used in the past in the search for new oil and gas pools are: (a) Surface structural mapping, which reached its peak application between 1920 and 1925 and as its use declined, it was replaced by (b) Subsurface structural mapping, which reached its peak application among petroleum geologists between 1925 and 1930. This method was gradually replaced by (c) Geophysical structural mapping (chiefly seismic and gravity) which reached its peak application during 1935 to 1937 and is now declining in importance. The decline in importance of each of these methods has not been due to failure of the method itself but rather to the fact that the field within which each method has been applied became exhausted.

Beginning with 1925 there has been a steady growth in the importance of well cutting examination until at present probably half of the effort of petroleum geologists is given to some phase of sample work. Heretofore the application of this type of geology has been chiefly for structural and production information, but there is evidence that future geological methods of oil finding will be more closely identified with samples and the stratigraphic information which they reveal.

Three trends seem evident in the thought of petroleum geologists as to the future methods which will be used. They are: (1) The changed thought as a result of what might be termed "layer cake" geology—that is the superposition of different layers of geology, each independent of the other and each with its own significance with respect to oil and gas accumulation. Much of our past production is from such an environment and its appreciation definitely increases the values given to new areas where the shallow geology is uninteresting from an oil standpoint.

(2) The rapid development of portable drilling outfits capable of drilling holes to 3,000 and 4,000 feet at a fraction of the previous costs has given petroleum geologists the effect of a new tool. These rigs open up to the geologist and wild-catter tremendous possibilities, particularly in the field of production from sand lenses, shoestring sands, overlaps, and porosity changes.

(3) Since the production in many of the present oil and gas provinces is found to occur at or in the vicinity of changes from porosity to non-porosity within the reservoir rock, it would appear that this phenomenon may be a critical factor in history of the province. There are many such areas of porosity edge yet almost wholly unexplored in the United States and the trend towards cheap drilling opens such areas up for exploration.

W. B. HEROY: *Objectives of research in petroleum geology.*

J. W. GREIG, *Secretary*

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BIOCHEMISTRY—*Some modern aspects of enzyme catalysis.*[1] A. K. Balls, Bureau of Chemistry and Soils.

It may appear to you at first sight as an understatement, but the fact is that all of us live, move and have our being by the grace of enzymes. This is not a new idea. People recognized the existence of a mysterious directive force in living tissues long before they had the technical jargon with which to talk about it. The attention of the old timers was naturally directed to fermentation and digestion. They talked of a principle that was called "fermentatio," from which comes our word ferment. When they found that fermentatio occurred in yeast it gave us our word enzyme. Digestion also was directed by a mysterious force that transformed food into living tissue, just as an alchemist transformed base metals into gold. No less a person than Paracelsus von Hohenheim said so in the early fifteen hundreds. There were then no adequate words to express a scientific idea, but Paracelsus said in part

> The alchemist separates the bad from the good, and changes the good into a tincture which tinges the body with life. . . . This alchemist dwells in the stomach . . . and as soon as the food comes into the stomach the alchemist is at once there and proceeds to digest it, rejecting that which is not healthful to the body into a special place, in order that the good may go where it belongs. And remember that each animal has its own peculiar food and its own special alchemist for the digestion thereof. The alchemist of the ostrich has the faculty of digesting iron. (*The author makes no mention of the goat.*) The hog eats dung, which is the bad part of food that has been cast off by the alchemist of man and other animals, and the alchemist of the hog can separate food from dung which the alchemist of man was unable to extract. For this reason pig's dung is not eaten by any animal.

Besides the fermentation and digestion which intrigued our forefathers, another type of enzyme action is now recognized, namely tissue oxidation. The data on these three reactions constitute what today may be called enzyme chemistry. It is a large subject for a

[1] Address presented before the Washington Academy of Sciences on March 17, 1938. Contribution No. 391 of the Food Research Division, Bureau of Chemistry and Soils. Received July 21, 1938.

small talk, and is best handled by the well-known expedient of starting in the middle and going backwards and forwards at one and the same time.

Technically speaking the enzymes are catalysts, which means that they may accelerate a reaction but cannot initiate one. All the reactions in a living cell would go on without enzymes, but they would proceed so slowly that the cell would die waiting for food to be digested or oxygen to become available. And once dead, the cell would take a long time to decay and disappear if there were no enzymes in the dead tissue to speed up its disintegration. Dead cells produce no enzymes, but enzymes formed during life disintegrate the dead cells.

Nearly all of the reactions of biochemistry fall naturally into two groups, the reactions of hydrolysis and the reactions of oxidation, and each kind of reaction is accelerated by its own particular ferments. Hydrolysis is essentially a process of breaking down, oxidation a process of energy liberation that permits of building up. In life the two processes nearly balance each other, with the oxidation processes having somewhat the edge on the others. After death, oxidation ceases, and hydrolysis holds sway alone. Decay is a hydrolysis.

Because our enzymes start nothing, but only keep things moving quickly, you might suppose that they exert no directive effect on life processes. This however would be a mistake. The complicated materials of biochemistry can usually react in more than one way. A particular enzyme will catalyse only one of these possible reactions.

TABLE 1.—EFFECT ON THE END-PRODUCTS CAUSED BY CATALYSING ONE OF A PAIR OF REACTIONS

Reaction	Normal Velocity	Catalysed Velocity
A→B	1	100
A→C	10	10
$\frac{B}{C}$ at end	$\frac{1}{10}$	$\frac{10}{1}$

The diagram in Table 1 shows what would happen if a relatively unimportant reaction (A→B) were accelerated a hundredfold, while a reaction originally more important (A→C) went on at the same rate as before. Judging by the end-products formed, the importance of the two reactions would be reversed. Instead of the second reaction representing the main course of the process, the first would do so during the catalysis.

This is an example of enzymic specificity, by which is meant that an enzyme accelerates a particular type of reaction on a special group of closely related substances called its substrates. A lipase does not catalyse protein decomposition, nor does a proteinase hydrolyse fats or carbohydrates. There seems to be a singularly definite division of labor between our ferments, hence the enzymes are best called by the substrates they act on.

You have doubtless heard that we know nothing about the nature of enzymes. This used to be true, if you go back far enough. Only a few years ago, in 1900, people thought of them as alive. As late as 1920 it was thought by many that enzymes belonged to a special class of matter that had never been chemically recognized. In a sense they do—they are proteins. (I say this with all due apology to the protein chemists, but I am unsure how much apology is owing.)

We know that many enzymes are proteins because in recent years crystalline proteins have been isolated that are these enzymes. In Figure 1 are shown photographs of crystalline proteinases from the animal digestive tract prepared in my laboratory by the methods of the discoverers, Northrop for pepsin (a) and Kunitz and Northrop for chymotrypsin (b). Plants as well as animals carry protein-digesting enzymes. Dr. Lineweaver, in our laboratory, has crystallized papain (Figure 1, c), the proteolytic enzyme of the papaya plant, the enzyme that is now used by the ton in making meat tenderizers. We would probably all be surprised to know the exact number of years of beef-life that is taken out of the steaks of this country by means of papain.

The crystallization of these proteins is usually not difficult, provided one first obtains them in the pure state. This sometimes requires considerable ingenuity. For example, Dr. Martin of our laboratory found that tobacco virus could be freed of other protein by treatment with trypsin. The trypsin digests the other proteins but not the virus. This scheme has greatly facilitated the preparation of the crystalline virus discovered by Stanley.

But though the enzymes are protein, it is quite evident that the catalytic properties must be due to some particular grouping or configuration in the molecule. As a matter of fact many enzymes behave as though this group was attached to the protein molecule in the form of a more or less separable entity, just as hemin and globin together constitute hemoglobin. Hemoglobin has been split into its two constituents—the protein and the iron-containing hemin—and then put together again. The same thing has been done in Warburg's laboratory with an oxidative enzyme called the yellow ferment. According to Willstatter's famous theory (made up long before anyone had proof of all this) an enzyme contains an active or functional

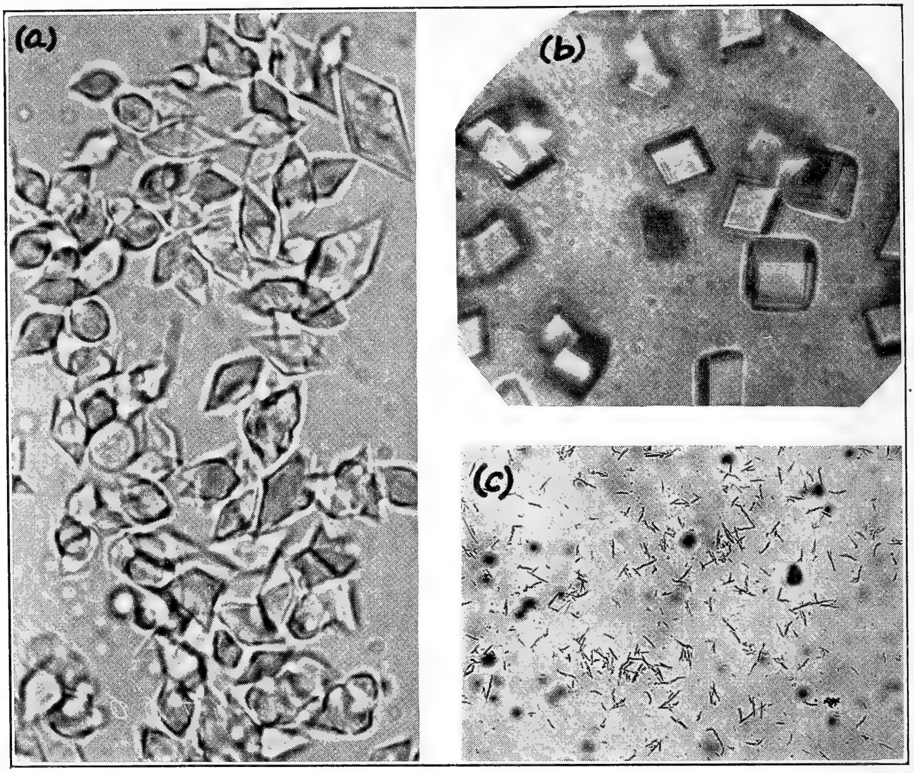

Fig. 1.—Crystals of (a) pepsin, (b) chymotrypsin, and (c) papain.

group attached to a much larger colloidal particle which present day experience seems to indicate is a protein. The nature of these functional groups has been determined in several cases.

The pyridine nucleotides appearing in Table 2 are related to nicotinic acid amide, the anti-pellagra vitamin; so that in perhaps 4 cases the active groups of the enzymes are related to the vitamins, and the idea has already been put forth that the function of such vitamins is to enable the body to synthesize the corresponding enzymes.

From the last table it is evident that two proteins form two different enzymes by combining with the same active group. As Warburg has pointed out, when an active group like cozymase is present in a system it acts as though the addition of one or another specific protein will catalyse one or another separate step in the process of fermentation. On this basis all dehydrogenases may be combinations of cozymase with various proteins.

The active group evidently performs the chemical reactions necessary to the catalysis, but the colloidal carrier is not without influence

TABLE 2.—COMPOSITION OF SOME ENZYMES

Enzyme	Reaction	Protein	Active Group
"Yellow Ferment"	Oxidizes the phosphopyridin nucleotides.	"Flavin Protein"	Phospho-flavine (Phosphorylated Vitamin B_2)
Hexose monophosphate dehydrogenase	Hexose monophosphate→ phospho-hexonic acid	"A" Protein	Triphosphopyridine nucleotide
Acetaldehyde dehydrogenase (alcohol oxidase)	Alcohol→Acetaldehyde	"B" Protein	Diphosphopyridine nucleotide (cozymase)
Pancreas lipase	Hydrolysis of fats and esters	"Lipase Protein"	Related to Ascorbic acid
Liver esterase	Hydrolysis of simple esters only	"Esterase"	Related to Ascorbic acid
Carboxylase	$CH_3CO \cdot COOH \rightarrow CH_3CHO + CO_2$		Mg+diphosphoaneurin (Phosphorylated Vitamin B_1)

on the behavior of the active group. Differences in size or shape or electrical charge between two carriers can certainly affect the speed with which the active group functions. This has been shown in the case of the sugar-splitting ferments, and also with the enzyme catalase. A whole series of "catalases" has been prepared by Stern. They are combinations of the same hemin, the active group, with different proteins. Thus in a sense hemoglobin is one variety of catalase and in fact any compound containing iron seems to be able to decompose H_2O_2 to some extent (Table 3). Each of these combinations has a different activity. Incidentally, the compound of hemin with the natural "catalase protein" is many thousand times the most efficient.

TABLE 3.—CATALASE EFFECT OF IRON

Iron in the form of:	Relative efficiency:
ions (Fe'' or Fe''')	10^{-5}
hemin	10^{-2}
hemin-globin	10^{-1}
hemin-catalase protein	10^{+5}

Thus an enzyme is like a man; it works with its hands, but its personality, so to speak, depends on its whole body.

Thus we know that the carrier particle affects the work of the ferment, but we probably know more about the mode of action of the active group itself. The active group combines with a particular characteristic group in the substrate. There are peptidases that anchor themselves to the free amino group of a peptide, and separate the amino acid to which that group belongs from the rest of the peptide. Similarly, another peptidase combines with the free carboxyl group in a peptide, and splits off the amino acid that bears it. If the amino group in the one case or the carboxyl group in the other is altered in any way, the whole peptide is protected against the action of the enzyme in question.

The actual reaction of the active group has been worked out by Warburg for one case, that of the transport of hydrogen by the diphosphopyridine nucleotide known as cozymase.

Thus the enzyme is able to attack only those substances having the necessary characteristic group. This limits its field of action to a comparatively small list. There is in this a beginning for understanding the phenomenon of enzymic specificity. But the presence of the necessary anchoring group in the substrate is not the only condition necessary for enzyme action.

Dr. Matlack and Mr. Tucker in my laboratory have observed with the fat-splitting ferment of the pancreas a phenomenon that might well be called pseudo-specificity. The specificity of this lipase for certain fats depends on the temperature. Apparently the molecules of some fats are too inert to combine with the enzyme under all conditions, but do combine at relatively high temperatures. These fats are therefore digested only at high temperatures. Other fats are digested at all temperatures and some are split rapidly below zero even when frozen. It depends on the size and type of the fatty acid. This observation bears on how well natural fats or fat meat will keep in cold storage. The fat in the meat varies with the kind of animal and with that animal's diet. So one kind of meat may keep better than another, and its keeping qualities may depend on what the animal was fed during its life.

The fats are not the only things that digest in cold storage, although they seem to go the fastest. Proteins are also affected, but it is not so easy to show this. A protein is such a large molecule that it is difficult to tell whether it has been hydrolyzed or not until the breakdown becomes very profound. Such a profound breakdown does not occur in the cold, but slighter changes do take place. We have shown that in this way: Most of the protein-digesting enzymes are able to clot milk. Mr. Hoover was able to show in the case of papain that there is a very curious relationship between the time required to clot the milk, the temperature and the amount of enzyme. The same type of information is also known for other protein-splitting enzymes, among them pepsin, although the relationships are different. If a little pepsin is added to milk—for example, enough to clot it in exactly an hour at 30°—and the milk is kept for a long time in the cold, apparently nothing happens. But when the milk is warmed up it clots immediately instead of requiring an hour. Evidently part of our enzyme reaction has been going on in the cold.

By now I suppose I have given you the picture of a live cell as a very busy place, where all the wheels are turning as fast as possible, the ferments supplying the grease. This is largely but not wholly true. An enzyme cannot start a reaction, although as you saw, it has

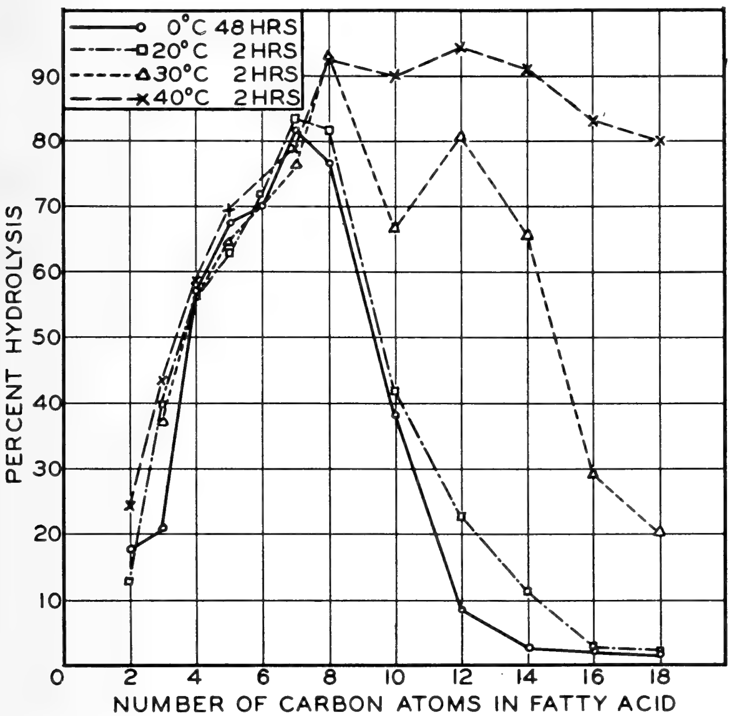

Fig. 2.—Effect of temperature on the digestion of several triglycerides, showing that the comparative rate of hydrolysis at 0° depends on the carbon chain of the acid in a saturated triglyceride.

a great effect on the result. But there are substances which can start and stop the enzymes. For want of better words, they are called activators and inhibitors. We know only a little about them. For example, in the papaya plant the enzyme which Dr. Lineweaver crystallized occurs along with a substance like glutathione. The presence of such a substance increases the enzyme action enormously. Other substances are known that have the same effect, cyanide for one and cysteine for another. This is not altogether a matter of purely academic interest. Dr. Hale[4] has lately discovered that an enzyme very similar to papain existed in traces in wheat kernels. A little of it gets into even the finest white flour, and its effect there is to soften the dough. It is all very well to have your dough softened, provided that the softening does not go very far. If it goes too far, the bread is heavy and poor. The importance of this observation rests on the fact that Dr. Hale's enzyme is like papain in being activated by glutathione, cysteine and other reducing agents, and conversely in being inhibited by oxidizing agents. So if the wheat proteinase is inactive, as sometimes happens during a drought, all that is needed is the addition of a little proteinase to the flour, or a little of one of the activating substances. It takes surprisingly little to get a big effect, because we are not changing the main reactants of the system, but are increasing the amount of catalyst present, and the effect of a few additional milligrams of a catalyst can sometimes be very striking. On the other hand, if flour contains too much proteinase (and this is the more usual case) it is only necessary to inactivate the enzyme by oxidation. Storage in air will do this, likewise traces of chlorine or bromate. In fact, there is a long series of oxidizing agents which usually improve the quality of the bread when a trace is added to the flour.

The effect of bleaching and storage and of such substances as bromates and persulphates has been known for many years, but it was a puzzle to cereal chemists to explain how such minute quantities of reagents could have such ponderous effects. The reason is that there is very little proteinase present in flour and very little reagent is needed to inactivate it.

As a corollary to the foregoing, it is evident that the effect of an enzyme may be out of all proportion to the quantity present if you give the reaction time enough, as is the case when food is kept in storage. An egg, for instance, takes up oxygen and gives off carbon dioxide all the time it is going down hill. However, if you prevent oxygen from entering and carbon dioxide from escaping you hinder the reaction. The catalyst has no option in such circumstances. This is the principle behind Dr. Swenson's process of pumping the air out of eggs meant for storage and coating them with a layer of heavy oil that seals up the shell pores. I know this sounds theoretical but I have also eaten the eggs. If on the other hand you wish to dry the whites of eggs you will find that you cannot properly dry the thick jelly from a fresh egg. If it stands long enough, the jelly-like white gets thin and then can be dried very nicely. But Dr. Swenson has found that the long period of standing is unnecessary if a little protein-digesting enzyme is added to the fresh egg white. In a few hours it is thin.

These are some of the important things we now know about enzymes, and some of the curious ways in which this knowledge may be twisted to become of industrial value. In general there are two kinds of practical questions—those of stopping enzyme action in dead material you wish to keep whole, and those of maintaining enzyme action on living material you wish to keep alive. The former case concerns the Food Research Division, the latter concerns us all.

I hope ladies and gentlemen that I have not disillusioned you. The living things of 1898 became the unknown catalysts of 1918 and are proteins in 1938. They are still the most mysterious of all substances; the least known; the most powerful; the closest approach to Maxwell's demon that nature seems able to make. We know very little about them yet we have made amazing progress in our knowledge. If you think any of my statements sound fantastic, let me take refuge in the words of the rhetorician Isocrates, written in the fourth century before Christ, "Can anything be supported by stronger evidence than by the oracle of the gods, the assent of many Greeks and the harmony of ancient legend with the deeds of today."

PALEONTOLOGY.—Setigerella *and* Worthenella, *two new subgenera of* Productus.[1] George H. Girty, U. S. Geological Survey.

At the time of this writing probably more than 50 names have been proposed for different groups of the old genus *Productus*. Dunbar and Condra list 42 and a number have since come into the literature. Some of these names are partial or complete synonyms; on the other hand, there are a number of Productoid types that have been overlooked but deserve distinction quite as much as some of those that have been named. These genera, if we may give them that rank, possess different degrees of distinction; they have been differently interpreted and differently classified by different authors, certain ones being considered genera by some, subgenera by others, and of no consequence at all by still others.

I am not wholly sympathetic with the movement which has led to the division of *Productus* into so many genera, but for the time being I would like to cooperate with it in two ways, (1) by using as subgenera under *Productus* the names already proposed where the

[1] Published by permission of the Director of the Geological Survey. Received Aug. 6, 1938.

application of the name seems not open to question, and (2) by naming other subgenera that seem to me to be equally worthy of recognition with those so accepted. If experience proves that the use of these names is not practicable or helpful, it would seem wise to abandon them. As they differ in systematic value, some are more likely to be retained than others. A decision cannot be reached out of hand but only after a period of trial.

Setigerella subgen. nov.

The type species of this subgenus is *Productus setiger* Hall.

The holotype of *Productus setiger* has been figured by both Hall and Stuart Weller, and I also have had the privilege of examining it. The description and figures given by these authors, though adequate in most respects, omit one feature that in my judgment has much significance. The type specimen, which retains both valves in articulation, is flattened on a slab of shaly limestone in such a way as to expose the dorsal valve but conceal all of the ventral valve except the umbonal portion and two tufts of slender spines projecting obliquely outward from the auriculations. The dorsal valve appears to be flat or nearly so over most of its surface, but it is bent upward abruptly about its margin to form a narrow, well defined trail. So far, the facts are of record. The character that I have not seen mentioned is that the marginal part of the dorsal valve is doubled back on itself to form a sort of trough or gutter. The structure recalls in a measure a similar one in *P. wortheni* and *P. marginicinctus*, but it is really essentially different for in those species the marginal part has the form of a ridge or outward-facing arch. A few other characters of the dorsal valve will bear repetition in this place, namely the fine sharp costae which are crossed by obscure concentric plications and the spines which are somewhat sparsely developed over most of the surface but more generously on the auriculations. On this head Weller says "Scattered spine bases occur about as on the opposite valve, [that is, scattered rather generally] increasing in numbers upon the cardinal auriculations."

S. setigera appears to be a rather rare species in the typical region. Weller, for instance, figured only two specimens, the holotype (which shows mainly the dorsal valve) and a somewhat crushed ventral valve from Hamilton, Illinois. I have a small number of specimens (15 or so) from the Keokuk limestone at Keokuk and Warsaw, and as some of these, both dorsal and ventral valves, have a reflexed rim like the type specimen I believe this to be a constant character of the species. It is, of course, a character that would not be shown by immature specimens because it had not yet been developed nor shown by mature ones that were imperfect at the margin. These causes are adequate to explain why some of my specimens from the Keokuk localities do not show the marginal channel.

Setigerella setigera, or a species extremely similar to it, occurs in the Boone limestone of southwestern Missouri and northeastern Oklahoma; only in this area these shells are abundant and many are somewhat larger than any that I have seen from the Keokuk limestone. Some of the specimens examined are testiferous and very well preserved; others occur as molds in fine-grained chert. Molds in any fine-grained material commonly show certain characters more clearly than specimens that retain the shell, for testiferous specimens are usually more or less exfoliated. I propose to redescribe *S. setigera* from the abundant and well preserved material at my command as a record of the characters shown by the species in an area somewhat removed from the one in which it was first recognized.

Productus (Setigerella) setiger Hall Figs. 1–7

Ventral valve.—Many of the specimens under consideration are somewhat larger than the holotype (and many also smaller), the largest having a width of about 50 mm as against 45 mm for the type. The length measured from the umbo is about equal to the width (slightly more in some specimens and slightly less in others), but if the length is measured from the hinge line the width is much the greater. From these measurements it would be rightly inferred that the umbonal parts project far beyond the hinge when the shell rests upon its aperture. The shape, consequently, is very irregular, the margin having a transversely subquadrate outline interrupted by the backward projection of the umbonal parts which conceal much of the hinge line. The convexity is high, the vault widening rapidly to the anterior margin and having an elongate triangular shape, more rarely quadrate. The sides of the vault descend steeply to the auriculations which are much less oblique and which if not broken are rather large. The cardinal angles are essentially quadrate. Apparently they are in some specimens slightly extended and in others slightly rounded, possibly by accident. A median sinus is a constant feature, though it may be so faint as to be hardly appreciable. More commonly it is rather strong and causes a perceptible emargination in the anterior outline.

The sculpture comprises radial costae, concentric corrugations, incremental lines, and spines. All these features are more or less interrelated in their development and differ in different specimens and on different parts of the same specimen. In the large, the sculpture appears very even and regular, but examined more closely it is seen to abound in small irregularities. The round costae are slender and rather uncommonly sharp in their definition, rising abruptly from rounded striae of about the same width or slightly less. Six or 7 costae are covered by a span of 5 mm, though they are apparently finer on some shells than on others. The spines are small, very numerous and, except for a tuft on the auriculations, rather regularly distributed. They are so small that they affect the costae very little, and as practically all specimens are denuded of them, they are hardly noticeable without a lens. Here and there a costa may bifurcate where a spine makes its appearance, or it may become somewhat elevated behind the spine and depressed in front of it. This last performance is more common over the visceral disc than farther forward, but it is rarely pronounced even there. On the lateral parts where the spines are especially numerous the costae are apt to become irregular and sometimes discontinuous; this heightens the appearance of the spine as arising from an elongated spine base. As already mentioned, a tuft of slender oblique spines is developed on each of the auriculations.

The spines, as in other species of *Productus*, are tubes which communicate with the visceral cavity by means of a small opening, many of which as growth proceeded became closed by deposits of shelly material. On internal molds of *S. setigera* the posterior part of mature specimens rarely shows any evidence of the spines that were dispersed over the exterior, but such evidence is generally distinct over the anterior half or more. On some specimens, presumably old ones, a deposit of shell was apparently laid around the opening of the spines, forming a ring; the internal mold is then pitted with round holes considerably larger than the spines of which they are the evidence. The concentric corrugations are as a rule strong, regular, and of good size on the sides of the vault, but they rapidly lose strength and regularity in passing across it. Specimens vary greatly in the character of this intermediate region. In some the corrugations are fine, regular, numerous, and faint; in others they are few, strong, and irregular; most, however, show intermediate conditions. It is not practicable to distinguish between mere corrugations and varices of growth; some of the stronger and more persistent corrugations may be varices. The corrugations are not confined to what might be called the visceral disc, though they are strongest in that region. On some specimens they are continued, though with diminished strength, far down the anterior slope. The corrugations become more or less obsolete on the auricles which are thickly covered with small spines. On the sides of the vault where the corrugations are strong, they tend to interrupt the costae, or cause them to be irregular and they also, to a considerable extent, control the distribution of the spines which generally rise from their crests. Well preserved surfaces show incremental lines which, if especially distinct, consist of regular concentric lirae which give the relatively coarse radial costae a crenulated appearance.

Dorsal valve.—This valve is seen to best advantage in the form of external molds in chert for external molds in limestone are more or less covered with shelly material which obscures the surface characters. Dorsal valves in their proper form as concave objects have not come under my observation. As an external mold this valve is of low convexity for the visceral disc is but gently arched and the trail is narrow. The visceral cavity therefore was capacious. The visceral disc and the trail are directed at nearly right angles and are connected by a short strong turn. As the trail approaches the hinge at the side it rather abruptly bends upward, forming a round groove which at the margin is broad and deep, but almost disappears before reaching the beak. The auriculation defined in this way is large, rounded, and very oblique.

The surface characters of this valve are in general like those of the ventral valve. Concentric corrugations are regular, and strong on the sides of the vault but diminish both toward the hinge and away from it. Those near the beak may extend to the hinge; the more lateral ones fall far short of it. Over the intermediate part of the vault the corrugations are much fainter and more irregular varying from specimen to specimen. Small spines are scattered rather liberally over the surface and are especially numerous on the auriculations. It has not been possible to observe this feature on two valves of the same individual, but though actually numerous, the spines

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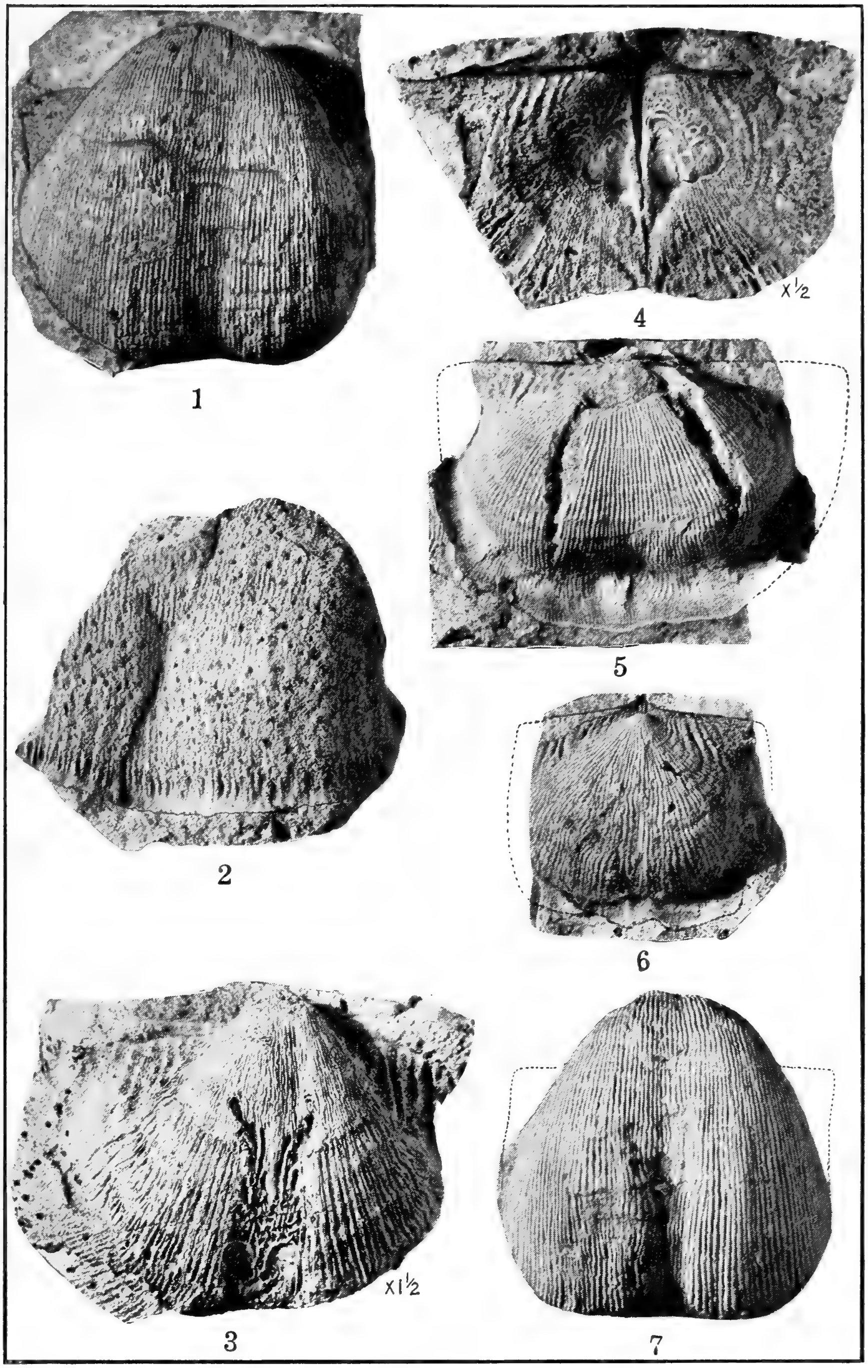
Figs. 1–7.—The localities for originals of these figures are as follows: Fig. 1, residual chert (station 7971), Webb City, Mo.; Figs. 2 to 6, residual chert (station 1310-B), Seneca, Mo.; Fig. 7, near the top of the Boone, on Grand River in the Wyandotte quadrangle, Arkansas (station 4021). All figures except 7 represent molds in chert, fig. 7 represents a testiferous specimen. Fig. 1 represents a large ventral valve which through breakage or non-development lacks the distinctive marginal rim. Fig. 2 represents a crushed ventral valve with the marginal feature as commonly seen. In some ventral valves the marginal rim is extended and upturned. This specimen also shows the pits made by annular deposits around the apertures leading into the spines. Fig. 3 shows the peculiar musculature apparently ending below in two rounded independent scars. Fig. 4 shows the musculature of the dorsal valve. Fig. 5 represents a dorsal valve with a highly developed marginal rim. Fig. 6 represents a smaller specimen also with conspicuous marginal features. Fig. 7 which represents a testiferous specimen can be compared with fig. 1 which represents an internal mold. This specimen also lacks the marginal trough though numerous testiferous specimens retain it.



Figs. 1–7.—*Productus* (*Setigerella*) *setiger* Hall. For description see opposite page.

appear to be appreciably less numerous and perhaps smaller on the dorsal valve than on the ventral valve.

Both valves at maturity exhibit a peculiar feature not as yet described but already referred to as present in the holotype and in other specimens from the Keokuk limestone at Keokuk and Nauvoo. It is indicated by Weller's illustration of the holotype, though not clearly, nor is it mentioned in his description. At maturity the marginal parts of both valves are reflexed to form a very pronounced trough or collar so that a section down the middle would be hook-shaped at the anterior end. This structure varies considerably in detail; it may be broad or narrow, it may be angular or rounded in section, it may be directed outward from the aperture or strongly backward, or it may be even and regular or rather strongly undulating. It seems generally to be more highly developed on the dorsal valve than on the ventral valve.

In the ventral valve the deflection of the marginal part is accompanied by a fairly strong and abrupt thickening of the shell so that internal molds appear also to be constricted at the aperture. The surface of the constriction is uneven, some of the costae becoming obsolete and others maintaining themselves in added size without however extending on to the recurved part. On the outer surface of the collar the radial costae are finer, fainter and more irregular than elsewhere, and over a certain part adjacent to the hinge line they die out completely, that part being marked by crenulating lines of growth such as cover the entire surface. As one would expect, no spines apparently are developed upon the collar.

On the dorsal valve the collar essentially duplicates that of the ventral valve though it commonly appears to be more extensive. The external surface is similarly marked by fine, rather faint radial costae which become obsolete over the parts adjacent to the hinge line so that even the collar, though not defined by any change in direction as it is across the front of the valve, is distinguished from the rest of the shell by a change in sculpture.

Internal structures.—Where these specimens occur in the form of molds, the ventral valve is mostly represented by internal molds and the dorsal valve by external molds for external molds of the ventral valve and internal molds of the dorsal valve are almost always fragmentary, and apt for that reason to be neglected in collecting.

Most of the internal molds of the ventral valve in chert show no distinct muscular imprints; the region where they should occur being marked by fine radial striation much like the rest of the surface. Where shown at all the musculature is somewhat out of the ordinary. It can be observed on a small number of specimens of which the one figured is representative. The other specimens, though differing somewhat in detail agree with that one in essentials. In the figured specimen (Fig. 3) the muscular tract appears to be narrow and elongate. Beginning some distance in front of the beak, it divides posteriorly into two branches and at the anterior end it terminates in two rather large oval scars. The part immediately above the scars especially is covered by an irregular reticulation of thin ridges. The muscular tract as here seen was the seat of the adductor muscles. *Productus* is generally described as having but a single pair of adductor muscles and they are characterized by having a complicated dendritic pattern. Anterior to the dendritic scars, however, an occasional specimen retains the imprint of a distinct and separate pair of scars having an oval shape. Hall and Clarke figure a specimen of "*Productus semireticulatus*" which has an accessory pair of adductor scars (Fig. 17, Pl. 17A). In general plan the imprints of the adductor muscles in that specimen and in this are closely comparable.

Broadly speaking, only exceptional specimens show the musculature of the ventral valve at all clearly, and the scars most commonly preserved are two large fan-shaped imprints made by the diductors, which may have definite outlines but are often distinguishable more by their radial striation. The diductors in the figured specimen of *S. setigera* are also distinguished in that way, but only as a variant from the rest of the surface which is also striated. The scars are sharply defined across their posterior end, partly by being just a little though abruptly depressed, and partly by being abruptly though just a little more coarsely striated. In both respects the scars seem to merge anteriorly with the rest of the surface. Such is their character on the internal mold; on the interior of the valve these features would be elevated. The diductor scars would be slightly though abruptly elevated across their posterior ends and the diductor tract as a whole would stand up still higher.

Of internal molds of the dorsal valve I have, in contrast, only a very few specimens, and here too the musculature appears to show a certain individuality. In *Productus* generally the dorsal valve bears a median septum which divides the impressions of the adductor muscles, these scars being strongly dendritic and rarely distinguishable into anterior and posterior elements. In addition, there are the so-called brachial ridges, which are loop-shaped and extend laterally from the anterior ends of the adductor imprints. This brief summary, I should state, is abstracted from Hall and Clarke. I have two internal molds of *S. setigera* which show the musculature and show it in the same way. The median septum is strongly developed, reaching about half the length of the valve. It is thin and high in the anterior part but as it passes backward it thickens, and becomes a stout ridge which joins a similar stout ridge that borders the hinge line to form a T-shaped figure. From the center of the hinge line, as if a prolongation of the septum, projects the stout cardinal process. The adductor imprints are sharply defined, but my specimens are without evidence of the branchial ridges which, however, can safely be assumed to be potentially present. The adductor scars consist of two subovate or triangular areas which are deeply excavated at the anterior end but only slightly excavated at the sides. The anterior depression is continued forward along the septum in a groove which rapidly becomes narrower and shallower, so that with this included the muscular tract as a whole has a somewhat cordate shape. The lateral and posterior parts of the adductor impressions have the normal vermiculate structure. The oblique anterior outline is somewhat lobate and two lobes on each side of the septum are especially conspicuous. The pair that are adjacent to the septum are so well marked as to suggest that they at least are independent points of muscular attachment. Different figures published to show the interior of the dorsal valve of *Producti* differ materially; the interior of *S. setigera* agrees with some, but not with others.

Almost all authors have shown caution in using internal characters of *Productus* for generic distinction. Some have said that the internal characters show little differentiation. This is perhaps not so true as that the internal characters of a species are not constant in detail and that, in addition, internal characters are so seldom open to observation as to destroy their utility from a practical standpoint. I hesitate to place great reliance upon the constancy or the individuality of the internal characters shown by my specimens of *S. setigera*, as described above.

The shells that I have been identifying with *Productus setiger* are extremely similar to a species that Moore figured as new under the name *P. newtonensis*. In fact, I can hardly doubt that they belong to the same species in spite of the fact that Moore does not mention some of the characters described above such as the marginal collar, and in spite of the fact that the two forms apparently came from widely separated horizons in the Boone. Moore's species is said to have been found in his Reeds Spring limestone, the horizon of which is some distance below the Short Creek oolite member, whereas my specimens came from 80 feet above the Short Creek oolite. A detailed exposition of this point seems desirable. I have a large collection from the residual cherts at Seneca, Mo., which contains *S. setigera* in abundance. The stratigraphic position of this fauna is of course conjectural. My testiferous specimens from the Joplin district were collected on mine dumps and of those specimens also the stratigraphic position is conjectural. Next, I have two good series of specimens from a whitish limestone in the Wyandotte quadrangle, Okla. One of these was made by Siebenthal and the locality is not at present known to me. The other collection was made by P. V. Roundy and myself, and not improbably came from nearly the same spot as Siebenthal's. The horizon of this collection was thought to be near the top of the Boone, but as we were uncertain whether some overlying beds did not also belong to the Boone the stratigraphic evidence of these two collections is likewise dubious. Finally, I have several collections from some of the higher chert beds of the Boone also in the Wyandotte quadrangle. One of these was made from loose blocks in a plowed field, another smaller collection of the same lithologic character and, so far as it goes, of the same faunal character, was obtained apparently in place from a locality nearby. The horizon of this collection as nearly as could be determined was about 80 feet above the Short Creek oolite member, and the fauna as just said is like the more extensive fauna from the loose blocks in the plowed field which in turn is almost identical with the fauna from the residual cherts of similar character near Seneca. The fauna from the whitish limestone near the top of the Boone is also in accord. There is, however, another angle to this matter. So far as I am aware the identity of the "Short Creek oolite" of the Wyandotte quadrangle with the typical Short Creek oolite near Joplin, has never been established though the presumption is strong that they are the same. If, however, there are two beds of oolite such precision as the evidence seems to possess vanishes, for the stratigraphic position of the Reeds Spring limestone member of Moore is determined with reference to one of them and the position of these specimens of *S. setigera* is determined with reference to the other. Even in that event, however, these specimens of *S. setigera* and the specimens of *Productus newtonensis* apparently come from widely separated horizons in the Boone.

It seems highly probable that the form here under consideration is Moore's *P. newtonensis* and both come from the same general region but from different horizons. On the other hand, I have little doubt that the form under consideration is also identical with typical *S. setigera* which occurs perhaps at nearly the same horizon but in a different region. Moore notes the resemblance of *P. newtonensis* to *S. setigera* but says that it "may be distinguished by its greater average size, its well defined mesial sinus and fold, and the character of the costae." The costae of *P. newtonensis* again are said to be the same in number per centimeter as those of *S. setigera*, but they readily distinguish *P. newtonensis* by "their more angular form, the scattered spine bases which they bear, and the presence of interfurrows broader than the costae." The specimen figured by Moore is considerably larger than most of mine and as already noted, many of my specimens from Oklahoma and Missouri are somewhat larger than my specimens from the Keokuk limestone but they are not much larger than the holotype of *S.*

setigera. On some of my specimens from the Keokuk limestone, the fold and sinus are well developed and in some of my specimens from Oklahoma and Missouri the fold and sinus are faint. The costae on my specimens from Oklahoma and Missouri are rounded, rather than angular and the striae between them are of about the same width. In this they are like many specimens from the Keokuk limestone, but the constancy if not the reality of the difference mentioned by Moore seems to me questionable. I mean that exfoliation in some specimens might readily increase the width of the grooves between the costae and *ipso facto* make the costae appear angular. In the matter of spines the distinction from *S. setigera* which Moore claims for *P. newtonensis* is not clear. He does not mention the presence of spines at all in his description of the ventral valve of that species; in the dorsal valve he says that the costae are "ornamented by the rather numerous irregularly placed spine base nodes." Weller, writing of *S. setigera*, says that spine bases are scattered rather generally over the surface of the ventral valve, at intervals of 5 to 10 mm; on the dorsal valve he notes scattered spine bases about as on the ventral valve increasing in number upon the auriculations. It is probable that Moore merely forgot to mention them, but if spines are really absent on the ventral valve of *P. newtonensis* and abundant on the ventral valve of *S. setigera*, we have a real difference. I doubt whether any such difference exists in this feature between *P. newtonensis* and *S. setigera*, and at all events we are left in doubt on that head.

For the species which I have just described at considerable length I propose the subgeneric term *Setigerella* with *S. setigera* as the type species. One of its distinguishing characters is the reflexed margin which forms a sort of trough about the anterior and lateral rims. It may be objected that this is a character of old age and that old age characters are of no value for generic classification. Both points are open to dispute. The character in question obviously was developed late in the life of the individual but that it is a character of old age rather than a character of maturity would be hard to demonstrate. The fact that it seems to be generally present in unbroken specimens of full size would suggest that it was not a post-mature character. It would also be difficult to demonstrate why an old age character is not of systematic value. If some species developed one sort of old age character, others developed another sort, and still others developed none at all, but just ceased to grow, these facts would unquestionably be significant though how they should be rated is debatable. The practical utility of a character that did not make its appearance until a fully matured stage was reached and that was liable to be lost by marginal breakage is, however, open to challenge, but *S. setigera* can be, and in fact has always been identified as a species on other characters than the one under consideration, and the identification of specimens as belonging to *Setigerella* need not wait upon observation of the marginal trough though according to my experience that structure is present in the majority of specimens. *S. setigera* has other claims to subgeneric rank, one being the abundance of spines on the dorsal valve, a decidedly primitive character; still another perhaps can be found in the muscular imprints, which appear to have some individual features, though the value of this character needs to be further tested as to degree and constancy. Another consideration is that the species does not adjust itself well to other named groups of *Producti*. It is not in accord with the semireticulate *Producti* by reason of its irregular and faint concentric corrugations, which are more or less obsolete except near the hinge line and which are not restricted to a well-defined visceral region but on some specimens continue to be developed on the anterior slope though rarely with the same strength. The *semireticulati* characteristically have rather coarse radial costae instead of fine ones, a few large spines instead of innumerable small ones, and a spineless or almost spineless dorsal valve. In fact, *Setigerella* is in some respects intermediate between the *semireticulati* and the *ovatus* group (*Linoproductus*). It has the fine lineation of that group and corrugations that are strong near the hinge and vague or obsolete over the vault. But it differs in the geniculate shape of the dorsal valve (*Linoproductus*, however, is not constant in that character), in the very large visceral cavity, and in the great number and small size of the spines, which are distributed over both valves, whereas the tendency in *Linoproductus* is to have a small number of large spines on the ventral valve but no spines at all on the dorsal valve, at least in the more representative species.

There is a possibility that *Setigerella* may conflict with Muir-Wood's genus *Sinuatella*, though this would seem unlikely from her generic description. Licharew[2] remarks that the trail of *Productus* may even be concave and instances *Sinuatella* under which genus (he classifies it, however, as a subgenus) he describes a new species *Productus* (*Sinuatella*) *subsinuatus*. His description and his figures (which are not very distinct and represent only imperfect specimens) seem to show a species that closely resembles *Setigerella* in configuration. The genotype of *Sinuatella* is *Productus sinuatus* de Koninck. Unfortunately the plate (plate 56) on which that species is figured in de Koninck's work is missing from the copy in the Survey Library. Davidson, however, figures a very perfect specimen which has remarkably large and reflexed auriculations. His specimen differs from *Setigerella* in that the feature which they appear to have in common, has just the opposite distribution in each. In *Setigerella* the shell is most extended and recurved in front, the curvature and probably the extension decreasing on the lateral slopes as the auriculations are approached. In *P. sinuatus* it is the auriculations alone that are expanded and upturned; from halfway down the sides the configuration is like that of any other species of *Productus*. In fact, the contrast might be still further enlarged upon for Davidson's figure shows a flattened area extending across the posterior margin of the ventral valve which connects the two large auriculations and from which the vault, divided by a deep sinus, rises rather abruptly. Commenting on the original specimens figured by de Koninck, Davidson says that they were imperfect and that none of them "retained the peculiarly extended and reflexed ears which I have drawn with great care from some very perfect specimens, etc." Muir-Wood does not mention this peculiarity of configuration as characteristic of *S. sinuatus* nor is it shown by her figures. The main distinctive characters of *Sinuatella* (which would otherwise apparently be one of the *semireticulati*) seem to be a well-defined cardinal area in the ventral valve with the delthryium closed by a deltidium, features also mentioned by Davidson and shown by one of his figures. Licharew found a cardinal area in *Productus* (*Sinuatella*) *subsinuatus* but could not detect a deltidium. I am satisfied that *Productus* (*Setigerella*) *setiger* has no real cardinal area and deltidium like those of *Sinuatella*, so that it has neither the configuration nor the structural features of that genus.

Worthenella subgen. nov.

There are two other Mississippian species which are closely related to each other and more loosely to *S. setigera*, all three distinguished in the

[2] Licharew, B. *Permian Brachipoda of North Caucasus.* Pal. U. S. S. R. Monographe **39**: 89. 1937.

mature stages by some remarkable development at the aperture. *Productus wortheni* and *P. marginicinctus* have already been mentioned and are outstanding developments of the Productoid stock in this country. They invite and perhaps deserve subgeneric distinction more than *S. setigera* for their distinctive characters were known even from the first whereas the distinctive characters of *S. setigera* are less striking and have generally been overlooked or unrecorded. If any of our Mississippian *Producti* deserve to be separated from the rest and given a distinctive name it is these two and I propose for them the subgeneric name *Worthenella* with *Productus wortheni* Hall as the genotype. The most distinctive character of *Worthenella* is the arch or fold passing transversely across the shell at the aperture. This development is accompanied by the disintegration of the costae into innumerable fine short spine bases. The objection that might be advanced against using the reflexed rim of *Setigerella* as a generic character would seem to hold almost equally against *Worthenella*. The counter arguments also would be the same and perhaps more telling.

Insofar as I am acquainted with foreign literature, *Worthenella* is a strictly American type. In its final relapse from a costate to a spiniferous condition it recalls *avonia* but *avonia* as originally conceived lacked the marginal arch which is so striking a feature of *Worthenella*, and as redefined it lacks the transition from a costate to a spinose type of sculpture—at least that change which seemed to figure importantly in the original definition, is generally omitted from later ones.

BOTANY.—*New varieties and combinations in* Salix.[1]

Carleton R. Ball, U. S. Department of Agriculture.

Willow collections are steadily accumulating as a result of the efforts of private and public collectors. This makes it possible, from time to time, to evaluate previously described species, especially those based on meager and/or juvenile specimens. It makes possible also the description of variations regarded as worthy of varietal rank. Two new varieties are described, and two new combinations made, in the present paper.

The herbariums in which the specimens examined are deposited are designated by the following abbreviations: CAS, California Academy of Sciences; CNM, Canadian National Museum; CRB, Carleton R. Ball; CUA, Catholic University of America; PC, Pomona College; SU, Stanford University; UC, University of California; UO, University of Oregon; USN, U. S. National Herbarium.

Salix alaxensis (Anders.) Cov. var. **obovalifolia,** n. var.

Folia obovalia vel obovata; petioli breves latique basi dilatata gemmam amplectante.

Shrubs, apparently low, 1-yr. and 2-yr. branchlets stout, 4-7 mm thick, mostly divaricate, densely clothed with yellowish pilose hairs, becoming gray with age; stipules lanceolate, 4–10 mm long, glandular-serrulate or -serrate, pilose; budscales 8–14 mm long, lanceolate to ovate-lanceolate, acute, densely long-pilose; leaves rather crowded on material

[1] Received July 15, 1938.

seen, stipulate on the more vigorous shoots; petioles consisting of a broadly expanded base which forms a clasping sheath for the bud, narrowed above to join the base of the blade but may develop a true narrowed petiole above the swollen base as the leaf becomes fully developed, densely pilose throughout; blades thick and firm, 3–5 cm long and 2.5–3.5 cm wide as seen, obovate to oboval, apex arounded or plicately apiculate on the larger blades but subacute on the lower smaller ones (quite possibly retuse to subcordate at base and short-acute at apex on vigorous shoots, when fully expanded), the base cuneate on developing blades but rounded on the more oboval apical blades, densely white shining pannose-tomentose beneath, thinly gray pubescent or puberulent above, especially on the sunken midrib and laterals (probably glabrate to glabrous in maturity).

Aments (only the staminate seen) sessile on 2-yr. wood, ovate-oblong, stout, 2–3 cm long, 1.5 cm wide in anthesis (the pistillate probably much longer); flower scales ovate, acute, blackish, densely long-pilose with straight white hairs; stamens 2, the long slender filaments glabrous; (pistillate aments, capsules, pedicels, styles, and stigmas probably as in the species).

In the species, *S. alaxensis*, the leaf blades are oblanceolate, elongated, cuneate at base and tapering to an acute apex. The petiole is slender and scarcely dilated at the base. *S. alaxensis* var. *obovalifolia* differs from it, therefore, in the obovate-oboval blades and the broad dilated clasping petiole, enclosing the bud. The previously recognized variety, *S. alaxensis* var. *longistylis* (Rydberg) Schneider, differs from the species, not in longer styles, but in the glabrous and often pruinose branchlets. The new variety differs from it, therefore, by all the differences mentioned in comparing it with the species and by the densely pilose branchlets as well.

The range of the species is from northern British Columbia to Alaska and Yukon. *S. alaxensis* var. *longistylis* has much the same range but probably is more common in the eastern portion of the area occupied by both. *S. alaxensis* var. *obovalifolia*, on the other hand, apparently is confined to the front range of the northern Rocky Mountains and the great interior basin to the eastward. This region is the meeting ground or separating area for the willows of northwestern America and those of northeastern America and Greenland. It also has some species peculiar to itself, as shown recently by Raup.

Much of the material heretofore brought out of this middle ground has been collected, not by professional botanists, but casually by explorers on other missions. For this reason, many of the specimens are scanty, frag mentary, and immature or incomplete and certain identification is not fully possible. Apparently, however, the new variety ranges from eastern Jasper Park in Alberta to the western shore of Hudson Bay at Cape Eskimo, and thence northward to the Mackenzie River Valley.

Specimens examined

MACKENZIE: Near Leith Point, Great Bear Lake, Edward A. Preble 290 (USN), Aug. 31, 1903. (Leaves just expanding, the largest 3.5 cm long, narrowly obovate, plicately apiculate at apex, the petiole short, stout, subclasping, pilose.

KEEWATIN: Baker Lake, on upper part of Chesterfield Inlet, Lat. 64° 30′ N., Long. 97° W., in central Keewatin, Pere A. Dutilly 444, 445 (CUA), the latter, the type, apparently had been browsed by animals some two years before the collections were made, Aug. 8, 1936, (Both staminate and the basis of the above description.) Hudson Bay, 25 mi. south of Cape (Point) Eskimo, (in southeastern Keewatin, Lat. about 61° N.), Edward A. and Alfred E. Preble 50 (USN), Aug. 12, 1900. (A fragment with leaves just unfolding but petioles already broad and blades broadening.)

Alberta: Jasper Park, open mountain slope just above Brule station, Wm. Spreadborough 95809a (CNM, fragment in CRB), June 24, 1918. (The available fragment is too small and immature for certain determination but apparently belongs here.)

Salix caudata var. **bryantiana** Ball and Bracelin, n. var.

A forma typica per ramellos aetatis uni aut duorum annorum, surculos annuos, squamas gemmarum, et stipulas aut glabros aut cito glabrescentes et per petiolos minus puberulos abludens.

Salix caudata var. *bryantiana* differs from the species in having those vegetative organs glabrous or glabrate which are pubescent or pubescent-pilose in *S. caudata.* These organs include seasonal shoots, 1-year and 2-year branchlets, budscales, stipules, petioles and midveins. The seasonal shoots and petioles may be puberulent when first developed but soon become glabrate. In other characters the variety does not differ consistently from the species.

S. caudata var. *bryantiana* bears the same relation to *S. caudata* that *S. gooddingii* var. *vallicola* bears to *S. gooddingii* Ball, namely, that of a more widely-distributed and glabrous or glabrate variety in comparison with a less widely distributed and pubescent species. It is the reverse of the relationship which the pubescent variety *S. lasiandra* var. *lancifolia* bears to its glabrate species *S. lasiandra,* and which the pubescent variety *S. laevigata* var. *araquipa* (Jepson). Ball bears to its glabrate species, *S. laevigata,* so far as relative pubescence is concerned. It has the same seasons of flowering and fruiting and the same habitats, as the species, where they occur together. At the higher elevations, flowering may be somewhat later. The type specimens are C. F. Baker's No. 1151, containing both staminate and pistillate material in the herbarium of the University of California. They were collected on June 24, 1902, in Snow Valley, Ormsby County, Nevada, at an elevation of 2460–2615 meters.

It is a pleasure to name this widely distributed variety in honor of Dr. Harold C. Bryant, a graduate and former member of the faculty of the University of California, long interested in the natural history and natural resources of the State, and now Assistant Director of the National Park Service of the Federal Department of the Interior. The eleven States in which variety *S. caudata* var. *bryantiana* is known to occur contain some fourteen of the National Parks, and eventually it probably will be found in most of them.

Salix caudata var. *bryantiana* occurs along mountain streams and in meadows of the Arid Transition and Canadian Zones of the western half of the United States. It is found at elevations of 4500 to 8500 feet (1350–2550 m) or more in the southern part of its range and at correspondingly lower elevations northward. Its range extends from north-central New Mexico northward to the Black Hills of South Dakota and the mountains of southern Alberta. Westward it extends across the Wasatch System and the ranges of the Great Basin to San Bernardino County, California, and northward in and east of the Sierra-Cascade System to southern British Columbia. Apparently it does not cross, and seldom enters, the Cascade range in Oregon and Washington. It is a plant of higher altitudes than the closely related *S. lasiandra* and therefore does not range as far south, west, or north, as that species.

Specimens examined

CALIFORNIA: *San Bernardino Co.*, 6 ft. high, Bear Valley, San Bernardino Mts. and their eastern base, elev. 6500 ft., S. B. Parish 3003, June 23, 1894 (SU). *Tulare Co.*, Soda Creek Canon near Soda Springs, Head of Kern River, elev. 6500–7500 ft., W. R. Dudley 1492a, July 17, 1897 (SU). *Placer Co.*, Tahoe National Forest, French Meadows, along Middle Fork of American River, on Sec. 16, Twp. 15 N, R. 14 E, elev. 6000 ft., L. S. Smith 1, May 22, 1931 (CRB, UC); 2 (CRB); 2626 (in part), Aug. 27, 1931, probably from same plant as No. 2 (CRB). *Nevada Co.*, Lower end of Donner Lake, A. A. Heller 6879, July 8, 1903 (PC). *Sierra Co.*, by bridge over Little Truckee River, Sierraville-Truckee Stage Road, W. R. Dudley 5524, June 12,1900 (SU). *Modoc Co.*, by Parker Creek near Modoc Natl. Forest Boundary, Roxana S. Ferris and Rena Duthie 188, June 14, 1919 (SU). *Plumas Co.*, Few shrubs, all male, east end of Bear Lake, Canadian Zone, alt. 6500 or 7000 ft., Mrs. C. M. Wilder 9331, July 10, 1912 (CRB). *Siskiyou Co.*, Jackson Lake, alt. 5900 ft., Annie M. Alexander and L. Kellogg 186, June 24, 1911 (UC, very immature).

The identifications of the Dudley collections from Sierra County, and of the Alexander-Kellogg specimen from Siskiyou County, are somewhat doubtful, owing to their juvenile condition. Possibly they may represent *S. lasiandra* Bentham.

NEVADA: *Ormsby Co.*, Snow Valley, alt. 2460–2615 m, C. F. Baker 1151, June 24, 1902, distributed as *S. arguta* var. *lasiandra* (Bentham) Anders. (PC, UC, 2 sheets, Nos. 75356 and 143186, each bearing staminate and pistillate types). *Washoe Co.*, Franktown, K. Brandegee, May, 1913 (UC).

OREGON: *Deschutes Co.*, vicinity of Redmond, Kirk Whited 444, 444a, June 3, 1921 (CRB); 506–66, April, May, Sept., 1922 (CRB); 8, May, June, 1923 (CRB); 28, June, 1923 (CRB). *Grant Co.* Along bottoms of Long Creek, near Long Creek, W. E. Lawrence 844, July 27, 1917 (CRB). Canyon City, Griffiths and Hunter 174, July 13, 1902 (CRB).

COLORADO: *Las Animas Co.*, Stonewall, Johnston and Hedgcock 493, June 19, 1917 (CRB). *Costilla Co.*, Culebra Creek bottom, San Acacia, alt. 7737 ft., E. R. Warren 70, July 1, 1912 (CRB). *Alamosa Co.*, Alamosa, south of Rio Grande River, near State St. Bridge, alt. 7536 ft., Hazel M. Schmoll 1016, 1017, June 12, 1924 (CRB). *Rio Grande Co.*, northeast of Monte Vista, alt. 7653 ft., Schmoll 1055, 1056, June 13, 1924 (CRB). Del Norte, Ellsworth Bethel, July, 1897 (CRB). *Gunnison Co.*, Abundant along creeks at Dayton, Ivar Tidestrom 1633, July 21, 1908 (CRB). Common at Gunnison, alt. 2300 m, Ivar Tidestrom 2235, 2236, June 14, 1909 (CRB). *Fremont Co.*, Canon City, T. S. Brandegee, May, 1877 (UC). Pike's Peak Region: *El Paso Co.*, Adams Crossing near Colorado City, alt. 6200 ft., I. M. Johnston 2703, (CRB, UC), 2704 (CRB) July 21, 1920, Ute Pass near

Long's Ranch, alt. 7000 ft., Johnston 2705, June 17, 1920 (UC); just east of Manitou, Johnston 2706, June, 1920 (CRB, UC). *Douglas Co.*, Lower part of Garber Creek, 8 mi. S.W. of Sedalia, Schmoll 703, June 7, 1923 (CRB). *Routt Co.*, River bank, 10–15 ft. high, Steamboat Springs, L. N. Goodding 1597, July 13 (CRB) July 20 (UC) 1903.

South Dakota: *Pennington Co.*, along North Rapid Creek, 1½ miles N.W. of Rochford, A. C. McIntosh 843, Aug. 24, 1926 (CRB). *Lawrence Co.*, Stream at edge of town, Deadwood, C. R. Ball 1356, Sept. 19, 1908 (CRB).

Wyoming: *Albany Co.*, Scarce, river bottoms, Little Laramie River, L. N. Goodding 4, June 14, 1901 (CRB). Sand Creek, 6–15 ft. high, along the creek, A. Nelson 6991, May 31, 1900 (CRB, UC). Chug Creek, common along the creek. A. Nelson 7346, June 30, 1900 (CRB). Centennial, A. Nelson 8834, June, 1902 (CRB). Stream near Centennial, Leon Kelso, 1021, 1037, June 20, 1930 (UC). Near Sheep Mt. in a dry, hilly locality, Leon Kelso 1004, 1011, 1012, July 5, 1930 (UC). *Sheridan Co.*, above Big Horn, alt. 4500 ft., Pammel and Stanton 207, June 26, 1897 (CRB). *Uinta Co.*, Fort Bridger, Aven Nelson 4596, June 8, 1898 (UC). Common along the creek, Evanston, Aven Nelson 7209, June 14, 1900 (CRB). In clumps 5–15 ft. high, Kemmerer, Aven Nelson 7179, June 13, 1900 (CRB).

Montana: *Gallatin Co.*, Bozeman, J. W. Blankinship, Oct. 13, 1900 (UC). Southeast of Fair Grounds, in swampy ground, C. R. Ball 1311, Sept. 3, 1908 (CRB). *Park Co.*, Cottonwood Creek, northwest of Wilsall, W. N. Suksdorf 924, Sept. 2, 1921 (CRB). *Powell Co.*, Mountain streams, alt. 5000 ft., Deer Lodge Valley, J. W. Blankinship 788, May 27, 1906 (UC). *Missoula Co.*, near mouth of Clearwater River, Clearwater, J. E. Kirkwood 1435, June 9, 1923 (UC).

Utah: *Piute Co.*, Mt. Belknap, Marysvale, E. D. Ball 1763, June 22, 1912 (CRB). *Sevier Co.*, head of Salina Canon, alt. 8000 ft., M. E. Jones 5427, June 15, 1894 (UC). *Sanpete Co.*, abundant along creek near Indianola, Ivar Tidestrom 2240, June 17, 1909 (CRB). Shrub 2–3 m high, along creek at Ephraim, Wasatch Mts., alt. 1650 m., Tidestrom 1118, June 11, 1908 (CRB). *Utah Co.*, Along streams, Lehi, L. N. Goodding 1162, June 20, 1902 (CRB, UC). Common along stream at Thistle Junction, Wasatch Mts., alt. 1500 m, Ivar Tidestrom 8, Aug. 8, 1907 (CRB); Tidestrom 1095, 1096, June 8, 1908 (CRB). *Salt Lake Co.*, near Salt Lake City, Mrs. E. J. McVicker, in 1901 (UC). *Dagget Co.*, Ditch bank, elev. 6000 ft., Louis Williams 413, May 28, 1932 (CRB); Lake shore, Green Lake, elev. 7400 ft., Williams 585, June 10, 1932 (CRB). *Summit Co.*, near R. R. Station, Echo, Wasatch Mts., C. R. Ball 1825, Aug. 19, 1913 (CRB). Myer's Ranch, Uintah Mts., alt. 7500–8000 ft., South of Evanston, Wyo., Pammel and Blackwood 4106, July 26–Aug. 1, 1902 (CRB). *Morgan Co.*, Peterson Canon, Peterson, alt. 8000–10,000 ft., Pammel and Blackwood 3999, July 19, 1902 (CRB). *Cache Co.*, Ditch south of College Hill, Logan, C. R. Ball 1313, Sept. 8, 1908 (CRB). Izatt's Swamp, Greenville, Logan, C. R. Ball 1703, Sept. 27, 1910; alt. about 6000 ft., in Logan Canon, Logan, C. R. Ball 1863, Aug. 18, 1914 (CRB).

Idaho: *Bear Lake Co.*, Creek bank, Montpelier, J. F. Macbride 17, May 15, 1910 (UC, mixed with *S. lutea*). *Fremont Co.*, Shrub 6–8 ft. high, river banks, St. Anthony, Merrill and Wilcox 820, July 4, 1901 (CRB). *Bonner Co.*, bottoms, Upper Priest River, alt. approx, 3000 ft., C. C. Epling 8608, July 1925 (CRB).

WASHINGTON: *Klickitat Co.*, Open slopes near Maryhill, J. Wm. Thompson 8184, April 15, 1932 (CRB). *Spokane Co.*, 5 or 6 miles southeast of Spangle, W. N. Suksdorf 8630, May 15, 1916 (CRB). Old bush, upper Hangman's Creek, F. A. Patty 14, May 2, 1932 (CRB, UC). *Okanogan Co.*, Head of Ross Canyon, West of Omak, C. B. Fiker 592, April 24, 1932 (CRB); Fiker 737, May 12, 1932 (UC). On Salmon Creek near weir, Fiker 612, May 5, 1932 (CRB). On bank of Okanogan River at Omak, Fiker 614, May 5, 1932 (UC); Fiker 618 and 619 (CRB), 620 and 621 (UC), all May 8, 1932.

ALBERTA, CANADA: Elbow River at Mission Bridge, Calgary, alt. 3400 ft., Malte and Watson 116725, June 28, 1925 (CRB, NMC, UC). Sand flat along Bow River, Calgary, Malte and Watson 116728, June 4, 1925 (CRB, NMC, UC).

Salix lasiolepis var. **sandbergii** (Rydberg) n. comb.

Salix sandbergii Rydberg in Bull. Torr. Bot. Club **39**: 304, 1912;—Fl. Rocky Mts. 192, 1917;—rev. ed. 192, 1922.
Salix lasiolepis, in part, of authors.
Salix lasiolepis bigelovii, in part, of authors.

Shrub 2–3 or sometimes 4 m high, sprangly or divaricately branching; branchlets softly gray-tomentose, the 2-year thinly, the 1-year and seasonal shoots usually densely so, brownish or the younger yellowish; budscales short, stout, ovate, obtusish, 4–8 or 10 mm long, colored and clothed as the branchlets.

Leaves petiolate, stipulate; stipules (on vigorous branchlets) reniform to semi-lunate or semi-cordate, 5–10 mm long, denticulate to dentate, colored and clothed as the blades; petioles rather slender, 7–15 mm long on seasonal shoots, pubescent; blades obovate or obovate-oval (on lower part of shoots) to broadly or narrowly oblanceolate or elliptical-oblanceolate or even lanceolate (on distal portions of shoots), 4–10 or more cm long, 2–4 cm wide, common sizes being 3×1.5, 4×2, 5–6×1.5–2.5, 7×2.5–3, 8×1.7–3.5, 9–10×3–4 cm, respectively, margins somewhat revolute, entire to irregularly and somewhat remotely glandular-crenulate-serrulate, or those of vigorous shoots sometimes closely crenate-dentate, the glands partly deciduous, the whitish midvein and slender primaries elevated on both surfaces, dull green (not shining) above, glaucous beneath, white-tomentose on both sides when unfolding, thinly pubescent to puberulent above and densely gray or silvery-gray pubescent beneath when full grown, sometimes becoming glabrate in autumn.

Aments midsize to large, precocious, sessile to very short-pedunculate, spreading; peduncles pubescent, 2–7 or 10 mm long, and bearing 3–5 or rarely 7 small leaf-like bracts which are early deciduous or the distal occasionally developing into small permanent leaves; pistillate aments 3–4.5 cm long and 1 cm wide at anthesis, becoming 4–6.5 cm long and 1.5 cm wide in fruit; capsule pedicelled, lanceolate, 4.5–5.5 mm long, brown, glabrous, the upper pedicels 1, and the lower to 2.5 mm long, glabrous, styles entire, 0.5–0.8 mm long, slender, glabrous, stigmas shorter, entire or mostly divided; staminate aments 2.5–4 cm long, 1–1.3 cm wide, sessile but with 1–4 small bracts at base; stamens 2, filaments slender, glabrous, commonly united at base; scales of both sexes obovate, rounded to subacute at apex, black, densely pilose on both surfaces with originally-straight white hairs.

Rydberg described *Salix sandbergii* in 1912 from a single immature, leafless fruiting specimen collected in northern Idaho. For 20 years its identity remained unknown. On May 17, 1932, the writer, in company with Harold E. Parks and Joseph P. Tracy, two exceedingly observant botanists of northern California, discovered and collected a peculiar willow in a dry arroyo on Berry's Mt., in Humboldt County. The old fruits indicated relationship with the common arroyo willow, *S. lasiolepis* Bent., but the plant differed in many ways. In October of that year, and in April and May of 1933, a later season, Tracy collected additional good material from the same plants. The leafless flowering and fruiting spring material recalled the specimen Rydberg had described and a comparison with the type proved the identity of the plants from California and Idaho. Abundant material, collected throughout the year, proved the material to represent a well-marked variety of *S. lasiolepis.*

Salix lasiolepis var. *sandbergii* differs from the species in the more broadly oblanceolate to obovate leaves and the much denser and more permanent pubescence of all the vegetative organs, namely, branchlets, budscales, and leaves. From variety *bigelovii* (Torrey) Bebb, it differs chiefly in the denser and more permanent tomentose pubescence just mentioned.

Salix lasiolepis var. *sandbergii* is distributed at least from northern California, in both the Coast Ranges and the Sierras, across eastern Oregon and Washington and western Idaho. It has not been collected again as far north in Idaho as the type locality. The species occurs more or less sparingly throughout the same range. The variety apparently tolerates the hotter and drier situations and occupies these alone, but in more favorable situations both may occur.

It is probable that the collecting of additional complete material may disclose the variety in localities farther south and perhaps farther east also.

Specimens examined

California: *Humboldt Co.* (southern), Miranda, along South Fork of Eel River, elev. 300 ft., Jos. P. Tracy 10914 (CRB, UC), 13090 (CRB), in 1933; Bridgeville, Van Duzen River, elev. 750 ft., Tracy 10126, 11 ft. tall (CRB, UC), 10130, 20–30 ft. tall (CRB, UC), both in 1932, and 10934 and 10968 (CRB), from the same plant as 10127, both in 1933; dense thickets 10–20 ft. high on Van Duzen River 2 mi. west of Bridgeville, Parks and Tracy 11005, 11006, 11007 (CRB). "Blue Slide" on Van Duzen R., elev. approx. 300 ft., Tracy 10753 (CRB) in 1932 and 10931, 10969 from same plant (CRB) in Mar.–Apr., and 13088 in Oct., 1933; Ball, Parks, and Tracy 01236 (CRB, UC), probably from same plant as Tracy 10753, 1932. *Humboldt Co.* (northern), Divaricate shrubs, 6–8 ft. high, in dry ravine on west slope of Berry's Mt., east of Redwood Creek on Trinity Highway, elev. 2500 ft., Ball, Parks, and Tracy 01323–01329, incl. (CRB, UC, USN 01323–24), May 17, 1932; Tracy 10865, 10866 (CRB, UC, USN 10865), 10867 (CRB), Oct. 8, 1932; Tracy 10959 (from same plant as B, P, and T 01324 and Tracy 10866) and 12184 (CRB, UC, USN 10959), April 2 and May 14, 1933; Tracy 10961 from same plant as Tracy 10867 (CRB), April 2, 1933. Buck Mt., shrub 15 ft. tall on lower foothills of its northern slope, elev. about 2500 ft., Jos. P. Tracy 10243, 10244 (CRB, UC), 10248 (UC), June 9, 1932. Three Cabins, shrubs 15 ft. tall, common in ravines of grassy slopes on lower western foothills of Chaparral Mt., elev. about 1500 ft., Tracy 10356, 10357 (CRB, UC), June 19, 1932. Dobbyn Creek, alt. about 500 ft., Tracy 13356 (CRB), July 9, 1934. Trinity River Valley at Willow Creek, alt. 500 ft., Tracy 9643 (UC), 12177 (CRB, UC), May 14, 1933. *Trinity Co.:*

Along stream, Weaverville, E. I. Applegate 7054 (CRB), April 14, 1932. *Del Norte Co.*, Gravel bars 5 mi. above mouth of Smith River, Tracy 9506 (CRB), May 30, 1931; Tracy 10822 (CRB, UC), Sept. 24, 1932. *Siskiyou Co.*, Siskiyou Mts., sunny south slope by well, Oak Knoll Ranger Station, Klamath River, alt. 2200 ft., Louis C. Wheeler 3363 (CRB), Dec. 13, 1934 (apical leaves of seasonal shoots still attached). Shrub to 3 m tall, in sunny seep, Greenhorn Creek, elev. 3000 ft., Wheeler 3492 (CRB), May 12, 1935. Klamath River 6 miles below Hornbrook, L. R. Abrams 9902 (CRB), Aug. 1, 1920. *Nevada Co.*, Dry arroyo above Grass Valley, Ball 2302 (CRB), Aug, 5, 1925. *Shasta Co.*, Squaw Creek, tributary of the Sacramento R. at Kennett, elev. about 500 ft., R. Ballaert (for C. J. Kraebel, For. Serv. erosion control), 1a to 1d incl. (CRB), Dec. 20, 1934; Shrubs in denuded clay soil of Kennett smelter-fume area, Redding quadrangle, east of Trinity Nat. For., C. J. Kraebel K501 (same plant from which cuttings 1a to 1d, above, were derived), K502, K503 (CRB), Sept. 23, 1933.

OREGON: *Jackson Co.*, Shrub 6–8 ft. high, by Highway 99, 5.2 mi. south of Siskiyou Pass, near Oreg.-Calif. boundary, Bertha S. and Carolyn S. Ball 2334 (CRB, UC, UO), Sept. 21, 1933. *Umpqua Watershed*, Low shrub on West Fork of Cow Creek, Cow Creek Mts., W. C. Cusick 4727a, 4728 (CRB), both depauperate, June 12, 1915. *Deschutes Co.*, Redmond, in Landes field, SE of barn, Kirk Whited (CRB), July 13, 1922; Main Ditch and Lateral C, Whited 508–68 (CRB), Sept. 3, 1922; Landes field, Whited 508–70 (CRB), Sept. 4, 1922. *Wasco Co.:* Dufur, L. R. Abrams 9517 (CRB), July 28–30, 1922.

WASHINGTON: *Klickitat Co.*, In the canyon north of Bingen, W. N. Suksdorf 10342, 10372 (CRB), April and July, 1920. Maryhill, open slopes near, J. Wm. Thompson 8183 (CRB), April 15, 1932. *Chelan Co.*, Moist creek bottom near foot of Blewett Pass, J. Wm. Thompson 6022 (CRB), April 18, 1931.

IDAHO: *Boise Co.*, Squaw (Sweet) Creek, stream banks, elev. 3500 ft., J. T. Macbride 859 (as S. Wolfii idahoensis Ball, USN), May 11, 1911. *Elmore Co.*, On banks of Canyon Creek, near Tollgate, north of Mountain Home, J. H. Christ and W. W. Ward 7028 (CRB), May 7, 1937. *Gem Co.*, In ravine in basalt cliffs, Black Canyon Diversion Dam, Emmett, Christ and Ward 6979, 6980 (CRB), May 3, 1937. *Nez Perce Co.*, Along Hatwai Creek, Sandberg, MacDougal, and Heller 71 (CRB, USN, isotype), April 28, 1892.

Salix pseudo-monticola var. **padophylla** (Rydberg) n. comb.

Salix padifolia Rydberg, in Bull. Torr. Bot. Club **28:** 272–73. 1901, not Andersson, 1858. *S. padophylla* Rydberg, nomen novum, in Bull. Torr. Bot. Club **28:** 499, 1901.

Rydberg's original description read as follows: "A shrub 1–7 m high, with light brown smooth bark. Young twigs strict, glabrous and shining, yellow, or often brown or purple: stipules ovate or rounded, glandular-dentate: leaves with petioles 5–8 mm long; blade oval or broadly elliptic, crenate, short-acute or obtusish, rounded at the base, 3–5 cm long, 1.5–2 cm wide, when young sparingly covered with silky hairs but soon glabrate, dark green above, paler beneath: pistillate aments 3–4 cm long, densely flowered, appearing usually before the leaves, borne on very short branches and subtended by 1–4 small leaves: bracts obovate, fuscous, covered on the outside with white wool; pistils nearly sessile, glabrous; style about 1.5 mm long: stigmas 2, nearly 1 mm long, 2-cleft: capsules ovate-conic, about 6 mm long: staminate aments almost sessile, 2–3 cm long, 10–12 mm in diameter: bracts as those of the pistillate aments: stamens 2, filaments glabrous."

With some exceptions to be noted later, this is a fairly complete description of the plant Rydberg had in hand. His species, however, received scant attention then or since. The reasons were two. In the first place, he compared it only with *S. mackenziana* and *S. cordata,* two species of the Section *Cordatae.* He made no mention of the Section *Commutatae,* to which the broad and short leaves and the elongated style and stigmas clearly showed it to belong, as did also some other characters and the general habit and habitat. He did not compare it with, or even mention, *S. monticola* Bebb, the common and well known representative of the *Commutatae* in the southern Rocky Mountains where his species occurred. In the second place, the other three species of *Salix* published in the same paper were speedily shown to be either previously described or of doubtful validity and these facts tended to discredit the standing of the plant under discussion. So also did the fact that the original name was preoccupied and had to be replaced by him.

In the light of more abundant material, Rydberg's description needs some emendation. The branchlets often are not strict but more or less divaricate, as in the species or in *S. monticola* Bebb. The leaves he described were those of flowering and fruiting branches. Mature leaves on such branches, and the full-grown leaves of seasonal shoots, probably will be larger, more produced at apex, and sometimes subcordate at base. Unfortunately, no collector seems to have collected all the stages of development from the same plant. Numerous specimens of mature foliage are found in herbariums but which ones actually represent the variety and which the species cannot be known with certainty until complete specimens are available.

The description of the leaves as merely "paler beneath" rather than glaucous beneath probably was due partly to the immaturity of the material and perhaps partly to faulty drying. Too rapid drying, especially by electric driers, often destroys the glaucous character. The aments are sessile to very short-peduncled at anthesis and the peduncle elongates thereafter. The staminate aments remain subsessile. The pedicels of the capsules vary from 0.5 to 1 or 1.5 mm, especially the lower, and the capsules are not "nearly sessile," as described.

Salix pseudo-monticola var. *padophylla* differs from the species, *S. pseudo-monticola* Ball, chiefly in having the aments borne on short leafy peduncles, whereas those of the species are sessile and scarcely even bracted at base. From *S. monticola* Bebb it differs in the pedunculate aments and also in the oval-ovate leaves, resembling those of the apple, as the name indicates. The leaves of *S. monticola* are lanceolate to broadly lanceolate-oblong and acute to subacuminate.

Salix barclayi Anders., also of the Section *Commutatae,* likewise has leafy-pedunculate aments. In general, however, the peduncles are much longer and more leafy. The branchlets usually are more or less hirsute and the leaves are oblanceolate, acute at the apex, usually narrowed at base, and commonly closely glandular-crenulate on the margins. The flower scales also are longer, narrower, and acute, with longer pilose hairs. Unfortunately, however, *S. barclayi,* in its most southward extension, tends to become more glabrate, the peduncles become reduced in length, and at least the lower (distal) leaves may be broadened at the base. Immature material is difficult to distinguish from immature specimens of the present variety of *pseudo-monticola*. Only the collection of complete specimens (flowers, fruit, and mature leaves from fruiting branchlets, and mature seasonal shoots) will enable the final solution of this problem.

The widespread and discriminating observations and collecting of Professor Edward C. Smith of the Department of Botany, Colorado Agricultural College, is producing information and material of much value in the solution of this and other problems of the Colorado willows. He recently has raised the question of the taxonomic status of the representatives of the *Commutatae* in that State and this contribution is a partial answer to the question. More complete collecting may make a complete answer possible.

It is probable that some of the mature-foliage specimens now assigned to *S. pseudo-monticola* really belong to the variety but this can be determined only after flowering, fruiting, and late foliage specimens from the same plant are available for study. The following flowering and fruiting specimens are referred to this variety.

Specimens examined

ARIZONA (east central): White Mts., south of Thomas Peak, Coville 2009 (USN), July 2, 1904.

COLORADO (western): *Gunnison Co.*, Vicinity of Mt. Carbon, elev. 2750 m., Eggleston 5671 (USN), June 11, 1910. *Hinsdale Co.* (Gunnison Watershed), Carson, elev. 11,000 ft., Baker 306 (USN), July 2, 1901. *Monterey* or *La Plata Co.*, Bob Creek, West La Plata Mts., elev. 10,000 ft., Baker, Earle, and Tracy 175 (USN, cited by Rydberg), June 28, 1898.

COLORADO (eastern): *Chaffee Co.*, Buena Vista, Eastwood 7071 (USN), June 18, 1918. *Conejos Co.*, Los Pinos, elev. 7000 ft., Baker 271 (USN, cited by Rydberg), May, 1899. *El Paso Co.*, Zanger Farm, Black Squirrell Creek, Christ 1955 (CRB), May 5, 1936; Pikes Peak Region, just east of Manitou, Johnston 2765 (CRB), June, 1920; Minnehaha, Pikes Peak, Johnston 2713 (CRB), June 2, 1920; Cog Road, Pikes Peak, Christ 168 (CRB), June 6, 1935. *Grand Co.*, Grand Lake, E. C. Smith (CRB), June 6, 1934. *Lake Co.*, Leadville, Eastwood 7143, 7144, 7154 (USN), June 19, 1819. *Larimer Co.*, Estes Park, elev. 7500 ft., E. C. Smith 446, 451 (CRB), June 11, 1934. *San Juan Co.*, Silverton, alt. 10,000 ft., Tweedy 268, 269 (USN, 268 doubtfully cited by Rydberg), July, 1895. *Teller Co.*, Divide, Christ 205, 206 (CRB), June 9, 1935; North Branch of Catamount Creek, elev. 9400 ft., E. R. Warren 9 (CRB), Sept. 2, 1926.

WYOMING: *Albany Co.*, Shrubs 3–8 ft. high, along stream, Nash's Fork, A; Nelson 7781, 7782 (CRB), July 28, 1900. Centennial, in bogs, Nelson 8823 (CRB), Aug. 7, 1902.

ZOOLOGY.—*Studies on trichinosis. X. The incidence of light infestations of dead trichinae in man.*[1] LEON JACOBS, National Institute of Health. (Communicated by W. H. WRIGHT.)

In a survey of the incidence of trichinae in man in the United States, begun at the National Institute of Health by Hall and Collins

[1] Received July 11, 1938.

(1937),[2] continued by Nolan & Bozicevich (1938),[3] and at present being carried on by the writer, two methods are used for the detection of trichina larvae in diaphragm muscle obtained at necropsy. These methods, which have been described in detail by the above-mentioned writers, are briefly, as follows:

The microscopic examination, in which one gram of muscle from around the tendinous portion of the diaphragm is pressed between two heavy glass plates in a metal press, and examined under the low power of the dissecting microscope (1.7× objective and 12.5× ocular). If live or dead trichinae are present in numbers large enough to be found by an examination of one gram, they will be revealed by this technique.

The digestion-Baermann technique, in which the major portion of the diaphragm is ground up and digested in artificial gastric juice. The residue, after sedimentation, is poured onto the screen of a Baermann funnel, and fluid from the bottom of the funnel is later drawn off and examined for trichinae. Live larvae, if present even in very small numbers, are detected by this method. Occasionally, also, calcified cysts will pass accidentally through the screen and will be found in the fluid at the bottom; the number so found, however, is not an indication of the intensity of infestation.

The two techniques supplement each other. The microscopic examination reveals live and dead cases when the infestation is of the order of at least one per gram, while the digestion-Baermann technique detects live larvae in any number. One-third of the positives are found by the microscopic examination alone, one-third by the digestion-Baermann technique alone, and one-third by both techniques. Only light infestations of dead trichinae of the order of less than one per gram can be consistently missed by both techniques. It was the purpose of the investigation recorded here to determine whether or not there exist in man infestations with dead trichinae of the order of less than one larva per gram, and if so, to what extent.

Material for this investigation was obtained from the diaphragms used in the routine studies. When large diaphragm samples were received, the major part, as usual, was digested, and one gram from around the tendinous portion was saved for the microscopic examination. An additional ten grams from regions around the tendinous portion were saved for the purpose of this second survey, and if the routine examinations showed the sample to be negative, these ten grams were examined for the presence of dead trichinae.

No attempt was made to sample the material systematically. The

[2] Hall, Maurice C. and Collins, Benjamin J. *Studies on trichinosis. I. The incidence of trichinosis as indicated by post-mortem examinations of 300 diaphragms.* Public Health Reports **52**(16): 468–490. 1937.

[3] Nolan, M. O. and Bozicevich, John. *Studies on trichinosis. V. The incidence of trichinosis as indicated by post-mortem examinations of 1000 diaphragms.* Public Health Reports **53**(17): 652–673. 1938.

sampling was left purely to chance, and depended upon the size of the diaphragm samples received and the amount of time available for work on the study. The first ten-gram sample came from diaphragm No. 1382, and the last from diaphragm No. 1874. Thus there was a random sampling of almost 500 diaphragms. Sometimes ten-gram samples from ten or more consecutive diaphragms were examined, with the double purpose of completing the survey as promptly as possible, and of ascertaining whether any positives were being missed when long series of negatives were found by the routine examinations. In this connection, it is interesting to note that only one case was found which was not detected, but should have been detected, by the routine digestion-Baermann technique. This case represented an infestation with only one live larva per 10 grams of material. Since that time, the digestion-Baermann technique has been changed slightly. Instead of sedimentation glasses into which the fluid from the Baermann funnel was drawn, and from the bottom of which, after an hour's standing, fluid was pipetted into Syracuse dishes, small funnels from the bottom of which the sediment can be drawn, have been introduced. The use of these funnels may lessen the possibility of missing a few live trichinae.

Of 100 diaphragms previously found negative in the routine examinations, the microscopic examination of an additional ten-gram sample revealed six cases positive for trichinae. One of these cases represented a live infestation, in which one uncalcified cyst containing a live larva was found in ten grams of muscle. Each of two other positives showed one uncalcified cyst containing a degenerated larva, and each of the remaining three cases showed one partially calcified cyst containing a degenerated or dead larva. In no case was an infestation of more than one cyst found in any of the ten-gram samples. Table 1 gives detailed results of the positive findings.

TABLE 1.—FINDINGS FOR POSITIVE CASES

Diaphragm	Larvae per 10 grams	Condition of Cyst	Condition of Larva
Number	Number		
1385	one	one pole calcified	degenerated
1437	one	uncalcified	alive
1590	one	partially calcified	degenerated
1617	one	uncalcified	degenerated
1694	one	uncalcified	degenerated
1709	one	polar calcification	dead

It appears significant to the writer that in none of the 100 examinations were positives revealed that had a greater probability than one chance out of ten of being discovered in the routine examination of a one-gram sample. Theoretically, of course, there is a possibility of missing in the microscopic examination of a one-gram sample cases in which as many as nine cysts are present in ten grams. The writer intends to make another survey of 100 ten-gram samples from diaphragms revealing one cyst per gram in the routine microscopic examination, with the intent of determining the distribution of cysts in the muscle around the tendinous portion of the diaphragm. It is known that the larvae are more concentrated around the tendinous part of the diaphragm than elsewhere, but it seems possible, from the data presented above, that the larvae are more or less evenly distributed around the tendons.

In the regular trichinosis survey being conducted at the National Institute of Health, it has been found that approximately 17 per cent of the total number of diaphragms examined contained trichinae. According to the data presented here, probably 5 or 6 per cent of the remaining diaphragms had infestations that were missed in the routine examinations. This adds approximately four or five per cent to the total incidence figure.

ZOOLOGY.—*Notes on the "culture" of aquatic nematodes.*[1] B. G. Chitwood and M. B. Chitwood, Bureau of Plant Industry.

Most aquatic nematodes seem to require considerable aeration and it is not customary to keep such forms alive in the laboratory. To the writer's knowledge, no one has succeeded in keeping marine nematodes reproducing in the laboratory. Eventually, when their feeding habits are sufficiently understood, it seems possible that we may be able to culture aquatic nemas in test tubes. The first steps in this direction are reported in the following experiments wherein such forms have been raised in balanced aquaria.

Aquarium A.—A one quart aquarium bowl, maximum depth 3 inches, was half filled with stream water, to which a little sand, algae and a minute aquatic flowering plant were added. Culture begun October 1937. Water was added to compensate for evaporation. On April 26, 1938, male and egg-laying females of *Tylenchus filiformis* v. *abulbosus* n. var. were secured from the sediment. Gastrotrichs, rotifers and planarians also abounded in this culture. Water, pH 8.3.

Aquarium B.—A rectangular tank 28 by 12 by 10 inches was filled to a depth of 4 inches with sievings from stream, some algae and a small flowering plant (*Lemna* sp.). Kept covered to three-quarters of its length with a

[1] Received July 29, 1938.

glass plate. Culture begun October 1937. Examined at intervals and fresh tap water added to maintain water-level. *Monhystera similis* with eggs and various developmental stages (at bottom). This species apparently reproduces without males. Another species, *Anaplectus granulosus,* found on the side of aquarium, together with green slime. Other organisms found include turbellaria, gastrotrichs, hydra, a dragon fly nymph (had become almost fully grown during winter). Water, pH 7.8.

Aquarium C.—Similar to B, but equipped with small aerator, an air pump delivering stream of bubbles every few minutes. Original material from another stream (not as in A & B), flowering plant absent; diatoms, copepods and bivalves present. Culture begun October 1937. Examined at intervals and tap water added occasionally. *Monhystera vulgaris* found reproducing in moderate numbers (no males); *Prismatolaimus intermedius* also seen. This aquarium has been neutral to alkaline as evidenced by the appearance of numerous snails during the winter. Water, pH 7.2 to 7.55.

Aquarium D.—Similar to B, but equipped with aerator and without glass top. Ocean sand, sea water and small marine life obtained from beach sand were placed in this aquarium in November 1937. Red and brown algae and sea lettuce were also put in; much of the latter had to be removed to obtain a proper balance. The water level was maintained by adding fresh water (1 pint) daily during winter months. Though a great diversity of species was originally placed in this aquarium, most of them were eliminated. The sea lettuce, red and brown algae, two small crabs, numerous protozoa, copepods and three species of nematodes survived. The latter seem to be doing well, males, egg-laying females and larvae being found. The species are *Metaparoncholaimus heterocytous* n. sp., *Oncholaimium oxyuris* v. *domesticus* n. var., and *Chromadora quadrilinea.* All three forms are apparently phytophagous and oxygen-loving. Algae grew on the aerator, sand became embedded therein and this spot is a veritable nest of oncholaims. Other specimens were found in the bottom sand and on the red alga, but not nearly in the abundance seen on the aerator. It is particularly interesting to note that we have, nematologically speaking, a culture of oncholaims and chromadorids despite the addition, from time to time of varied samples of other nematodes. Water, pH 8.2; total salt 3.35 per cent.

Tylenchus filiformis v. **abulbobus** n. var. Fig. 1A–B

Description.—Stylet devoid of any indication of knobs, prorhabdions, as seen in molting specimen, extremely short; excretory system on right side. Sublateral alae close together; striae exceedingly fine.

Male 630μ long; α, 38; β, 6.5; γ, 5.5. Spicules arcuate, distinctly subdivisible into capitulum calomus and lamina; gubernaculum present.

Female 609 to 709μ long; α, 24 to 27; β, 4.9 to 6.3; γ, 6 to 6.3; vulva 62 to 65%.

Habitat.—Debris at bottom of aquarium; original source, stream.

Locality.—Babylon, N. Y.

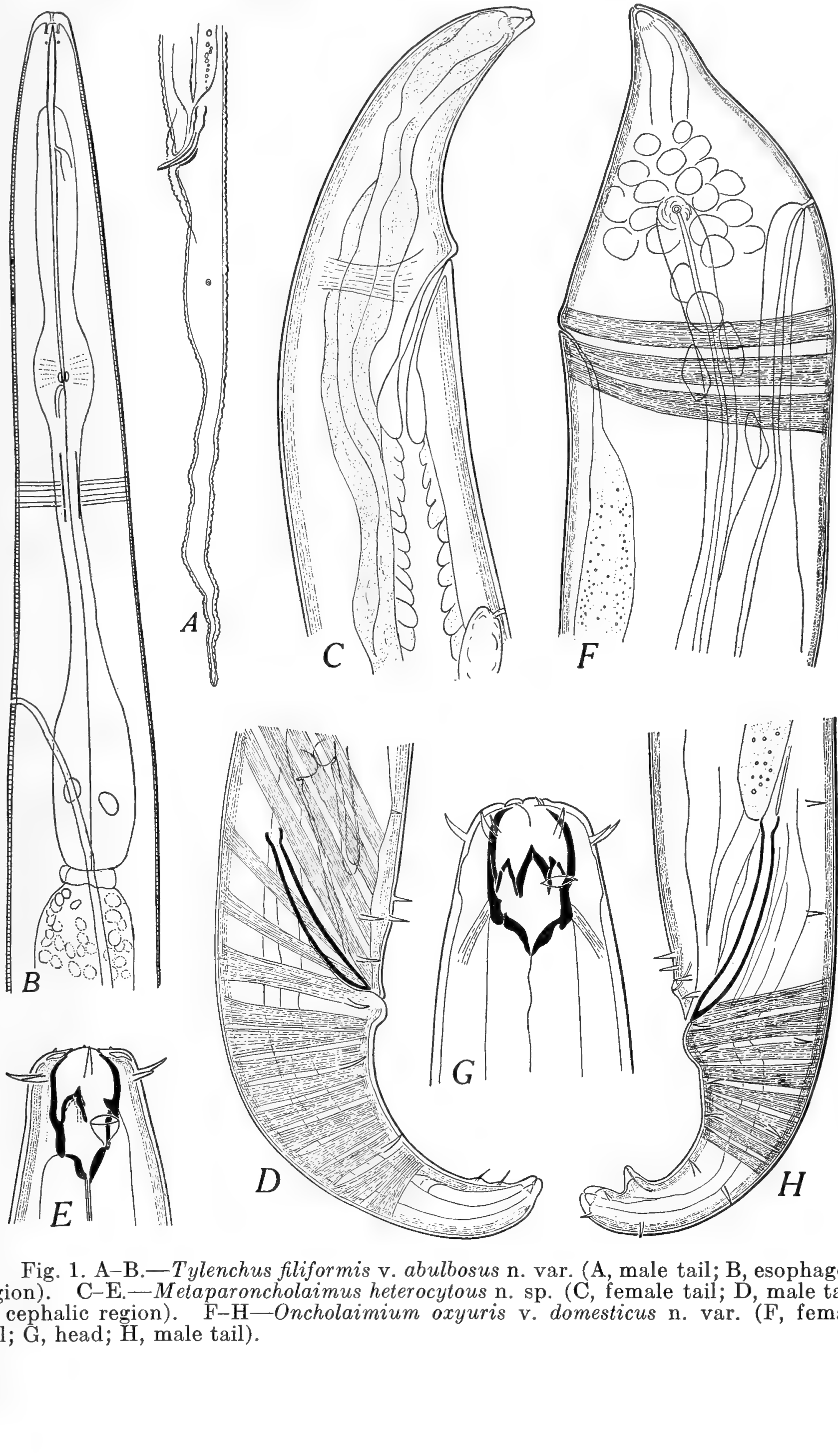


Fig. 1. A–B.—*Tylenchus filiformis* v. *abulbosus* n. var. (A, male tail; B, esophageal region). C–E.—*Metaparoncholaimus heterocytous* n. sp. (C, female tail; D, male tail; E. cephalic region). F–H—*Oncholaimium oxyuris* v. *domesticus* n. var. (F, female tail; G, head; H, male tail).

The species *T. filiformis* (Bütschli, 1873) is described as having weak knobs at the base of the stylet. The present variety is absolutely devoid of such knobs even when the gut is removed from the body. According to recent keys this variety would be transferred to the monotypic genus *Psilenchus* de Man, 1921. However, this hardly seems warranted, nor do we consider the genus *Psilenchus* as valid.

Metaparoncholaimus heterocytous n. sp. Fig. 1C–E

Description.—Subventral teeth subequal, dorsal tooth small. Excretory pore 4 stomatal lengths from anterior end; excretory cell 2.2 esophageal lengths from anterior end.

Male 3.7 to 4.3 mm long; α, 90 to 107, β, 8.6 to 10; γ, 38 to 50. Spicules 1 to $1\frac{1}{2}$ anal body diameters in length, sometimes without apparent cephalation, sometimes cephalated. Without apparent preanal or postanal supplements.

Female 3.7 to 4.9 mm long; α, 65 to 100; β, 9 to 9.5; γ, 55 to 73; vulva 71 to 75%; uterus $\frac{1}{4}$ to $\frac{1}{6}$ length of body, containing up to 6 eggs; tail 1.8 anal body diameters in length. Demanian system opening 2 anal body diameters anterior to anus.

Habitat.—Marine aquarium, among algae in vicinity of aerator; original source, beach.

Locality.—Babylon, N. Y.

Miscellaneous notes.—The intestine contains olivaceous sphaeroids and numerous heterocytes.

The present species differs from *M. campylocercoides* (de Coninck & Stekhoven, 1933) in the absence of a preanal appendage and it differs from *M. campylocercus* (de Man, 1878) in that the tail is cylindrical for $\frac{1}{2}$ its length (compare Fig. 1C), and the vulva is more anterior (at 57 to 60 per cent in *M. campylocercus*).

Oncholaimium oxyuris (Ditl., 1911) v. **domesticus,** n. var. Fig. 1F–H

Description.—Similar to *O. oxyuris* but differing as follows: In *O. oxyuris* the tail is abruptly narrow and cylindroid in its distal half while the female is figured with a row of short eggs in the uterus; in the present form the tail is narrow only in the distal third and the female seems habitually to carry 2 eggs that are 1.5 body diameters long.

Male 4.3 mm long; α, 82; β, 9.3; γ, 50.

Female 3.5 to 4.2 mm; α, 53 to 85; β, 7.0 to 8.5; γ, 53 to 67; vulva 62 to 65%. Excretory pore 3 to 4 stomatal lengths from anterior end; excretory cell $1\frac{2}{3}$ esophageal lengths from anterior end. The demanian system apparently has 2 pairs of exits posterior to the anus.

Habitat.—Marine aquarium, among algae and on aerator; original source, beach.

Locality.—Babylon, N. Y.

Miscellaneous notes.—The intestine of this form contains neutral fats and olivaceous sphaeroids. The latter turn blue in nile blue sulphate, blue in potassium ferricyanide. After alcohol the latter cannot be stained, but numerous small sphaeroids in the chords stain selectively. Birefringents are apparently confined to intestinal contents. The intestinal circumference includes 25 to 40 cells, the cells being rhomboidal to longitudinally diamond-form. Heterocytes are few; they contain small colorless sphaeroids and deep orange sphaeroids, the latter being similar in color to the intestinal contents. The faeces of this species contain some living bacteria and rich orange pigment which is quickly diffused in the water. The dead colorless bodies of many flagellates were seen in the faeces while similar, pigmented flagellates lived free in the aquarium. The demanian exit ducts may become colored by this pigment.

Chromadora quadrilinea Filipjev, 1918 Fig, 2A–B

Description.—Alae absent, cuticle punctate with 4 to 6 lateral rows of enlarged punctations. Amphids transversely elongated; 4 long cephalic setae. Stoma with 3 well developed, medially directed teeth. Esophagus terminated by a simple bulb. Intestine 4 to 6 or 8 cells in circumference.

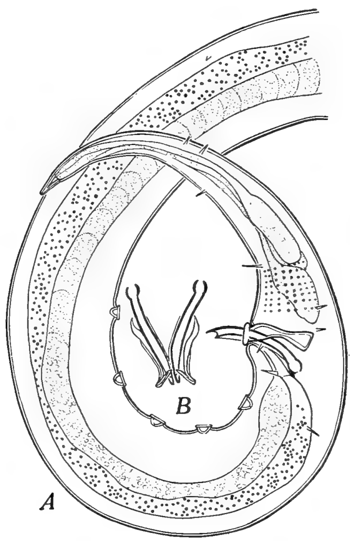


Fig. 2.—*Chromadora quadrilinea* Filipjev, 1918 (A, male tail; B, spicules and gubernaculum).

Male 816 to 840μ long; α, 28 to 35; β, 5.7 to 7.5; γ, 8.8 to 9. Spicules arcuate, indistinctly divisible into capitulum, calomus and lamina; lamina with delicate ala and distally forked. Gubernaculum with weak corpus and well developed crura with square ends. Supplementary organs 5 in number. Filipjev's (1918) original illustration shows no split in the spicule tip but this might be easily overlooked due to the complicated gubernaculum. He also characterized the species as having 6 supplementary organs but Micoletzky (1924) found specimens from the Mediterranean with 5 supplements.

Female 730 to 840μ; α, 22 to 25; β, 6.3; γ, 7.4 to 8; vulva, 47 to 52%.

Habitat.—Marine aquarium, in sea lettuce (*Ulva*) and on aerator.

Locality.—Babylon, N. Y.

Miscellaneous notes.—The intestine contains bright orange sphaeroids soluble in alcohol, birefringent, with negative ninhydrin reaction. Apparently they represent absorbed chlorophyl. The large cell posterior to the excretory cell is apparently a coelomocyte which functions as an athrocyte extracting neutral red or methylene blue from solution; 4 or 5 heterocytes in the posterior third of the intestine behave similarly.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

501ST MEETING

The 501st meeting was held at the University of Maryland, College Park, Maryland, on Thursday, May 12, 1938, President DRAKE presiding. The meeting was preceded by an informal dinner in the University Dining Hall. After the reading of the minutes the Secretary gave a brief report on the Dallas meeting of the American Chemical Society. Of especial interest to the Society was the adoption by the council of resolutions submitted by the Chemical Society of Washington, and dealing with the indiscriminate sale to the public of possibly dangerous drugs, such as the recently notorious "elixir of sulfanilamide," which caused upwards of seventy deaths. The resolutions as adopted read as follows: "*Resolved*, that the American Chemical Society, the representative body of American chemists, urges the Congress of the United States to set up reasonable and adequate safeguards for the public in all cases of new drugs, substances and mixtures thereof, for use in the diagnosis, cure, mitigation, treatment or prevention of disease in man or other animals."

After the conclusion of the business session, the Society divided into three sections for the reading of papers.

Section of inorganic chemistry, C. E. WHITE presiding.

JOHN KEENAN TAYLOR and EDGAR REYNOLDS SMITH: *Reproducibility of the silver-silver chloride electrode.*—A study was made of the reproducibility of the electrolytic, thermal-electrolytic, and thermal types of the silver-silver chloride electrode in 0.05 N solution of potassium chloride. The presence or absence of light, and of air dissolved in the solution, have no significant effect on their potentials. A marked aging effect was noted, the origin of which was traced to concentration-polarization occurring during the preparation of the electrodes. The attainment of concentration equilibrium between freshly-prepared electrodes and solution is slow and may require from 1 to 20 days, depending on porosity of the electrodes and stirring of the solution. For the same reason, freshly-prepared electrodes behave as cathodes towards aged electrodes, the initial difference in potential often exceeding a millivolt. When sufficient time is allowed for the establishment of concentration equilibrium, these types of silver-silver chloride electrodes assume the same potential, within about 0.02 mv. The significant effect of concentration-polarization and the requirement of sufficient aging time to attain concentration equilibrium within the porous silver chloride, offer a possible explanation for the conflicting data in the literature on this electrode. (*Authors' Abstract.*)

A. L. PITMAN: *Electrochemical production of sodium chlorate.*—This paper has been published in Chem. and Met. Eng. **44**, 302 (1937).

F. C. Kracek, G. W. Morey, H. E. Merwin: *The system: water-boron oxide.*—The equilibrium diagram for the system of water and boron oxide has been established by measuring the solubility over the whole range of compositions. The crystalline phases which occur in the system are: ice, H_3BO_3, three modifications of HBO_2, which are monotropically related to each other, and crystalline B_2O_3. Solubility relations have been determined for each of these phases.

The solubility curve for ice extends only from the melting point of ice to the cryohydric point at $-0.76°C$. The curve for H_3BO_3 rises smoothly from this point to a maximum at the melting point (metastable) of H_3BO_3, 170.9°C, and then descends, to end at the metastable eutectic for HBO_2**III** and H_3BO_3. The three forms of HBO_2 melt congruently; HBO_2**I**, the stable modification, at 236°C, and HBO_2**II** and HBO_2**III**, both metastable, at 200.9°C and 176.0°C, respectively. Their solubility curves have flat maxima at the composition HBO_2. The curve for the stable form, HBO_2**I**, intersects the curve for H_3BO_3 at 169°C, at which point H_3BO_3 decomposes to form HBO_2**I** and a solution of the equilibrium composition. The reaction is abnormally sluggish, so that the metastable continuation of the solubility curve of H_3BO_3 is realized as if HBO_2**I** did not exist. The curves of HBO_2**II** and HBO_2**III** intersect that of H_3BO_3 at metastable eutectics located at 169.6°C and 158.5°C respectively. Crystalline B_2O_3 melts at $450° \pm 2°C$. It has been crystallized from solutions in sealed tubes, as well as in open vessels at atmospheric pressure, and various factors influencing its spontaneous growth have been established. The solubility curve extends from the melting point to the intersection with the curve of HBO_2**I** at 235°C, and with that of HBO_2**II** at 200°C. Both of these points are eutectics, the second being metastable. From the slope of the solubility curve the latent heat of fusion of B_2O_3 is calculated to be 97 cal/g.

P-T-X relations for the saturated solutions have been evaluated by combining the solubility data with deductions based on existing vapor pressure measurements. The resulting diagram brings out among other things the interesting fact that, contrary to prevalent suppositions, B_2O_3 can coexist in the crystalline form with solutions at a considerable vapor pressure of water vapor, this being nearly 3 atmospheres in the neighborhood of 280°C. The oxide crystallizes relatively rapidly in sealed tubes at this temperature. On the other hand, it crystallizes exceedingly slowly from nearly anhydrous melts of vitreous B_2O_3, and never spontaneously, in this region of composition. The spontaneous crystallization is initiated in the more highly aqueous solutions by the presence of HBO_2**I**, but not by the presence of the other modifications of metaboric acid.

The crystallographic and optical properties of the new crystal phases were measured, and are described in detail in the complete text. (*Authors' Abstract.*)

Section of physical chemistry, M. M. Haring presiding:

F. G. Brickwedde: *The vapor pressure differences of isotopic modifications of methane.*—Working with Mr. R. B. Scott, of the Cryogenic Laboratory of the National Bureau of Standards, measurements were made of the differences between the vapor pressures of CH_4, two samples of CD_4 prepared in different laboratories, and single samples of CD_3H, CD_2H_2 and CDH_3. The non-methane impurities of the methane samples were removed by fractional distillation and their isotopic compositions were determined in one laboratory using a mass spectrometer and checked in another laboratory using a different mass spectrometer. Using the analyses and the vapor pressure data, the vapor pressures of the pure isotopic varieties were calculated.

At the boiling point of methane (−152°C) the vapor pressure of a heavy methane is greater than that of a lighter isotopic variety. The sign of the vapor pressure difference for the liquid methanes is opposite to that for H_2, HD and D_2 for which the heavier variety has the lower vapor pressure. However, the sign of the vapor pressure differences of the methanes changes at lower temperatures so that at temperatures below −200°C the vapor pressure of a heavy solid methane is lower than that of a lighter variety.

The normal behavior has been considered to be that which gives rise to a lower vapor pressure for the heavier variety as in the case of H_2, HD and D_2, and the solid methanes below −200°C. Heavy acetic acid (CH_3COOD) and deuterium fluoride have higher vapor pressures than their corresponding light varieties, the greater vapor pressure of the heavier variety being attributed to molecular association in the vapor state. This explanation is not applicable to the methanes. It is proposed that the greater vapor pressure of a heavier isotopic variety arises from a decrease, upon condensation of a vapor, in the frequency of some internal motion of a molecule or of an associated molecule. Such frequency changes upon condensation have been observed experimentally in the Raman and infra-red absorption spectra of vapor and condensed phases.

A general law is proposed for vapor pressure differences of isotopic molecules: "Vapor pressure differences of isotopic varieties arise because of quantum effects, and disappear for conditions under which classical and quantum theories give equivalent results. Vapor pressure differences are connected with a change in the frequency of some intermolecular or intramolecular motion in the process of vaporization. A decrease in some frequency (e.g., frequency of intermolecular vibrations of a lattice) acts in the direction to make the vapor pressure of the heavier variety less than that of the lighter, whereas an increase in some frequency (e.g., the frequencies of intramolecular vibrations of methane, or acetic acid and hydrogen fluoride dimmers) acts in the direction to make the vapor pressure of the heavier variety greater." (*Author's Abstract.*)

John Beek, Jr.: *The calculation of entropy from measurements of heat capacity.*—The usual method of obtaining the entropy of a substance as a function of the temperature is to evaluate the integral

$$S_2 - S_1 = \int_{T_1}^{T_2} \frac{C}{T} dT. \tag{1}$$

The principal source of error in this method is in the calculation of the heat capacity from differences between measured values of the temperature. This source of error may be eliminated from the calculation by considering the measurements as giving the heat content, rather than the heat capacity, as a function of the temperature. The entropy is then calculated according to either of the following equations, which are equivalent as regards precision.

$$S_2 - S_1 = \int_{T=T_1}^{T=T_2} \frac{1}{T} d(H - H_0) \tag{2}$$

$$S_2 - S_1 = \frac{H_2 - H_0}{T_2} - \frac{H_1 - H_0}{T_1} + \int_{T_1}^{T_2} \frac{H - H_0}{T^2} dT. \tag{3}$$

If an adiabatic calorimeter is used in making the measurements, the heat content is given directly as a function of the temperature. If a non-adiabatic calorimeter is used, the change in the heat content of the sample corresponding to the drift of the temperature between successive measurements may be calculated from an interpolated value of the heat capacity.

A series of measurements made by Bekkedahl and Wood, J. Research Natl. Bur. Standards **19**: 551. 1937, during their investigation of the thermodynamic properties of isoprene is used to illustrate the improvement in precision obtained by the method of this paper. It is found that the uncertainty in the value of ΔS for the interval from 200° to 300°K is in this case of the order of ten times as great when the heat capacity is used as it is when the heat content is used for the calculation. (*Author's Abstract.*)

Paul S. Roller: *Size distribution and statistical size constants of subdivided materials.*—Typical analyses (percentage by weight at different sizes) are given for various materials, including ball clay, kaolin, talc, hydrated lime, soil, litharge, cement, flint, pulverized coal and run-of-mine coal. To assess the size character of these materials statistically, it is necessary to have a distribution function. Such a function is provided by the equation: $y = ax^{1/2}e^{-b/x}$, where y is percentage by weight of all sizes less than x, and a and b are parameters. Significant statistical size constants are, surface area per gram, number of particles per gram, coefficient of uniformity, and efficiency ratio (efficiency of mechanical reduction of the coarsest sizes). All of these are simple functions of the distribution parameters a and b. For example, surface area is proportional to $(a/b)^{1/2}$, and coefficient of uniformity to $ab^{1/2}$, the proportionality constant including a factor, usually close to unity, which takes into account the finite upper limit of size.

For the materials cited above, surface area ranges from 200,000 to 400,000 sq.cm/gm for ball clay, through 20,000 to 75,000 for kaolin, 12,000 for talc, 4000 to 6000 for hydrated lime, 4000 for certain soils, 2000 for cement and 12 for run-of-mine coal. The coefficient of uniformity at about 0.1 is lowest for the run-of-mine coal and for talc, indicating a tendency to produce an excess of fines. On the other hand, the coefficient at about 1.15 is unusually high for litharge (sublimed) and for hydrated lime (chemical crystallization). It will be noted that these materials are produced by crystal growth rather than by mechanical reduction; the relatively small production of fine sizes is thereby understandable.

For coarse material, such as run-of-mine coal, crushed ores, etc., a double distribution occurs, each distribution however satisfying the same law given above. The origin of the double distribution is believed to be the presence of points of weakness (edges, corners and crystal defects) which give rise on shear to a secondary aggregation of fine sizes. As the material becomes finer, the parameters of the two distributions become more nearly alike until the distributions appear to merge into the one distribution that is characteristic of finely divided material. (*Author's Abstract.*)

Section of organic chemistry, N. L. Drake presiding:

C. S. Hudson: *The structure of sedoheptulosan (anhydro-sedoheptose).*—This paper has been published in J. Am. Chem. Soc. **60**: 1241. 1938.

S. Palkin, E. E. Fleck and T. C. Chadwick: *Cyclic mono- and di-terpene derivatives of pine oleoresin.*—Two distinct types of pine oleoresin (from same species of trees, P-palustris and P-caribaea), one from old stumps, the other from the living tree, were described and differences in composition pointed out. The turpentine portion of stump resin oil was shown to consist mainly of dicyclic monoterpene—α-pinene; several monocyclic hydrocarbons; small amounts of secondary and tertiary alcohols, oxides, phenols, phenol ethers and other compounds: that from the resin of the living tree consisted essentially of the two dicylic terpene isomers, α- and β-pinene.

The diterpenes, a complex series of isomeric resin acids, were discussed as to properties and methods of isolating individual isomers. Derivation of structure and distribution of the two double bonds in the three isomers, α- and β-pimaric acids and 1-abietic acid, was briefly reviewed. The highly stable so-called "pyroabietic" acids (formerly considered isomers) were discussed as to method of preparation and experiments leading to resolution of the complexes by fractional crystallization of ammonium salts and methyl esters into dehydro-, dihydro- and tetrahydro-abietic acids. Isolation of dehydro- and hydrogenated acids, together with gasimetric data obtained from closed system experiments, showed the reaction involved in conversion of abietic acid to "pyroabietic" acid was essentially one of dehydrogenation and disproportionation. (*Authors' Abstract.*)

B. A. Brice, E. E. Fleck and S. Palkin: *Ultra-violet absorption spectra as an aid in studying isomeric resin acids.*—Preliminary results in an investigation of the ultra-violet absorption spectra of pine resin acids were presented. Levo-abietic acid showed four poorly resolved absorption maxima with principal maximum at 242 mu. Oxidation was shown to decrease the intensity of absorption in this region. Levo-pimaric acid showed three poorly resolved maxima, with peak absorption at 271.5 mu. Dextro-pimaric acid gave similar but weak absorption in this same region, and it was concluded that the sample examined contained a small proportion of l-pimaric acid. Samples of α-pyroabietic acid, its methyl ester, and dehydroabietic acid showed three maxima, the long wave-length maximum at 276 mu being particularly well-resolved. Additional maxima at 251 and 242 mu for the latter sample were interpreted as being due to about 1% of levo-abietic acid as an impurity. It was concluded that the principal constituent of α-pyroabietic acid and dehydroabietic acid are at least similar in structure. Weak absorption maxima obtained for a sample of tetrahydroabietic acid were attributed to the presence of a small amount of dehydroabietic acid. Samples of dihydro-l-pimaric and dihydro-d-pimaric acids showed no trace of absorption maxima for less saturated acids. (*Authors' Abstract.*)

Frank C. Kracek, *Secretary.*

CONTENTS

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JOURNAL
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Vol. 28 November 15, 1938 No. 11

CHEMISTRY.—*A critical survey of the literature dealing with the chemical constituents of* Cannabis sativa.[1] A. H. Blatt, Howard University, in cooperation with the U. S. Treasury Department.

Investigations of the chemical constituents of *Cannabis sativa*, which is the source of marihuana, hashish, and allied narcotics,[2] have been appearing for over eighty years but no surveys of this work, other than those found in the introductory portions of the individual publications, are available. Recent years have seen an increased incidence in the use of marihuana in the United States, and so serious has the problem become that the 75th Congress passed a Federal Marihuana Act in 1937. A direct result of the passage of this Act is a many-sided study of cannabis problems, under the general supervision of the Bureau of Narcotics, and of the office of the Consulting Chemist, U. S. Treasury Department. To facilitate the study of the chemical phases of the problem, and for the use of others interested in the chemistry of cannabis, the present survey has been prepared.

The chemical literature dealing with cannabis is rather extensive but it is filled with contradictions, and the articles which contain significant results are relatively few in number. Consequently, the principal problem in reviewing this literature is one of elimination. In the preparation of this survey, therefore, an effort has been made to examine all relevant publications but no attempt has been made to offer a complete summary and bibliography. Instead, there will be presented only those facts which can be considered as definitely established, together with the much larger amount of information which, though only probably correct, is significant to future workers. In keeping with this point of view the presentation is not strictly historical.

Two chemical individuals, neither one responsible for the characteristic physiological activity of the plant, have been isolated from cannabis. In addition, three other products, none isolated as a pure chemical substance, have been obtained, and the physiological ac-

[1] Received October 1, 1938.
[2] Definitions of cannabis and the more important preparations made from it are given at the end of this article.

tivity has been shown to reside in the third of these. The two chemical individuals are *n*-nonacosane and cannabinol; the three other products are a terpene, a sesquiterpene and crude cannabinol. We shall describe the isolation and chemical study of these substances and products, but it is first imperative to distinguish clearly between cannabinol and crude cannabinol.

The basis for this distinction is the following. Vacuum distillation of extracts made from cannabis yields a high boiling fraction generally referred to as cannabinol or as the "red oil." Most of the chemists studying cannabis obtained this red oil and most of the chemical work on cannabis has been done with this material. Wood, Spivey and Easterfield,[3] however, in 1899 obtained from the red oil a crystalline acetate in a yield of about twenty-five per cent. This preparation was successfully repeated for the first time thirty-two years later by Cahn.[4] Since then a crystalline p-nitrobenzoate has been reported but not described.[5] The isolation, in about a twenty-five per cent yield, of a crystalline ester makes it clear that the red oil is a mixture; it will therefore be referred to henceforth, following Cahn,[4] as *crude cannabinol*, and the term cannabinol without qualification will be reserved for the chemical individual obtained by hydrolysis of the pure, crystalline acetate. Parenthetically, it may be remarked that one major reason for the slow progress made in the attempts to isolate and determine the structure of the active principle of cannabis has been that chemists have worked with an impure material, crude cannabinol, and have assumed that this mixture was a pure compound.

In order to secure from cannabis the two chemical individuals and the three other products mentioned before, either the plant itself, usually the flowering tops, or the resinous exudate, can be used as the raw material. The exudate is, naturally, much richer in active material. Ether, petroleum ether, or alcohol can be used successfully as the solvent for extraction. Alcohol dissolves less of the paraffin hydrocarbon, *n*-nonacosane, present but extracts more chlorophyll than does petroleum ether. The extracts are concentrated and the residue may then be distilled directly or subjected first to a chemical separation using carbonate and caustic. Although fairly elaborate claims

[3] WOOD, SPIVEY and EASTERFIELD, J. Chem. Soc., **75**: 20. 1899. A year earlier DUNSTON and HENRY, J. Chem. Soc., Proc. **1898**, p. 44, reported the isolation of a crystalline cannabinol acetate but they gave no experimental details.

[4] CAHN, J. Chem. Soc., **1931**: 630.

[5] BERGEL, TODD and WORK, Chem. and Ind., **1938**: 86.

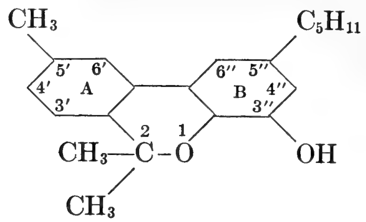
have been made for the chemical separation by some workers,[6,7] others have gotten equally satisfactory results without it and report it to be more troublesome than useful.[4] Bergel[8] reported the isolation from the alkaline extract of an oily acid, which on reduction yielded stearic acid, and a solid acid, which was probably palmitic acid.

From the material left after removal of the extracting solvent Wood, Spivey and Easterfield[9] obtained two principal fractions, a lower boiling one distilled at atmospheric pressure, and a higher boiling one distilled at reduced pressure. Redistillation of the former furnished a terpene and the residue from this distillation yielded, on steam distillation, a sesquiterpene. The residue from the steam distillation was added to the higher boiling principal fraction. This mixture deposited the paraffin hydrocarbon, *n*-nonacosane, and the filtrate, after removal of the hydrocarbon, was redistilled in vacuum and furnished crude cannabinol, the red oil. Other workers have not troubled to isolate the terpene and sesquiterpene and have removed the paraffin hydrocarbon, whenever it appeared, by taking advantage of its sparing solubility in alcohol. The yields of these various products are not particularly significant since different workers started usually with different preparations made from cannabis and none of these preparations is of constant composition; the principal product was, however, always crude cannabinol.

The hydrocarbon, *n*-nonacosane, $C_{29}H_{60}$, was recognized very early as a paraffin[10] but its correct empirical formula was not established until much later.[9] It has recently been definitely identified as *n*-nonacosane although there are indications that it is contaminated with small amounts of some other material.[4] *n*-Nonacosane melts at 63–64° and is physiologically inactive.

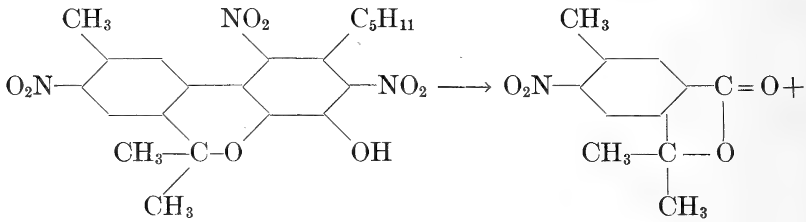
Cannabinol, the second pure chemical individual obtained from cannabis, has the empirical formula $C_{21}H_{26}O_2$. It is a liquid which boils at 263–264°/20 mm.[4] The structure of cannabinol has been fairly definitely established as 3″-hydroxy-2,2,5′-trimethyl-5″-n-amyldibenzopyran (I) although the location of the substituents in ring B is not certain. This structure is a result of the excellent investigations of Cahn, which are in turn based upon the earlier work of Wood, Spivey and Easterfield and are supported by some synthetical experiments of Bergel and Vögele.

[6] Hofmann-LaRoche and Co., Ger. Pat., 285,829 (1913).
[7] Casparis, Pharm. Acta Helv. **1**: 210. 1926.
[8] Bergel, Ann. **482**: 55. 1930.
[9] Wood, Spivey and Easterfield, J. Chem. Soc. **69**: 539. 1896.
[10] Personne, J. Pharm. **31**: 47. 1857.



I

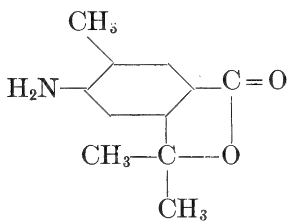
Cannabinol is isolated from crude cannabinol as the crystalline acetate which is then hydrolyzed.[3,4] Cannabinol, and also crude cannabinol, can be nitrated to furnish trinitrocannabinol (II—the positions occupied by the groups in ring B are not definitely known) and the nitric acid oxidation of trinitrocannabinol furnishes *n*-butyric, valeric and caproic acids together with nitrocannabinolactone (III)—also called oxycannabin. Nitrocannabinolactone (III) can be reduced to the aminolactone (IV) and this can be converted, by replace-



II III

$$CH_3(CH_2)_nCO_2H, \text{ where } n=2, 3, 4.$$

ment of the amino group by iodine and subsequent reduction, to cannabinolactone (V). Cannabinolactone (V) on alkali fusion yields *m*-toluic acid (VI) and on oxidation with permanganate followed by an alkali fusion furnishes isophthalic acid (VIII) *via* the intermediate



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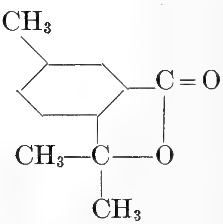
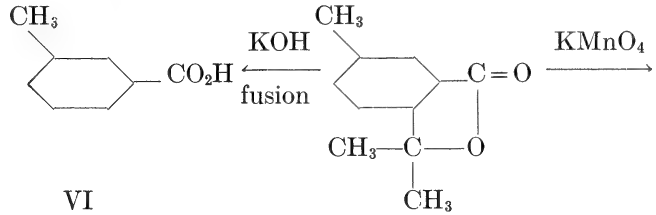


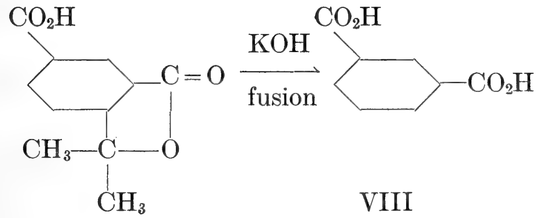
V

cannabinolactonic acid (VII). These reactions were first carried out



VI

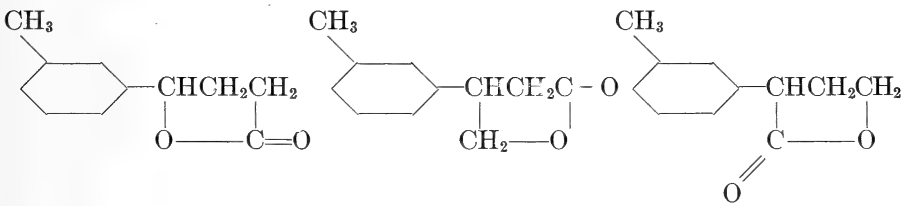
V



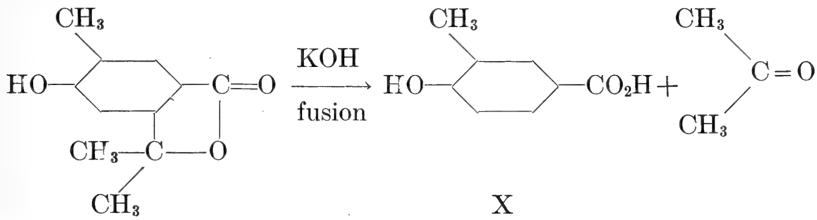
VIII

VII

by Wood, Spivey and Easterfield[3] but they formulated cannabinolactone not as the phthalide derivative (V) but as one of the following γ-lactones.



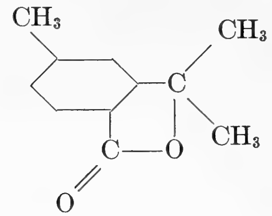
Cahn[11] prepared hydroxycannabinolactone (IX) by diazotization and replacement of the amino group in (IV) by an hydroxyl group. Alkali fusion of this material furnished 6-hydroxy-*m*-toluic acid (X) and acetone, which led to the suggestion of the phthalide structure for this series of compounds. At one time Cahn adopted, then abandoned, the alternative phthalide formula (XI).



X

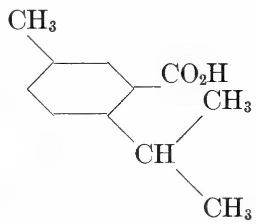
IX

[11] Cahn, J. Chem. Soc., **1930,** 986.

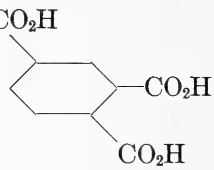


XI

Wood, Spivey and Easterfield had shown that cannabinolactone could be oxidized to the acid (VII). Cahn established the identity of this acid with a synthetic sample of 4-carboxydimethylphthalide. At about the same time Bergel and Vögele[12] synthesized cannabinolactone (V) and the acid (VII) from 6-isopropyl-*m*-toluic acid (XII). Finally, Cahn showed that the acid (VII) could be oxidized to trimellitic acid (XIII).



XII

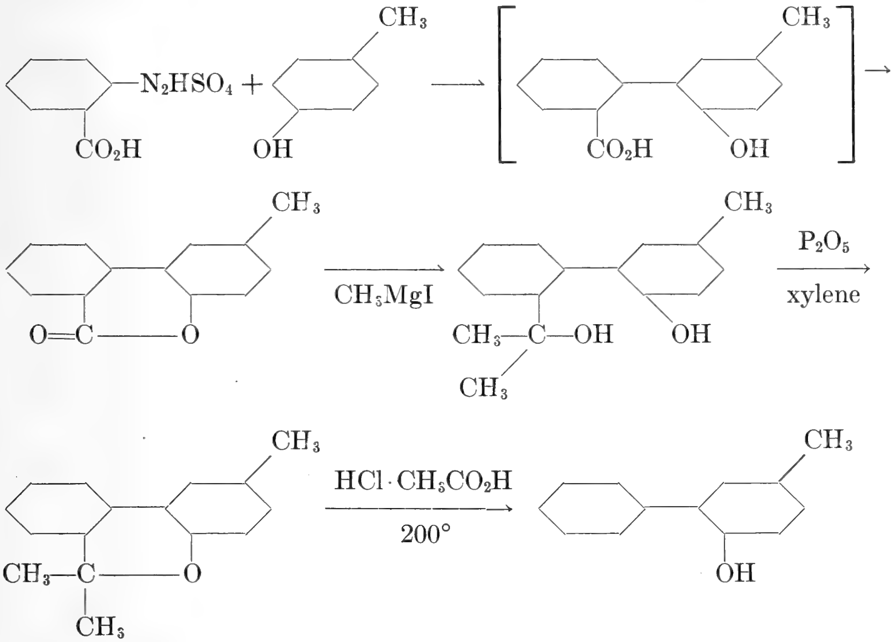


XIII

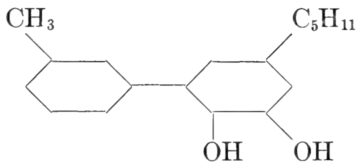
The evidence for the structure of cannabinolactone (V) is conclusive and this material accounts for eleven of the twenty-one carbon atoms present in cannabinol. Cannabinol also contains an hydroxyl group, shown by the formation of an acetate. This hydroxyl group is, in all likelihood, phenolic, for in acetone with methyl iodide or sulfate and potassium carbonate, cannabinol furnishes a methyl ether. The second oxygen atom in cannabinol is not present as a carbonyl group, for the material does not react with carbonyl reagents; neither is this oxygen atom part of a simple alkoxyl group, for with hydriodic acid cannabinol furnishes no volatile alkyl iodide. Cannabinol also should contain a straight chain of six carbon atoms at least five of which are saturated, for it furnishes caproic acid on oxidation. These facts are accounted for by the structure (I) suggested by Cahn.[13] And, although the positions of the hydroxyl and amyl groups in ring B have not been definitely established, Cahn has advanced additional evidence for the dibenzopyran formula.

[12] Bergel and Vögele, Ann. **493**: 250. 1932.
[13] Cahn, J. Chem. Soc., **1932**, 1342.

2,2,5″-Trimethyldibenzopyran (XIV) was synthesized from anthranilic acid diazonium sulfate and p-cresol.[14] The pyran (XIV), like cannabinol, is unusually stable but it can be cleaved by concen-



XIV XV



XVI

trated hydrochloric acid and acetic acid at 200° to what is probably (XV). Cannabinol on similar treatment furnishes an analogous product, believed to be (XVI), which with alkali gives a purple color similar to that obtained from cannabis in the Beam test (see below). Unfortunately, (XVI) was obtained in such small amounts that a detailed study in order to establish its structure and locate the amyl and hydroxyl groups could not be made. In general, however, the behavior of the pairs, cannabinol (I) and the pyran (XIV), and the phenols (XV) and (XVI) are sufficiently similar to lend confidence to the structures proposed and to suggest both the timeliness and the desirability not only of further synthetical experiments but, particu-

[14] CAHN, J. Chem. Soc., **1933**, 1400.

larly, of a detailed study of (XVI) which is the only degradation product of cannabinol in which the two phenyl groups are intact. Cannabinol, it may be mentioned in concluding this discussion, though not responsible for the characteristic physiological properties of cannabis,[14] is toxic,[5] and it may not be an unreasonable prediction that the active principle of cannabis will be found to be structurally related to cannabinol.

Two of the three products obtained from cannabis and not isolated as pure chemical substances can be dealt with briefly. These are the terpene and the sesquiterpene. The information concerning them is meagre. The terpene has been described as an oil boiling over the range 160–180°, having the composition $C_{10}H_{16}$ and molecular weight 65, which resinifies on exposure to air and furnishes an oily monohydrochloride.[9] The sesquiterpene is also a liquid, which boils at 258–259°, has the composition $C_{15}H_{24}$ and molecular weight 101.[9]

Neither the terpene nor the sesquiterpene just described is responsible for the characteristic effects of cannabis. That activity resides in crude cannabinol.[7,8,15] It has already been pointed out that crude cannabinol is a mixture from which the only chemical individual so far isolated is cannabinol. It has also been pointed out that the great bulk of the chemical work on cannabis has been done using crude cannabinol and assuming that this material was a pure substance. Consequently, the many observations made on crude cannabinol are of value only to the extent that they may furnish clues as to the nature of the substance or substances other than pure cannabinol present in crude cannabinol. In the discussion of the chemistry of crude cannabinol which follows, those observations made on this material which are obviously accounted for by the presence of pure cannabinol are omitted.

Crude cannabinol is described as a yellow to red oil which is semisolid below 60° and can be distilled under reduced pressure. Boiling points recorded for the material are as follows:

Temperature °C.	Pressure in mm	Observer and Reference
315	100	Wood, Spivey and Easterfield[9]
300	46	Wood, Spivey and Easterfield[9]
265	20	Wood, Spivey and Easterfield[9]
210–240	0.5	Fränkel[15]
180–185	0.5	Bergel[8]
183–185	0.05	Casparis[7]
156	0.05	Bergel[8]
160–161	0.005	Casparis[7]

[15] Fränkel, Arch, exp. Path. Pharmakol. **49**: 226. 1903.

The composition of crude cannabinol has been given as $C_{18}H_{24}O_2$,[9] $C_{21}H_{30}O_2$,[15] and $C_{20}H_{30}O_2$.[7,8] Molecular weights in agreement with these empirical formulas have been found: 275,[9] 337,[15] and 306,298.[7,8] The refraction, density, optical activity and adsorption spectrum for the mixture have been recorded.[7,8] More useful at the present time than these exact data are certain qualitative observations made by Casparis:[7] crude cannabinol gives no color in alcoholic solution with ferric chloride; it dissolves in acetic acid without the development of color; it dissolves in alcoholic potassium hydroxide to furnish a violet solution whose color changes to yellow upon acidification; it gives a red precipitate in the cold when Millon's reagent is added to its alcoholic solution; it reduces ammoniacal silver nitrate slowly in the cold and rapidly on heating; it does not reduce Fehling's solution. Casparis also tried certain sterol tests with crude cannabinol: when a chloroform solution of crude cannabinol was shaken with concentrated sulfuric acid, a blood red color developed in the acid layer; with acetic anhydride and sulfuric acid a yellow color resulted; with trichloroacetic acid a strawberry red color was obtained; the Liebermann-Burchard and digitonin tests were negative. A direct comparison of the behavior of pure and crude cannabinol toward these various reagents is not available.

Chemical reactions, as opposed to the chemical tests just described, have been tried in large number with crude cannabinol. Casparis and Baur[16] acetylated crude cannabinol and from the hydrolysis of the liquid acetylation product concluded that more than one and less than two acetyl groups per mole had been introduced. Bergel[8] likewise acetylated crude cannabinol but his liquid acetylation product had approximately the composition of a monoacetate of $C_{20}H_{30}O_2$ and showed one acetyl group on hydrolysis. Zerewitinoff determinations by Casparis and Baur and by Bergel indicated the presence of one hydroxyl group in crude cannabinol. Bergel obtained a liquid benzoylation product but Casparis and Baur obtained only tarry products with benzoyl chloride and phthalic anhydride. The latter workers found no reaction with such hydroxyl group reagents as phenyl- or naphthylisocyanate.

Bromination of crude cannabinol gave only intractable products as did the addition of hydrogen chloride.[16] Bromine titration in alcoholic solution indicated the addition of two atoms of bromine and the replacement of two hydrogen atoms by bromine—six atoms of bro-

[16] Casparis and Baur, Pharm. Acta Helv. 2: 107. 1927.

mine were consumed and two moles of hydrogen bromide were formed.[16] Comparable data were obtained by Bergel.[8]

Catalytic reduction of crude cannabinol using a platinum catalyst resulted in the addition of one mole of hydrogen—based on the empirical formula $C_{20}H_{30}O_2$.[8,16] Using a nickel catalyst, reduction was incomplete on the same formula basis.[16] Crude dihydrocannabinol gave the same qualitative tests as crude cannabinol. No crystalline derivatives were obtained from the dihydro product which showed one hydroxyl group in a Zerewitinoff determination[16] and yielded a liquid acetylation product. This acetylation product, which Bergel also obtained by catalytic reduction of crude cannabinol acetate, showed one acetyl group on hydrolysis and gave a negative Millon test.[8] Crude dihydrocannabinol showed two double bonds on bromine titration according to Casparis and Baur while, according to Bergel, only replacement of two hydrogen atoms by bromine took place. Casparis and Baur were unable to reduce crude cannabinol beyond the dihydro stage but Bergel, using platinum oxide and hydrogen at 70–80° and a pressure of 80 atmospheres, obtained a perhydro product whose composition, $C_{20}H_{38}O$, corresponded to the removal of an oxygen atom from, and addition of eight hydrogen atoms to crude cannabinol.

Zinc dust distillation of crude cannabinol and dehydrogenation with sulfur furnished Casparis and Baur with no definite products.

Numerous workers have reported that crude cannabinol undergoes oxidation on exposure to the air and that this oxidation is accompanied by the loss of physiological activity but there is no agreement among different observers either as to the extent or the rate of this loss of activity.[17] Detailed studies of the oxidation of crude cannabinol and dihydrocannabinol have been made by Casparis and Baur and by Bergel. Ammoniacal silver nitrate, chromic acid, permanganate and ozone were used as oxidants but only the latter two furnished definite products. Casparis and Baur reported the formation, without satisfactory identification, of caproic and heptoic acids by permanganate oxidation of crude cannabinol in water-free neutral acetone. Bergel, however, was able to isolate and identify only caproic acid; this acid is known to be formed by the permanganate oxidation of pure cannabinol so that its appearance is without significance. Permanganate oxidation of crude dihydrocannabinol furnished Casparis and Baur, in addition to the acids obtained from crude cannabinol, caprylic acid but Bergel again was able to isolate and identify only caproic acid although he did obtain an unknown acid $C_{10}H_{18}O_2$. Using

[17] MARSHALL, Pharm. J. **1909**, p. 418.

ozone, Casparis and Baur reported from crude cannabinol the formation of oxalic, butyric, caproic and isoamylacetic acids, and from crude dihydrocannabinol the formation of oxalic acid, butyric acid and an oenanthic acid. Of these they believe the isoamylacetic acid to be the only one fully identified. However, no direct comparison was made between this acid or its anilide and synthetic material.

The chemistry of crude cannabinol has been described in detail because the active principle or principles of cannabis are present in this material and because, after the removal of pure cannabinol from the crude, the activity is found in the residue.[5] Consequently the point of attack in the isolation and study of the active principle of cannabis must be crude cannabinol from which pure cannabinol has been removed. And since the traditional methods of isolation have been given a more than fair trial by chemists in the past eighty years, primary reliance will have to be placed on newer methods such as adsorption, molecular distillation and the use of solvents at low temperatures. A promising start in the first of these directions has very recently been announced by Bergel, Todd and Work.[5] In future work some guidance can be had from observations already available about crude cannabinol. Thus from the data on bromine and hydrogen addition it is clear that the unknown material in crude cannabinol is in part at least unsaturated; however, a more specific interpretation of these results cannot be made until information about the behavior of pure cannabinol toward the same reagents is at hand. Further, the unknown material in crude cannabinol is at least in part hydroxylic as is shown by Zerewitinoff analyses. Finally, reduction of crude cannabinol and acetylation of the crude dihydro product do not destroy the characteristic physiological activity of the material.

Before the last topic, tests for cannabis, is discussed one striking enigma presented by crude cannabinol should be mentioned. Frequent reference has been made to the fact that experienced chemists for over thirty years have considered crude cannabinol to be a pure substance. Crude cannabinol behaves like a pure substance. The customary high vacuum distillation technique fails to separate it into its constituents. It not only furnishes on analysis values for carbon and hydrogen which are consistent with the composition $C_{20}H_{30}O_2$, but acetylation and reduction yield products whose composition corresponds closely to the expected derivatives of $C_{20}H_{30}O_2$. By the professional chemist the explanation for this remarkable behavior will be eagerly awaited.

Two tests, one old and one new, have been used for the detection of cannabis in forensic work. The old test due to Beam[18] depends upon the colors produced when alcoholic potash or alcoholic hydrogen chloride acts upon extracts made from cannabis using various solvents. Many modifications of the technique have been made and the reliability of the test has often been questioned. The new test is due to Duquenois and Hassan Negm Moustapha.[19] It depends upon the color given by the residues of cannabis extracts with an alcoholic solution of vanillin and acetaldehyde. Probably because of its newness, this last test has not yet been subject to criticism. A detailed discussion of the techniques, merits and drawbacks of these tests is unnecessary in this place. To the point, is the obvious fact that a forensic test may be based upon either a physiologically inactive or a physiologically active constituent; equally obvious, the latter is preferable. Consequently, now that it is possible to secure a fraction which contains the physiologically active material from cannabis it would seem well worth while to search for specific tests given only by this active fraction.

DEFINITIONS

All definitions have been obtained from the Bureau of Narcotics, U. S. Treasury Department.

There is only one species of hemp, *Cannabis sativa* L., though this has been subdivided into several agronomic types and varieties.

Charas. Raw resin extracted from the tops of the female plant of *Cannabis sativa* L.

Chira. Chira is the name given to charas in the Balkans and North Africa.

Hashish. This term, which is often used as a general term for Indian hemp, is in reality the name given to various preparations of resin or resinous leaves in Egypt, Persia and Turkey.

Esrar. Esrar, which means "secret," is the name given in Turkey to the principal electuary of hemp, obtained with pure water or alcoholized water as the medium.

Madjun. The Arab madjun is a preparation obtained by soaking the inflorescences of the cannabis with butter and water and mixing the fat product which results with nuts, ground almonds, sugar or honey.

Ganja. The ganja of India is composed of flowering or fruiting tops of the cultivated female plants.

Takruri and Kif. The takruri of Tunis or kif of Morocco is made of tops of the female hemp plant, dried and minced small for smoking.

Bhang. Indian bhang is obtained by drying hemp leaves roughly powdered.

Djamba. Djamba is the name given to the hemp cultivated in Central Africa. It is also the name given to the variety of Indian hemp which grows in Brazil.

Marihuana. Marihuana is the name given to the leaves and flowering tops of cannabis. The term is extensively used in the Western Hemisphere and has been defined in The Marihuana Tax Act of 1937 as follows:

"The term 'marihuana' means all parts of the plant *Cannabis sativa* L., whether

[18] C. A. **6**: 1952. 1912. The formation of a purple color on treatment of crude cannabinol with alcoholic alkali was observed earlier by Fränkel.

[19] Duquenois and Hassan Negm Moustapha, J. Egypt. Med. Assoc. **21**: 224. 1938.

growing or not; the seeds thereof; the resin extracted from any part of such plant; and every compound, manufacture, salt, derivative, mixture, or preparation of such plant, its seeds, or resin; but shall not include the mature stalks of such plant, fiber produced from the stalks, oil or cake made from the seeds of such plant, any other compound, manufacture, salt, derivative, mixture, or preparation of such mature stalks (except the resin extracted therefrom), fiber, oil, or cake, or the sterilized seed of such plant which is incapable of germination."

CHEMISTRY.—*Note on cyanogenesis in* Liriodendron tulipifera *L.*

JAMES F. COUCH and REINHOLD R. BRIESE, Bureau of Animal Industry.

Greshoff,[1] by means of a color reaction, detected small quantities of acid in the leaves of tulip tree (*Liriodendron tulipifera* L.) and the Chinese species *L. chinense*, Sarg. He gives no information concerning the quantity of HCN and although the American species is a very common tree no one seems to have checked the observation or determined the HCN quantitatively.

In connection with studies on cyanogenesis in plants that are in progress in this laboratory it was of interest to obtain more exact data on this point. Collections of samples of the leaves were made in 1937 and 1938 from a mature tree 20 to 25 years of age. Other samples were collected from two year old saplings and from seedlings 2 to 7 inches in height. All samples were allowed to macerate in 1% mercuric chloride solution[2] for 4 weeks before analysis to ensure completion of cyanogenesis and no loss of HCN. The results of the analysis are presented in table 1.

TABLE 1.—HYDROCYANIC ACID OBTAINED FROM SEEDLINGS AND LEAVES OF LIRIODENDRON TULIPIFERA

Material used and date collected	Moisture	Hydrocyanic acid in 100 g fresh plant	Hydrocyanic acid in 100 g calcd. to dry matter
	percent	mg	mg
Seedlings, Sept. 20, 1937	75.22	8.7	35.1
Leaves, 2-year-old trees, Sept. 13	54.99	10.2	23.3
Leaves, mature tree, Sept. 13	66.51	2.5	7.1
Leaves, mature tree, May 30, 1938	75.01	14.9	62.1

These data indicate that the quantities of potential HCN in this tree vary with age and season in a manner similar to that observed with other cyanogenetic plants like sorghum, Sudan grass and the wild cherries. The first three samples were collected at about the same date and the younger plants contained the larger quantity of potential HCN. The largest quantity was furnished by leaves collected in the spring from the mature tree and amounted to nearly nine times

[1] GRESHOFF, M., *Phytochemical Investigations at Kew.* Bul. Misc. Inf. Kew, **10**: 412. 1909.

[2] BRIESE, R. R. and COUCH, J. F., J. Agric. Res. **57**: 81–107. 1938.

the quantity present in leaves from the same tree collected during the preceding September. The quantities of HCN obtained from these samples are, however, well below the toxic limit of 20 mg provisionally established as the minimum concentration of HCN in sorghum that will cause poisoning in animals. There is little danger of poisoning of livestock by leaves of the tulip tree.

The distillates from the analytical samples were tested for benzaldehyde and acetone and none was found. No clue was obtained as to the nature of the cyanogenetic compound present in the leaves.

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

Of the eleven new species of Asteraceae described in this paper, four were collected by Mrs. Ynes Mexia in Ecuador, in the course of her work for the Division of Plant Exploration and Introduction, Bureau of Plant Industry, United States Department of Agriculture, and four in Chiapas by E. Matuda. The others are from Costa Rica, Texas, and Mexico, collected by A. F. Skutch, B. H. Warnock, and Mrs. Ruth Q. Abbott respectively. A few minor forms and new combinations are included.

Vernonia polypleura Blake, sp. nov.

Frutex (?); caulis et inflorescentia densissime rufescenti-pilosula; folia oblonga majuscula utroque acuminata obscure calloso-serrulata chartacea supra lucidula in pagina subdense pilosula pilis mox deciduis basibus minutis exceptis in costa pilosa subtus dense griseo-pilosa pilis patentibus penninervia nervis ca. 13–15-jugis subtus prominentibus; cymae racemiformes axillares et terminales subpedales subrectae v. parum curvatae saepius basi semel furcatae hinc illinc bracteatae; capitula sessilia subremota 21-flora mediocria; involucri ca. 7-seriati valde gradati 6 mm alti subcampanulati appressi phyllaria exteriora anguste triangularia ad lanceolata acuminata media oblongo-lanceolata acuta interiora anguste oblonga mucronulata infra apicem paullum contracta, omnia subcoriacea pallide brunnea prope apicem laxe pilosa; achenia erecto-pilosa; pappi pallide brunneo-albidi squamellae persistentes lineari-lanceolatae acutae ca. 0.5 mm longae 0.15 mm latae, setae facile deciduae 4 mm longae ad apicem paullulum clavellatae.

Probably shrubby; stem herbaceous above, solid, with pale brown pith, bluntly sulcate-angled, 5 mm thick, very densely and softly pilosulous with straight spreading brownish hairs; leaves alternate; internodes 1–1.5 cm long; petioles slender, naked, densely pubescent like the stem, 1.5–2.8 cm long; blades oblong or elliptic-oblong, 15–18 cm long, 3.8–5 cm wide, acuminate and somewhat falcate, at base acuminate, plane, above brownish green, somewhat shiny, at first rather densely pilose, the hairs quickly deciduous leaving small light-colored bases, along the costa persistently pilose,

[1] Received July 23, 1938.

not glandular, beneath on surface densely and softly griseous-pilose and sessile-glandular, on the costa densely spreading-pilosulous, on the veins densely pilose with mostly antrorse hairs, penninerved, the chief veins subparallel, prominulous above, prominent beneath, the secondaries prominulous-reticulate; cymes solitary in the upper axils and terminal, 15–32 cm long (including peduncle, this 3–7 cm long), the heads mostly 1–1.5 cm apart, frequently in part subtended by reduced leaves (0.8–6 cm long); heads in fruit (as pressed) 7 mm high, 8–11 mm thick; receptacle shallowly alveolate; corollas (not normally developed?) erect-puberulous on teeth, 4.8 mm long (tube 2.3 mm, throat 0.5 mm, teeth triangular, 2 mm long); achenes oblong, 10-ribbed, brownish, 1.8 mm long, rather densely erect-pilose chiefly between the ribs, eglandular; pappus double, the squamellae numerous, the bristles about 50.

MEXICO: Mt. Orando, Chiapas, 23 Dec. 1936, *E. Matuda* 730 (type no. 1,686,105, U. S. Nat. Herb.; dupl., herb. Univ. Mich.).

Despite its occasionally but never uniformly bracteate cymes, this species is evidently a member of the *Scorpioideae aphyllae*, related to *Vernonia brachiata* Benth. and *V. scorpioides* (Lam.) Pers. In *V. brachiata* the leaves are larger, obovate, sessile or subsessile, sharply serrate or serrulate, and, like the stem, only sparsely pubescent. In *V. scorpioides* the leaves are smaller, shorter-petioled, mostly broader in proportion to their length, variable in pubescence but never with that of *V. polypleura*, and with much less numerous and less conspicuous veins; the cymes are much shorter; the involucre is shorter and much more densely and evenly pubescent, and the inner phyllaries are acuminate.

Eupatoriastrum opadoclinium Blake, sp. nov.

Frutescens?; caulis (v. ramus) infra inflorescentiam simplex densissime brunneo-pilosus, internodiis foliis multo brevioribus; folio oblongo-ovata ca. 12 cm longa 4 cm lata decussate opposita obtuse acuminata basi leviter cordata brevissime petiolata crenata subcoriaceo-chartacea penninervia utrinque prominulo-reticulata supra brunneo-pilosula subtus dense brunneo-pilosa; capitula subcylindrica ca. 12 mm alta 43–47-flora dense et fastigiate cymoso-paniculata, pedicellis capitulis subaequalibus; involucri ca. 11 mm alti ca. 10-seriati valde gradati phyllaria oblonga v. oblongo-ovalia in linearia transeuntia apice rotundata straminea albida 3-vittata margine crispe ciliolata ceterum glabra dorso rotundato-convexa; receptaculum ubique paleatum, paleis angustissime lineari-spathulatis glabris flores subaequantibus; corollae ut videtur albidae; achenia tenuia in costis hispidula.

Stem (or branch) solid, terete, 5 mm thick, very densely and sordidly subtomentose-pilose with spreading somewhat matted many-celled acuminate brownish hairs about 1 mm long; internodes 2–4 cm long; petioles broad, thick, unmargined, densely pubescent like the stem, 2–4 mm long; leaf blades oblong-ovate, 10–12.5 cm long, 3.2–5.2 cm wide, broadest near the middle, rather shortly acuminate to an obtuse apex, crenate throughout except toward apex with rounded or obtuse teeth or toward base crenate-serrate with obtusely callous-pointed teeth (teeth 12–15 pairs, 0.5–1 mm high, mostly 4–7 mm apart), above brownish green, somewhat shining, brownish-pilosulous chiefly along veins and veinlets (densely so along costa) with many-celled spreading hairs, beneath somewhat yellowish brown, densely pilose with spreading lax many-celled hairs, feather-veined, the chief lateral veins about 5–7 pairs, curved-anastomosing, 2 or 3 pairs near middle of leaf stronger than the others; panicle terminal, rounded, many-headed, dense, 12–15 cm wide, densely pubescent like the stem, the lowest branches subtended by not reduced leaves, the uppermost bracts linear to lanceolate, 5–10 mm long, the pedicels slender, densely pubescent like the stem, 5–10 mm long, often bearing a linear bract; heads (moistened) campanulate-cylindric, 12–13 high, 5 mm thick; phyllaries very numerous, the outermost oblong, about 3 mm long, 1.5 mm wide, pilosulous on back and ciliolate, the middle ones oblong to oval, 3.5–5 mm long, about 2 mm wide, laxly ciliolate but otherwise glabrous, the inner linear or linear-spatulate, about 7.5 mm long, 1–1.3 mm wide, obscurely ciliolate, the inmost narrowly linear-spatulate, similar to the pales of the disk; all the phyllaries except the inmost shallowly boat-shaped, the upper ones in the dried state somewhat lax at tip but not spreading; receptacle flattish, foveolate, 1.5 mm wide; pales of the receptacle very narrowly linear-spatulate, nearly equaling the flowers, stramineous, 1-nerved, 9–9.5 mm long, glabrous except for the obscurely ciliolate, obtuse or rounded, somewhat inflexed apex, this about 0.7 mm wide; corollas apparently whitish, subcylindric, without distinct throat, subsessile-glandular below and on teeth, 6 mm long (tube 2.8 mm, throat 2.8 mm, teeth deltoid-ovate, acute, 0.4 mm long); achenes brownish black, slender, 4.3 mm long, with stipitiform base (0.7 mm long), sparsely hispidulous on the 5 whitish ribs; pappus 1-seriate, persistent, of about 34 whitish, minutely hispidulous, not apically thickened, somewhat unequal bristles, the longest 5 mm, the few shorter ones about 3.5 mm long; anther tips ovate, obtuse or slightly emarginate; style branches linear, not evidently clavate, the finely papillose appendage 2 mm long, slightly longer than the stigmatic lines.

MEXICO: Mt. Orando, Chiapas, *E. Matuda* 702 (type no. 1,685,252, U. S. Nat. Herb.).

In external appearance this is very similar to the section *Cylindrocephala* of *Eupatorium* and utterly distinct from the two species of *Eupatoriastrum* hitherto known (from southern Mexico and El Salvador), which have broadly ovate or deltoid, slender-petioled leaves, broad heads in looser inflorescences, and broad involucres of acute or acuminate phyllaries of different texture and either subequal or much less conspicuously graduate. Careful dissection, however, shows that every flower in the head is subtended by a pale, and it is necessary to refer the species to *Eupatoriastrum* or to suppress the latter genus, a course which seems unjustified. Separation of the species as a new genus based on the differences mentioned would certainly not be advisable in this group. In the texture and convexity of its phyllaries *E. opadoclinium* is very similar to the Brazilian *Eupatorium epaleaceum* (Gardn.) Robinson. *Eupatorium epaleaceum* and *E. horminoides* (DC.) Baker, both Brazilian, constitute the section *Chromolaena* of *Eupatorium*, which makes a definite approach to *Eupatoriastrum* in having the receptacle paleaceous here and there but never, apparently, throughout as in *Eupatoriastrum*.

Mikania melastomacea Blake, sp. nov.

Scandens; caulis firmus medullosus (medulla solida alba) dense sessiliglandulosus ceterum glaber, nodis brunneo-pilosulis exceptis; folia ovalia mediocria brevipetiolata breviter et obtuse acutata basi late rotundata v. rotundato-cuneata integra pergamentacea 5-plinervia supra dense subtus densissime sessili-glandulosa; capitula parva racemosa, racemis laxis paniculatis; involucri 4.5 mm alti phyllaria linearia obtusa ad apicem pilosula; corolla albida, tubo fauce campanulata longiore, dentibus fauce subduplo brevioribus; achenia 2.5 mm longa apice puberula; pappus albidus corollam aequans.

Series *Racemosae;* stem herbaceous above, subterete or obscurely hexagonal, multistriatulate, with solid white or in age brownish pith, 4 mm thick, light brown, apparently rarely branched below the inflorescence; leaves opposite; internodes 3–8 cm long; petioles slender, naked, not appendaged, densely sessile-glandular and rather densely but inconspicuously hirsute-pilose with several-celled mostly appressed hairs, 1–1.5 cm long; blades oval, 6.5–10.5 cm long, 3.5–6 cm wide, rather abruptly and very obtusely short-pointed, above dark green, scarcely or not at all shining, on surface densely dotted with shining brown glands and sparsely and inconspicuously puberulous with several-celled hairs, along the chief veins hirsute-pilose, glabrescent, beneath brownish green, very densely dotted with sessile brownish yellow glands, sparsely and obscurely puberulous on surface and more densely so on veins, 5-pli- or obscurely 7-plinerved within 0.5–1.5 cm of base, the nerves prominulous beneath, flattish above, the chief veinlets rather numerous, somewhat prominulous on both sides, spreading from the costa at nearly a right angle, with the tertiaries loosely and inconspicuously reticulate; racemes rather sparsely puberulous with weak mostly incurved hairs and sparsely sessile-glandular, loosely flowered (internodes mostly 2–4 mm long), mostly 4–8 cm long, compounded into a large convex terminal panicle about 30 cm long and 18–30 cm wide; bracts of inflorescence minute, subulate, 1.5 mm long, the pedicels very slender, 2–3 mm long; heads 4-flowered, slender, 5–6 mm high; involucre ebracteolate, 4.5–4.8 mm long, the phyllaries 4, subscarious, brownish, obscurely ciliolate, sparsely sessile-glandular, toward apex pilosulous, at base corky-thickened and shortly calcarate; corollas "whitish," sparsely subsessile-glandular on tube and teeth, about 3.4 mm long (tube 1.7 mm, throat campanulate, longer than wide, 1.2 mm, teeth deltoid-ovate, acute, 0.5 mm long); achenes olivaceous, 5-ribbed, at apex minutely puberulous and with a few sessile glands, 2.2–2.5 mm long; pappus whitish, 3–3.5 mm long, the bristles about 38–39, minutely hispidulous, clavellate at apex.

Ecuador: Vine climbing small trees, in clearing in forest, near Puyo, Prov. Napo-Pastaza, alt. ca. 400 m., 20 Feb. 1935, *Ynes Mexia* 6947 (type no. 1,692,970, U. S. Nat. Herb.).

A member of the series *Racemosae,* nearest *Mikania houstoniana* (L.) Robinson. In that species the stem is hollow and weak and the leaves are normally ovate, thinner, and longer-petioled, although exhibiting considerable variation.

Mikania eupatorioides Blake, sp. nov.

Frutex scandens; caulis teres multistriatus cavus pilosulus; folia ovata v. lanceolato-ovata petiolata mediocria longe acuminata basi cuneata prope basin 5-plinervia subintegra tenuiter herbacea supra dense in venis et sparse in pagina subglandulari-puberula et sparse pilosula subtus obscure pilosula et glandulis flavulis adspersa; capitula mediocria cymoso-paniculata saepius breviter pedicellata, paniculis specialibus parvis terminalibus et axillaribus incurvo-puberulis cunctis paniculam thyrsoideam foliosam efformantibus; bracteola ovata v. oblongo-ovata acuta herbacea apice puberula 2.6–3 mm longa; involucri 6 mm alti phyllaria oblonga acutiuscula basi suberosa prope apicem sparse puberula; corollae anguste infundibuliformes, dentibus erectis fauce triplo brevioribus.

Series *Thyrsigerae;* "woody vine, with white flowers"; stem 5 mm thick, brownish, glabrescent; branches slender, essentially straight, greenish or brownish, rather densely pilosulous with several-celled spreading or upcurved hairs and somewhat dotted with sessile glands; internodes of branches 3–5 cm long; leaves opposite; petioles slender, naked, 1–1.8 cm long, pilosulous or puberulous chiefly above, connected at base by a narrow pilosulous line but not appendaged; blades 11.5–15 cm long, 3–6 cm wide, long-acuminate with somewhat falcate tip, sharply cuneate or the larger rounded-cuneate at base, entire or very obscurely denticulate with small remote teeth, thin, not thickened on the obscurely ciliolate margin, green on both sides, quintuplinerved within 1–2 cm of base, above densely subglandular-puberulous on the chief veins and sparsely so on surface, also sparsely pilosulous on surface, beneath sparsely and obscurely pilosulous or puberulous on veins and surface with several-celled hairs and dotted with sessile yellowish glands, the primary nerves and their chief lateral veins prominulous beneath, the veinlets translucent; individual panicles convex, pubescent like the stem, small, 3–5 cm wide, the lower and middle ones surpassed by the subtending leaves, the whole forming an open leafy thyrsoid panicle (7) 15–24 cm long and 8–15 cm wide; ultimate bracts of inflorescence lanceolate, 3–10 mm long, mostly shorter than the peduncles; pedicels slender, 2 mm long or less, often bearing a small bract; heads 4-flowered, 7–9 mm high; involucre 5.5–6 mm high, the phyllaries 4, narrowly oblong, acutish, thin, greenish with narrow pale thinner margin, weakly about 5-nerved, puberulous toward tip, glabrous below, corky-thickened at base but not calcarate; corollas more or less gland-dotted, sparsely puberulous below or subglabrous, about 4.5 mm long (tube 1–1.2 mm, throat narrowly funnelform, 2.5 mm, teeth 5, broadly ovate, acutish, 0.8 mm long, erect or somewhat inflexed below the apex); achenes slender, 5-angled, toward apex puberulous and with a few sessile glands, 3 mm long; pappus flesh-colored, 4.2 mm long, of 47–50 minutely hispidulous bristles, very obscurely thickened toward apex.

COSTA RICA: Edge of forest, vicinity of El General, Prov. San José, alt. 1525 m., Dec. 1936, *A. F. Skutch* 3041 (type no. 1,643,504, U. S. Nat. Herb.); same data, alt. 1070 m., *Skutch* 3017.

The gross appearance of this plant, with its straight branches, is very suggestive of *Eupatorium*. Its only close allies in Central America are *Mikania hylibates* Robinson, *M. nubigena* Robinson, and *M. pittieri* Robinson, the types or type collections of which are all in the United States National Herbarium. In *M. hylibates* the leaves are thin-coriaceous and 3–5-nerved from the very base, with thickened, nerviform, glabrous margin, and the stem is glabrous. In *M. nubigena* the stem and petioles are completely glabrous, the leaves are coriaceous and conspicuously thickened but not ciliolate on margin, the (young) inflorescence is much looser and more open, and the heads are sessile. In *M. pittieri* the stem, petioles, and leaves are glabrous, the leaves are coriaceous and with a perceptibly thicker and paler margin, the heads are sessile, and the proper tube of the corolla is nearly as long as the campanulate limb.

Mikania iodotricha Blake, sp. nov.

Scandens; caulis dense longe villosus pilis purpureis vel interdum brunneis; folia deltoideo-ovata acuta basi cordata v. subtruncata grosse crenato-serrata v. majora dupliciter crenato-serrata bene petiolata crassiuscula supra viridia bullata hirsuta pilis basi incrassatis subtus purpureo-villosa lacunoso-reticulata e basi 3–5-nervia; capitula majuscula 10–12 mm alta numerosa pedicellata cymoso-paniculata, paniculis majusculis rotundatis; involucri 10 mm alti phyllaria lineari-oblonga acuta medio suberosa margine submembranacea purpurascentia purpureo-pilosa; corolla 7 mm longa purpurea, tubo faucem campanulatam aequante, dentibus fauce triplo brevioribus; achaenia glabra.

Series *Corymbosae;* "vine, climbing 2 m"; stem herbaceous above, subterete, striatulate, hollow, 3.5 mm thick, opposite-branched, densely spreading-villous with many-celled purple hairs (or sometimes light brown) becoming brown and 3–4 mm long in age, pilosulous between them, in age glabrescent, light-brown-barked, and roughened with the persistent bases of the longer hairs; leaves opposite; internodes of main stem 4–10 cm long, those of the branches shorter; petioles stout, unmargined, densely purple-villous, those of the larger leaves 8–18 mm long, slightly enlarged at base and connected by a fringe of cilia but not appendaged; blades 2.8–4 cm long, 2.6–3.6 cm wide, merely acute, at base shallowly cordate or truncate-rounded and usually very shortly cuneate-decurrent on the petiole, above evenly but not densely hirsute with spreading brownish hairs with conspicuously thickened yellowish white persistent bases, beneath densely purple-villous especially on the exserted veins and veinlets; leaves of the inflorescence similar but smaller, the uppermost reduced to lanceolate or linear-spatulate bracts 7 mm long or less; panicles terminal and in the upper axils, trichotomously divided, 6–15 cm wide, purple-villous, the pedicels slender, sparsely villous, 2–10 mm long; involucre obconic, 10 mm high, slightly shorter than the flowers, ebracteolate, 4-flowered, the phyllaries 4, linear-oblong, about 2 mm wide, merely acute but often involute-margined above and appearing acuminate, usually purple-tinged especially above, with somewhat corky-thickened body extending about half their length and submembranous greenish margin, obscurely 5-nerved, scarcely calcarate, thinly pilosulous with white hairs and slightly ciliate, the outer purple-pilose especially above the middle, the inner very sparsely so at apex; corollas mulberry-purple, about 7 mm long, glabrous except on teeth (tube 3 mm, throat campanulate, considerably longer than wide, 2.7–3 mm, teeth ovate, erectish, 1–1.2 mm long, puberulous with few-celled blunt hairs); achenes brownish with 5 white ribs, 5.2 mm long, 1.3 mm wide, essentially glabrous or with a very few hairs on the ribs; pappus brownish, purplish-tinged, 6–6.5 mm long, of about 89 subequal minutely hispidulous bristles, not thickened at apex.

ECUADOR: Occasional in open woods, trail from Olivos to Morán, Cantón Tulcán, Prov. Carchí, alt. 3400 m., 12 July 1935, *Ynes Mexia* 7469 (type no. 1,692,986, U. S. Nat. Herb.).

A very distinct species of the series *Corymbosae*, resembling *Mikania aristei* Robinson of the series *Thyrsigerae* in pubescence and foliage. In all features except its 5-ribbed achenes the plant so much more closely resembles such species of the genus *Kanimia* (distinguished by having 7–10-ribbed achenes) as *K. corymbulosa* (Benth.) B. & H. and *K. violascens* Robinson, particularly the latter, as to suggest that the generic distinction is a rather artificial one.

Mikania napensis Blake, sp. nov.

Scandens; caulis et rami subglabri, ramulis inconspicue puberulis; folia ovata majuscula pergamentacea petiolata acuta v. breviter acuminata base late rotundata or cuneato-rotundata in margine leviter revoluto obscure calloso-serrulata 5–9-plinervia supra lucida utrinque inconspicue puberula; capitula mediocria 8–9 mm alta cymoso-paniculata, paniculis rotundatis; involucri 4 mm alti phyllaria oblonga rotundata puberula; corolla ca. 5.3 mm longa "virescenti-lutea," tubo faucem infundibuliformi-campanulatam aequante, dentibus deltoideis fauce subquintuplo brevioribus; achenia sparse puberula; pappus pallide brunneus.

Series *Corymbosae;* stem herbaceous above, subterete, multistriatulate, hollow, olivaceous, 5 mm thick, sparsely and obscurely puberulous with many-celled subappressed hairs, spreading-branched, the branchlets more densely but still inconspicuously puberulous; leaves opposite; internodes mostly 5–12 cm long, shorter or longer than the leaves; petioles rather stout, naked except at apex, not appendaged at base, finely subappressed-puberulous, those of the larger leaves 12–18 mm long; blades ovate to broadly ovate, 8–13.5 cm long, 4–9.5 cm wide, at base very shortly cuneate-decurrent on the petiole, above shining, light green and appearing glabrous but under a strong lens sparsely subappressed-puberulous, beneath dull green, evenly but not densely puberulous with several-celled subappressed hairs, 5–7 (–9)-plinerved within 1–2 cm of the base, loosely prominulous-reticulate beneath, not puncticulate, the veinlets by transmitted light appearing densely dotted by orange glands; panicles terminal and in the upper axils, compounded, 4–5 cm wide, densely but inconspicuously sordid-puberulous with mostly incurved hairs, essentially ebracteate; heads 4-flowered, mostly in ultimate groups of 2–3, sessile or on pedicels 2 mm long or less; bractlet linear-lanceolate, acute, 1–1.5 mm long; phyllaries 4, oblong or obovate-oblong, 1.5–1.8 mm wide, broadly rounded at apex, corky-thickened but not calcarate at base, with thickish greenish about 7-vittate body and thinner paler narrower margin, ciliolate, rather sparsely subappressed-puberulous below, densely so above; corollas "greenish yellow" (appearing yellowish white when dry), sparsely puberulous toward tip, about 5.3 mm long (tube 2.3–2.5 mm, throat funnelform-campanulate, 2.5–2.7 mm, teeth deltoid, 0.3–0.5 mm long); achenes greenish, 5-ribbed, sparsely erectish-puberulous, 3 mm long; pappus brownish, 5–5.3 mm long, of about 58–63 minutely hispidulous bristles, not thickened at apex; style appendages densely hispidulous, the hairs about as long as the breadth of the branches.

Ecuador: Vine, climbing small trees in forest border, frequent near Archidona, Cantón Napo, Prov. Napo-Pastaza, alt. 650 m, 19 Apr. 1935, *Ynes Mexia* 7259 (type no. 1,692,951, U. S. Nat. Herb.).

A species of the series *Corymbosae,* allied to *Mikania seemannii* Robinson and *M. tafalla* Humb. & Bonpl., but distinct from both in its much shorter involucre; related about as closely to several other species of western South America, such as *M. aschersonii, M. lehmannii,* and *M. multinervia,* but distinguished from all of these by features of foliage, involucre, or corolla.

Aplopappus trianthus Blake, sp. nov.

Frutex tenuis cortice albo, ramis erectiusculis tenuibus hornotinis pallide viridibus viscidis paullum striatis sparse scabro-tuberculatis; folia alterna sparsa lineari-filiformia semiteretia supra sulcata subtus rotundata subpollicaria apice saepius breviter recurva et subobtuse calloso-apiculata sparse tuberculata obscurissime punctata; capitula minima 3-flora homogama discoidea sessilia v. brevissime pedicellata in apicibus ramulorum pollicarium per 3–5 coartata; involucri obconici appressi 4 mm alti ca. 5-seriati valde gradati phyllaria pauca (ca. 12–13) linearia obtusa chartacea albida apice viridia et incrassata infra apicem breviter ciliata ceterum glabra; corollae aureae bilabiatae; achenia oblonga 5-nervia dense erecto-pilosa 2 mm longa; pappi straminei subbiseriati 4 mm longi setae ca. 30 subrigidae minute hispidulae; appendices ramorum styli subulato-lineares subacuminate hispidulae partem stigmatiferam subaequantes.

Twiggy shrub, the main stem up to 3 mm thick, subterete, with fissured white glabrous bark, the erectish branches about 30 cm long, whitish below, pale green above; internodes mostly 4–8 mm long; leaves erectish to somewhat spreading, without axillary fascicles, 8–20 mm long, about 0.7 mm wide, rounded and nerveless beneath, flattish and slenderly sulcate above, or the smaller subterete, the upper gradually reduced, the younger obscurely punctate; heads in flower 7–8 mm high, sessile or on pedicels up to 2.5 mm long, crowded in groups of about 3–5 at tips of naked or few-leaved branchlets, the branchlets usually about 5–7, racemosely arranged toward tip of branches, mostly 8–25 mm long, their bracts much shorter than the heads; involucre 4–4.5 mm high, 2 mm thick (when moistened), the phyllaries sometimes in rather definite vertical ranks, somewhat boat-shaped, 0.5–0.7 mm wide, whitish, chartaceous, and 1-nerved below, thinner and subscarious toward margin, with much shorter, thickened, not evidently glandular green tip, short-ciliate below the apex; receptacle small, naked; corollas glabrous or sparsely hispidulous on lower part of throat, 4.8–5.2 mm long (tube about 2–2.2 mm, throat cylindric-funnelform, not sharply delimited from tube, about 1.3–1.7 mm, teeth unequal, one on outside of the flowering head 1.5 mm long, the others united into a 3–4-toothed lamina with essentially equal teeth 0.5–0.7 mm long); pappus 4 mm long, somewhat graduated, rather indefinitely about 2-seriate, the principal bristles slightly but definitely flattened, a few shorter outer ones capillary, half as long as the inner; style branches 2–2.7 mm long, the linear-subulate subacuminate hispidulous appendages (1–1.3 mm long) equaling or very slightly longer than the stigmatic area.

TEXAS: Frequent along road from Study Butte to Terlingua, Chisos Mountains area, Brewster Co., 31 Aug. 1937, *B. H. Warnock* 1126 (type no. 1,728,979, U. S. Nat. Herb.).

The affinities of this species are unquestionably with *Aplopappus sonoriensis* (Gray) Blake of Lower California and islands, Sinaloa, and Sonora, a member of the section *Ericameria*. In habit, foliage, inflorescence, and involucre the two plants are strikingly similar, the most significant difference being that the young branches and foliage of *A. sonoriensis* are profusely glandular-punctate, while *A. trianthus*, although viscid on the younger parts, is only very obscurely impressed-glandular. In *A. sonoriensis* the receptacle normally bears one or few subulate pales, undoubtedly representing that excessive development of the walls of the alveolae which is not infrequent in Astereae, and not to be regarded, as Hall suggested, as "remnants" of walls of the alveolae; the flowers are more numerous (about 4–7); the corolla teeth are normally equal and rather longer; the pappus is more copious and less stiff, all the bristles being essentially capillary; and the style appendages are rather broadly triangular and several times shorter than the stigmatic lines. The tendency of the phyllaries in *A. trianthus* to fall into rather definite vertical ranks, suggesting relationship with the very poorly differentiated genus *Chrysothamnus*, is found to a less extent in *A. sonoriensis* and was commented on by Hall.

The apparently normally bilabiate corollas of *A. trianthus* constitute a rather striking feature, which is probably correlated with the reduced number of flowers in the head. Those flowers in which the larger (inner) lip is made up of only 3 teeth are tetramerous, having only 4 stamens. Flowers with the inner lip 3- or 4-toothed occur in the same head. It is surprising that Hall[2] was unable to detect the presence of ray flowers in *A. sonoriensis*, since they are by no means of rare occurrence. In his original description of *Ericameria diffusa* (a synonym of *A. sonoriensis*) Bentham described the disk flowers as 4–5 and the ligule as solitary, shorter than the disk, subbilabiate, often with two linear lobes at base; Gray in 1873 mentioned the occasional presence of one or two imperfectly ligulate marginal flowers; and I described the rays as 0–2, small, in my treatment of the Asteraceae in Standley's *Trees and shrubs of Mexico*. In the specimens in the U. S. National Herbarium of *Palmer* 815 (of 1890) and *Brandegee* (20 Nov. 1904, Altata, Sinaloa), both examined and cited by Hall, rays are present and can be seen with the hand lens. A typical head examined contained 7 flowers, 4 tubular and hermaphrodite, 3 pistillate and imperfectly ligulate, the lamina of the ray in each being 1–1.5 mm long, in two cases shorter than the style branches, in the other longer. In one the lamina was 3-toothed and bore 2 linear lobes at the base, just as described by Bentham; in another the outer lip was unequally 3-toothed, with a single inner lobe of nearly the same length; and in the third the lamina was deeply 2-lobed with one of the divisions 2-toothed and there were no inner lobes. In another head one of the pistillate flowers had an unequally 4-toothed outer lip and a considerably shorter inner lobe, and there were 3 style branches. The significant differences between such flowers and the bilabiate ones of *A. trianthus* are that in *A. sonoriensis* such flowers are pistillate and the large lip is exterior, while in *A. trianthus* the flowers are hermaphrodite and the large lip is interior.

Aplopappus viscidus (Woot. & Standl.) Blake

Sideranthus viscidus Woot. & Standl. Contr. U. S. Nat. Herb. **16**: 180. 1913.

In his monograph of "Haplopappus," Hall did not give this plant independent rank, but regarded it a form of his *Haplopappus spinulosus* ssp. *scabrellus* (Greene) H. M. Hall, listing it as "minor variation 32" of *H.*

[2] *The genus* Haplopappus 272. 1928.

spinulosus. The specimens on the type sheet in the U. S. National Herbarium, collected by E. O. Wooton near Hope, Eddy County, New Mexico, 3 August 1905, all lack the root. A specimen in the National Arboretum Herbarium (no. 33,359), collected near edge of Caprock, Lea County, New Mexico, 5 September 1937, by Dan King (no. 72), agrees with the type in all essential characters and possesses the greater part of its root, which is clearly annual. All the forms of *Aplopappus spinulosus* are perennial. *Aplopappus viscidus* appears to be a fairly distinct species, marked not only by its annual root but by its dense glandularity, its oblong or obovate merely serrate primary leaves, and its lack of any bristle on the tip of the phyllaries.

Lea County, where this specimen was collected, is of relatively recent creation, and is not shown on older maps. It is the southeasternmost county in New Mexico, and was formed from about the eastern two-fifths of Eddy and Chaves Counties. Caprock is in the northwestern part, in the Staked Plains, in what was formerly Chaves County, and is in about the same latitude as Roswell.

Erigeron inornatus f. **pseudoradiatus** Blake, forma nov.

Capitula pseudoradiata, corollis exterioribus 10–12 radiiformibus parvis discum paullum superantibus 5.4–6 mm longis lavandulaceis, staminibus abortivis liberis donatis, tubo 1.5–1.8 mm longo, fauce tubulosa 1.5–3.5 mm longa, lamina 1.5–3.5 mm longa elliptica concava 3-denticulata interdum prope basin dentibus 1–2 minoribus donata.

NEVADA: Open sunny places among rocks, public camp ground, Mt. Rose, 7 miles west of Reno Hot Springs, Washoe Co., alt. 1700 m. (6100 ft.), 12 July 1937, *W. A. Archer* 5580 (type no. 37,207, Nat. Arboretum Herb.).

This rather insignificant form is given a name only because it so simulates *Erigeron foliosus* Nutt. in its pseudoradiate heads that it might be confused with that species. Other collections by Dr. Archer in the National Arboretum Herbarium (nos. 5595, 5668, 5807) from the same general region agree precisely in every way except in having discoid heads, and show that the plant should be appended as a form to *E. inornatus* and not to *E. foliosus*, which is not known from Nevada. Forma *pseudoradiatus* is very similar to *E. inornatus* f. *subradiatus* Blake,[3] but in that plant the false rays are pale yellow; in both forms the disk is yellow as normal in *E. inornatus*. The type locality (Tahoe Tavern) of f. *subradiatus* was wrongly given as in Eldorado County in the original description; it is really in Placer County. All these plants agree in being referable to the var. *viscidulus* Gray, as at present understood, rather than to the typical form, having the stem and leaves densely pubescent and the involucre hispidulous or both glandular and hispidulous. *P. B. Kennedy* 1913, also from Washoe County, the basis for the inclusion of the species in Tidestrom's "Flora of Utah and Nevada," is similar. Typical *E. inornatus* Gray, with the stem glabrous at least above and the involucre glabrous, is not known from Nevada.

[3] This JOURNAL **19**: 270. 1929.

Desmanthodium caudatum Blake, sp. nov.

Herbaceum (?) verisim. elatum subglabrum, ramis inflorescentiae lineatim pilosulis exceptis; folia ovata pro genere maxima subpedalia falcate caudato-acuminata in basim late alatam abrupte angustata conspicue connato-perfoliata papyracea crenato-serrata e basi laminae trinervia supra subglabra subtus in nervis laxe brunneo-pilosa v. subglabra; capitula parva 9–11-flora glomerulata, glomerulis numerosissimis paniculam subnudam v. foliaceo-bracteatam pro genere laxam 23–28 cm latam efformantibus.

Upper part of stem herbaceous, 4–6 mm thick, with solid or hollow pith, brown, rounded-striate, glabrous below the inflorescence; leaves opposite; internodes 5–8 cm long; leaves at base of branches of inflorescence 22–30 cm long (including the winged petiole), 7–13 cm wide, gradually narrowed into a long falcate attenuation with obtusish callous tip, broadly cuneate at base into the winged petiole, rather coarsely crenate-serrate except at lower part of base of blade and at apex (teeth about 20–35 pairs, 1–2.5 mm high, 4–7 mm apart, with very blunt mostly incurved callous tips), above deep green, slightly shining, obscurely puberulous along costa and chief veins or there essentially glabrous, toward margin somewhat bullate and sparsely hirsutulous with slightly tuberculate-based hairs, beneath somewhat lighter green, laxly sordid-pilose along the chief veins and veinlets or essentially glabrous, 3-nerved from base of proper blade and lightly prominulous-reticulate beneath; petioles broadly winged throughout and conspicuously connate-clasping at base, 5–7.5 cm long, 1.3–2.5 cm wide, entire or with one or two small teeth above, the abruptly dilated clasping base about 1–1.8 cm wide; leaves of the inflorescence smaller, not connate-perfoliate, subsessile or very short-petioled; panicle somewhat convex, the primary branches erectish, the others divergent-ascending, all usually densely sordid-pilosulous in 1 or 2 lines, the ultimate ones more or less compressed, slender, 2–20 mm long, the ultimate bracts lance-ovate, acute, subcoriaceous, about 3 mm long; glomerules 6–10 mm thick, 4–5 mm high, composed of several or many heads and subtended by about 2 appressed bracts, these ovate, 3–4 mm long, obtuse or acutish, subcoriaceous, thinner-margined, about 7-nerved, sparsely pilosulous on base of midrib and slightly ciliolate at base; heads about 4–5 mm high, 3 mm thick; involucre of 3–5 bracts (each subtending a pistillate flower inclosed in its phyllary), these ovate to lance-ovate, acute or acutish, 3–5-nerved, glabrous or sparsely pilosulous on midrib above, 3–4 mm long; pistillate flowers 3–5 (usually 3), each enclosed in a sac-like, submembranous, short-beaked, more or less compressed or trigonous phyllary about 3.5 mm long and 1.5 mm wide, ciliate on the angles, short-pilose above outside; corolla cylindrical, fleshy, whitish, obscurely 3-denticulate at apex, 0.7 mm long, less than half as long as the style; achenes slenderly obovate, plano-convex or 3-angled with concave sides, blackish, glabrous, epappose, 2–2.5 mm long; receptacle naked inside the pistillate flowers; hermaphrodite (sterile) flowers 6–7, their ovaries stipitiform, subglabrous or slightly hispidulous above, up to 3.5 mm long, their corollas white, sparsely hispidulous above, 3.2 mm long (tube 1 mm, throat campanulate, 1.2 mm, teeth 5, ovate, erect, 1 mm long).

MEXICO: Finca Juarez, Escuintla, Chiapas, 12 Aug. 1937, *E. Matuda* 1750 (type no. 1,689,119, U. S. Nat. Herb.); same locality and date, *Matuda* 1756.

The only other species of *Desmanthodium* with connate-perfoliate leaves, *D. perfoliatum* Benth. of Guerrero and Oaxaca, has much smaller leaves (not over 14 cm long and 4.5 cm wide), strongly glaucous beneath and not caudate-tipped, a relatively dense and much smaller panicle (about 10 cm wide or less), and hermaphrodite corollas that are densely short-pilose on the limb.

Clibadium mexiae Blake, sp. nov.

Caulis supra densissime molliter breviterque subtomentoso-pilosus pilis patentibus griseis; folia magna longe petiolata late ovata acuminata basi late rotundata v. obscure cordata (minora breviter cuneata) grosse crenato-serrata triplinervia tenuiter papyracea supra scabriuscula dense hirsutula et sparsius hirsuta pilis patentibus basi tuberculatis subtus in pagina subdense et juventate subgriseo hirsuto-pilosa pilis patentibus basi vix incrassatis et glanduloso-adspersa in nervis densissime pilosula et hirsuto-pilosa; capitula minima sessilia irregulariter approximata 3–3.5 mm alta; phyllaria 3 ovata ad suborbicularia acuta v. acutiuscula hispidula et ciliolata 3–7-nervia; fl. fem. 3, hermaph. 6; receptaculum intra fl. fem. nudum v. subnudum; achenia late ovalia basi rotundata apice pilosa et glandulosa 2.3 mm longa.

"Perennial herb, 4 m high"; stem herbaceous above, subterete, white-pithy, 4 mm thick, opposite-branched above; leaves opposite; upper internodes 3–13 cm long; petioles slender, naked, densely pubescent like stem, those of the leaves of the main stem directly below the inflorescence 7–10.5 cm long, of the rameal leaves 1.3–4 cm long; blades of the larger leaves (directly below the inflorescence) broadly ovate, 18 cm long and more (tip wanting), 10–16 cm wide, broadly rounded or obscurely cordate at base, not at all decurrent on the petiole, loosely prominulous-reticulate beneath, 3- or 5-plinerved, coarsely crenate-toothed (teeth depressed, mucronulate, 1.5 mm high or less, 3–5 mm apart); branch leaves ovate, 8–15 cm long, 5–10.6 cm wide, with falcate-acuminate subentire tip, subtruncate to bluntly short-cuneate at base; panicles terminating stem and branches, convex or flattish, 6–11 cm wide, many-headed, densely and griseously subtomentose-pilose with spreading hairs, their branches divergent, their bracts minute, subulate, about 1 cm long or less; heads very small, obovoid-subglobose, 3–3.5 mm high (corollas fallen), 2–2.5 mm thick; phyllaries 3, whitish, the outermost ovate, acute, 3–4-nerved, hispidulous and short-ciliate, 2–2.5 mm long, 1.6–1.8 mm wide, the others broadly oval to suborbicular, 3–3.3 mm long, 2–2.8 mm wide, 5–7-nerved, acutish or abruptly short-pointed, hispidulous toward apex and short-ciliate; receptacle naked inside the pistillate flowers or with a single oblong pale, the pales of the pistillate flowers suborbicular, obtuse, about 5–7-nerved, short-ciliate, 2.5–3.3 mm long; pistillate corollas white, 1.5 mm long, sparsely sessile-glandular above, otherwise glabrous, subequally 5-toothed, the ovaries densely pilose at tip; hermaphrodite corollas (scarcely mature) rather densely short-pilose above, 2 mm long, the ovaries linear, densely long-villous above, sparsely so below, 1.8 mm long; achenes broadly oval-obovate, rounded at base, obcompressed, densely short-pilose and white-glandular toward apex, 2.3 mm long, 1.8 mm wide.

Ecuador: Common in forest clearing, near Puyo, Prov. Napo-Pastaza, alt. ca. 400 m., 20 Feb. 1935, *Ynes Mexia* 6946 (type no. 1,692,969, U. S. Nat. Herb.).

A species of the general group of *C. surinamense*, most nearly allied to *C. sodiroi* Hieron. and *C. oligandrum* Blake, the former Ecuadorian, the latter Guatemalan. All three agree essentially in the small number of flowers in the heads (3–5 pistillate, 4–6 hermaphrodite). In *C. oligandrum* the leaves are much narrower (3–6.5 cm wide) and acutely cuneate at base, and the heads are larger; in *C. sodiroi* (from description) the branches are setose-hirtous with reclinate hairs, the leaves are smaller, on shorter petioles (1–1.5 cm long), and the heads are much larger (5 mm long).

Rumfordia media Blake, sp. nov.

Caulis subsparse pilosus; folia deltoidea v. triangulari-ovata utroque latere 1–2-hastato-dentata calloso-serrulata acuminata in petiolos ubique alatos basi connatos abrupte angustata membranacea 3-nervia supra sparse pilosa subtus dense cinerascenterque subtomentoso-pilosula; capitula radiata aurea majuscula parum numerosa cymoso-paniculata, pedicellis glanduloso-pilosis; phyllaria exteriora ovata acuminata 1.5 cm longa 4–8 mm lata extus puberula et glandulosa, interiora stipitato-glandulosa et sparse pilosa; radii 10–11 mm longi.

Doubtless tall, the lower part not seen; upper part of stem herbaceous, bluntly 6-angled, somewhat compressed, striatulate, hollow, 3–4 mm thick, brownish green, not densely short-pilose and puberulous with several-celled mostly wide-spreading hairs with scarcely enlarged base; leaves opposite; internodes 6–8 cm long; petioles narrowly cuneate, winged throughout, 3–9 cm long, 1–2 cm wide at apex, 3–8 mm wide at base and there slightly ampliate and connate, remotely callous-serrulate, pubescent like the blade; leaf blades 10–17 cm long, 6–14 cm wide, callous-serrulate essentially throughout (teeth somewhat unequal, mostly 0.5 mm high or less and 2–5 mm apart), 1–2-hastate-toothed on each side at base of blade (teeth broadly triangular, acute, 1 cm long or less), above deep green, evenly but not densely short-pilose with several-celled lax spreading hairs slightly enlarged at base, beneath especially in youth densely and griseously subtomentose-pilosulous with lax several-celled hairs, somewhat pilose along costa, 3-nerved from base of blade, loosely prominulous-reticulate especially beneath; leaves at base of panicle much reduced, 3–4.5 cm long, their petioles connate at base; panicle terminal, about 15–20-headed, convex or flattish, 10–16 cm wide, the bracts very small, 1 cm long or less, the pedicels slender, 1.5–4.5 cm long, densely pilosulous with gland-tipped hairs and less densely pilose with several-celled longer hairs; heads about 2.8 cm wide at maturity, the spread involucre about 3.8 cm wide; disk 8–11 mm high, 1–1.8 cm thick; outer phyllaries 5, spreading or reflexed at maturity, ovate, lance-ovate, or elliptic-ovate (unequal in breadth in the same head), at maturity 15–17 mm long, 4–8 mm wide, thin-herbaceous, 3–5-plinerved and veiny, outside rather thinly puberulous and both stipitate- and sessile-glandular, densely and finely griseous-puberulous on margin, inside essentially glabrous; inner phyllaries (subtending the rays) ovate, acuminate, densely stipitate-glandular and sparsely pilose, ciliolate, 6 mm long; rays about 10–13, golden yellow, fertile, the tube at maturity 4.5–5 mm long, stipitate-glandular and sparsely hirsute, bearing 2 abortive stamens at apex, the lamina linear-elliptic, 10–11 mm long, 2–2.5 mm wide, pilosulous on back, 3-toothed (teeth blunt, 0.7–1.5 mm long), 8-9-nerved; disk corollas very numerous, fertile, their corollas golden yellow, about 6.5 mm long (tube much swollen at base, stipitate-glandular and sparsely hirsute, 3–3.2 mm, throat slender-campanulate, sparsely stipitate-glandular, 2.8 mm, teeth ovate, pilose, 0.7 mm long); pales membranous, oblong or obovate-oblong, obtuse to acute, subsessile-glandular, short-hirsute, and ciliate, 4–5 mm long; achenes of ray and disk similar, obovoid, plump, obscurely quadrangular, brownish black, glabrous, epappose, 2 mm long, 1 mm wide.

MEXICO: Mt. Orando, Chiapas, 20 Dec. 1936, *E. Matuda* 710 (type no. 1,686,103, U. S. Nat. Herb.; dupl., herb. Univ. Michigan).

This species is somewhat intermediate between *Rumfordia aragonensis* Greenm., of Costa Rica, and *R. attenuata* Robinson, of Michoacan or Guerrero, combining the connate-based, completely winged petioles of the former and the glandular-pubescent pedicels and longer rays of the latter species.

Wulffia baccata var. **discoidea** Blake, var. nov.

Capitula discoidea.

ECUADOR: Scandent perennial herb up to 3 m. high, with orange flowers and black fruit, thicket along trail side, trail from Tena to Napo, Cantón Napo, Prov. Napo-Pastaza, alt. 400 m., 5 April 1935, *Ynes Mexia* 7170 (type no. 1,692,980, U. S. Nat. Herb.); leaning herb with orange flowers, in partial opening in forest, Hacienda Salento, Cantón Pujilí, Prov. León, alt. 1000 m., 19 Nov. 1934, *Mexia* 6702.

Beyond the discoid heads, I can find no character to distinguish this plant from the somewhat variable *Wulffia baccata* (L.f.) Kuntze, in which the rays are sometimes deciduous soon after flowering. Dissection of heads of the new form in which the flowers have not yet opened shows that no rays are present. The involucre is short (4–5 mm high) and the phyllaries rather broadly ovate or oblong-ovate, acute or sometimes obtuse, or the inner occasionally subacuminate.

Psacalium mollifolium Blake, sp. nov.

Herba plusquam 70 cm alta, basi invisa; folia basalia suborbicularia 17 cm longa et lata peltata 7-lobata supra viridia subaspere pilosa pilis multiloculatis subtus densissime mollissimeque albido-lanato-tomentosa, lobis late cuneatis 3–4.5 cm longis 3.5–5.5 cm latis 3–lobatis obtusis sparse mucronulato-denticulatis; caulis densissime glanduloso-puberulus sparse laxeque pilosus pilis multiloculatis infra inflorescentiam simplex infra medium folium peltatum 5-lobum 8 cm latum, supra medium folium non peltatum 3-lobum valde reductum gerens; inflorescentia racemiformis ca. 22 cm longa, ramis brevibus 1-2-cephalis, bracteis linearibus pedunculos subaequantibus dense glanduloso-puberulis piloso-ciliatis; capitula ca. 12 discoidea nutantia ca. 24-flora; bracteolae 5–6 lineares involucro paullo longiores, dense glanduloso-puberulae et piloso-ciliatae; involucri ca. 1.5 cm alti glanduloso-puberuli et sparsius pilosi phyllaria 13 oblongo-lanceolata subacuminata; tubus corollae limbo multo longior, limbo paene ad basin 5-partito; achenia glabra; pappus albus 11 mm longus.

Stem scapiform, rather slender (5 mm thick below), greenish white, subterete, multistriate, solid, pithy; basal leaf attached to the petiole 3.5 cm above base, palmately 7-nerved, papery, the callous mucronulations of the teeth 1 mm long or less, the petiole (incomplete) stout, densely lanate-tomentose, 10 cm long; petiole of the lower stem-leaf about equaling the blade; bracts of inflorescence linear, 2–4 cm long, 2.5–4 mm wide, acute, sessile, entire, somewhat pilose dorsally; peduncles mostly 2–4 cm long, naked or essentially so; disk in flower 1.8–2 cm high, 1.1–1.7 cm thick (as pressed), oblong-campanulate; bractlets of involucre linear or lance-linear, acuminate, 2–2.5 cm long, 1.5–2 mm wide, erectish, herbaceous; phyllaries

2–3 mm wide; corollas apparently white, about 14.3 mm long (tube 8.5 mm, throat campanulate, 0.8 mm, teeth narrowly triangular, acute, recurved, 5 mm long); achenes oblong, greenish white, somewhat flattened, multistriate, 4.8 mm long; pappus pure white, rather copious, 11 mm long; style branches elongate, linear, recurved, obtuse, dorsally densely short-hispid, the hairs extending to slightly below the fork.

MEXICO: Taxco, Guerrero, 12 Aug. 1937, *Ruth Q. Abbott* 353 (type, Gray Herb.).

Nearest *Psacalium conzattii* (Rob. & Greenm.) Rydb., but readily distinguished by the dense, soft, lanate tomentum of the lower leaf surface. The specimen was sent for identification by Dr. I. M. Johnston. The genus *Psacalium* Cass., reestablished by Rydberg, seems to be well defined, and the following species from Jalisco should be transferred to it.

Psacalium eriocarpum Blake

Cacalia eriocarpa Blake, Journ. Washington Acad. Sci. **19**: 279. 1929.

ZOOLOGY.—*A new species of fish of the family Disparichthyidae from off Cuba.*[1] LEONARD P. SCHULTZ, United States National Museum. (Communicated by L. STEJNEGER.)

Disparichthys herrei n. sp.

This new species differs from *Disparichthys fluviatilis* Herre, first described in Field Museum Natural History, Publication **335,** Zoological Series **18** (12): 383–384, fig. 31, 1935. Type locality, a brook at Marienberg, Sepik River, New Guinea and also in Herre's 1936 paper,[2] the only other species in the genus and the only genus in the family Disparichthyidae, by having different proportions of the body as indicated in the following description.[3]

Holotype.—A specimen 174 mm in total length taken in a dipnet by Dr. Paul Bartsch on the Smithsonian-Roebling Exploring Expedition, April 8, 1937, at Corrientes Bay anchorage, as it came up to a submarine light. U. S. N. M. Cat. No. 107044.

Description.—An exceedingly slender eel, the length of the head (5.4 mm) contained in the total length 32.2 times and the depth of the body (1.7 mm at two head lengths behind the snout) 102 times; body scaleless, tapering from the head gradually to the tail which is almost thread-like, there is no caudal filament and none appears to have been broken off; a pair of small bony structures coming to the surface of the skin just back of the head (6.3 mm behind tip of snout) in midline of back. This pair stained red in alizarin and can be traced anteriorly a short distance in the flesh, appearing as though each might be a minute tube. The small size renders difficult the study of this organ and its significance is not known. Additional specimens should make possible its dissection and mounting but the author does not wish to spoil the only specimen known. Although this structure is in about

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received September 6, 1938.

[2] HERRE, A. W., *Fishes of the Crane Pacific Expedition,* Field Mus. Nat. Hist., Zool. Ser. **21**: 436. 1936.

[3] The author is very grateful to Mr. Alfred C. Weed, Curator of Fishes, Field Museum of Natural History, Chicago, for several measurements of the type of *Disparichthys fluviatilis* Herre, used in this study.

the same position as a bony projection on the Fierasferidae, its structure is entirely different. In *D. fluviatilis* this same structure occurs as observed by Mr. Weed. I quote part of his letter of Aug. 12, 1938:

> The peculiar bony structure is on the back of our specimen in about the position you describe. With the microscope equipment available it seems to be a bony tube about 0.2 mm in diameter.

No teeth at front of premaxillary, there being a toothless space about the size of the pupil; the first premaxillary tooth is a little enlarged and curved slightly inward followed by smaller teeth; the vomer is enlarged and its anterior portion is longitudinally sharp edged, followed posteriorly at each side by two small tooth-like projections with large bases; the teeth are in single series in both jaws, the maxillary is toothless.

Mr. Weed in his letter to me makes the following comments about the teeth of *D. fluviatilis:*

> The premaxillary teeth are graduated in size from the very large ones in front to much smaller ones behind. The lower teeth are even height, smaller than the large, hooked ones at front of premaxillary but larger than others on that bone. The second tooth on vomer is about half as long as width of iris. It is very thick and heavy at base and strongly hooked. It is separated from the first by about the length of its base.

The anus is far forward, 6.6 mm behind the tip of the snout, and just below the rear edge of the head; the anal fin is well developed, beginning just behind the anus and continuing to end of tail, the rays becoming very feeble posteriorly, so much so it is not possible to correctly count them, the length of the anal rays anteriorly are a little greater than the diameter of the pupil; dorsal fin very feeble, its origin not definitely determinable but probably about 26 mm (4.8 head lengths) behind tip of snout. The jaws are short and blunt, the lower a trifle shorter than upper; premaxillary not protractile; the maxillary lies above the premaxillary and overlapping it, and when the jaws are closed it is almost completely shielded by the fleshy preorbital above.

The long, narrow tongue is adherent to the floor of the mouth; the anterior nostril, somewhat tubular, is a little in advance of midway between eye and tip of snout; the posterior nostril is in the form of a crescent-shaped opening in front of middle of eye, its length about the size of the pupil, and the convex side nearest the eye (in *fluviatilis* Mr. Weed remarks, "Posterior nostril a straight slit 0.5 mm high at front edge of iris. Its lower end is at center of height of eye."); the posterior edge of the large eye is at about the center of the head; the gill openings are wide and extend far forward, but are not confluent, joining the narrow isthmus at its anterior end; the pectorals are small, rounded, their bases somewhat fleshy; the branchiostegals number 6 or (?) 7.

The following measurements[4] (recorded in mm) were made by use of a vernier on a mm rule: Length of head 5.4 (4.8); length of snout 1.6 mm; 0.30; diameter of eye 1.2; 0.22 (1.3; 0.21); length from tip of snout to rear edge of maxillary 2.3; 0.43 (2.2; 0.46); distance from tip of snout to center of anus 6.7; 1.24; tip of snout to center of anterior nostril 0.6; 0.11; depth

[4] The measurements are first given in mm followed by this value divided by the length of the head. Figures inclosed in parentheses are Mr. Weed's measurements of the type of *D. fluviatilis* Herre, and those outside the parentheses are for the new species. The total length of *D. fluviatilis* is too uncertain to express the measurements in hundredths of the standard length.

of head at occiput 2.5; 0.46; depth of body at two head lengths behind tip of snout 1.7; 0.32 (1.3; 0.22); length of longest pectoral fin ray about 0.8; 0.15 (0.75; 0.16); tip of snout to origin of anal fin 7.0; 1.3 (8.0; 1.67); anal fin origin to anus 0.6; 0.11 (4.5; 0.94); tip of snout to bony structure back of head 6.3; 1.17 (5.1; 1.06); width of premaxillary toothless space 0.4; 0.07 (0.05; 0.14); height of base of pectoral fin 0.9; 0.17 (1.0; 0.13); width of iris 0.4; 0.07 (0.4; 0.08).

The pectoral fins have 17 and 18 rays (20 or 21 on left side of *fluviatilis*). By staining the specimen in alizarin it was possible to count with great difficulty about 165 vertebrae.

There are four mucous pores on the preorbital; 7 or 8 black pigment cells on each side of the midline on the upper surface of the snout just above the anterior nostril; about 1+2 or 3 pointed, rather short gill rakers on first gill arch; along midline of belly, a fleshy kiel extends from in front of anus to anterior end of isthmus (also present in *D. fluviatilis*).

The color before staining with alizarin was plain light gray in alcohol.

Although this genus is referred to the eels, it does possess characters which might place it somewhere among the elongate jugular fishes. However, until its skeleton is carefully studied, I believe it should be referred to the apodal fishes.

Only the holotype known.

Named in honor of Dr. A. W. T. Herre who discovered this remarkable family of fishes.

ZOOLOGY.—*List of the gray foxes of Mexico.*[1] E. A. GOLDMAN, Bureau of Biological Survey.

Gray foxes occur throughout Mexico wherever local conditions are suitable. They favor rocky, partially wooded areas, where crevices or cavities afford suitable natural shelter, and are generally absent on broad expanses of open, level plain; but they also invade heavily forested regions in the eastern part of the republic. Gray foxes everywhere climb trees to some extent, especially to escape when hard pressed by enemies, but in the "cloud forests" along the eastern flank of the Mexican tableland and in the nearly unbroken lowland forests of the Yucatan peninsula the arboreal habit is more strongly developed. In these regions the claws are more recurved and sharper than in territory where the foxes are more terrestrial. In the gray foxes individual variation in size and color and in cranial and dental details covers a wide range, but combinations of characters distinguish closely allied geographic races.

The gray foxes in a broad belt extending nearly across the northern end of the Mexican mainland are referred to *Urocyon cinereoargenteus scottii*, which extends into the region from Arizona and Texas. The

[1] Received September 17, 1938.

name *Urocyon cinereoargenteus texensis* for the fox described from the junction of the Devils River with the Rio Grande, Texas, appears to belong in the synonymy of *scottii*, as regarded by Bailey (North Amer. Fauna, **25**: 180, Oct. 24. 1905). Near the Isthmus of Tehuantepec larger foxes give way to decidedly smaller, more southern races, but specimens from the Isthmian region present evidence that intergradation is complete. *Urocyon parvidens* from Merida, Yucatan, proves to be identical with the earlier named animal, *Urocyon cinereoargenteus fraterculus*, from San Felipe, Yucatan. The range of *Urocyon cinereoargenteus californicus* extends from southern California into northern Lower California, but passes farther south into that of *Urocyon cinereoargenteus peninsularis*. Two subspecies are here described as new.

List of Mexican subspecies of Urocyon cinereoargenteus, *with type localities*

Urocyon cinereoargenteus californicus Mearns. San Jacinto Mountains, Riverside County, California (altitude 8,000 feet).

Urocyon cinereoargenteus peninsularis Huey. San Ignacio, southern Lower California, Mexico.

Urocyon cinereoargenteus scottii Mearns. Pinal County (probably near Oracle), Arizona.
Synonym—*Urocyon cinereoargenteus texensis* Mearns. Junction of Devils River and Rio Grande, Texas.

Urocyon cinereoargenteus colimensis subsp. nov. City of Colima (three miles west), Colima, Mexico (altitude 1,700 feet).

Urocyon cinereoargenteus orinomus subsp. nov. Orizaba, Vera Cruz, Mexico (altitude 4,000 feet).

Urocyon cinereoargenteus fraterculus Elliot. San Felipe, Yucatan, Mexico.
Synonym—*Urocyon parvidens* Miller. Merida, Yucatan, Mexico.

Urocyon cinereoargenteus guatemalae Miller. Nenton, Huehuetenango, Guatemala (altitude 3,000 feet).

Descriptions of new subspecies

Urocyon cinereoargenteus colimensis, subsp. nov.

Colima Gray Fox

Type.—From three miles west of City of Colima, Colima, Mexico (altitude 1,700 feet). No. 33519/45564, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Nelson and Goldman, April 1, 1892. Original number 2378.

Distribution.—Western Mexico, mainly in and along the Sierra Madre and the more elevated parts of the plateau region, from northern Sinaloa south to near the Isthmus of Tehuantepec. Altitudinal range: From sea level along Pacific coast to at least 8,500 feet on mountains bordering the Valley of Mexico.

General characters.—Closely allied to *Urocyon cinereoargenteus scottii* of Pinal County, Arizona, but usually smaller; pelage shorter; color normally darker, the outer sides of feet more mixed with brown or black; cranial details distinctive. Similar in general to *Urocyon cinereoargenteus fraterculus* of Yucatan, and *Urocyon cinereoargenteus guatemalae* of southeastern Mexico and Guatemala, but decidedly larger than either, and skull characters different.

Color.—*Type* (pelage somewhat worn): Upper parts in general a coarsely grizzled mixture of gray and black, the gray predominating, and the black most strongly in evidence on tips of longer guard hairs along median line of back; outer sides of forearms and thighs grayish buff; under parts in general whitish, becoming pinkish buffy on sides of neck and along sides of abdomen; chin blackish; muzzle grayish brown, darkest at base of vibrissae; ears clothed with buffy hairs, becoming rusty reddish or tawny at posterior base; sides of neck ochraceous tawny; lower part of cheeks white in continuation with white of throat; upper and outer sides of feet light buff, finely mixed with brown, the inner sides pale buff; tail with a narrow, black crest, as usual in the group, giving way abruptly to grayish buff along sides and pinkish buff below, becoming black all around at tip. In some specimens the postauricular areas are paler, less tawny, and the buff on sides of neck and abdomen lighter in tone.

Skull.—Closely resembling that of *scottii*, but somewhat smaller; braincase narrower; rostrum broader; nasals shorter; jugal narrower at insertion in maxilla, as viewed from side; interpterygoid fossa shorter; mandible deeper and heavier, more convex in lower outline near symphysis; auditory bullae usually smaller, narrower, less fully inflated; upper carnassial and first upper molar variable but usually smaller. Similar to *guatemalae*, but decidedly larger, with relatively smaller auditory bullae. Compared with that of *fraterculus* the skull is much larger, with more strongly developed temporal ridges, and relatively smaller, less inflated auditory bullae.

Measurements.—*Type:* Total length, 960 mm; tail vertebrae, 410; hind foot, 138. Average of three adult female topotypes: 927 (880–965); 385 (360–400); 130 (120–146). *Skull* (type [♂] and an adult female topotype, respectively): Greatest length, 117, 114; condylobasal length, 116, 114; zygomatic breadth, 65.6, 64.9; breadth of braincase, 44.2, 44.1; interorbital constriction, 24, 23.7; width of rostrum (just behind exposed canines), 19.2, 19.4; length of nasals, 37.3, 39.5; maxillary toothrow (front of canine to back of last molar), 50.4, 47.8; length of upper carnassial (inner side), 10.3, 10.3.

Remarks.—Specimens from various localities indicate the intergradation of *colimensis* with the closely allied race *scottii* toward the northern end, and along the eastern side of the Sierra Madre. Those from near the Isthmus of Tehuantepec exhibit an approach to *guatemalae*.

Specimens examined.—Total number, 35, as follows:

COLIMA: Colima, 5; Hacienda Magdalena (20 miles southwest of Colima), 1.

DURANGO: Chacala, 2.

GUERRERO: Tlapa, 1.

HIDALGO: El Chico, 1; Tula, 1.

JALISCO: Ameca, 1; Atemajac, 1; Barranca Ibarra (Canyon de Oblatos), 2; San Sebastian, 1.

MEXICO: Huitzilac, 1.

MICHOACAN: La Huacana, 1; La Salada, 2; Los Reyes, 1; Mount Tancitaro, 1; Patzcuaro, 2.

MORELOS: Cuernavaca, 1; Tetela del Volcan, 1.

NAYARIT: Acaponeta, 2; Tepic, 1.

OAXACA: Juquila, 1; Llano Grande, 2.

PUEBLA: Piaxtla, 1.

SINALOA: Sierra de Choix, 1.

ZACATECAS: Hacienda San Juan Capistrano (about 25 miles northwest of Valparaiso), 1.

Urocyon cinereoargenteus orinomus, subsp. nov.

Vera Cruz Gray Fox

Type.—From Orizaba, Vera Cruz, Mexico (altitude 4,000 feet). No. 58411, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection); collected by Nelson and Goldman, January 18, 1894. Original number 5679.

Distribution.—Eastern Mexico, from southern San Luis Potosi south to central Oaxaca. Altitudinal range: From 2,000 feet at Jalpan, Queretaro to 10,000 feet on Cerro San Felipe, Oaxaca, mainly in the Humid Tropical Zone.

General characters.—A dark-colored, humid tropical forest-inhabiting geographic race, closely allied to *colimensis* of western Mexico, but darker, the upper parts more heavily overlaid with black; postauricular areas deeper tawny; feet usually more clouded with dusky; claws more recurved, laterally compressed and sharper pointed; skull differing in detail, especially the relatively high, narrow braincase. Similar in general to *scottii* of Arizona, but usually smaller; pelage shorter; color darker, the gray element less predominant, the upper parts more heavily overlaid with black; postauricular areas deeper tawny; feet more clouded with dusky; skull smaller, with distinctly narrower braincase. About like *guatemalae* of southeastern Mexico and *fraterculus* of Yucatan in color, but much larger than either, and cranial features different.

Color.—*Type* (fresh pelage): Upper parts a coarsely grizzled mixture of gray and black, the black most strongly revealed on the tips of the longer guard hairs on the neck, back and rump; outer sides of forearms and thighs finely grizzled black and gray, suffused with "ochraceous tawny" (Ridgway, 1912); lower part of cheeks, throat, chest, inguinal region and a line along inner side of hind leg white; under side of neck crossed by a band of "cinnamon-buff," abdominal area irregularly invaded by "pinkish buff," muzzle chin, and lips blackish; ears grayish brown, becoming rich "orange-cinnamon" at posterior base, fading to "cinnamon" on sides of neck; upper sides of feet a mixture of black and gray suffused with buff, the hind feet varying to between "cinnamon" and "orange-cinnamon" along outer sides; tail with a narrow, conspicuous black crest, giving way to buffy gray along sides, and between "pinkish buff" and "cinnamon-buff" below, becoming black all around at tip.

Skull.—Not very unlike that of *colimensis*, but somewhat lighter in structure; braincase still narrower, the vault rising more steeply to median line between parietals; rostrum narrower; dentition similar. Similar in general to that of *scottii*, but somewhat smaller; brain case narrower; nasals shorter;

jugal narrower at insertion in maxilla, as viewed from side; interpterygoid fossa shorter; auditory bullae smaller; dentition variable, much as in *scottii*. Similar to *guatemalae*, but decidedly larger, with relatively smaller auditory bullae. Compared with *fracterculus* the skull is much larger, with more prominent temporal ridges; auditory bullae relatively smaller, less inflated; dentition heavier.

Measurements.—Type: Total length, 935 mm; tail vertebrae, 358; hind foot, 128. An adult male topotype: 948; 376; 125. *Skull* (type [♀] and an adult male topotype, respectively): Greatest length, 111.6, 112,6; condylobasal length, 109.3, 110.7; zygomatic breadth, 65.1, 67.5; breadth of braincase, 42.3, 43.5; interorbital constriction, 22, 23.1; width of rostrum (just behind exposed canines), 18.6, 17.8; length of nasals, 35.9, 36; maxillary toothrow (front of canine to back of last molar), 48.8, 49; length of upper carnassial (inner side), 12.5, 10.7.

Remarks.—The dark coloration of this geographic race seems to be associated with its humid tropical forest habitat. General comparisons indicate intergradation on the north with *scottii*, on the west and south with *colimensis*, and toward the east with *fraterculus* and *guatemalae*.

Specimens examined.—Total number, 10, as follows:

OAXACA: Cerro San Felipe (10 miles north of City of Oaxaca), 1; Totontepec (20 miles northeast of Mount Zempoaltepec), 1.

QUERETARO: Jalpan, 1.

SAN LUIS POTOSI: Rio Verde, 1.

VERA CRUZ: Jalapa, 1; Las Vigas, 1; Orizaba, 4.

ZOOLOGY.—*A new woodrat of the genus* Hodomys.[1] E. A. GOLDMAN, Bureau of Biological Survey.

The genus *Hodomys* includes large, peculiar, tawny-backed woodrats known to range from Rosario, southern Sinaloa, southward at low elevations near the Pacific coast to Acapulco, central Guerrero, southwestern Mexico. One less vividly colored species (*Hodomys vetulus*) inhabits interior valleys as far east as southeastern Puebla, in the Atlantic drainage two-thirds of the distance across the continent. The largest individuals of *Hodomys alleni* present the maximum size attained by any of the many species of North American round-tailed woodrats (type of *alleni:* total length, 472; tail vertebrae, 225; hind foot, 46 millimeters). A new geographic race of lesser dimensions may be known by the following description.

Hodomys alleni guerrerensis, subsp. nov.

Acapulco Woodrat

Type.—From Acapulco, Guerrero, Mexico (sea level). No. 70574, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, January 6, 1895. Original number 7321.

[1] Received September 17, 1938.

Distribution.—Known only from the type locality, but probably has an extensive range at low elevations along the Pacific coast.

General characters.—Closely allied to *Hodomys alleni alleni* of Manzanillo, Colima, but decidedly smaller; color about the same; skull smaller and lighter in structure. Somewhat similar to *Hodomys vetulus* of Tehuacan, Puebla, but larger; upper parts near tawny instead of cinnamon buff; tail unicolor (tail bicolor in *vetulus*); cranial details distinctive.

Color.—*Type* (unworn pelage): Upper parts from top of head over back to rump near "tawny" (Ridgway, 1912) moderately mixed with black, paling to "cinnamon," the dark hairs thinning out along flanks; muzzle, sides of head, areas around eyes, outer sides of forearms and thighs dull grayish brown; under parts dull white, the hairs white to roots along median line from chest to inguinal region and "light drab" under color showing through on throat, inner sides of limbs and sides of abdomen; ears thinly clothed with dusky hairs; fore feet dull white; hind feet whitish mixed with brownish black, the ends of toes clothed with tufts of silvery white bristles; tail thinly haired, black all around. In most of the topotypes the basal color on the under parts is uniformly "light drab" and the hind feet are more extensively mixed with brownish black.

Skull.—Very similar to that of typical *alleni*, but smaller and of lighter proportions; maxillary arm of zygoma slenderer; molars relatively smaller. Compared with that of *vetulus* the skull is similar in general form but larger, more elongated; interparietal longer; molar toothrows longer and actually as well as relatively narrower.

Measurements.—*Type:* Total length, 408 mm; tail vertebrae, 200; hind foot, 42. Average of four adult topotypes: 423 (390–446); tail vertebrae, 206 (181–224); hind foot, 42 (40–43). *Skull* (type [♂] and an adult female topotype, respectively): Occipitonasal length, 49.8, 50.7; zygomatic breadth, 24.9, 24.7; interorbital constriction, 6.1, 5.9; length of nasals, 19.2, 19.9; length of incisive foramina, 9.5, 9.5; length of palatal bridge, 9.5, 10; maxillary toothrow (alveoli), 10.4, 10.1.

Remarks.—*Hodomys alleni guerrerensis* is a southern geographic race, distinguished from typical *alleni* mainly by smaller size. It requires no close comparison with *vetulus* of the interior valleys to the northward, although the two are not very distantly related.

Specimens examined.—Twelve, all from the type locality.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

RECENTLY ELECTED TO RESIDENT MEMBERSHIP IN THE ACADEMY

Clarence Cottam, senior biologist, Bureau of Biological Survey, in recognition of his contributions to the knowledge of the food habits and economic status of vertebrates and to wild life conservation.

Ernest Werner Eickelberg, assistant chief, Division of Terrestrial Magnetism and Seismology, U. S. Coast and Geodetic Survey, in recognition of his work on the magnetism of the United States and the development of magnetic observations at sea.

Ned Royce Ellis, senior chemist, Bureau of Animal Industry, in recognition of his contributions to the nutrition of animals and particularly the chemistry of animal fats.

Clement Leinster Garner, chief, Division of Geodesy, U. S. Coast and Geodetic Survey, in recognition of his contributions to geodetic and hydrographic surveying, and in particular his researches covering geodetic observing methods and improvements in instruments.

Lawrence Henry James, professor of bacteriology and head of department, University of Maryland, in recognition of his researches on food bacteriology and microbial thermogenesis.

Raymond Alexander Kelser, chief, Veterinary Corps, U. S. Army, in recognition of his contributions in the field of veterinary bacteriology.

Allen McIntosh, associate zoologist, Bureau of Animal Industry, in recognition of his contributions to the taxonomy of helminths of wild animals and birds.

James Edward McMurtrey, Jr., senior physiologist, Bureau of Plant Industry, in recognition of his work in plant physiology, particularly plant nutrition.

Charles William Rees, associate zoologist, Bureau of Animal Industry, in recognition of his contributions to medical and veterinary protozoology.

Francis M. Uhler, associate biologist, Bureau of Biological Survey, in recognition of contributions in the field of food habits and economic status of birds, mammals, reptiles and amphibians.

Egbert Hamilton Walker, Division of Plants, Smithsonian Institution, in recognition of his studies on the taxonomy of Chinese plants and the preparation of a bibliography of eastern Asiatic botany.

Lawrence Arnell Wood, assistant physicist, National Bureau of Standards, in recognition of his work on electrical properties of semi-conductors in particular his researches on the Hall effect and on blocking-layer photocells; also work on the physics and chemical thermodynamics of rubber.

SCIENTIFIC NOTES AND NEWS

Scientific Events

American Ornithologist's Union.—The American Ornithologist's Union held its fifty-sixth stated meeting in Washington, D. C., at the United States National Museum, October 17–22. The meeting was one of the largest yet held, with a total registration of about 330. Officers elected for the ensuing year were President, Herbert Friedmann, U. S. National Museum; Vice Presidents, James P. Chapin, American Museum of Natural History, and James L. Peters, Museum of Vertebrate Zoology; Secretary, Lawrence E. Hicks, Ohio State University; Treasurer, Rudyerd Boulton, Field Museum of Natural History. New members of the Council elected for a period of three years were Robert T. Moore, California Institute of Technology, John T. Zimmer, American Museum of Natural History, and W. L. McAtee, Biological Survey.

One of the features of the meeting was a symposium (the first in many years) on the problem of the individual versus the species in modern studies of avian behavior. Another feature was a number of excellent motion pictures in natural color, revealing a great advance over previous natural history photography. On Friday, October 21, there was an all day excursion to the Patuxent Wild Life Research Refuge operated under the auspices of the Biological Survey, while on Saturday morning members inspected the new buildings and collections at the National Zoological Park.

The 1939 meeting is to be held in the San Francisco Bay region, California.

Obituary

Victor Knight Chesnut, for many years a chemist with the Department of Agriculture, died suddenly on August 29 at his home in Hyattsville, Md., at the age of 71.

Born in Nevada City, Calif., Mr. Chesnut studied at the University of Chicago and at George Washington University. He became an assistant professor in chemistry at the University of California in 1890 and was assistant botanist in charge of poisonous plant investigations of the Department of Agriculture from 1894 to 1904. He was made an assistant chemist in the Division of Drugs in the Bureau of Chemistry of the Department of Agriculture in 1907 and served until 1916, when he was made an assistant chemist in the Phytochemical Laboratory. From 1924 until his retirement in 1933 he was an associate chemist in the Bureau of Chemistry and later in the Food and Drug Administration. Mr. Chesnut was widely known as an authority in his field, and contributed frequently to magazines and scientific publications.

A fellow in the American Association for Advancement of Science, Mr. Chesnut was active in the American Chemical Society, which he joined in 1895; he served as president of the Washington Section in 1901. He was a member of the Washington Academy of Sciences (vice president 1901), the American Horticultural Society, the American Civic Association and the Cosmos Club.

Guy N. Collins, principal botanist in the Division of Cereal Crops and Diseases of the Bureau of Plant Industry, U. S. Department of Agriculture, died on August 14, 1938, of endocarditis at his home at Lanham, Maryland. Mr. Collins was born at Mertensia, New York, on August 9, 1872. He attended Syracuse University but terminated his college career as an undergraduate in 1895 to join a survey expedition to Liberia for the New York Colonization Society. On his return to the United States in 1898 he spent a few months on the Florida Keys as a free lance botanical collector. Shortly after the close of the Spanish American War he joined the staff of the U. S. Department of Agriculture as Assistant Botanist in the Office of Botanical Investigations and Experiments. The remainder of his life was spent in the service of the Department of Agriculture, his assignments and titles undergoing many transformations.

His first expedition to the American Tropics was in company with O. F. Cook, exploring the newly acquired territory of Puerto Rico and their expedition resulted in the still standard publication "Economic Plants of Porto Rico." Returning from Puerto Rico Mr. Collins entered the Seed Laboratory of the Division of Botany and there devised apparatus for subdividing large lots of seeds into samples for germination and purity tests.

He never lost interest in the statistical problems of seed testing, an interest manifested many years later in the publication "The Application of Statistical Methods to Seed Testing." Many expeditions to the American Tropics followed his trip to Puerto Rico and from one of these came the introduction of the Guatemalan "hard shelled" avocado which has been utilized extensively in developing the commercial varieties of this fruit grown in Florida. While on another of these expeditions to Southern Mexico, accompanied by C. B. Doyle, he collected the Acala variety of cotton now grown extensively in California and the Southwest.

The last thirty years of his service were devoted to a study of inheritance in Indian corn and to the application to that study of biometrical methods without which, he was convinced, no adequate conclusions could be reached. He was among that early group of investigators whose work provided the foundation on which rests the present popular system of producing commercial corn crops from hybrid seed. His studies of inheritance in maize led quite naturally to an interest in the origin of this crop and his articles on the phylogeny, agricultural history, and origin of maize are definite contributions ranking equally in importance to his contributions to maize heredity. His insistence on the use of biometry not only on his own data but on those of his associates in the Bureau of Plant Industry compelled him to contribute much of his time to other investigators, at that time feeling their way through the labyrinth of statistical methods. In this manner he made contributions to much of the research of his colleagues.

Mr. Collins was highly regarded for his absolute honesty and for the objectivity with which he approached all problems whether of a personal or scientific nature. In his death biological science has lost a great spirit always fired with enthusiastic curiosity on scientific questions and one tempered with a reasonableness that can come only with the highest intellectual development.

Mr. Collins was a member of the Washington Academy of Sciences, the Botanical Society of America, the Botanical Society of Washington, the American Genetic Association, the Genetic Society of America, the National Parks Association and the Cosmos Club.

Earl Baldwin McKinley, bacteriologist, geo-pathologist, and administrator, was lost when the Hawaii Clipper disappeared, 2:11 P.M. (Guam time), July 29, 1938, some six hundred miles southeast of Manila. Dr. McKinley was on his way to the Orient to carry out serological tests bearing on the etiology of leprosy and he was engaged, while en route, with Mr. Fred C. Meier, of the Department of Agriculture, in making studies of the flora of high altitudes, work in aerobiology sponsored by the National Research Council.

Dr. McKinley was born September 28, 1894, at Emporia, Kansas. His university and professional training were received at Michigan, from which he received the degrees of A.B. and M.D., and as a Fellow of the National Research Council at the Pasteur Institute of Belgium at Brussels under the renowned Jules Bordet. McKinley received his M.D. degree in 1922. His first academic positions thereafter were held at Baylor University. Here he served one year as Assistant Professor of Medicine and one year as Professor of Hygiene and Bacteriology. Then came his year at Brussels, following which he was for a year Assistant Professor of Bacteriology and a year Associate Professor of Bacteriology at Columbia University. In 1927 he went to the Philippines as a Field Director of the International Health

Board of the Rockefeller Foundation. While in Manila he was also a member of the Advisory Committee to the Governor General for the control of leprosy and a lecturer at the University of the Philippines. In 1928 he returned to the Occident to become Professor of Bacteriology in Columbia University and the Director of the School of Tropical Medicine at San Juan, Puerto Rico, a part of the University of Puerto Rico under the auspices of Columbia University. In 1931 he was appointed Dean, Professor of Bacteriology, and Director of Research in the Medical School of the George Washington University, positions held by him at the time of his disappearance. His war record comprised twenty-eight months of service of which a year was spent overseas.

Dr. McKinley's scientific connections were too numerous to detail in this brief notice. Most prominent were his memberships in the local and national medical associations, American Society for Experimental Pathology, Society of American Bacteriologists (Editorial Board), American Association of Immunologists (Editorial Board), American Association of Pathologists and Bacteriologists (President), American Association for the Advancement of Science (Executive Committee), National Research Council (Executive Committee, Division of Medical Sciences), Academy of Medicine of Washington, D. C. (organizer and Chairman), Washington Academy of Sciences, Society for Experimental Biology and Medicine, American Leprosy Foundation (Secretary and member, Medical Advisory Board), American Society of Tropical Medicine (Council), American Foundation for Tropical Medicine (Executive Secretary), American Academy of Tropical Medicine (one-time Secretary), American Public Health Association, International Association of Geographic Pathology, Sigma Xi, and the Cosmos Club.

Dr. McKinley's publications, which number more than one hundred, are distributed in various fields: immunology, pathology, ultramicroscopic viruses, tropical medicine, cultivation of *Mycobacterium leprae*, medical history, climate and health, and geography of disease.

"Earl Baldwin McKinley possessed the delving mind of a scientist, the dynamic enthusiasm of a promoter, the altruistic instincts of a humanitarian and the simple friendliness of true gentility."

TRUMAN MICHELSON, ethnologist on the staff of the Bureau of American Ethnology, Smithsonian Institution, died on July 26, 1938, at his home in Washington, D. C. as the result of a heart attack. The son of the famous scientist Albert Michelson, Dr. Michelson was born August 11, 1879 at New Rochelle, N. Y. He received the degree of A.B. from Harvard University in 1902 and the degree of A.M. in 1903 and the Ph.D. degree in 1904 from the same university. During the years 1904 and 1905 he studied at the universities of Leipzig and Bonn. In 1909 and 1910 he studied under Dr. Franz Boas at Columbia University. During the years 1905 and 1906 he was instructor in Latin at the University of Missouri and was connected with the United States Immigration Commission in 1909. On June 1, 1910 he was appointed ethnologist on the staff of the Bureau of American Ethnology, which position he filled until his death. In addition to his duties at the Smithsonian Institution, he was professor of ethnology at George Washington University from 1917 until 1932.

During his 28 years with the Bureau of American Ethnology, Dr. Michelson established himself as the foremost authority on the large and important Algonquian tribes of Indians. Every year during this period he spent a certain time in field researches among the widespread tribes of this group.

In addition to scores of publications, Dr. Michelson left behind him a vast accumulation of manuscript material which is preserved in the archives of the Bureau of American Ethnology. Although the Algonquian Indians constituted his special field, his interest in the field of ethnology and of linguistics were remarkably versatile. A secondary interest of much importance was in the field of Indo-European languages. As an indication of his linguistic ability, he possessed a command of 19 different languages.

Dr. Michelson was a Fellow of the American Association for the Advancement of Science, and of the American Ethnological Society; a member of the American Anthropological Association, Anthropological Society of Washington (president, 1923–25), American Folk-Lore Society, American Philological Association, American Oriental Society, Linguistic Society of America, Washington Academy of Sciences; corresponding member of the Société des Américanistes de Paris.

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 28 DECEMBER 15, 1938 No. 12

PHYSICS.—*Time measurements.*[1] FRANK WENNER, National Bureau of Standards, Washington, D. C.

INTRODUCTION

According to precedent it is time for an address by your Junior Past President and the subject chosen is: Time Measurements. I propose to discuss very briefly concepts of time, units of time and a few of the many standards of time; and more in detail that particular class of time measurements which constitutes one of the three component parts of a fundamental or absolute measurement of electrical resistance, which at this time is my job.

The subject is timely, since most everyone is concerned with time measurements or at any rate talks about time, in the day time, in the summer time and at other time. We hear of fast time, slow time, record breaking time, waltz time, swing time, standard time, daylight saving time, sun time, middle European time, spring time, vacation time, slack time, Christmas time, correct time, present time, past time, future time, geologic time, all sorts of time, any time and more or less all the time, here, there and most everywhere. We even hear of before time began and when time shall be no more. We time the plays of a hand of bridge, our start to work in the morning, our going to meals and most everything we do. In the home we time the boiling of eggs, the baking of a cake, the roasting of a piece of meat, etc., etc. We also time the start of the cooking of the various parts of a meal so that each part will be finished at a more or less definitely specified time in advance of the time it is to be served.

Incidentally, what is the time: judging from my watch it is approximately 8:30 and it is p.m. (not a.m.) January 15, 1938. But it is 7:30 p.m. in Chicago, 6:30 p.m. in Denver and 5:30 p.m. in San Francisco. Furthermore, it is 2:30 a.m. January 16, 1938, in Berlin. Yet time is the same everywhere—or is it possible that it is not. At any rate, it is approximately one hour and 30 minutes January 16, 1938, Greenwich Meridian time here and elsewhere on this earth. However, time does

[1] Address of the retiring president of the Philosophical Society of Washington, delivered January 15, 1938. Received October 31, 1938.

not have much if any meaning to us as something apart from the place in which we are. Time and place, or more specifically space, are of equal importance to us and are more or less inseparable. For example, some of us have found by sad experience that two people cannot occupy the same space at the same time.

Since apparently there are many kinds of time, and time and space are so intimately associated, it would be in order, before proceeding further, for each of us to ask herself or himself what is time and what is space. A little thought will lead to the conclusion that to most of us at any rate the words time and space denote fundamental concepts or general ideas which cannot be defined. Our concept of time and of space differs more or less depending on our individual experiences, but presumably all will agree that time and space serve to specify the when or duration and where or size of any event. You are not likely to attend a party to which you may have been invited unless you know both when and where the party is to occur.

Considering only the experiences of most of us, time and space may be thought of as separate entities to about the same extent as the space coordinates usually designated x, y and z may be thought of as independent. Letting t represent time, the coordinates applying to any particular event may be taken as t, x, y and z. Only by a process of mental abstraction can one of the space coordinates be separated from the other two or the time coordinate be separated from the space coordinates.

To see that this is so, consider how a measurement of length or of time could possibly be made without at least a limited amount of three dimensional space in which to make the measurement. To coordinate a few of the observations of a relatively few broader concepts of time and space are required. As a consequence we hear of relativity theories and space of more than three dimensions. However, in this discussion of time measurements consideration will be given only to problems in which relative velocities are small in comparison with the velocity of light, that is to problems not requiring these broader concepts of time and space.

In order to specify an event it is necessary to select an origin for each of these 4 coordinates and a unit for each. For the 3 space coordinates usually 3 mutually perpendicular planes, with the point of their intersection taken at will, serve as the origins of the space coordinates and the same unit is used for each. For the time coordinate the origin may be taken at will, while usually the mean solar second is used as the unit. Other units of time used are the sidereal second, the

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minute, hour, day, week, the mean solar day, month, etc. In the measurement of time as in the measurement of other quantities we must have not only a unit and frequently an origin but also a standard or measuring instrument.

The unit, origin, and standard used in any particular case depend to a greater or less extent on the nature and purpose of the time measurement. With reference to events of interest throughout the world usually the Gregory calendar with its fixed origin serves in determining the year, the month and the day of the month, while the mean solar second and multiples of it such as the minute and hour together with a standard time zone is used in specifying the time. For example, a particular train may have left the Union Station, Washington, D. C., on December 14, 1937, at 4 h, 29 min, 37 seconds p.m. Eastern Standard Time. The observation of when the train left the station constituted a time measurement in the sense of accurately determining a date. In many cases a time origin is of minor importance. For example we hear such expressions as "Meet me at 12th and G Streets in half an hour." Obviously, therefore, clocks and watches are used in measuring time intervals or the difference between two dates which are nearly the same and may or may not be known.

If the time interval to be measured is very short an ordinary watch or clock cannot be used in the measurement except possibly indirectly.

In still other cases the measurement consists in determining the time interval between a more or less continuously reoccurring event. For example, a machine has a rotating part and the time measurements consist in determining the average over a few or many revolutions of the time interval of one revolution. If the time interval is short usually the result obtained is expressed not as the duration of one event but as the number of repetitions of the event in a unit of time, while the measurement is called a frequency determination. Precise frequency determinations generally are the most difficult and most intriguing class of time measurements, since in many cases they involve the maintenance of the frequency to be determined.

Time measurements in general, therefore, may be divided into 5 or more classes, such as extremely long time intervals, dates, moderately short time intervals, extremely short time intervals, and frequencies.

THE PRIMARY STANDARD AND UNIT OF TIME

Having mentioned some of the classes of time measurements it is in order to consider briefly some of the standards used. As has already been pointed out, for at least most time measurements some sort of standard of time is necessary while a standard suitable for one class of measurement may not be suitable for some other class. Consequently different types of standards are used. That the result obtained with one type of standard shall be the same as though some other were used the different types must be compared among themselves and if more than one standard of a particular type is used these must be compared either directly or indirectly with each other. From among the vast number of standards it has been found convenient to select one for use as a primary standard, that is as a standard with which to compare all other time standards or time measuring devices. The one selected is the revolution of the earth on its axis. The duration of one revolution of the earth on its axis constitutes a sidereal day, which might be used as a unit of time, but the use of this unit would be decidedly inconvenient. Other standards which might be used as a primary standard are the revolution of the earth's moon in its orbit, the eclipsing of one of the moons of Jupiter, the eclipsing of a bright and dark star doublet, or one of the periods of the light radiation from some particular chemical element.

Some of these apparently would serve as a more reliable primary standard than the one being used.

From long continued astronomical observations the relation between the sidereal day and the mean solar day and consequently the mean solar second (the commonly used unit of time) has been accurately determined. While the primary standard is available to all, only those having very special equipment could use it directly in any precise measurement they might desire to make. In most time measurements some type of clock or watch is used either directly or indirectly as a standard. Clocks and watches are set and regulated by comparisons with the primary standard, but for the most part these comparisons are decidedly indirect. In various countries some one or more laboratories make observations of the primary standard and broadcast the data obtained in such form that they may be used readily in setting, adjusting rates and determining rates of clocks and watches. In this country our Naval Observatory furnishes this service.

PRECISION CLOCKS

All here are familiar with the pendulum clock, in general use in Washington until comparatively recently and still in general use in most rural districts, with watches and with the balance wheel type of clock. In passing it should be pointed out that the so-called electric clocks now in general use in Washington and most cities are not clocks but synchronous motors suitably geared to hands moving over clock dials. Time will not permit of descriptions of any of the great variety of clocks, chronometers and other time measuring devices which are one or two orders better than household clocks or serve some special purpose. Therefore, our consideration of clocks will be limited to those of precision types. In design, materials and workmanship these are as much superior to ordinary household clocks as the automobiles of today are superior to the ox-carts of a hundred years ago. Only a few of these clocks can or need be described and in the descriptions an effort will be made to point out essential features rather than details. In other words, the descriptions will be from the standpoint of the physicist rather than from the standpoint of the master craftsman.

Usually it has been assumed (at any rate until very recently) that a pendulum swinging without interference or with the least practicable interference by the driving mechanism constituted the best means of realizing really high quality clocks. Consequently a great deal has been said about free pendulums, while a free pendulum is so definitely an ideal towards which designers strive that they are reluctant in admitting that their clocks do not have completely free pendulums.

This matter was discussed more than 15 years ago by one of your past presidents, but I am sure that those of you who were here then and remember what he said will pardon me if I follow to some extent his procedure in analyzing the effect of the driving mechanism of an oscillating system upon its rate. Assume that a pendulum swinging without restraint, other than air damping, receives a sudden driving impulse somewhat past the center of each third swing to the right. For these conditions the energy changes are shown to a first approximation by figure 1. Here the approximate spiral is made up of semicircles drawn about the points a and b. The square of the radius vector R is proportional to the energy stored in the system, that is to the square of the displacement plus the square of the velocity. During the impulse the radius vector changes from o-m to o-n, that is, is increased in length and is set backward in its rotation. It is set backward because the velocity is increased without an appropriate increase of the displacement. It will be seen that except during impulses the radius vector decreases more during the time the velocity is towards the center of oscillation than it does during the time the velocity is away from the center of oscillation, showing that air damping slows the rate or increases the period. Energy diagrams of this general type serve to show, at a glance, qualitatively and to a considerable extent quantitatively how the rate is affected by the abstraction of energy from or the addition of energy to the oscillating system in any part or parts of a cycle. It will be seen that driving impulses when the system is at the center of its swing do not affect the rate. Consequently many de-

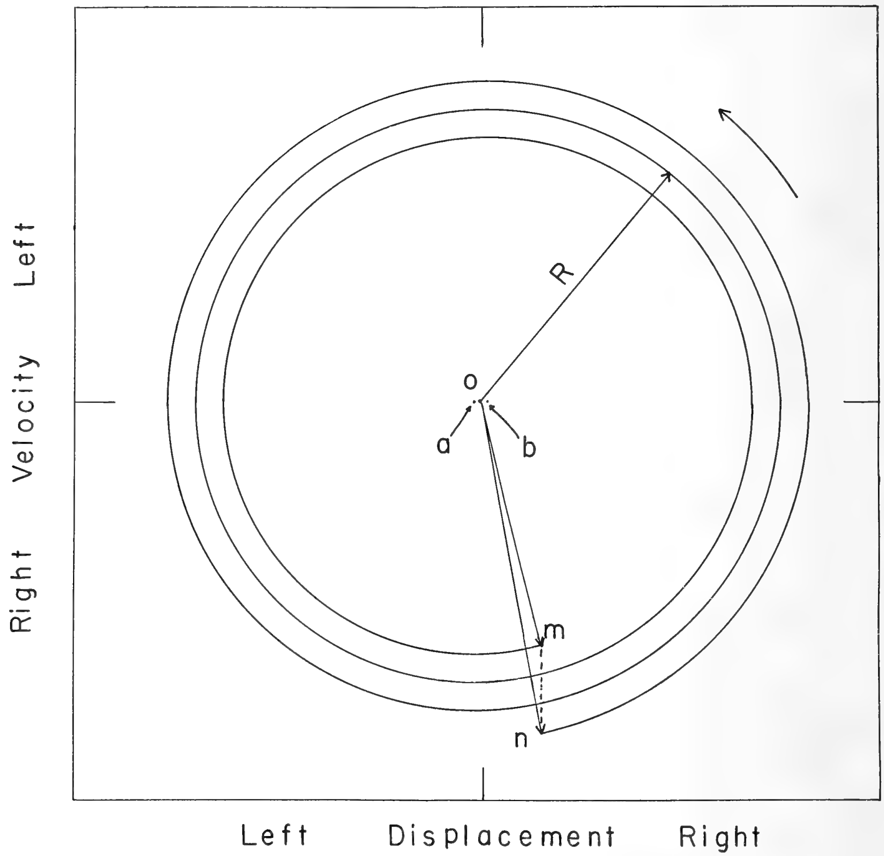


Fig. 1.—Energy diagram of damped oscillating system. Oscillation sustained by sharp driving impulse slightly past the center of each third swing.

signers strive for very short driving impulses at instants when the system is at its center of swing. However, it is readily seen that impulses whether positive or negative do not affect the rate if distributed symmetrically about the center of oscillation.

Strictly speaking, a free pendulum is one whose rate is not affected by the energy taken from nor the energy added to it. However, it is generally considered that a pendulum is free if the only energy taken from it is that absorbed by air damping and this energy is supplied by a driving mechanism which does not affect the rate.

Thirty years ago the Riefler clock was generally considered to be the best of the precision clocks. As it is still being used to a considerable extent and is described as having a completely free pendulum, let us consider the basis for this claim and at the same time note how the motion of the pendulum is maintained.

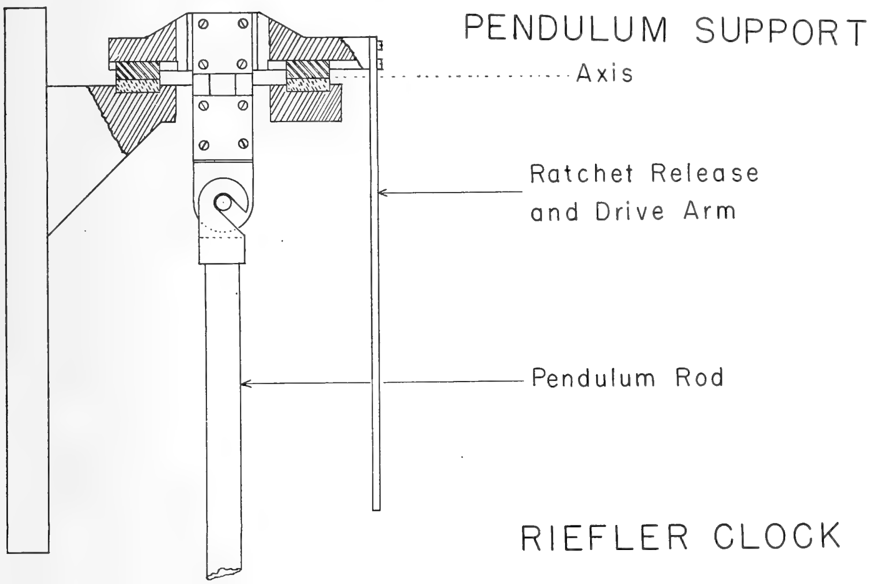


Fig. 2.—Riefler pendulum support and driving mechanism.

Figure 2 shows the pendulum support, driving spring, and ratchet release and driving arm. The ratchet release and driving arm contacts two toothed wheels mounted on the drive shaft. One of these toothed wheels and jewelled pawls on the ratched release and driving arm serves to intercept the forward motion of the drive shaft. Following releases of the ratchet, slightly after the pendulum passes the center of its swing, the other toothed wheel and pins on the ratchet release and driving arm move the driving arm in a direction opposite to that in which it moved in releasing the ratchet, bringing the driving arm against a definite stop. The result is that following each release of the ratchet the driving spring is suddenly stressed in the direction tending to move the pendulum towards the center of its swing, while the motion of the pendulum is away from its center of swing. The ratchet wheel teeth and jewelled pawls are so shaped that friction of the ratchet is largely compensated.

Figure 3 shows the manner in which the force exerted by the driving spring is distributed throughout a cycle, assuming that the friction of the ratchet release is perfectly compensated. Here the enclosed area is proportional to the energy transmitted to the pendulum by the driving spring during a complete period. It will be seen that driving impulses are neither concentrated near nor symmetrically distributed about the center of swing. Also it will be seen that the motion of the pendulum is continuously influenced by the driving mechanism, that is the pendulum is not free during any part of a cycle nor during

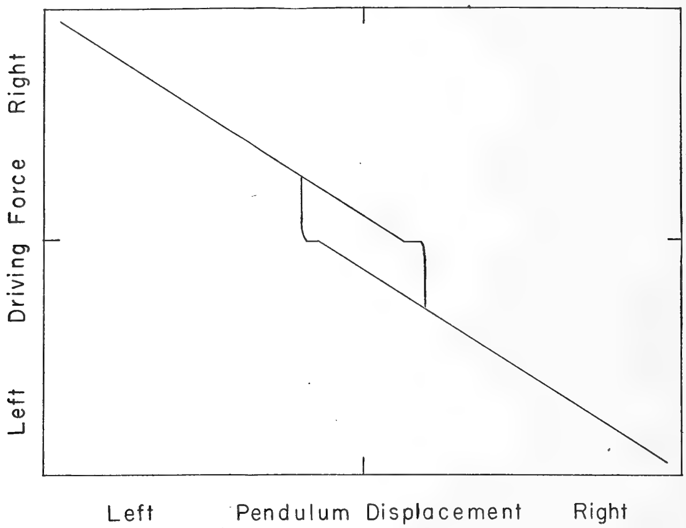


Fig. 3.—Action of Riefler ratchet release and drive spring.

any part of the time. Furthermore, friction of the ratchet release can not be perfectly compensated since static friction exceeds moving friction and the viscosity of the lubricant changes with time. Consequently the effect of the driving mechanism upon the rate cannot be presumed to remain constant.

In the Riefler clock time signals are given by an electrical contact operated by a third toothed wheel mounted on the drive shaft. Since the ratchet release is not positive in its action and the teeth on neither of the two wheels involved can be alike, time intervals between successive contacts are not constant. In case of the Riefler with which I have had much sad experience these time intervals vary by as much as 0.02 second.

A clock of more recent design is the Shortt Synchronome. This clock consists of two distinct parts each having a pendulum. These parts, designated "Free" and "Slave," may be located at a considerable distance from each other since connection between them is by means of electrical circuits. The slave, which runs slightly slow, operates the contact in the circuit supplying the power driving the free pendulum. It also operates clock dials and time pick-up contacts. The free pendulum keeps time and each 30 seconds closes a contact in a circuit which in case the slave is slightly behind, steps it forward a few thousandths second. The free pendulum receives a driving impulse each 30 seconds. Otherwise its motion is free except for air friction and unavoidable movements of its support.

Figure 4 shows the manner in which the driving impulses are transmitted to the pendulum as well as the manner in which the contact synchronizing the slave is operated. It should be pointed out that a driving impulse is applied to the pendulum only when it is near the center of a swing. Furthermore, the driving impulses begin slightly before the pendulum reaches the center of its swing and continue until the pendulum is slightly past its center of swing. Aside from air damping the pendulum is strictly free about 99 per cent of the time.

Time signals are given by a contact operated by the slave. Consequently they are affected by the method of synchronization of the slave with the free pendulum. The contact made by the free pendulum is undoubtedly more reliable but not sufficiently frequent for many purposes. Time will not permit of descriptions of the various devices which have in individual cases been added to Riefler and Shortt clocks to give more satisfactory time pick-ups. Both of these clocks usually are operated in a partial vacuum for the purpose of reducing the power required to drive them since a reduction of the power reduces the effect of the drive on the rate, that is makes the pendulum more nearly free. However, it also makes the arc of the pendulum swing more subject to variation and variations of arc result in variations of the rate. One of the most important developments in pendulum clocks since the advent of the Shortt is the maintenance of a constant or practically constant amplitude. Various means have been devised for accomplishing this.

Obviously, the drive affects the rate not only of pendulum clocks but also of watches, chronometers and all other types of clocks involving an oscillating system, whether mechanical or electrical, or partially mechanical and partially electrical. It is now in order to state an ideal towards which designers of clock drives might well strive: namely, drives having a constant direct effect on the rate and maintaining a constant amplitude best suited to each individual case. Whether or not the effect of the drive on the rate is zero is immaterial. However, in most cases the more nearly it is zero the more easily it may be made constant.

The Riefler and Shortt clocks were designed primarily for use in astronomical observations. They are not very suitable for the measurement of relatively short intervals of time: First, because their rates are continuously changing on account of microseisms which are more or less harmonic movements of the ground having periods usually in

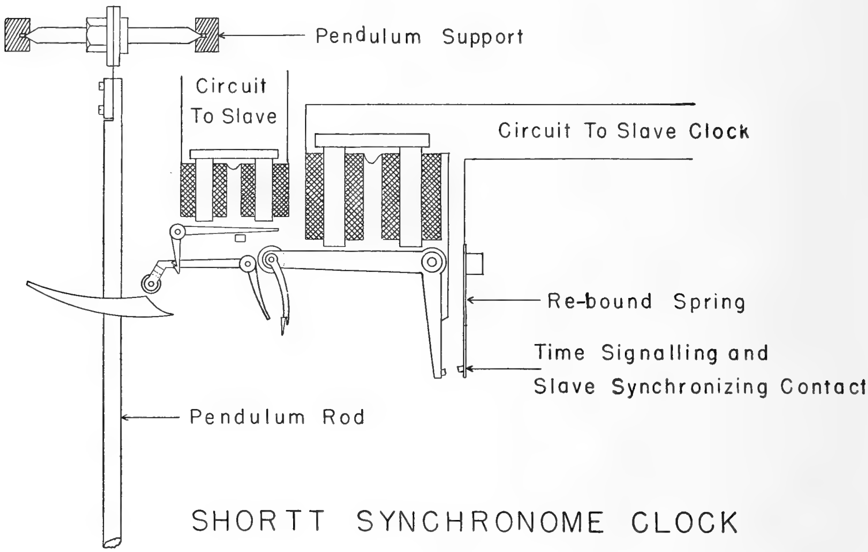


Fig. 4.—Shortt synchronome free pendulum support and driving mechanism.

the range from 3 to 8 seconds and amplitudes of a few microns. Microseisms keep the pendulum support in an extra motion which changes the rate alternately in one direction and then in the other. Second, because it is not possible to pick up time from these clocks neither precisely enough nor frequently enough for use directly in certain classes of physical measurements. For some of these measurements what is needed is a precision clock which, to use a homely expression, "ticks" a relatively large number of times per second, while it is desirable that the number of ticks per second be adjustable in definite step up to a maximum of not less than 100,000,000. To date this feature has been realized only in the crystal clock with its auxiliary equipment.

All the better types of clocks have a mechanically oscillating system, such as a pendulum acted upon by gravity, a balance wheel acted upon by a spring, or other device having mass which may be dis-placed or distorted and an elastic restoring force proportional to the displacement or distortion. In the crystal clock this mechanically oscillating system is a quartz crystal cut to dimensions such as to give a desired period or frequency. Quartz in addition to having excellent elastic properties is piezo-electric. That is, changes its dimensions when placed in an electric field and produces an electric field when its dimensions are changed.

(A large quartz crystal shown and optic and electric axes pointed out. The manner in which the crystal would be cut relative to these axes in making a piezo-electric oscillator explained. An unmounted oscillator having a frequency of approximately 200,000 cycles per second shown. Also an oscillator mounted between plates used to apply the electric field necessary to maintain the mechanical oscillation and from which this oscillation is picked up electrically without mechanical contacts shown.)

In what follows I shall assume that you are familiar with the simpler radio tubes, the simpler radio circuits and the symbols used to

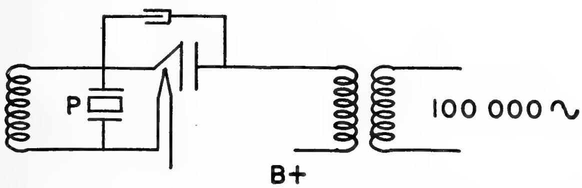


Fig. 5.—Piezo-electric oscillator drive and pick-up circuit.

represent the various parts of such circuits. Figure 5 shows one of the simpler electric circuits serving to maintain a quartz crystal in oscillation and at the same time supply an alternating current of the same frequency as the mechanical oscillation of the crystal. Here P represents a quartz crystal assumed to be so cut as to have a natural frequency of 100,000 cycles per second. Otherwise the arrangement is a simple oscillating circuit with a capacitance feed back and transformer output. Figure 6 shows a circuit of a frequency multiplier. Here it is assumed that the input to the first tube is 100,000 cycles per second and of such amplitude as to greatly overload the tube. Consequently the output of this tube is rich in harmonics either odd or even or both odd and even. The input to the other tube is tuned to one of these harmonics in the same way that an ordinary radio receiving set is tuned to a particular broadcasting station. Consequently if the second tube is operated without appreciable distortion most of its output will have a frequency of N 100,000 cycles per second where N is an integer in the range from 1 to 15.

Figure 7 shows a circuit of a frequency divider. The arrangement is such that each of the two tubes feeds through a capacitor to the grid of the other. The capacitances and resistances are so chosen that the system tends to oscillate when there is no input with a frequency of

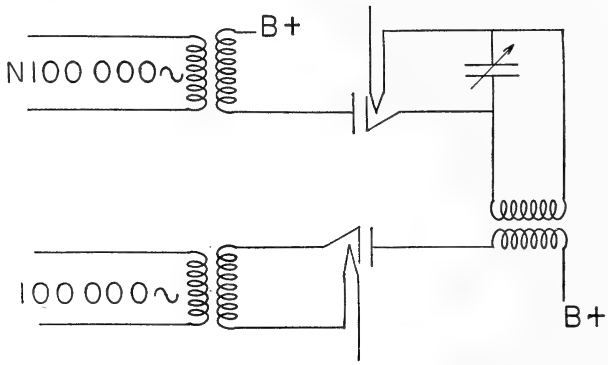


Fig. 6.—Frequency multiplier circuit.

approximately 50,000 cycles per second. Then in case of an input of exactly 100,000, 150,000, 200,000 etc., cycles per second it will oscillate at exactly 50,000 cycles per second. A circuit of this type may be definitely synchronized at a frequency which is a simple fraction of the input frequency. While divisions of 10 or more may be made in this

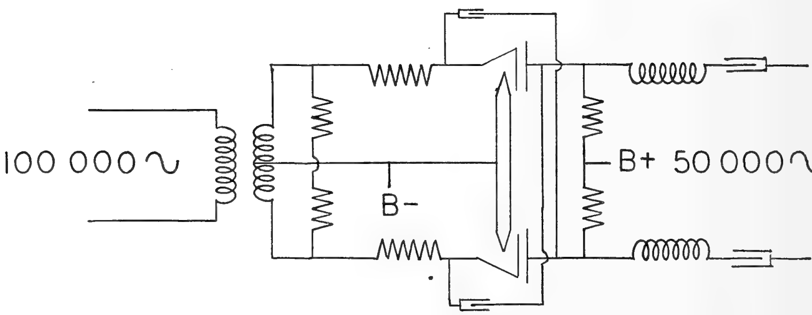


Fig. 7.—Frequency divider circuit.

way adjustments are more easily made and maintained if the division does not exceed 5.

Frequency multipliers and frequency dividers may be used in tandem and in combinations with each other so as to give a great range of frequencies, all having a fairly simple and definitely known relation to the initial frequency.

A crystal clock with frequency multipliers and frequency dividers constitutes a precision time measuring equipment giving simultaneously different frequencies or numbers of ticks per second ranging from 1000 or less to 100,000,000 or more. If in addition a synchronous motor is driven from one of the lower frequencies and this motor drives a clock train which operates electrical contacts the range may be extended downward an additional 5 or more orders. It is also possible to extend the lower end of the range somewhat without the use of a synchronous motor or other moving mechanical parts.

Which of the various number of ticks per second that are available or might be made available may be observed or counted depends upon the purpose for which they may be used. In cases in which electrical contacts are operated by a synchronous motor observation and use may be similar to that which is used with clocks of the pendulum type or chronometers. However, in most cases the number of ticks used lies somewhere within the range from 1000 to 100,000,000 per second. How a large number of ticks per second (5,000,000 for example) might be observed and used need not be discussed here since the National Bureau of Standards issues in mimeographed form instructions for their observation and use for a particular purpose. Later I shall try to explain somewhat in detail how 1000 ticks per second may be used so as to give, in effect, time pick-ups every 0.011 second to a precision of approximately 0.00001 second.

TIME SERVICES

The Naval Observatory broadcasts time signals during the last 5 minutes of most every hour of the day. In some cases these broadcasts are on two or more carrier frequencies, all outside the regular broadcast band and all without an audio frequency modulation. These signals consist of second pulses with certain omissions which serve to identify both the minute and second of each pulse. They serve in giving the time of day usually to a few hundredth second and are used directly in setting, adjusting rates, determining rates and determining corrections to the better grades of watches, clocks and chronometers and indirectly in the setting of most, if not all, household clocks and watches.

Regular broadcast stations usually announce the time every 15 minutes. This is undoubtedly the most generally used time service.

To a limited extent portions of broadcast programs are recorded photographically at a number of places along with time signals from a local clock. These records when brought together serve as a means of determining the correction to the signals from each clock relative to the time signals given by one of the clocks used as a reference standard.

Power service stations for the most part maintain the frequency very close to 60 cycles per second. Further, they operate cycle counters or synchronous motors driving a clock train and from time to time speed up or slow down their generators so that the average of the frequency between interruptions of the service is almost exactly 60 cycles. This is what may be called an extra service purely for the convenience of those using so-called electric clocks.

The National Bureau of Standards broadcasts on Tuesdays and Fridays

from 10:00 to 11:30
a carrier frequency of 5 mc/s
from noon to 1:30
a carrier frequency of 10 mc/s
from 2:00 to 3:30
a carrier frequency of 20 mc/s

each without modulation, except a short pulse each second and announcements at the beginning and end of each 90-minute period.

On Wednesdays at the same hours and on the same carrier frequencies a 1000 c/s 30% modulation except during announcements.

Evenings except Saturday and Sunday from 4 p.m. to 2 a.m. and except during rather frequent announcements full modulation at a frequency of 440 c/s on a carrier frequency of 5 mc/s.

In general the frequencies broadcast, whether carrier or modulation, differ from their nominal values by not more than 1 part in 10,000,000. The second signals on the average have the same accuracy as the carrier frequencies. However, it should be pointed out that all time signals transmitted by radio are affected by the time of travel from the sending station to the receiving station, which varies to some extent because of what is popularly known as fading.

The 5, 10 and 20 mc/s serve broadcast stations and others concerned with radio transmissions, in adjusting their carrier frequencies. The 1000 c/s serves in testing audio equipment and in scientific investigations. The 440 c/s serves musicians since this is the international standard A above middle C pitch. Neither the second signals nor the modulations interfere in any way with the use of the carrier frequencies for their primary purpose.

These various time services, that is of the Naval Observatory, etc., in no way involve a duplication of effort. Each represents an effort to meet a distinctly different need and each is supplemental to the others.

REGULATION AND MEASUREMENT OF SPEED OF ROTATION

Near the beginning of this talk the statement was made that precise frequency determinations usually are the most difficult and most intriguing type of time measurement since in many cases they involve the maintenance of the frequency to be determined.

Those of you who are familiar with measurements in general know that the accuracy attainable in any measurement may be limited by a lack of constancy or definiteness of the quantity being measured. As an illustration consider the distance from the trunk of a tree to the tip of a branch which is being swayed by the wind. While the position of the tip at some particular instant might be noted and the distance from this position to the trunk measured, the result obtained very probably would differ considerably from the result which would be obtained by again noting the position of the tip of the branch and measuring the distance from this second position to the trunk of the tree. Obviously if the distance from the trunk to the tip of the branch is to be more or less dissociated from time some means must be provided for preventing the swaying.

If a measurement of the frequency of a rotating machine, that the number of revolutions per second over a more or less indefinite time instead of the number of revolutions in a particular second, one sixtieth of the number of revolutions in a particular minute or other time having an arbitrarily selected origin, is to be made to a specified accuracy, means must be provided for keeping the frequencies constant, at least within limits corresponding to the specified accuracy.

In the investigation referred to above and on which most of the members of my section in the National Bureau of Standards are devoting their major effort, it is necessary to determine the average speed of a rotation shaft as weighed in a particular way over successive 15-second intervals of time to one or two parts in 1,000,000, with a variable friction load amounting to about 1/3 horsepower. While this is a rather vague statement of the problem, a definite statement would require a discussion of the characteristics of some of the instruments used and the analysis of experimental data pertaining to parts of the investigation not being considered at this time. The solution obtained may be understood more readily by considering an analogy. Since the weighted average peripheral speed of one of the wheels mounted on the shaft is 44 miles per hour, it will be assumed that an automobile is kept at the rate of 44 miles per hour by the following procedure. Along the course to be followed by the automobile the distances to be covered in each 0.011 second are marked off. Also the distances to be covered in each 0.001 second are marked off. The former marks are for use in controlling and measuring the speed. The latter are for casual visual observations, just to see that the control is functioning properly. The operation is in semi-darkness and the clock used in the measurement flashes a lamp each thousandth second, illuminating the marks showing the distances to be covered each 0.001 second. If the control of the speed were perfect and the action of the clock were perfect persistence of vision would make these marks appear stationary. The arrangement constitutes what is generally known as a stroboscope.

The lines spaced at the distances to be covered each 0.011 second consist of electrically insulating paint on an otherwise electrically conducting road bed. Two brushes, placed adjacent each other and carried forward by the automobile, contact the road bed. These brushes are connected by wires to a mechanism which shifts the engine throttle between stops. When the throttle is set against one of the stops the power developed by the engine is not sufficient, while when it is set against the other stop it is in excess of that required to maintain the specified speed. Furthermore, each 0.001 second the clock used in measuring the speed applied an electromotive force to the circuit for approximately 0.0002 second. In case the brushes touch one of these insulating lines during the 0.0002 second time intervals it is an indication that the automobile is ahead of its schedule. This condition manifests itself by the appearance of an electrical potential difference between the brushes. The equipment is made sufficiently sensitive that should this potential difference continue for only 0.0001 second or even less it will cause the throttle to shift to the position at which the power developed by the engine is not sufficient to maintain the specified speed, or specified time distance schedule. A hundredth second later the throttle is automatically set to the other position, that is to the position at which an excess power is developed by the engine and after an additional thousandth second the cycle begins repeating itself, provided the automobile is still ahead of its schedule. However, if it is behind its schedule there is no electromotive force in the circuit during the time the brushes are insulated. Consequently the throttle is left in the position at which an excess power is developed. The throttle remains in this position until the automobile is again ahead of its schedule and the brushes are insulated during a part of the following time signal from the clock, when the throttle is shifted against the other stop. It will be noted that the power developed by the engine is always more or less than that which would maintain the time-distance schedule. There is no provision for supplying at each instant the amount of power which might be required in maintaining the schedule. Yet at no time is the automobile ahead or behind its schedule by as much as 0.0001 second or 0.1 inch from the place at which, according to the schedule, it should be. Furthermore, the automobile is alternately ahead and behind schedule four to six times each second, by approximately equal amounts.

From the brief description given above of the method of control there has been omitted an important element, namely time lags. It would not be possible to change the setting of the throttle from one stop to the other instantaneously. In addition, the time pick up from the clock is not continuous but only once each 0.011 second. Consequently there is a possibility of a time lag of from 0 to 0.011 second from this source. Time lags from other sources may amount to as much as 0.002 second.

A little consideration will show that without a stabilizing device time lags would cause the automobile to run alternately ahead and behind its schedule by ever increasing amounts until out of control.

(Illustrated by both hand operated and fully automatic demonstration apparatus.)

No precision clock has ever been made from which time can be picked up continuously while with moving mechanical parts it is not practicable to use an exceedingly large number of ticks per second, so it is not possible to eliminate the cause of the oscillation. However, if the time lags are not excessive, the amplitude and period of the oscillation may be stabilized but cannot be suppressed entirely.

To obviate this difficulty when the throttle is against the stop for which the power is excessive both stops are moved somewhat gradually in the direction reducing the power. Likewise, when the throttle is against the stop for which the power is deficient both stops are moved somewhat gradually in the direction increasing the power.

(That this results in stabilization illustrated by fully automatic demonstration apparatus.)

The problem under consideration is an almost exact duplicate of the imaginary one just considered except that only a relatively small space is required instead of miles and miles of clear roadway; the power is supplied by an electric motor or rather two electric motors instead of an automobile engine; the power is controlled by a grid tripping mercury vapor tube instead of a throttle; and stabilization is accomplished by an inductor instead of mechanical displacements.

To facilitate quick responses to changes in the load and in the potential difference of the power supply the number of mechanical parts operating independently of each other are reduced as far as possible. Excepting vibrations resulting from defects in the balance and other mechanical imperfections, the only mechanical movements in the entire system are the vibration of the quartz crystal of the clock and the rotation of parts rigidly connected to the shaft or in effect so connected.

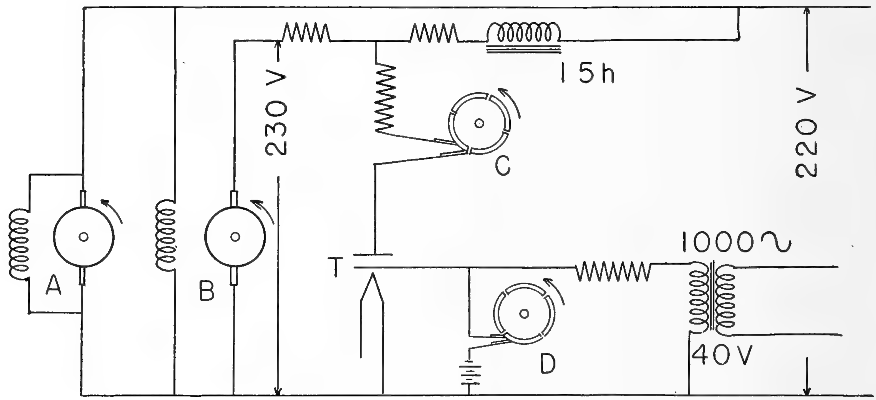


Fig. 8.—Drive circuit of direct current motor synchronized with alternating electromotive force.

The circuit arrangement, excepting the clock supplying the 1000 cycle per second control electromotive force and the stroboscope, is shown in figure 8. An important element of this circuit is the grid tripping mercury vapor tube designated T.

(A tube of this type shown and its action explained.)

A represents a motor supplying power in excess of the mechanical load. B represents a motor over excited so that it functions as a generator thus absorbing power from the rotating shaft. The amount of power absorbed from the shaft depends upon the current in the armature of the motor, B, and this in turn depends on whether the mercury vapor tube is in the conducting (ionized) or non-conducting (deionized) state and the current in the 1.5 henry inductor. The commutator C serves to break the circuit through the mercury vapor tube each 0.011 second for approximately 0.001 second, the time required for the tube to deionize. The commutator D in conjunction with the 1000 cycle per second control electromotive force serve to trip (that is ionize) the mercury vapor tube when the motor is ahead of its schedule.

The manner in which the potential on the grid of the mercury vapor tube varies during a small fraction of a revolution of the motor when it is a few hundred-thousandths of a second ahead of its schedule is shown in figure 9.

The manner in which the power supplied by the motor A exceeds the power absorbed by the motor B under normal operating conditions is shown in figure 10.

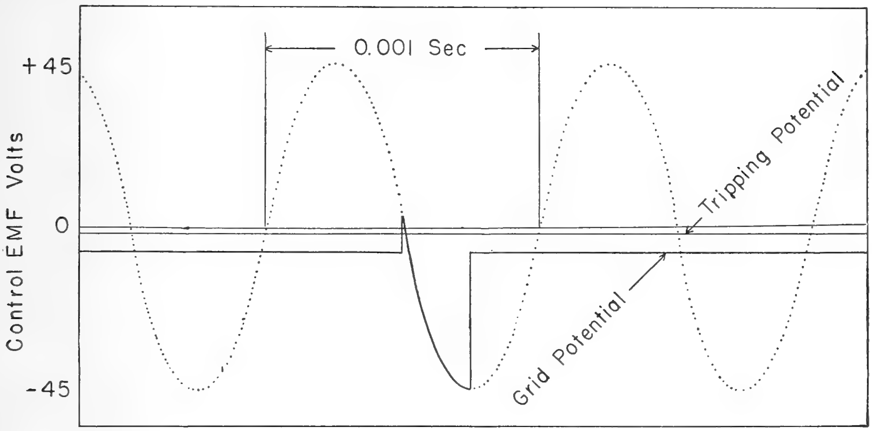


Fig. 9.—Action of time-up with motor slightly ahead of its schedule.

The apparatus was so designed that with a constant time lag of 0.01 second its operation would be stable and oscillate above and below the synchronous speed about 5 times per second. The period of oscillation is determined by time lags and electrical constants of the circuit. The amplitude of the oscillation is determined by the difference between the two amounts of power developed by the motors and the moment of inertia of the rotating system. The moment of inertia might be made so large that the amplitude of the oscillation would be exceedingly small. However, if the amplitude were exceedingly small to obtain positive operation it would be necessary that the time pick up from the clock be much more precise than 0.00001 second. Time pick ups to a precision of 0.000001 or even 0.00000001 second present no difficulties provided no mechanical movements are involved in the process. However, when they involve the use of mechanically operated contacts, 0.00001 second seems to be nearly the limit attainable.

It should be pointed that the comparison of the average angular speed of rotation of the shaft with the rate of vibration of the piezo-electric oscillator or crystal clock is made by a visual observation of the stroboscope to see that the equipment is functioning properly.

The performance of the clock is checked more or less continuously by those maintaining a group piezo-electric oscillators and determining their rates by comparisons with time signals from the Naval Observatory. Assuming no systematic errors in these time signals, the

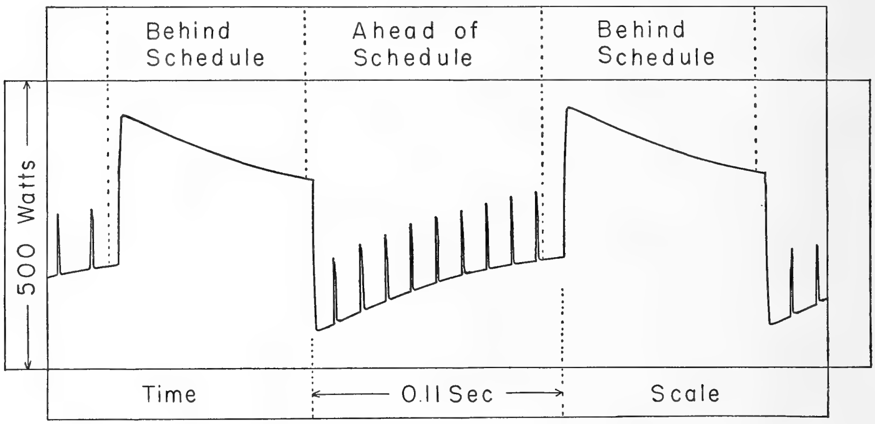


Fig. 10.—Variation of electric power supplied to direct current motor synchronized with 1000 cycle per second alternating electromotive force, under normal operating condition.

rate of the crystal clock used is known at all times to better than 1 part in 10,000,000, or about 1 second per year.

The equipment was not designed to give the highest attainable constancy of angular speed with a considerable variation in the mechanical load, but only a sufficient constancy to meet the requirements of the investigation in which it is being used. Some of you have seen the apparatus in operation and all of you are hereby invited to do so. It is expected that the apparatus will be kept in readiness for use or demonstration at almost any time during the next few years so you can see it more or less at your convenience.

In this talk on time measurements it has been possible merely to touch upon a few of what may be called high spots. No phase of the subject has been covered in detail. Furthermore, no reference has been made to measurement of the time two elastic bodies are in contact in case of collision, the design of extremely fast acting relays, and measurement of the time of their action, nor to the design of a machine gun control and measurement of the time of action of the component parts. These are mentioned now merely because it is customary for each of your presidents on retiring to give a fairly comprehensive report on his work (or what one has more aptly called explorations) in some particular field. Possibly at some future time I may be permitted to tell you something of the other component parts of the investigation mentioned at the beginning of this talk. While I have been a member of this society for slightly more than 30 years and am now (to some extent at least) being relieved of responsibility in connection with its management, I trust that you will not look upon me as a retired member.

BOTANY.—*New South American species of* Dryopteris, *section* Glaphyropteris.[1]

C. V. Morton, U. S. National Museum.

Glaphyropteris is entirely an American section of *Dryopteris*, distinguished from section *Lastrea* by the presence of aerophores at the base of the costae, and usually also of the costules. Six species are recognized by Christensen in his monograph of *Dryopteris*.[2] Recent South American collections have revealed four additional species. In order to relate these satisfactorily to those previously known, a key to all has been prepared. A few notes on the older species are given also, but the present treatment is not to be regarded as a critical revision of the section. The types of most of the species are not available for study, and the writer has accepted Christensen's identifications and delimitations, except for one variety here raised to specific rank. Since the citations and synonymy are easily available in Christensen's work, they are not repeated. All the specimens cited are in the U. S. National Herbarium, except the type of *Dryopteris tatei*.

KEY

Segments not ciliate; costae beneath puberulous with stellately fasciculate hairs; costae above short-pilosulous; auriculiform basal pinnae present; indusia present.

Segments entire or rarely crenulate toward apex; abortive basal pinnae numerous.

Leaf surface with red glands beneath .... 1. *D. stuebelii.*

Leaf surface without red glands beneath.

Segments obtuse; indusium pilosulous.

Costae minutely puberulous beneath; sori medial or inframedial *D. cañadasii*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 3, 1938.

[2] Dansk Vidensk. Selsk. Skr. VII. **10**: 157–161. 1913.

Costae pilosulous beneath; sori distinctly supramedial 3. *D. andina.*

Segments acute; indusium glandular; sori supramedial 4. *D. macradenia.*

Segments serrate; abortive basal pinnae few........5. *D. boliviensis.*

Segments long-ciliate; costae beneath puberulous or pilosulous with simple hairs; costae above antrorsely long-pilose; auriculiform basal pinnae absent; indusia absent.

Aerophores at base of costules absent...............6. *D. mapiriensis.*

Aerophores at base of costules present.

Costules with long, spinose hairs above.

Costae, costules, and veins minutely puberulous beneath, the hairs less than 0.25 mm long; red glands present ; veins 21–48 pairs.

Veins 29–48 pairs; segments 60 to 80 pairs; veins glabrous above 7. *D. decussata.*

Veins 21–27 pairs; segments about 50 pairs; veins with a few hairs above........................7a. *D. decussata* f. *velutina.*

Costae, costules, and veins long-pilose beneath, the hairs 0.5–3 mm long; red glands absent; veins 11–20 pairs.........8. *D. comosa.*

Costules glabrous above. Red glands absent.

Pinnae 5–7 cm wide, the segments 6–7 mm wide..9. *D. polyphlebia.*

Pinnae 2.5–4.5 cm wide, the segments 3.5–4 mm wide.

Receptacle elongate: veins of larger segments about 50 pairs, about 18 per cm............................10. *D. brasiliensis.*

Receptacle not elongate; veins 19–27 pairs, 12 to 15 per cm 11. *D. tatei.*

1. Dryopteris stuebelii Hieron.

The name *D. thomsonii* (Jenm.) C. Chr. used for this species by Christensen is a later homonym of *D. thomsonii* Kuntze and is consequently invalid. This species is common in Jamaica and is known also from Hispaniola. The South American specimens examined are:

Colombia: Road from Pamplona to Toledo, Dept. Norte de Santander, alt. 2800–3000 meters, *Killip & Smith* 19971. Eastern páramos of Guasca, toward Gachetá, *Ariste-Joseph* s. n.

2. Dryopteris cañadasii (Sod.) C. Chr.

Known definitely only from Ecuador. We have seen a specimen collected at Palmira by A. Mille at an altitude of 2600 meters. The following two collections perhaps represent forms of this species, but differ in smaller size and fewer veins: Monte Lirio, Río Chiriquí Viejo, Panama, *Seibert* 185; Mito, Peru, *Macbride & Featherstone* 1618.

3. **Dryopteris andina** Morton, sp. nov.

Rhizoma elongatum; stipites straminei, inermes, puberuli; lamina lanceolata, pinnis ligulatis (basalibus glanduliformibus numerosis), membranaceis, costa subtus pilosula, pilis stellato-fasciculatis, segmentis oblongis, rotundatis, eciliatis, integris, margine revolutis, supra scaberulis, subtus in costulis et venis puberulis, in mesophyllo eglandulosis; venae 14- vel 15-jugae, simplices; sori supramediales; indusia minuta, longe ciliata.

Rhizome elongate, sparingly palaeceous with large, flat, brown, dull, glabrous scales, the persistent stipe-bases about 10 cm long; fronds erect, about 1.4 m long, the stipes about 50 cm long, bisulcate on upper side, stramineous, not spiny, deciduously subappressed-puberulous, densely and persistently palaeceous at base, the scales large, dark brown, dull, glabrous, entire; blade lanceolate, about 90 cm long and 30 cm wide, the rachis puberulous with stellately fasciculate hairs; pinnae about 40 pairs, the basal 2 or 3 abruptly reduced (abortive glanduliform pinnae extending almost to base of stipe), alternate or subopposite, ligulate, up to 15 cm long and 2.3 cm wide, the costa above puberulous, beneath pilosulous with stellately fasciculate hairs, with longer hairs up to 0.5 mm long intermixed, bearing at base a slender aerophore about 6 mm long; segments about 40 below the subentire apex, 10–11 mm long, 2.5–3 mm wide, the apex rounded, the margin entire, not ciliate, revolute, the costules, veins, and leaf surface above sparingly scaberulous, the costules and veins beneath puberulous, eglandular, lacking aerophores at the base of the costules, the leaf surface with a few, scattered, simple hairs, not red-glandular; veins 14 or 15 pairs, simple; sori distinctly supramedial throughout and partially hidden by the revolute margins, the receptacle a little elongate; indusium persistent, minute, long-ciliate; annulus 15-articulate; spores about 44μ long.

Type in the U. S. National Herbarium, nos. 1,694,885–6, collected at Hacienda Sailapata, Department of Cochabamba, Bolivia, altitude 2800 meters, December, 1935, by M. Cárdenas (no. 3145).

Most nearly related to *D. cañadasii*, from which it differs in its pilosulous rather than closely puberulous costae and costules beneath, and in its distinctly supramedial sori.

4. Dryopteris macradenia (Sod.) C. Chr.

There is in the National Herbarium a specimen collected by Sodiro on the road from Quito to Manabi and labeled *Nephrodium macradenium* Sod., n. sp. It was collected, however, in 1903 and is therefore, not part of the type material. In fact, the specimen disagrees with the original description in having obtuse segments and inframedial sori, and is doubtless to be referred to *D. cañadasii*.

5. **Dryopteris boliviensis** Morton, sp. nov.

Stipites puberuli, mox glabrati, inermes; lamina oblongo-lanceolata, pinnis ligulatis (basalibus glanduliformibus paucis), membranaceis, costa subtus pilosula, pilis stellato-fasciculatis, segmentis anguste oblongis, rotundatis, eciliatis, medio serratis, margine revolutis, supra scaberulis, subtus in costulis et venis stellato-puberulis, in mesophyllo parce puberulis, parce rubroglandulosis; venae 18- vel 19-jugae, simplices; sori mediales; indusia persistentia, pilosula.

Frond about 1.5 m long, the stipe probably about 50 cm long, stramineous, puberulous, soon glabrate, not spiny, epaleaceous except at base; blade oblong-lanceolate, about 1 m long, about 46 cm wide, the rhachis pilosulous;

pinnae about 37 pairs, the basal ones a little reduced (abortive glanduliform pinnae one pair), alternate, ligulate, the larger 23 cm long and 3.6 cm wide, the costa pilosulous above, beneath pilosulous with stellately fasciculate hairs, the basal aerophores small; segments about 40 pairs below the subentire apex, narrowly oblong, up to 18 mm long and 3 mm wide, the sinuses broad, the apex rounded, the margins not ciliate, those of the larger segments serrate at the middle, subentire toward base and apex, slightly revolute, the costules, veins, and leaf surface scaberulous above, the costules and veins stellate-puberulous beneath, eglandular, the basal aerophores reduced to glands, the leaf surface with a few, short, simple hairs and a few, small, red glands; veins 18 or 19 pairs, simple; sori medial, the receptacle scarcely elongate; indusia persistent, pilosulous and glandular; annulus 13- or 14-articulate; spores about 45μ long.

Type in the U. S. National Herbarium, nos. 1,618,895–6, collected at Sailapata, Department of Cochabamba, Bolivia, altitude 2600 meters, January, 1935, by M. Cárdenas (no. 3077).

In its serrate segments, the present species differs from all other members of the section *Glaphyropteris,* in which the segments are entirely or rarely a little crenulate at apex. The few abortive glanduliform basal pinnae well distinguish it in its group.

6. Dryopteris mapiriensis Rosenst.

This Bolivian species is known only from the type collection, *Buchtien* 1131 from Mapiri, Bolivia. It is distinguished from all other members of *Glaphyropteris* by the absence of aerophores at the bases of the costules. The specimen of the original material in the National Herbarium is in poor condition.

7. Dryopteris decussata (L.) Urban.

This well known species is common in the West Indies. The continental specimens, from Costa Rica to French Guiana, Ecuador, and Peru, are mostly if not all to be referred to f. *velutina* (Sod.) C. Chr., which may represent a valid species.

8. **Dryopteris comosa** Morton, sp. nov.

Stipites brunnei, puberuli, plus minusve aculeati; lamina oblongo-lanceolata, pinnis ligulatis (basalibus glanduliformibus nullis), costa supra pilosa, subtus longe pilosa, eglandulosa, segmentis anguste oblongis, rotundatis, longe ciliatis, supra in costulis et venis hirtis, subtus longe pilosis, eglandulosis; venae 11–20-jugae, 16–18 per cm; sori proxima supramediales, ceteri inframediales, exindusiati.

Rhizome massive, erect; fronds few, 60–100 cm long, the stipes 19 to 50 cm long, brown, shining, minutely puberulous, somewhat spiny, sparsely paleaceous, the scales light brown, membranous, glabrous, entire; blade oblong-lanceolate, 43–58 cm long, 20–29 cm wide, the rhachis puberulous and long-pilose, the pinnae 27–30 pairs, subopposite below, alternate upwardly, the basal 2 pairs slightly or strongly reduced (auriculiform basal pinnae absent), all ligulate, the larger 17 cm long and 2.5 cm wide, the costae above antrorsely pilose, beneath long-pilose, the hairs 1–3 mm long, minute hairs and glands absent; segments about 40 pairs below the acuminate entire apex, narrowly oblong, 15 mm long or less, about 3.5 mm wide, the sinuses rather broad, the apices rounded, the margin ciliate, entire, the costules and veins above with long, stiff hairs, the costules and veins beneath pilose with long hairs, short hairs and glands absent; veins 11–20 pairs, simple, 16–18 per cm; sori supramedial toward base of segments, inframedial toward apex (immature in specimen examined).

Type in the U. S. National Herbarium, no. 1,694,884, collected at Dos de Mayo, Pichis Trail, Department of Junín, Peru, altitude 1700–1900 meters, July 3, 1929, by E. P. Killip and A. C. Smith (no. 25872).

This is a most distinct species, easily recognizable by its small size and few veins, and especially by the long, soft pubescence of the costae, costules, and veins beneath.

9. Dryopteris polyphlebia C. Chr.

Described from the Andes of Quito. It is found also at low altitudes in Costa Rica, but has not been recently collected.

10. **Dryopteris brasiliensis** (C. Chr.) Morton, comb. nov.

Dryopteris decussata var. *brasiliensis* C. Chr. Dansk. Vidensk. Selsk. Skr. VII. **10**: 161. 1913.

Stipe rather densely paleaceous, bearing numerous spinelike processes, long-pilose in lower part; larger pinnae ligulate, 37 cm long, 4.5 cm wide, the segments over 70 pairs, up to 23 mm long and 4 mm wide, the sinuses broad, the margins ciliate, the upper surface and veins glabrous, costae antrorsely pilose above, sparingly short-puberulous beneath with simple hairs, eglandular, costules and veins beneath pilosulous, eglandular, leaf surface beneath glabrous eglandular; veins of larger segments about 50 pairs, close, about 18 per cm; sori in well developed pinnae supramedial, exindusiate, the receptacle distinctly elongate.

Type collected at Joinville, State of Santa Catharina, Brazil, in 1906, by E. O. Müller (no. 103).

11. **Dryopteris tatei** Maxon & Morton, sp. nov.

Stipites parce aculeati, longe pilosi; lamina oblongo-lanceolata, pinnato-pinnatifida, pinnis ligulatis (basalibus glanduliformibus nullis), costa supra longe pilosa, subtus puberula, pilis simplicibus, segmentis integris, longe ciliatis, rotundatis, supra glabris, subtus in costulis pilosulis; venae 19–27-jugae, simplices, 12–15 per cm; sori mediales vel supramediales, exindusiati, receptaculo non elongato.

Stipe up to 1.3 m long, dark brown, deeply bisulcate on upper side, rather strongly paleaceous in lower half (the scales pale brown, dull, thin, lanceolate, about 5 mm long, entire, glabrous), bearing spinelike processes either in lower half or toward apex, conspicuously pilose in lower half, the hairs straight, slender, whitish, simple, eglandular; blade over 60 cm long, oblong-lanceolate, pinnate-pinnatifid, the rachis epaleaceous, closely but minutely puberulous; pinnae more than 20 pairs, subopposite, sessile throughout, ligulate, the larger 19 to 23 cm long and 2.5–3.5 cm broad, antrorsely curved, the lower retrorsely curved, scarcely reduced (basal auriculiform pinnae none), all pinnately parted to within 1 mm of midrib, at apex linear and entire, the costa long-pilose above, puberulous beneath, the hairs simple; segments nearly horizontal, 40–50-jugate in the lower pinnae, narrowly oblong, the larger 14–20 mm long, 3.5–4 mm wide, rounded at apex, slightly broadened at base, papyraceous, dull green, entire, glabrous above, ciliate with long, white hairs, the costules conspicuously pilosulous beneath, the leaf surface bearing a few scattered hairs; aerophore at the base of the pinnae 4–8 mm long, persistent, the aerophores at the base of the costules subulate, about 0.5 mm long; veins 19–27-jugate, simple, free, 12–15 per cm, elevated above; sori medial or supramedial, exindusiate, the receptacle not elongate; sporangia relatively few, non-setose, the annulus 15-articulate; spores about 50μ long.

Type in the New York Botanical Garden, collected at Ticunhuaya, Cordillera Real, Bolivia, altitude 1500 meters, Apr. 20–24, 1926, by G. H. H. Tate (no. 1068). Fragment and photograph in the U. S. National Herbarium.

The most nearly related species is *Dryopteris decussata* (L.) Urban, of the West Indies, Guiana and Venezuela, which may be distinguished as follows:

Veins 19–21-jugate, 12–15 per cm; segments broadened at base, not close, not over 40 pairs; pinnae 19–23 cm long, 2.5–3 cm wide; stipe conspicuously pilose in lower half; leaf surface eglandular, more or less hairy; sori medial, the receptacle not elongate; costules glabrous above . . . . *D. tatei.*

Veins 29–48-jugate, 17–23 per cm; segments hardly broadened at base, and therefore very close, sometimes even overlapping, 60–80 pairs; pinnae 25–45 cm long, 3–4.5 cm wide; stipe merely puberulous; leaf surface conspicuously red-glandular, glabrous; sori inframedial, the receptacle a little elongate; costules hairy above . . . . *D. decussata.*

From *D. brasiliensis* the present species differs in its medial sori, smaller pinnae with fewer, smaller segments, and especially its fewer, more distant veins. In *D. brasiliensis* the veins of the larger pinnae are about 50-jugate.

BOTANY.—*A new taxonomic arrangement of the orange subfamily, Aurantioideae.*[1] WALTER T. SWINGLE, Bureau of Plant Industry.

I have been for the past three years engaged in a study of the wild relatives of Citrus and have prepared a synopsis of the tribes, subtribes and genera. This synopsis represents a new classification made possible by a prolonged and detailed study of all obtainable material of the 33 genera now included in the Orange subfamily. Many botanical institutions in Europe, Asia, Australia, Brazil and the United States of America have made generous loans of herbarium material which were supplemented by extensive collections made by me in China, Japan and the Philippines as well as in the United States during the past 25 years. In addition, what is probably the largest single collection in the world of living plants belonging to the Orange subfamily representing 25 out of the 33 genera, has been assembled from

[1] Received November 3, 1938.

many parts of the Old World and is now found in the Citrus greenhouses of the Bureau of Plant Industry at Washington, D. C. Most of these wild relatives of Citrus are also growing vigorously in the subtropical regions of Florida and California.

The herbarium material has been studied by restoring the flower buds, flowers and young fruits to as near their original fresh condition as possible by prolonged treatment with hot water, dilute ammonia and, in some cases, dilute hydrofluoric acid; then by using a modification of Juel's[2] method, serial microtome sections were made, stained and mounted permanently on glass slides. With the skillful assistance of Dr. A. H. Tillson more than 100,000 such sections have been made and in many cases they have enabled me to bring to light important new characters that have permitted a rational and, I believe, natural classification of the Orange subfamily including Citrus and its wild relatives. The tribes, subtribes and the 10 groups of genera that compose the three subtribes of the tribe Citreae will be discussed in another paper to appear later.

A NEW CLASSIFICATION OF THE ORANGE SUBFAMILY, AURANTIOIDEAE

Tribe 1. Clauseneae

Subtribe 1. MICROMELINAE

1. *Micromelum* (9)

Subtribe 2. CLAUSENINAE

2. *Glycosmis* (35)
3. *Clausena* (29)
4. *Murraya* (10)

Subtribe 3. MERRILLINAE

5. *Merrillia**[3]

Tribe 2. Citreae

Subtribe 1. TRIPHASIINAE

6. *Wenzelia* (5) 7. *Monanthocitrus** 8. *Merope**	A *Wenzelia group.*
9. *Triphasia* (3) 10. *Pamburus**	B *Triphasia* group.
11. *Oxanthera* (3)	C *Oxanthera* group.
12. *Luvunga* (12) 13. *Paramignya* (14)	D *Luvunga* group.

Subtribe 2. CITRINAE

14. *Severinia* (8) 15. *Pleiospermium* (5) 16. *Burkillanthus** 17. *Limnocitrus** 18. *Hesperethusa**	A Primitive citrus fruit trees.

[2] Juel, H. O. *Beiträge zur Blütenanatomie und zur Systematik der Rosaceen*, in Kungl. Svenska Vet. Handl. **58**:1–81, figs. 1–135, Stockholm, 1918.

[3] Genera marked with an asterisk are monotypic, i.e., have only one species.

19. *Citropsis* (11) 20. *Atalantia* (9)	B Near-citrus fruit trees.
21. *Fortunella* (4) 22. *Eremocitrus** 23. *Poncirus** 24. *Clymenia** 25. *Microcitrus* (6) 26. *Citrus* (16)	C True citrus fruit trees.
Subtribe 3. BALSAMOCITRINAE	
27. *Swinglea**	A Tabog group.
28. *Aegle** 29. *Afraegle* (4) 30. *Aeglopsis** 31. *Balsamocitrus**	B Bael-fruit group.
32. *Feronia** 33. *Feroniella* (3)	C Wood-apple group.

Totals: 2 tribes, 6 subtribes, 33 genera, 201 species, and 15 varieties.

In connection with the reclassification of this subfamily some transfers of species from one genus to another, as well as some allocations of species to varietal rank (and vice versa) have been necessary. These transfers are listed below. Three new genera, eight new species and three new varieties were also discovered and named; one old species had to be given a new name. They are also listed in proper order, but will be published in another paper.

LIST OF NEW GENERA, NEW SPECIES, NEW VARIETIES AND NEW COMBINATIONS.[4]

3. **Clausena dentata** var. **dulcis** (Bedd.), n. comb.
 Cookia ? dulcis Beddome, in Madras Journ. of Lit. and Sci. **22**: 70, 1861.

4. **Murraya alternans** (Kurz), n. comb.
 Limonia ? alternans Wall., in Voigt, Hort. suburb. Calcut. p. 139, 1845. Nomen nudum.
 Limonia alternifolia ("Wall. ap. Voigt") Kurz, in Journ. Asiat. Soc. Bengal **42**: 64, 1873.
 Limonia alternans (Wall.) Hook. f., Fl. Brit. India **1**: 508, 1875.
 Limonia alternans Kurz, For. Flora Burma p. 192, 1877.
 M. glabra (Guill.), n. comb.
 Micromelum glabrum Guillaumin, in Lecomte, Not. Syst. **1**: 216, 1910.
 M. stenocarpa (Drake), n. comb.
 Atalantia stenocarpa Drake, in Morot, Journ. Bot. **6**: 277, 1892.

6. **Wenzelia grandiflora** (Lauterb.), n. comb.
 Citrus grandiflora Lauterbach, in Nova Guinea **8**: 293, 1910.
 W. melanesica, n. sp., Solomon Islands.
 W. melanesica var. **morobeana,** n. var., New Guinea.

9. **Triphasia Brassii** (White), n. comb.
 Paramignya Brassii White, in Journ. Arn. Arboret. **7**: 231, 1926.

[4] The genera in this list are numbered as in the preceding outline of the new classification.

13. **Paramignya scandens** var. **Ridleyi** (Burk.) n. comb.
Paramignya Ridleyi Burkill, in Gard. Bull. Str. Settlem. **5:** 214, 1931.
P. scandens var. **hispida** (Pierre), n. comb.
Atalantia hispida Pierre ex Guill., in Lecomte, Not. Syst. **1:** 182, 1910.
P. hainanensis, n. sp., Hainan Island.
P. cuspidata (Ridl.), n. comb.
Atalantia cuspidata Ridley, in Journ. Asiat. Soc. Str. Branch No. **82:** 174, 1924.
14. **Severinia buxifolia** var. **brachitica**, n. var., China (?) Cult.
S. disticha (Blanco), n. comb.
Limonia disticha Blanco, Fl. Filip. p. 356, 1837.
S. linearis (Merr.), n. comb.
Atalantia linearis Merrill, in Philip. Journ. Sc. **1** (Suppl. 3): 200, 1906.
S. paniculata (Warb.), n. comb.
Atalantia paniculata Warburg, in Engl. Bot. Jahrb. **13:** 340, 1891.
S. retusa (Merr.), n. comb.
Atalantia retusa Merrill, in Philip. Journ. Sci. **1** (Suppl. 3): 200, 1906.
S. trimera (Oliv.), n. comb.
Atalantia trimera Oliver, in Journ. Linn. Soc. **5** (Suppl. 2): 24, 1861.
S. Lauterbachii, nomen nov.
Atalantia litoralis Lauterbach (non Guill. 1913), in Nova Guinea **14:** 146, 1924.
15. **Pleiospermium sumatranum,** n. sp., Sumatra.
P. longisepalum, n. sp., Banguey Island.
P. latialatum, n. sp., North Bornea.
16. **Burkillanthus malaccensis** (Ridl.), n. gen. and n. comb.
Citrus malaccensis Ridley, Flora Malay Penin. **1:** 359, 1922.
17. **Limnocitrus littoralis** (Miq.), n. gen. and n. comb.
Paramignya littoralis Miquel, in Ann. Mus. Lugd. Bat. **1:** 211, 1864.
19. **Citropsis latialata** (De Wild.) Swing. and M. Kell., n. comb.
Limonia Poggei var. *latialata* De Wildeman, in Ann. Mus. Congo, Bot. 5 sér. **1:** 160, 1904.
C. Gilletiana Swing. and M. Kell., n. sp., Belgian Congo.
C. gabonensis var. **Gentiliana** Swing. and M. Kell., n. var., Belgian Congo.
C. Daweana Swing. and M. Kell., n. sp., Portuguese East Africa.
C. Tanakae Swing. and M. Kell., n. sp., Sierra Leone.
21. **Fortunella Hindsii** var. **chintou,** n. var., China, Japan.
24. **Clymenia polyandra** (Tan.), n. gen. and n. comb.
Citrus polyandra Tanaka, in Studia Citrol. **2:** 163, 1928.
25. **Microcitrus Maideniana** (Domin), n. comb.
Citrus Maideniana Domin, in Bibl. Bot. No. **89:** 297, 1927.
26. **Citrus celebica** var. **Southwickii** (Wester), n. comb.
Citrus Southwickii Wester, in Philip. Agr. Rev. **8:** 16, 1915.
C. macroptera var. **Kerrii,** n. var., Siam.

ENTOMOLOGY.—*The genus* Chramesus *Leconte in North America (Coleoptera: Scolytidae).*[1] M. W. BLACKMAN, Bureau of Entomology and Plant Quarantine. (Communicated by C. F. W. MUESEBECK.)

The scolytid genus *Chramesus* Lec., although not known to include any species of primary economic importance, is of considerable interest both from biological and from taxonomic standpoints. The North American members of the genus breed entirely in deciduous trees and shrubs, utilizing only material which is severely injured, decadent, or dead. So far as is known none of the species ever successfully attacks parts of hosts which are in a vigorous condition, although bark still green and moist is usually preferred. Trees which serve as hosts of species of *Chramesus* in the United States are the hickories, hackberry, locust, oak, and mimosa.

Taxonomically, *Chramesus* has no close relatives in North America and can be instantly recognized by the structure of the antennae alone. Blandford (3) briefly discusses the question of the relationships of *Chramesus* and believes the most natural grouping is to place it near *Phloeotribus* Latreille. He also points out certain similarities in antennal structure with the genus *Eulytocerus* Bldfd. described (1897) from Panama. While Blandford is probably right, the relationship to *Phloeotribus* and *Eulytocerus* appears to be by no means close.

In 1909 Hagedorn (7) described *Chramesus acuteclavatus* from Argentina. This species while not a true *Chramesus* is closely related to that genus, as is indicated by the attachment of the large antennal club to the five-jointed funicle by its superior margin, and by numerous other similarities. However, *acuteclavatus* is fundamentally different from all species of true *Chramesus* in several respects and must be removed from that genus. The United States National Museum contains a good series of several closely related species from Argentina and Bolivia and the new genus to which they belong will be treated in a forthcoming paper. These facts are mentioned here because the undescribed genus represented by *C. acuteclavatus* Hagedorn appears to be either in the direct line of descent of *Chramesus* or is an offshoot from this line of descent. Undoubtedly it is much more closely related than either *Phloeotribus* or *Eulytocerus* or any other genus known at present.

The probable relationships discussed above lead us to suspect a tropical or subtropical origin for the genus *Chramesus,* and this idea

[1] Received September 23, 1938.

receives added support from the fact that only two of the eight species known to occur in this country, *C. hicoriae* Lec. and *C. chapuisii* Lec., have been found farther north than Louisiana and Arizona. Even though we know comparatively little of the bark-beetle fauna of Central and South America, seven species of *Chramesus* have been described from those regions and there is reason to believe that a number of species at present unknown to science occur there.

Genus **Chramesus** Leconte

Chramesus Leconte, Amer. Ent. Soc. Trans. **2**: 168. 1868; Leconte, Amer. Phil. Soc. Proc. **15**: 374. 1876 (redescription); Blandford, Biol. Centr.-Amer., Coleoptera **4** (6): 169. 1897; Swaine, N. Y. State Mus. Bul. **134**: 88. 1909; Hagedorn, Genera Insectorum, Coleoptera, fasc. **111**: 66. 1910; Hopkins, U. S. Natl. Mus. Proc., **48**: 118. 1914; Swaine, Dominion Ent. Branch, Dept. Agr. Bull. **14**: 58. 1917; Blackman, Miss. Agr. Expt. Sta. Tech. Bull **11**: 50. 1922. Bruck, Bull. So. Calif. Acad. Sci. 35,141,123, 1936 (Genotype, *Chramesus hicoriae* Leconte, monobasic.)

Rhopalopleurus Chapuis, Mem. Soc. Sci. Liege, Ser. 2, **3**: 255. 1873. (Author's extract issued 1869 p. 46); Leconte, Amer. Phil. Soc. Proc. **15**: 374. 1876 (=*Chramesus*).

Body stout, oval, convex, ornamented with hairs, stout bristles, and scales; *head* with the beak very short; frons convex in the female, concave in the male; eyes elongate oval, entire; antenna with the scape long, the funicle 5-jointed, attached at the upper margin of the club, which is very large, flattened, and unsegmented; *pronotum* short, much wider than long, asperate on the sides of the disk, the posterior outline bisinuate, extended in the median area; dorsal outline of *elytra* oblique, with the declivity but slightly more arcuate, and the bases strongly crenate, the vestiture consisting of stout bristles and short scale-like hairs.

The genus *Chramesus* forms a very compact group, easily recognized from other more or less closely related genera by the characters given above. The antennal structure is especially distinctive, and alone serves to distinguish *Chramesus* from all other scolytid genera.

The antennal characters are also of value in dividing the genus into primary divisions. One group containing *hicoriae, asperatus, subopacus, canus,* and *gibber,* which has a very large, more slender antennal club and the scape with only a few hairs in either sex, is readily separated from the group containing *chapuisii, dentatus,* and *mimosae,* which has a smaller and broader antennal club, and has the scape in the male at least, ornamented with a beard of long hairs.

The further subdivision of the genus into species is dependent upon the size and proportions of the body; the shape, sculpture, and vestiture of the pronotum; the form, sculpture, and vestiture of the frons; the punctation and width of the striae; the vestiture of the interspaces, etc.

In addition to the North American species mentioned in an earlier paragraph which are later treated in detail, eight species have been described from outside the borders of the United States.

Chapuis (4), in 1869, described (*Rhopalopleurus*) *Chramesus tuberculatus, rotundatus,* and *pumilus* from New Grenada, Guadeloupe, and Teapa, Mexico, respectively.

Blandford (3), in 1897, described *Chramesus tumidulus* from Guatemala.

Hagedorn (7) in 1909 described *Chramesus globosus* and *C. acuteclavatus* from Argentina. The latter is not a *Chramesus.*

Stebbing (18) described *Chramesus globulus* from India in 1914. On the evidence furnished by the description and figures, it should be excluded from *Chramesus* and seems to be more closely allied to *Sphaerotrypes* Blandford.

Eggers (5) described *C. barbatus* from Mexico in 1930.

KEY TO THE NORTH AMERICAN SPECIES OF CHRAMESUS LEC.

A. Antennal scape without a tuft of long hairs in either sex; club very large, rather slender, more than 2.5 times as long as wide.

B. Pronotal disc opaque or subopaque, moderately to strongly asperate at the sides, the posterior margin moderately to strongly produced in median area.

C. Less than 2.0 mm long; pronotum with posterior margin rather strongly produced, median area of disc granulate-punctate, vestiture hairlike; elytral interspaces with median row of rather long, slender, erect bristles.

D. Pronotum less strongly sculptured; elytral striae slightly narrower, with fine, moderately close punctures; Eastern States, in *Hicoria*. . . . . *hicoriae* Leconte

DD. Pronotum more strongly sculptured; elytral striae wider, with the punctures closer and slightly coarser; Southwestern States, in *Robinia*. . . . . *asperatus* Schaeffer

CC. More than 2.25 mm long; pronotum with posterior margin moderately produced, median area of disc punctured, vestiture more scalelike; elytral interspaces with median row of bristles shorter and stouter.

D. Pronotum less than 1.3 times as wide as long; elytral striae very narrow, the punctures very fine and inconspicuous; frons in female without a median fovea. . . . . *subopacus* Schaeffer

DD. Pronotum more than 1.3 times as wide as long; elytral striae much wider, the punctures much coarser and distinct; the frons in female with a median fovea. . . . . *canus,* new species

BB. Pronotal disc shining, very sparsely asperate at the sides, the posterior margin rather weakly produced. . . . . *gibber,* new species

AA. Antennal scape with a tuft of long hairs in the male at least; the club smaller and broader, less than 2.25 times as long as wide.

B. Female frons with median fovea, scanty fine hairs, no epistomal tooth; male frons concave, with a tooth on each lateral margin; antennal scape with a tuft of long hairs in the male only; elytral interspaces wide and striae narrow. . . . . *chapuisii* Leconte

BB. Female frons with or without fovea, with a median epistomal tooth, the hairs stouter; male frons concave, with a median epistomal tooth and none at the sides; antennal scape bearded in the male or in both sexes; elytral interspaces narrower and striae wider.

C. Antennal scape bearded in the male only; female frons with a median fovea; vestiture concolorous........... *dentatus* Schaeffer

CC. Antennal scape bearded in both sexes; female frons devoid of a median fovea; vestiture bicolorous......... *mimosae*, new species

Chramesus hicoriae *Leconte*

Chramesus hicoriae Leconte, Amer. Ent. Soc. Trans. **2**: 168, 178. 1868; Felt, N. Y. State Mus. Mem. **8** (2): 448. 1906; Swaine, N. Y. State Mus. Bull. **134**: 88. 1909; Blackman, Miss. Agr. Expt. Sta. Tech. Bull. **11**, p. 50. 1922; Blackman, N. Y. State Col. Forestry Tech. Bull. **17**, p. 143. 1924 (biology); Leonard et al., Cornell Univ. Agr. Expt. Sta. Mem. **101**, p. 515. 1928.

Chramesus icoriae Leconte, Amer. Phil. Soc. Proc. **15**: 375. 1876; Hubbard & Schwarz, Amer. Phil. Soc. Proc. **17**: 666. 1878 (Michigan); Packard, U. S. Ent. Comn. 5th Rept., p. 296. 1890; Hopkins, W. Va. Agr. Expt. Sta. Bull. **31**, p. 140; **32**: 212. 1893; Hopkins, Canad. Ent. **26**: 280. 1895; Blandford, Biol. Centr.-Amer., Coleoptera Pt. 6, p. 170. 1897; Smith, Rept. Ins. N. J., p. 403. 1910; Swaine, Dominion Ent. Branch Dept. Agr. Bull. **14** (2), p. 58. 1918.

Rhopalopleurus lecontei Chapuis, Ext. Mem. Soc. Sci. Liege. (2), **3**, p. 46. 1869; Leconte, Amer. Phil. Soc. Proc. **15**: 375. 1876 (=*C. icoriae* Lec.).

Female.—Varying from brown to piceous black in color, with cinereous bristles and scales; 1.5 to 1.9 mm long, about 1.65 times as long as wide.

Frons flattened, subopaque to feebly shining, with an arcuate, feebly elevated line between the bases of the antennae, finely, rather obscurely punctured, with a few short, fine, reclinate hairs. *Eye* large, elongate oval, rather coarsely granulate, the inner line not emarginate. *Antenna* yellow, the scape long, slender, without long hairs; pedicel irregularly urn-shaped, enlarged ventrally; the club large, about 2.65 times as long as wide, with the 5-jointed funicle attached at its upper margin (Fig. 3).

Pronotum about 1.33 times as wide as long;[2] the posterior outline bisinuate, moderately produced in the median line; sides arcuate and strongly converging anteriorly, moderately broadly rounded in front, feebly, transversely impressed just behind front margin; surface subopaque, the disc moderately granulate-punctate in median area, the lateral areas rather strongly asperate; sides granulate-punctate; the entire surface moderately clothed with rather coarse, subreclinate, cinereous bristles, directed postero-mesially on the disc.

Elytra distinctly wider than pronotum, about 1.12 times as long as wide; the bases separately arcuate, the margins elevated and serrate; sides feebly arcuate, subparallel on the anterior half, broadly rounded behind; dorsal outline arcuate and obliquely descending from the base; the surface opaque; the striae narrow, impressed, moderately shining, with fine, moderately closely placed punctures; interspaces wider, subconvex, with a sparse median row of granules, from the base of each of which arises an erect, stout

[2] Measurements of the pronota of this and the other species were made from a point perpendicular to their centers. This is to avoid the variable foreshortening due to differences in the angle of vision.

bristle; sides of interspaces and intervals between granules finely punctured and bearing short, stout, reclinate scalelike hairs. Declivity oblique, arcuate, unmodified.

Male.—Similar in habitus but readily distinguished by the character of the frons, which has a strong concavity, longer than wide, and bordered on each side by a sharp elevated margin, usually with a sharp toothlike projection just below the level of each antennal insertion.

This species was described by Leconte from specimens obtained from hickory twigs in Pennsylvania. The writer has studied specimens from New York, New Jersey, Pennsylvania, Maryland, the District of Columbia, West Virginia, Virginia, North Carolina, Georgia, and Mississippi. It is also reported from eastern Canada by Swaine. All specimens studied were obtained from twigs of various species of *Hicoria*.

Chramesus asperatus Schaeffer

Chramesus asperatus Schaeffer, N. Y. Ent. Soc. Jour. **16**: 220. 1908. Bruck, Bull. So. Calif. Acad. Sci. **35**: 125. 1936.

Female.—Dark reddish-brown to piceous; 1.97 mm long, about 1.6 times as long as wide.

Frons feebly convex, transversely impressed below, arcuately elevated between the antennae, slightly flattened just above; surface moderately shining, very finely punctured, with inconspicuous, fine, short hairs. *Eye* narrow, elongate oval, moderately granulate, the inner line entire. *Antenna* testaceous, the scape long, slender, devoid of long hairs; the club nearly three times as long as wide (Fig. 2).

Pronotum obliquely descending from its base, actually 1.35 times as wide as long, but appearing shorter in dorsal view; posterior outline bisinuate, rather strongly extended at median line; sides arcuate and strongly converging anteriorly, moderately rounded in front, somewhat impressed just behind the front margin; surface rather shining, the disc asperate throughout except in the middle half of the median longitudinal line, which is slightly elevated, shining and devoid of punctures, hairs, and granules, the asperities stronger at the sides of the disc; sides granulate-punctate; the entire surface, except median line, clothed with thickened, semierect, cinereous bristles of medium length.

Elytra distinctly wider than pronotum, about 1.11 times as long as wide, the bases separately arcuate, the margins elevated and strongly serrate; the sides subparallel, moderately broadly rounded behind; dorsal outline arcuate, less oblique than in *hicoriae;* surface subopaque; striae rather narrow, distinctly impressed, the punctures fine and close; interspaces rather wide, subconvex, uniserially granulate-punctate, each with a median row of erect, stout bristles and at each side a row of small, rather narrow, reclinate scales. Declivity unmodified.

Male.—Pronotum more strongly, transversely impressed in front, the smooth median longitudinal line almost lacking, the front of the head shiny, broadly, rather deeply concave, with the margins rather sharply elevated and with a small tooth at each side opposite the insertion of the antenna.

Schaeffer described this species from a short series of specimens given to him by E. A. Schwarz, taken from a long series collected by H. G. Hubbard June 1–3, 1897, in Pine Canyon, Chiracahua Mts., Ariz. These were collected in the twigs of *Robinia neo-mexicana.* The parent series contains 127 additional specimens. This is a common species in the twigs of *Robinia neo-mexicana* in Arizona. The writer has studied several hundred specimens from the Kaibab National Forest, Williams, Prescott, Santa Catalina Mts., Chiricahua Mts., and Huachuca Mts. The species as usual shows considerable individual variation in the degree of development of the frontal and antennal structures, and many specimens show little or no indication of the smooth longitudinal line of the pronotum.

Schaeffer's cotypes of this species were presented to the U. S. National Museum by the Brooklyn Museum. One of these cotypes, a female, is selected as the lectotype and the preceding description was taken from it.

Type locality.—Pine Canyon, Chiracahua Mts., Ariz.

Host.—*Robinia neo-mexicana* Gray.

Lectotype female, 2 male paratypes.—U. S. N. M., No. 42486.

Chramesus subopacus Schaeffer

Chramesus subopacus Schaeffer, N. Y. Ent. Soc. Jour. **16:** 221, 1908. Bruck. Bull. So. Calif. Acad. Sci. **35:** 124. 1936.

Female.—Dark brown, almost black; 2.29 mm long, 1.66 times as long as wide.

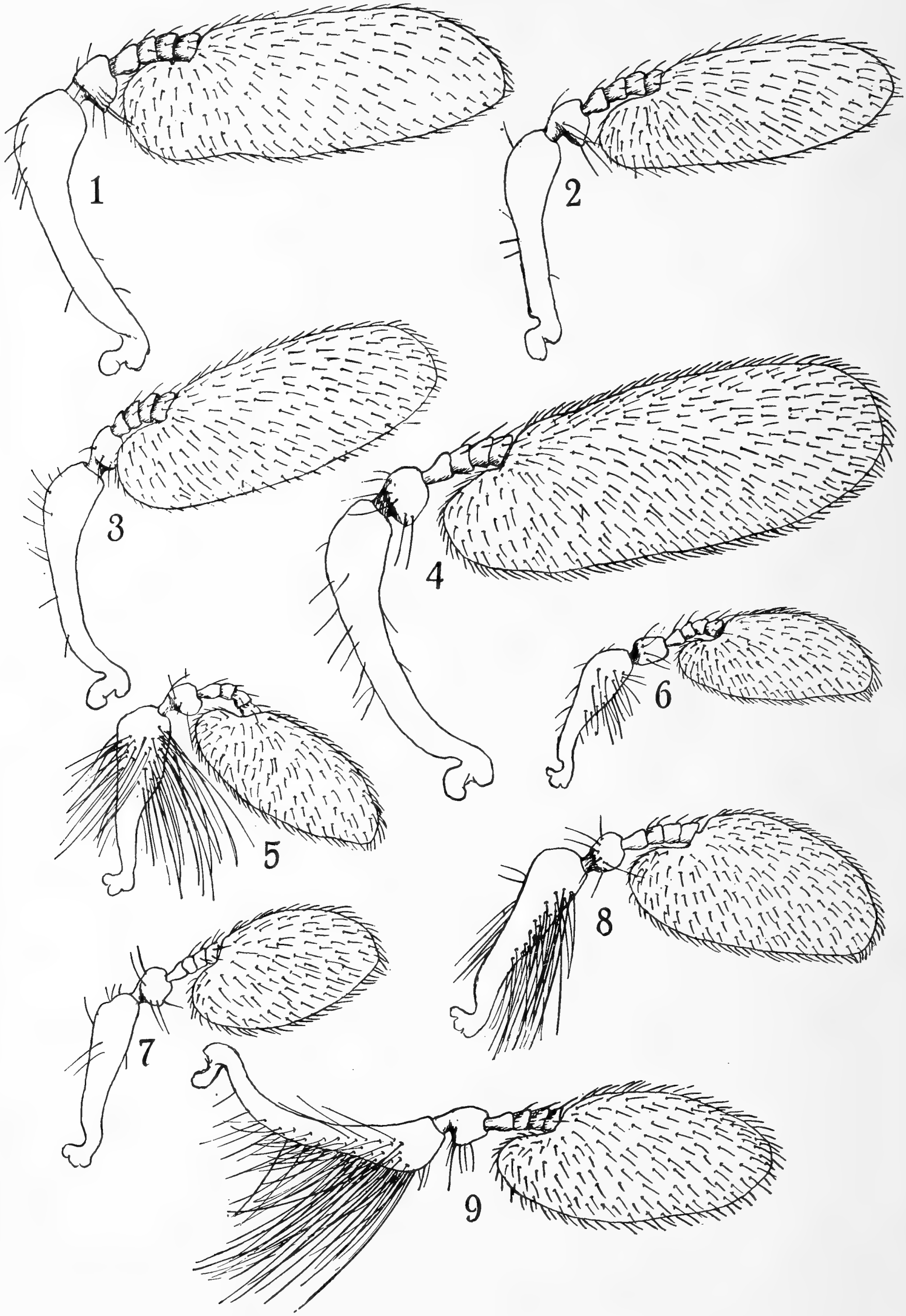
Frons convex, broadly transversely impressed below, with this broad impression bordered at each side by an elevated line; surface subopaque, finely granulate-punctate, with fine, short, inconspicuous, cinereous hairs. *Eye* large, elongate oval, coarsely granulate, the inner line entire. *Antenna* yellow, the scape long and slender, the pedicel with a protuberance; the club very large (Fig. 1), 2.70 times as long as wide.

Pronotum 1.28 times as wide as long, the posterior outline bisinuate, moderately produced in the median line, sides arcuate and strongly converging anteriorly, broadly rounded in front, transversely impressed just behind the front margin; surface subopaque, the disc granulate-punctate, more finely and closely than in *hicoriae,* the lateral areas more sparsely asperate; sides granulate-punctate; the entire surface clothed with appressed, cinereous scales varying from two to three times as long as wide.

Elytra distinctly wider than pronotum, about 1.12 times as long as wide; the bases separately arcuate, the margins moderately elevated, moderately serrate; sides subparallel on more than the basal half, very broadly rounded behind; dorsal outline more strongly arcuate and less oblique than in *hicoriae;* surface opaque; the striae very narrow, moderately strongly impressed, with very fine punctures, separated by as much as, or more than, their own diameter; interspaces much wider, feebly convex, with a median row of very fine punctures bearing suberect, spatulate bristles, the remainder of each interspace rather densely clothed with short, broad, appressed, cinereous scales. Declivity unmodified, the interspaces devoid of granules as on the disc.

Male.—Frons deeply concave, with the surface shining, very finely punctured, and with sparse, short, very fine, reclinate, cinereous hairs, the side of the concavity bordered by a raised margin which on the anterior half is very strongly elevated and extended to form a sharp ridge.

The writer has studied 30 specimens of this species, of which two specimens, a male and a female, are Schaeffer's cotypes received from the



Figs. 1–9.—For explanation see opposite page.

Brooklyn Museum. Twenty-eight additional specimens were bred from wood of *Celtis*, taken at San Antonio, and La Grange, Tex., by W. F. Fiske in 1907. The female cotype has been selected as the lectotype.

Type locality.—Huachuca Mts., Ariz.

Additional localities.—San Antonio and La Grange, Tex.

Host.—*Celtis.*

Lectotype female and 1 male paratype.—U. S. N. M., No. 42934.

Chramesus canus, n. sp.

Female.—Brown with grayish vestiture; 2.5 mm long, 1.66 times as long as wide. Closely allied to *Chramesus subopacus* Schaeffer.

Frons transversely impressed below, the impression bordered at each side by an elevated ridge, with an arcuate elevation between the bases of the antennae, convex above, with a distinct, large fovea in the median line just above the arcuate elevation; surface subopaque, very finely and closely granulate-punctate, with very fine, cinereous hairs, scarcely visible except in profile. *Eye* elongate oval, rather finely granulate, the inner line entire. *Antennal club* very large, 2.8 times as long as wide (Fig. 4).

Pronotum 1.3 times as wide as long; the posterior margin bisinuate, moderately produced in the median line; sides arcuate and converging strongly anteriorly, broadly rounded in front, feebly impressed behind the front margin; surface subopaque; disc with the median area finely, moderately closely punctate, scarcely granulate, the lateral areas more strongly asperate than in *subopacus;* sides finely granulate-punctate; the surface clothed with appressed scales which are rather more slender than in *subopacus.*

Elytra wider than pronotum, similar to *subopacus* in form and proportions, but with the basal margin more strongly elevated; the striae wider and with coarser punctures; the discal interspaces slightly flatter, each with a median row of fine granules and a row of suberect, spatulate, rather short bristles, inconspicuous except in profile; appressed scales large and rather slender.

Male.—Frons with the usual secondary sexual differences and differing from that of *subopacus* in the concavity being slightly narrower and deeper and the marginal ridge somewhat thicker.

Type locality.—Tallulah, La.

Host.—Unknown.

Holotype female, allotype, and 1 male and 1 female paratype.—U. S. N. M., No. 43841.

The holotype, allotype, and two paratypes bear the data—"Tallulah, La., 2–6–11; Hunter, No. 1984; G. D. Smith, Collector."

Chramesus gibber, n. sp.

Female.—Yellowish brown (immature); 2.0 mm long, 1.66 times as long as wide.

Fig. 1.—Antenna of *Chramesus subopacus* Schaeffer, male; Fig. 2.—Antenna of *C. asperatus* Schaeffer, female; Fig. 3.—Antenna of *C. hicoriae* Leconte, female; Fig. 4.—Antenna of *C. canus*, n. sp., female; Fig. 5.—Antenna of *C. mimosae*, n. sp., male; Fig. 6.—Antenna of *C. mimosae*, n. sp., female; Fig. 7.—Antenna of *C. dentatus* Schaeffer, female; Fig. 8.—Antenna of *C. dentatus* Schaeffer, male; Fig. 9.—Antenna of *C. chapuisii* Leconte, male.

Frons somewhat flattened, transversely impressed below, with an arcuate transverse elevation between the bases of the antennae; surface moderately shining, very finely punctured, and with very fine, short, inconspicuous hairs. *Eye* elongate oval, finely granulate, the inner margin entire. *Antenna* testaceous, the scape long and rather slender; the club moderately large, 2.36 times as long as wide.

Pronotum 1.34 times as wide as long, posterior outline bisinuate, weakly produced in the median region; sides arcuate, moderately strongly converging anteriorly, transversely impressed just behind the broadly rounded front margin; surface shining; median area of disc moderately punctured (more coarsely than in *hicoriae*) and without granules, lateral areas of disc sparsely, not strongly, asperate; sides moderately punctured; sides and disc rather sparsely clothed with rather short, stiff, moderately stout, semierect setae.

Elytra wider than pronotum, 1.07 times as long as wide; sides subparallel, broadly rounded behind; basal margins separately arcuate, strongly elevated and crenate; dorsal outline oblique, the declivity strongly arcuate; surface rather shining; the striae narrow, moderately impressed, the punctures deep, fine, separated by their own diameter or more; interspaces wide, weakly convex, devoid of granules, each with a median row of erect, spatulate bristles of moderate length, the surface sparsely clothed with rather slender, appressed scales. Declivity unmodified except that the strial punctures are finer and both striae and interspaces narrower.

Male.—Frons deeply, broadly concave, the side margins sharply elevated below, with a low tooth just mesad and ventrad of each antennal insertion; the antennal scape with a few hairs of moderate length not forming a tuft.

Type locality.—Cloudcroft, N. M.

Host.—*Robinia.*

Holotype female, allotype and 1 male paraytpe.—U. S. N. M., Mo. 43842.

The holotype, allotype, and paratype bear the data—"Hopk. U.S. 7208; W. F. Fiske, Collector; Cloudcroft, N. M., *Robinia.*"

Chramesus chapuisii Leconte

Chramesus chapuisii Leconte, Amer. Phil. Soc. Proc. **15**: 375. 1876; Schwarz, Ent. Amer. **2**: 54. 1886; Blackman, Miss. Agr. Expt. Sta. Tech. Bull. **11,** p. 51, 1922.

Female.—Piceous to black in color; 1.48 to 1.97 mm long, 1.7 times as long as wide.

Frons convex, transversely impressed below, with a transverse, arcuate elevation between the bases of the antennae, and with a small but distinct pit or fovea in the median line just above it; surface subopaque, reticulate, with rather sparse, very fine punctures and scanty, rather short, appressed hairs. *Eye* elongate oval, rather coarsely granulate, the inner line entire. *Antenna* testaceous, the scape rather long and slender, with a few hairs of moderate length; the club little more than twice as long as wide (Fig. 9).

Pronotum 1.33 times as wide as long; posterior outline bisinuate, not strongly extended at the median line; the sides arcuate, rather strongly converging anteriorly, very feebly transversely impressed, moderately broadly rounded in front; surface subopaque, disc granulate-punctate in the median area, the lateral areas moderately strongly asperate; sides finely granulate-punctate; vestiture on sides and disc consisting of cinereous, spatulate-hairs, the latter slightly more slender in median area of disc.

Elytra wider than pronotum, about 1.12 times as long as wide; the sides subparallel, moderately rounded behind; anterior margins separately arcuate, elevated and strongly crenate; dorsal outline not strongly oblique, moderately strongly arcuate on the declivity; surface subopaque; striae rather narrow, moderately impressed, with fine, closely placed punctures; interspaces about four times as wide as striae, feebly convex, each with a median row of erect spatulate hairs, rather densely clothed with small, nearly circular, appressed, cinereous scales, the first three interspaces with a sparse, median row of small granules.

Male.—Similar in size and habitus, but with the frons concave, bordered at each side by a distinct carina which is elevated to form a small, sharp tooth just ventrad of each antennal insertion; the antennal scape with a tuft of long cinereous hairs.

This species breeds in hackberry and occurs in the Southeastern States. The writer has studied specimens from Texas, Louisiana (the type locality), Mississippi, Florida, Maryland, Pennsylvania, and Kansas. The Maryland specimens are from Plummers Island. All specimens were taken from *Celtis.*

Chramesus dentatus Schaeffer

Chramesus dentatus Schaeffer, N. Y. Ent. Soc. Jour. **16:** 221. 1908. Bruck. Bull. So. Calif. Acad. Sci. **35:** 124. 1936.

Female.—Dark reddish brown, 1.74 mm long, 1.78 times as long as wide.

Frons feebly convex; surface reticulate, subopaque; finely, rather sparsely punctured, with short, stout, scalelike hairs; with a small, toothlike epistomal process, and above it, in the median line, a small fovea. *Eye* elongate oval, rather finely granulate, the inner margin entire. *Antenna* paler in color, the scape slightly widened distally, with a few rather short hairs, not forming a tuft; the club much smaller and wider than usual, scarcely twice as long as wide, the distal end subacute (Fig. 7).

Pronotum 1.22 times as wide as long, obliquely descending from the base; posterior outline bisinuate, scarcely extended in the median line; sides arcuate, converging anteriorly; moderately transversely impressed just behind the front margin; surface subopaque, disc with the median area granulate-punctate, elevated in the median line on the posterior half; lateral areas of disc sparsely, rather finely asperate; sides more shining, granulate-punctate; the entire surface clothed with small, subreclinate, scalelike, yellowish-brown hairs.

Elytra distinctly wider than pronotum, 1.2 times as long as wide; the sides subparallel, broadly rounded behind; anterior margins separately arcuate, elevated and finely crenate; dorsal outline only slightly oblique, strongly arcuate on the declivity; surface subopaque; striae wider than in any of the preceding species, rather feebly impressed, the punctures of moderate size, separated by less than their own width; interspaces narrower than in preceding species, subconvex, with a median row of small punctures, bearing short, stout, suberect bristles and with very small, appressed scales rather sparsely covering the interspaces and occasionally arising from the striae between the punctures.

Male.—Frons broadly, moderately deeply concave, with the margins not sharply elevated, the surface somewhat shining, finely reticulate, with sparse, fine punctures bearing appressed, moderately short, cinereous hairs; epistomal process elevated to form a sharp tooth; scape of antenna bearing a tuft of long hairs (Fig. 8).

The type series in the National Museum consists of three male cotypes and one female cotype bearing the data "Huach. Mts., Ariz." and the Brooklyn Museum Collection label. They were obtained from oak twigs girdled by *Oncideres quercus* Skinner. Three other specimens bear only the Brooklyn Museum labels, without further data, but seem to be mounted identically and probably are from the same original lot. The female cotype has been selected as the lectotype.

Type locality.—Huachuca Mts., Ariz.

Host.—*Quercus* sp.

Lectotype female and 3 male paratypes.—U. S. N. M., No. 42487.

Chramesus mimosae, n. sp.

Female.—Dark brown to piceous, with the elytra reddish brown basally; 1.57 mm long, 1.8 times as long as wide.

Frons flattened, very feebly concave between the eyes, the epistomal margin with a minute, sharp tooth; surface opaque, reticulate, with very fine punctures from which arise conspicuous, short, stout, appressed, scalelike, cinereous hairs; with a dense fringe of longer cinereous hairs extending from the epistomal margin nearly to the ends of the mandibles in front, and to about one-half of their length at the sides. *Eye* elongate oval, finely granulate, the inner line entire. *Antenna* testaceous, the scape moderately widened distally, with rather numerous moderately long hairs; the club scarcely more than twice as long as wide, the distal end subacute (Fig. 6).

Pronotum 1.25 times as wide as long, obliquely descending; posterior margin bisinuate, distinctly extended in the median line, sides arcuate, strongly converging in front of the center; moderately rounded in front and feebly transversely impressed just behind the front margin; surface opaque, feebly and sparsely asperate at sides of disc; median area very finely and rather closely punctured; entire surface clothed with closely placed, small, reclinate, cinereous, scalelike hairs.

Elytra wider than pronotum, about 1.23 times as long as wide; sides subparallel, rather broadly rounded behind; anterior margins separately arcuate, elevated and crenate; surface opaque; striae narrower than in *dentatus*, rather weakly impressed, the punctures fine and close; interspaces moderately wide, feebly convex, each with a sparse median row of moderately long, spatulate, cinereous bristles and rather closely arranged, appressed scales which are cinereous on the first interspace and on the sides and anterior disc, but light brown on second to fourth interspaces from basal third nearly to apices of elytra, the scales slightly larger and more slender than in *dentatus;* strial punctures at the sides larger than on the disc, interstrial bristles less numerous.

Male.—Frons broadly and rather deeply concave, with margins moderately but not sharply elevated, surface subopaque, reticulate, ornamented with appressed, cinereous hairs; epistomal margin with a small, sharp tooth; scape of antenna with a tuft of longer hairs (Fig. 5) much larger than in female.

Type locality.—Brownsville, Tex.

Other locality.—Monterrey, Mexico.

Host.—Mimosa (*Leucaena pulverulenta*)

Holotype, allotype, and 638 paratypes.—U. S. N. M., Mo. 52803.

The holotype, allotype and 637 paratypes were collected and bred from mimosa (*Leucaena pulverulenta*) at Brownsville, Tex., by H. S. Barber. A single paratype bears the labels "Monterrey, Mexico, 25.11; E. A. Schwarz collector."

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Obituary

WILLIS RAY GREGG, meteorologist and late Chief of the Weather Bureau, died in the Blackstone Hotel at Chicago, Ill., on Sept. 14, 1938. Dr. Gregg was born at Phoenix, New York, January 4, 1880. He received the B.A. degree from Cornell University in 1903, and was awarded the honorary degree of Sc.D. in 1937 by Norwich University. He entered the Weather Bureau on March 1, 1904 at Grand Rapids, Michigan. At the research laboratory at Mt. Weather, Va., where he served for seven years, he took part in important studies dealing with the upper air. In 1914 he was called to Washington, D.C. where he was Assistant Chief and later Chief of the Aerological Division, which not only promoted and carried out many technical studies pertaining to meteorology but was charged also with the problem of giving an adequate meteorological service to aviation which was in process of extremely rapid development and expansion.

This training and experience coupled with an untiring devotion to duty, equable temper, an inherent sense of fairness and keen mind, well-equipped him for the important position of Chief of the Weather Bureau to which he was appointed in January 1934. There is little doubt that his untiring devotion to the responsibilities of his office contributed to his untimely demise.

He was a member of the National Advisory Committee for Aeronautics, the International Meteorological Organization, the Guggenheim Committee on Aeronautical Meteorology, and other organizations including the Royal Meteorological Society, the American Meteorological Society, the Washington Philosophical Society, The Washington Academy of Sciences, the American Geophysical Union and fellow of the American Association for the Advancement of Science. His relation with some of these organizations was not a passive one for he served the American Meteorological Society as Treasurer and President, the Washington Philosophical Society as Treasurer, and the Geophysical Union as Chairman of the Section on Meteorology.

He was the author of a number of technical articles and in addition was author of *The Standard Atmosphere*, *Aerological Survey of the United States*, and *Aeronautical Meteorology*.

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An * denotes the abstract of a paper before the Academy or an affiliated society.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

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