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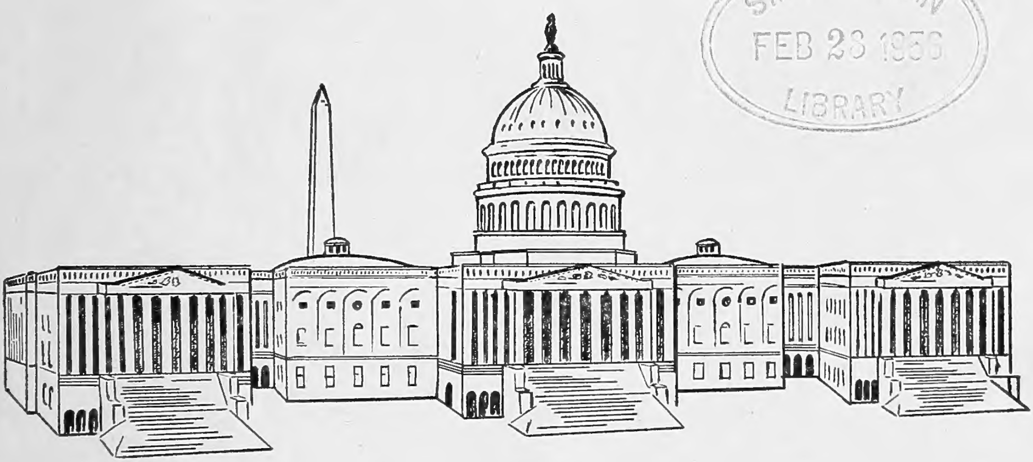

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EDITORIAL

The work of an editor is not only to read papers, accepting some and tactfully rejecting others, but also to improve the service rendered to both readers and authors. My previous editorial (June 1955) was addressed primarily to readers. These remarks are directed to authors.

The cost of publication, especially of scientific material, has increased tremendously in recent years. The Academy has been spending a large part of its income to subsidize publication of the results of scientific research, by paying direct printing expenses and supplying reprints at less than actual manufacturing cost. Early this year a cost accounting resulted in raising the price of reprints to approximately their cost. A strong protest was raised, but our Ways and Means Committee was already in action and had made some progress. An arrangement has now been completed whereby papers can be reprinted at less cost, by starting each paper on a new page. This will sometimes threaten large blank spaces; but your editor will endeavor to avoid this by inserting quotations or other material. Such extraneous matter will not appear in reprints. The new price schedule for reprints is given on the inside front cover of this issue.

Unfortunately, no rearrangement of layout will reduce the printing cost of the papers themselves. Many scientific journals offer authors' institutions the opportunity to partially defray this cost by honoring page charges. Publication of results is a vital part of any research project, and publication cost should be considered part of the research cost. Organizations financing research should not depend on private charity for dissemination of results. The Board of Managers of the Academy has therefore established a *voluntary* publication charge; it is hoped that our local scientific institutions, both private and governmental, will be able to honor this charge and thereby further the interchange of information among the various fields represented by the Academy.

SIXTEEN YEARS AGO

The following item appeared in the July 1939 issue of this Journal:

The 1148th meeting was held in the Cosmos Club Auditorium, Saturday, March 11, 1939, President Brickwedde presiding.

Program: Richard B. Roberts, Department of Terrestrial Magnetism of the Carnegie Institution: *The splitting of uranium and thorium nuclei by neutrons.*—Several years ago Fermi and collaborators observed that artificial radioactivity is induced when uranium is bombarded by neutrons. Recently Hahn and Strassman have shown by chemical methods that among the radioactive elements produced are barium, cerium, and lanthanum. This observation was explained by Meitner and Frisch as a fission of the uranium nucleus into two roughly equal parts with approximately 200 million electron-volts of energy released in the process. This theory was soon confirmed by observing the ionization produced by these heavy and highly energetic particles. Neutrons were also found to be emitted in this fission process and these neutrons might conceivably lead to an exothermic chain-reaction. However, it appears very probable that separated isotopes of uranium in large quantities would be necessary to sustain such a chain-reaction.

PHYSICS.—*Effect of defects on lattice vibrations, II: Localized vibration modes in a linear diatomic chain.*[1] P. MAZUR, E. W. MONTROLL, and R. B. POTTS,[2] University of Maryland.

INTRODUCTION

The influence of defects or local disturbances in otherwise regular media is a subject of great current interest in physics. The electrical properties of semiconductors are mainly due to impurity levels from which electrons can easily be excited into a conducting state. The interaction of elementary particles is the result of the manner in which their existence disturbs the field of the vacuum or "ether."

In a previous publication,[3] hereafter referred to as I, a discussion was given of the effect of defects on the vibrations of monatomic crystal lattices. Generally all motions of a lattice can be expressed as linear combinations of normal modes of vibration. In a regular lattice these normal or collective modes are plane waves. Generally normal modes of all frequencies in a certain continuum band or range exist. The lattice propagates driven oscillations whose frequencies lie in this band. But frequencies which are outside of it are damped out in a short distance. The higher the frequency of such an oscillation the shorter the distance required for a given degree of damping. The motion of various atoms contributes equally to the component of a thermodynamic quantity (say free energy or heat capacity) derived from a particular mode.

It was shown that certain types of defects in a crystal lattice give rise to localized normal modes whose associated atomic motions are concentrated in those atoms that are near the defects. The corresponding vibrational frequencies form a discrete set, which is displaced out of the continuum of frequencies of the perfect crystal. The atoms that participate in localized modes are responsible for more than their share of the internal energy of the crystal. Hence the region around the defect is equivalent to a "hot spot" in the lattice. A localized mode (either in the interior or on the surface of a crystal) might catalyze physical and chemical processes which would not normally occur at the existing temperature of the crystal. Local surface defect modes might also excite molecules adsorbed on the surface by having a frequency almost equal to a vibrational frequency of the adsorbed molecule.

It was also pointed out in I that attractions or repulsions occur between defects. These are due to both the localized modes and to the slight displacements which occur in all the lattice frequencies. We shall show in another paper that the pair theory of nuclear forces is essentially equivalent to the continuum limit of the interaction between two holes in a crystal lattice.

It is the purpose of the present paper to discuss the effect of defects in a linear alternating diatomic lattice. Although the general method developed in I is used, the diatomic lattice introduces several new features such as the well-known splitting of the frequency band into two bands, the acoustical and the optical, separated by a gap of forbidden frequency levels. It is necessary to cover a wide range of masses since in the alkali halides, for example, the mass difference may vary from as little as 1 or 2 per cent to as great as a factor of 20.

Our results are analogous to those of Saxon and Hutner[4] and Koster and Slater[5] for localized wave functions and impurity levels in semiconductors.

PERFECT LATTICE

Consider a chain of $4N + 1$ particles of masses either m or M arranged alternately such that those at the ends are of mass m. Let each particle be connected to its nearest neighbor by a spring of stiffness γ. The equations giving the $4N - 1$ normal modes of longitudinal vibrations of the chain are

[1] This research was supported by the United States Air Force through the Office of Scientific Research of the Air Research and Development Command.

[2] On leave from the University of Adelaide, South Australia.

[3] MONTROLL, E. W., and POTTS, R. B., Phys. Rev. **100:** 525. 1955.

[4] SAXON, D. S., and HUTNER, R. A., Philips Research Reports **4:** 81. 1949.

[5] KOSTER, G. F., and SLATER, J. C., Phys. Rev. **95:** 1167. 1954.

$$
\begin{aligned}
&m\omega^2 u(n) \\
&\quad + \gamma[u(n+1) - 2u(n) + u(n-1)] = 0 \\
&\qquad n = 0, \pm 2, \cdots, \pm(2N-2) \\
&M\omega^2 u(n) \\
&\quad + \gamma[u(n+1) - 2u(n) + u(n-1)] = 0 \\
&\qquad n = \pm 1, \pm 3, \cdots, \pm(2N-1) \\
&\qquad\quad u(2N) = u(-2N) = 0
\end{aligned}
\tag{2.1}
$$

where ω is the normal frequency and $u(n)$ the displacement of the nth particle from its equilibrium position. We have postulated the end particles to be fixed. The solutions of these equations are

$$
\begin{aligned}
u_j(n) &= A \sin(2N+n)\varphi_j \qquad n \text{ even} \\
u_j(n) &= B \sin(2N+n)\varphi_j \qquad n \text{ odd}
\end{aligned}
\tag{2.2}
$$

with

$$\varphi_j = j\pi/4N \quad j \text{ an integer} \tag{2.3}$$

and

$$\frac{A}{B} = \frac{2\gamma - M\omega^2}{2\gamma \cos\varphi_j} = \frac{2\gamma\cos\varphi_j}{2\gamma - m\omega^2} \tag{2.4}$$

There are $2N$ symmetric (i.e., $u(-n) = u(n)$) modes with frequencies given by

$$
\begin{aligned}
\left(\frac{mM}{\gamma}\right)\omega_\pm^2 &= m + M \\
&\quad \pm(m^2 + M^2 + 2mM\cos 2\varphi_j)^{\frac{1}{2}}
\end{aligned}
\tag{2.5}
$$

or

$$
\begin{aligned}
&\left(\frac{2mM}{\gamma}\right)^{\frac{1}{2}}\omega_\pm \\
&\quad = [m + M + 2(mM)^{\frac{1}{2}}\sin\varphi_j]^{\frac{1}{2}} \\
&\quad \pm[m + M - 2(mM)^{\frac{1}{2}}\sin\varphi_j]^{\frac{1}{2}}
\end{aligned}
\tag{2.6}
$$

where

$$\varphi_j = j\pi/4N, \qquad j = 1, 3 \cdots, 2N-1. \tag{2.7}$$

Also there are $2N - 1$ antisymmetric (i.e., $u(-n) = -u(n)$) modes, with frequencies given by (2.5) and (2.6) with

$$\varphi_j = j\pi/4N, \quad j = 2, 4, \cdots, 2N-2 \tag{2.8}$$

and in addition the frequency given by

$$\left(\frac{2mM}{\gamma}\right)^{\frac{1}{2}}\omega_- = 2(m)^{\frac{1}{2}} \quad \text{for} \quad m < M \tag{2.9}$$

or

$$\left(\frac{2mM}{\gamma}\right)^{\frac{1}{2}}\omega_+ = 2(M)^{\frac{1}{2}}. \quad \text{for} \quad m > M \tag{2.10}$$

In the unusual terminology, the frequencies

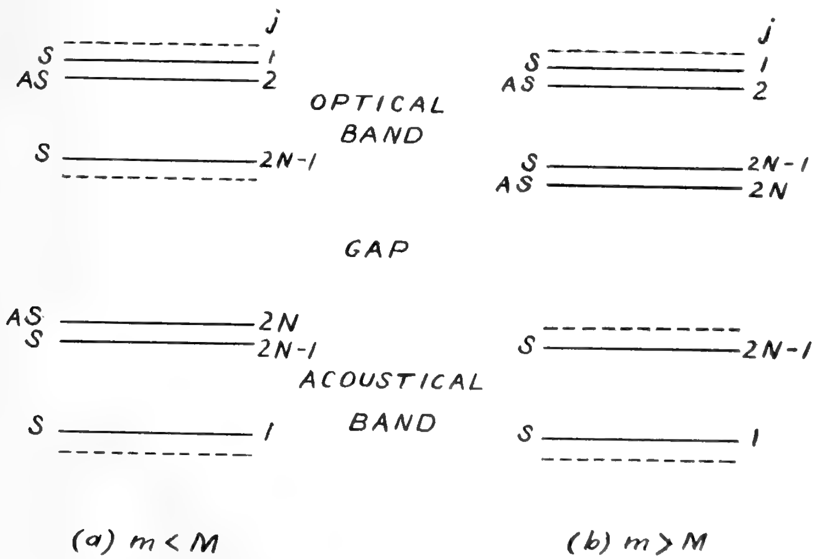
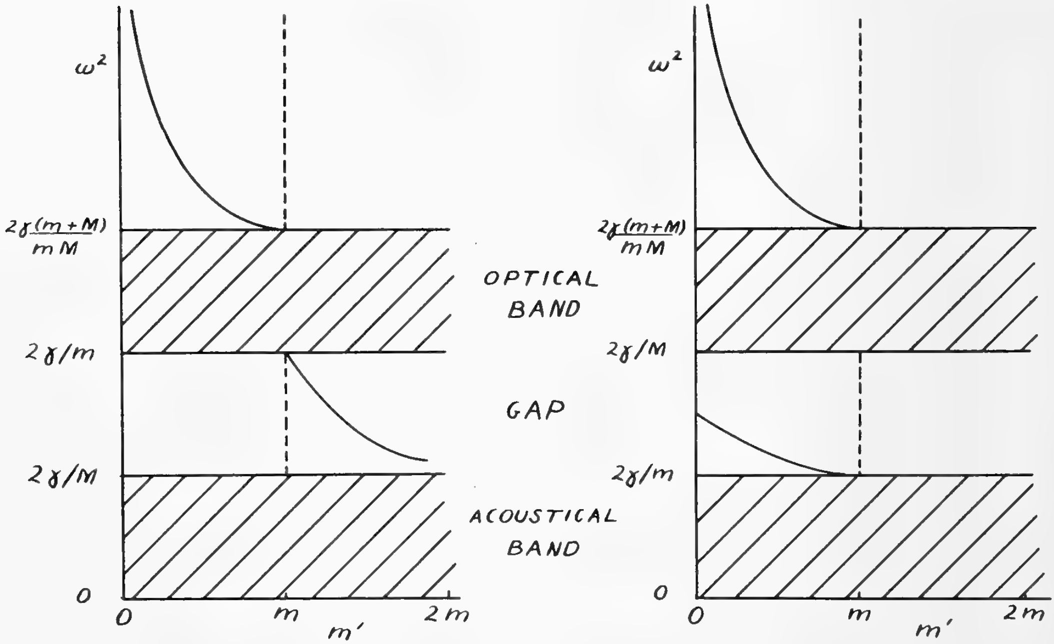


FIG. 1.—Normal frequency levels for the vibrations of a perfect alternating lattice. S = symmetric modes; AS = antisymmetric modes.



(a) $m < M$ (b) $m > M$

FIG. 2.—Plot of ω^2 versus defect mass m' for frequencies that emerge from the bands

ω_+ form the optical band and the ω_- the acoustical band (see Fig. 1). Note that in both cases a level at the top of the optical band, viz.,

$$\left(\frac{2mM}{\gamma}\right)^{\frac{1}{2}} \omega_L = 2(m + M)^{\frac{1}{2}} \tag{2.11}$$

and the level $\omega = 0$ at the bottom of the acoustical band are missing.

ONE ISOTOPIC DEFECT

(a) *Effect on the frequency levels*

We now consider the effect of replacing the central particle of mass m by one of $m' = (1 - \varepsilon)m$. Four possibilities will be considered since m' may be greater or less than m and m may be greater or less than M. The only change in the fundamental equations (2.1) is that the equation for $n = 0$ is replaced by

$$\begin{aligned}(1 - \varepsilon)m\omega^2 u(0)& \\ + \gamma[u(1) - 2u(0) + u(-1)] &= 0\end{aligned} \tag{3.1}$$

The $2N - 1$ antisymmetric modes of the perfect lattice, since they force $u(0) = 0$, are unchanged by the change in the mass of the central particle. Hence the only alteration is to the symmetric modes. This observation enables one to predict the effect of the isotope on the frequency levels; for noting that reduction of the mass increases the frequencies and vice versa one can predict that for $m' < m < M$ the top S level will rise out of the optical band but for the acoustical band the top S level cannot rise above the AS level above it; for $m < M$ and $m' > m$ the S levels are lowered and the bottom S level of the optical band falls into the gap. For $m > M$ and $m' < m$ one level raises out of the optical band and another from the acoustical band and for $m' > m > M$ no levels come out of the bands (see Fig. 2). These predictions are confirmed from the following detailed analysis.

Since we are concerned only with the symmetric modes we try for the solution of (3.1)

$$\begin{aligned} u(n) &= A_1 \sin(2N \mp n)\varphi \\ n &= 0, \pm 2, \cdots, \pm(2N - 2) \\ u(n) &= B_1 \sin(2N \mp n)\varphi \\ n &= \pm 1, \pm 3, \cdots, \pm(2N - 1) \end{aligned} \tag{3.2}$$

Apart from the connecting equations we get, as before,

$$(m\omega^2 - 2\gamma)(M\omega^2 - 2\gamma) - 4\gamma^2 \cos^2 \varphi = 0 \tag{3.3}$$

and the connecting equation with $n = 0$ is

$$(1 - \varepsilon)m\omega^2 A_1 \sin 2N\varphi + \gamma[2B_1 \sin (2N - 1)\varphi - 2A_1 \sin 2N\varphi] = 0 \tag{3.4}$$

or using (2.4)

$$[(1 - \varepsilon)m\omega^2 - 2\gamma][M\omega^2 - 2\gamma] - 4\gamma^2 \sin (2N - 1)\varphi \cos \varphi = 0.$$

Use of (3.3) then gives the characteristic equation

$$\cot 2N\varphi - \varepsilon \operatorname{cosec} 2\varphi \, K_{\pm} (\varphi) = 0 \tag{3.5}$$

with

$$K_{\pm}(\varphi) = [M + m \cos 2\varphi \pm (m^2 + M^2 + 2mM \cos 2\varphi)^{\frac{1}{2}}]/m \tag{3.6}$$

the solutions of which are to be inserted into (3.3) to give the required frequencies. It can be easily verified that for the special case $M = m$ the equation (3.5) reduces to that considered in I (see eq. A.8). The solution of (3.5) can be investigated from the graphs of $\cot 2N\varphi$ and of

$$f_{\pm}(\varphi, \varepsilon) = \varepsilon \operatorname{cosec} 2\varphi \, K_{\pm}(\varphi). \tag{3.7}$$

For the case $m < M$ these graphs are sketched in Fig. 3.

For $m' < m$ or $\varepsilon > 0$ one intersection of the f_+ curve with the $\cot 2N\varphi$ curve is "lost" or is given by $\varphi = i\psi$ and this corresponds to the discrete frequency rising from the top of the optical band. For $m' > m$ or $\varepsilon < 0$ the "intersection" $\varphi = \pi/2 + i\psi$ corresponds to the discrete frequency falling into the gap from the optical band. This is as illustrated in Fig. 2.

For the case $m > M$ the graphs are sketched in Fig. 4. For $m' < m$ or $\varepsilon > 0$ the intersection on f_+ at $\varphi = i\psi$ corresponds to the discrete level emerging from the top of the optical band and that of f_- at $\varphi = \pi/2 + i\psi$ to the level emerging from the top of the acoustical band. For $m' > m$ or $\varepsilon < 0$ there are no discrete levels; this is as illustrated in Fig. 2.

(b) *Evaluation of the discrete frequencies*

The discrete frequencies can be calculated for the limiting case $N \rightarrow \infty$. For the intersection $\varphi = i\psi$ equation (3.5) becomes with

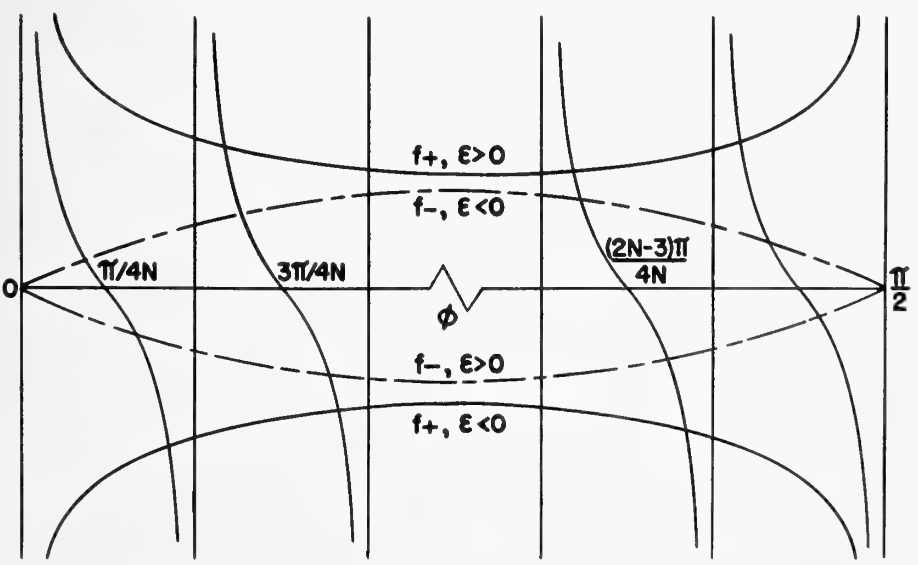


FIG. 3.—The graph of the function $f_{\pm}(\varphi,\varepsilon)$ with $m < M$ given by (3.7) and $\cot 2N\varphi$. The intersections give the solutions of (3.5).

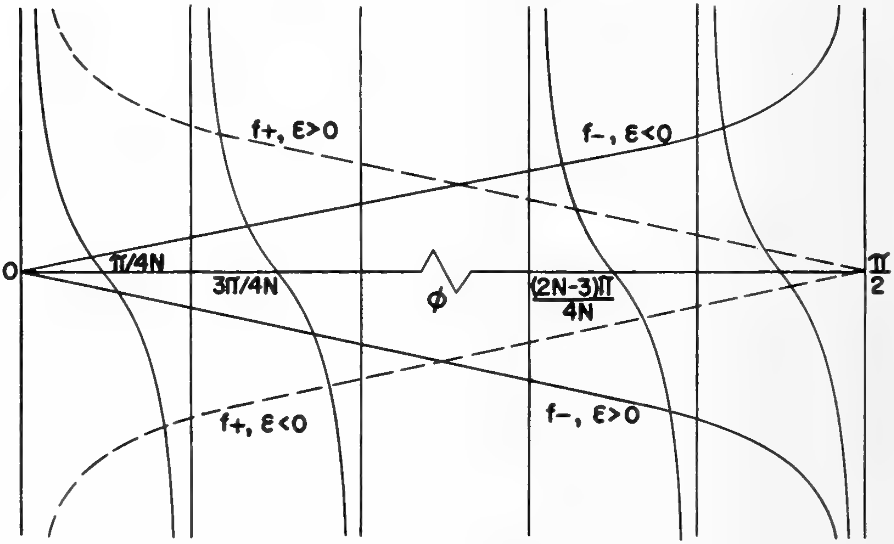


FIG. 4.—The graph of the function $f_{\pm}(\varphi,\varepsilon)$ with $m > M$ given by (3.7) and cot $2N\varphi$. The intersections given the solutions of (3.5).

$\coth 2N\psi \to 1$ as $N \to \infty$

$$m - \varepsilon \operatorname{cosech} 2\psi[M + m \cosh 2\psi \pm (m^2 + M^2 + 2Mm \cosh 2\psi)^{\frac{1}{2}}] = 0 \qquad (3.8)$$

or

$$(1 + \varepsilon^2) \sinh 2\psi - 2\varepsilon \cosh 2\psi = 2\,\varepsilon\, M/m \qquad (3.9)$$

For the level emerging from the top band (i.e., for the cases $m' < m$ with $m < M$ or $m > M$)

$$\left(\frac{mM}{\gamma}\right)\omega^2 = m + M + (m^2 + M^2 + 2mM \cosh 2\psi)^{\frac{1}{2}} = m + m(\varepsilon^{-1} \sinh 2\psi - \cosh 2\psi) \qquad (3.10)$$

which gives, on using (3.9),

$$\left(\frac{mM}{\gamma}\right)\omega^2 = m + (1 - \varepsilon^2)^{-1} \cdot \{2M + [m^2(1 + \varepsilon^2)^2 + 4\varepsilon^2 (M^2 - m^2)]^{\frac{1}{2}}\}. \qquad (3.11)$$

The special case $M = m$ gives

$$(m/\gamma)\omega^2 = 4(1 - \varepsilon^2)^{-1} \qquad (3.12)$$

as obtained in I, (A.10). Also, for small ε, (3.11) gives

$$\omega^2 = \omega_L^2[1 + (M/m)\varepsilon^2 + 0(\varepsilon^4)] \qquad (3.13)$$

where ω_L is the top of the optical band (see 2.11). This equation shows that as $\varepsilon \to 0$ or $m' \to m$, the discrete level returns to the top of the band.

For the intersection $\varphi = \pi/2 + i\psi$ a similar analysis leads to the result

$$\left(\frac{mM}{\gamma}\right)\omega^2 = m + (1 - \varepsilon^2)^{-1} \cdot \{2M - [m^2(1 + \varepsilon^2)^2 + 4\varepsilon^2 (M^2 - m^2)]^{\frac{1}{2}}\}. \qquad (3.14)$$

This formula gives the frequency level which falls into the gap from the top band when $m' > m$ and $m < M$ and the level which rises into the gap from the bottom band when $m' < m$ and $m > M$. For small ε, (3.14) gives

$$\left(\frac{mM}{\gamma}\right)\omega^2 = 2M + 2(M/m) \cdot (m - M)\,\varepsilon^2 + 0(\varepsilon^4) \qquad (3.15)$$

so that as $\varepsilon \to 0$, $(mM/\gamma)\omega^2 \to 2M$ from below if $m < M$ and from above if $m > M$; in the first case $\omega = (2\gamma/m)^{\frac{1}{2}}$ is the bottom of the optical band and in the second case it is the top of the acoustical band.

A special case of some interest is when

$\varepsilon \to 1$ or $m' \to 0$. Then (3.11) and (3.14) give

$$(mM/\gamma)\omega^2 = (2M \pm 2M)(1 - \varepsilon^2)^{-1} + m \mp M + 0(1 - \varepsilon^2). \tag{3.16}$$

The top signs (corresponding to the frequency emerging from the top of the optical band) give $\omega \to \infty$ as $\varepsilon \to 1$ and the bottom signs (for the frequencies in the gap)

$$\left(\frac{mM}{\gamma}\right)\omega_c^2 = M + m. \tag{3.17}$$

This value of ω_c^2 is half that of ω_L^2, and also the average of ω^2 for the bottom of the top band and the top of the bottom band. This result has an interesting interpretation for the case $m' < m$ and $m > M$. As $m' \to 0$ one frequency $\to \infty$ (accounting for the loss of one degree of freedom) and the frequency given by (3.17) is a so-called surface frequency. The effect of $m' \to 0$ is to reduce the lattice to two chains each with one end fixed and the other free. This problem is being considered in detail by Wallis.[6]

In the case $m < M$ and $m' > m$ the limiting case $\varepsilon = 1 - m'/m \to -\infty$ corresponds to the central mass being infinite and hence fixed, the lattice dividing into two separate lattices with fixed ends. From (3.14), as $\varepsilon \to -\infty$, $\omega^2 \to (2\gamma/M)$ which corresponds to the top frequency of the bottom band. Hence the level in the gap falls from the bottom of the top band to the top of the bottom band. The bottom S level of the bottom band has meanwhile $\to \omega = 0$ accounting for the lost mode.

The frequency levels given by (3.11) and (3.14) are plotted in Fig. 2.

[6] WALLIS, R. F., private communication.

ZERO-POINT ENERGIES

(a) *Perfect lattice*

The zero-point energy of the perfect lattice with $m < M$ is

$$E_0 = \sum \tfrac{1}{2}\hbar\omega \tag{4.1}$$

with ω given by (2.6) and (2.9). Hence

$$\frac{E_0}{\frac{1}{2}\hbar\omega_L} = (m + M)^{-\frac{1}{2}}\{m^{\frac{1}{2}} + (m^{\frac{1}{2}} + M^{\frac{1}{2}}) \cdot \sum_{j=1}^{2N-1} [1 - 4(mM)^{\frac{1}{2}}(m^{\frac{1}{2}} + M^{\frac{1}{2}})^{-2} \cdot \sin^2(j\pi/8N)]^{\frac{1}{2}}\} \tag{4.2}$$

and in the limit as $N \to \infty$, E_0 can be expressed in terms of an elliptic integral of the second kind:

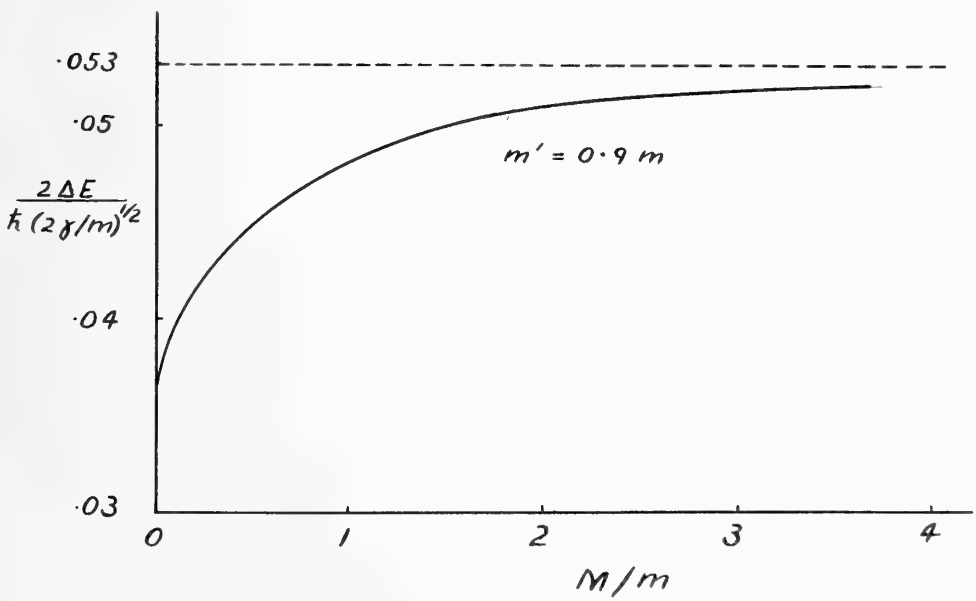


FIG. 5.—Self energy of an isotope plotted as a function of M/m for fixed m

$$\frac{E_0}{\frac{1}{2}N\hbar(2\gamma/m)^{\frac{1}{2}}} = [1 + (m/M)^{\frac{1}{2}}]\frac{8}{\pi} \cdot \int_0^{\pi/4} [1 - 4(mM)^{\frac{1}{2}}(m^{\frac{1}{2}} + M^{\frac{1}{2}})^{-2} \cdot \sin^2\theta]^{\frac{1}{2}}\, d\theta. \tag{4.3}$$

(b) *Self energy of an isotope*

The change in zero point energy when the central particle of mass m is replaced by an "isotope" of mass m' can be calculated using the method of contour integration as discussed in I. The starting point is the formula

$$\frac{\Delta E}{\frac{1}{2}\hbar\omega_L} = \frac{1}{2\pi i}\int_c \sum_{\pm} \frac{\omega_\pm(z)}{\omega_L}\frac{d}{dz} \cdot \ln \Phi_\pm(z, \varepsilon)\, dz \tag{4.4}$$

where from (3.6),

$$\Phi_\pm(z, \varepsilon) = 1 - \varepsilon \tan 2Nz \operatorname{cosec} 2z\, K(z) = 1 + \varepsilon \tan 2Nz - (\varepsilon/\gamma)\tan 2Nz \operatorname{cosec} 2z\, \omega_\pm^2(z) \tag{4.5}$$

and C is the contour which is a rectangle with corners $\pm ia$, $\pi/2 \pm ia$. Since this integral cannot be evaluated in closed form, two extreme cases will be considered, firstly when $m \approx M$ and secondly when $m \gg M$.

(i) $m \approx M$

In this case we assume $M = m(1 + \eta)$, η small. For the contour C we can let $a \to \infty$ so that the only contribution to the intergral comes from the integration along the imaginary axis, using $\omega_-(z)$ and $\varphi_-(z, \varepsilon)$ giving for large N.

$$\frac{\Delta E}{\frac{1}{2}\hbar\omega_L} = \frac{-1}{\pi(2m + 2M)^{\frac{1}{2}}} \cdot \int_0^\infty \{[m^2 + M^2 + 2Mm\cosh 2t]^{\frac{1}{2}} - [m + M]\}^{\frac{1}{2}} \frac{d}{dt}\ln \Phi_1(t)\, dt \tag{4.6}$$

where

$$\Phi_1(t) = 1 - \varepsilon \tanh t + \varepsilon \operatorname{cosech} 2t[(m^2 + M^2 + 2Mm\cosh 2t)^{\frac{1}{2}} - (M + m)]/m. \tag{4.7}$$

Using $M = m(1 + \eta)$, we obtain

$$\frac{[(m^2 + M^2 + 2Mm\cosh 2t)^{\frac{1}{2}} - (M+m)]^{\frac{1}{2}}}{(2m + 2M)^{\frac{1}{2}}} = \sinh \tfrac{1}{2}t + 0(\eta^2) \tag{4.8}$$

and

$$\ln \Phi_1(t) = \ln(1 - \varepsilon \tanh \tfrac{1}{2}t) + \tfrac{1}{2}\varepsilon\eta \tanh \tfrac{1}{2}t \operatorname{sech} t(1 - \varepsilon \tanh \tfrac{1}{2}t)^{-1} + 0(\eta^2). \tag{4.9}$$

When these are inserted in (4.6) the term without η gives precisely the result obtained in I(4.15) for the monatomic lattice while the term in η gives, after integration by parts, the contribution

$$\frac{\varepsilon\eta}{4\pi}\int_0^\infty \frac{\tanh 2t\, dt}{\cosh t - \varepsilon \sinh t}. \tag{4.10}$$

This integration can be reduced to standard integrals by writing

$$\frac{\tanh 2t}{\cosh t - \varepsilon \sinh t} = \frac{2}{1 + \varepsilon^2}\left[\frac{\sinh t - \varepsilon \cosh t}{\cosh 2t} + \frac{\varepsilon}{\cosh t - \varepsilon \sinh t}\right] \tag{4.11}$$

and the final result is

$$\frac{\Delta E}{\frac{1}{2}\hbar\omega_L} = -\tfrac{1}{2} + (2\pi)^{-1}(1 - \varepsilon^2)^{-\frac{1}{2}} \cdot (\pi + 2\sin^{-1}\varepsilon) + (8\pi)^{-1}(1 + \varepsilon^2)^{-1} \cdot \varepsilon\eta[2\sqrt{2}\ln(1 + \sqrt{2}) - \sqrt{2}\,\varepsilon\pi + 2\varepsilon(1 - \varepsilon^2)^{-\frac{1}{2}}(\pi + 2\sin^{-1}\varepsilon)] + 0(\eta^2) \tag{4.12}$$

(ii) $m \gg M$

In this case we let $M = \xi^2 m$, ξ small. In the contour C we now cannot let $a \to \infty$ but rather $a \to 0$. In (4.4) we have to insert

$$\omega_+/\omega_L = 1 - \tfrac{1}{2}\xi^2 \sin^2 z + 0(\xi^4) \tag{4.13}$$

$$\omega_-/\omega_L = \xi \sin z[1 - \tfrac{1}{2}\xi^2(1 + \cos^2 z)] + 0(\xi^5) \tag{4.14}$$

$$\Phi_+(z, \varepsilon) = 1 - \varepsilon(1 + \xi^2)\tan 2Nz \cot z + 0(\xi^4) \tag{4.15}$$

$$\Phi_-(z, \varepsilon) = 1 + \varepsilon(1 - \xi^2) \tan 2Nz \tan z + 0(\xi^4). \quad (4.16)$$

For small a only the integration along the horizontal sides of the rectangle C contribute to the integral giving

$$\frac{\Delta E}{\frac{1}{2}\hbar\omega_L} = \frac{1}{2\pi i}\int_0^{\pi/2} \sum_{\pm} \frac{\omega_\pm(x - ia)}{\omega_L} \cdot \frac{d}{dx}\ln \Phi_\pm(x - ia, \varepsilon) - \frac{\omega_\pm(x + ia)}{\omega_L} \quad (4.17)$$

$$\frac{d}{dx}\ln \Phi_\pm(x + ia, \varepsilon)\, dx.$$

In the limit of large N

$$\tan 2N(x \pm ia) \to \pm i \quad (4.18)$$

with considerable simplification of formulae (4.15) and (4.16). In evaluating (4.17) for the limiting case $a \to 0$ two features are important. Firstly to get the correct value for ΔE the cases $\varepsilon > 0$ and $\varepsilon < 0$ have to be distinguished because in the first case the discrete levels above both bands (corresponding to $z_1 = i\psi_1$ and $z_2 = (\pi/2) + i\psi_2$) have to be added while in the second case there are no discrete levels which have to be allowed for (c.f. Fig. 2b). The formulae (3.11) and (3.14) give for the levels coming out of the top and bottom bands respectively

$$\frac{\omega}{\omega_L} = 1 + \frac{\xi^2\varepsilon^2}{2(1 - \varepsilon^2)} + 0(\xi^4)$$

$$\frac{\omega}{\omega_L} = \xi(1 - \varepsilon^2)^{-\frac{1}{2}}[1 - \tfrac{1}{2}\xi^2(1 - \varepsilon^2)^{-1}] + 0(\xi^5). \quad (4.20)$$

The second important feature is that in some of the integrals which arise, the integration has to be performed before the limit $a \to 0$ is taken. A useful check on the integrations is afforded by putting $\omega = \omega_L$ so that the contour integral counts (the number of levels in the band for the imperfect lattice) minus (the number of levels

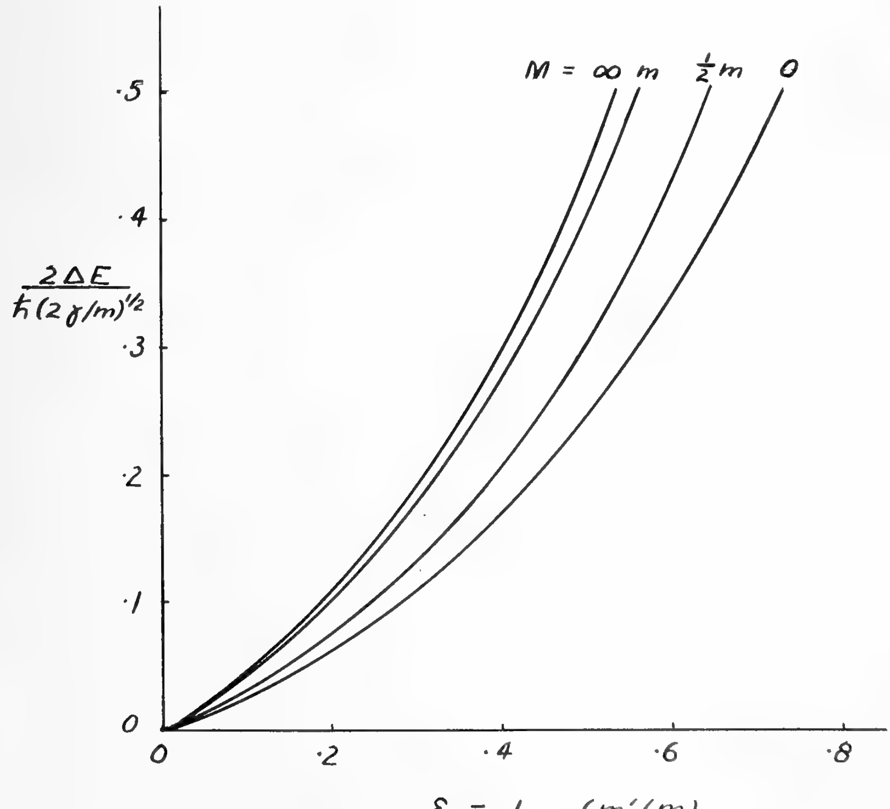


FIG. 6.—Self energy of an isotope plotted as a function of ε

in the band for the perfect lattice). For each band this is 0 or -1 according to $\varepsilon < 0$ or $\varepsilon > 0$. The final expression for the self energy is

$$\frac{\Delta E}{\frac{1}{2}\hbar\omega_L} = \xi\left[-\frac{1}{2}+\frac{1}{\pi}(1-\varepsilon^2)^{-\frac{1}{2}}(\pi/2+\sin^{-1}\varepsilon)\right]+\frac{\xi^2\varepsilon}{4(1-\varepsilon)} + \xi^3\left[\frac{1}{4}-\frac{\varepsilon}{2\pi}(1-\varepsilon^2)^{-1} - \frac{1}{2\pi}(1-\varepsilon^2)^{-\frac{3}{2}}(\pi/2+\sin^{-1}\varepsilon)\right] + 0(\xi^4) \qquad (4.21)$$

Two equations, (4.11) and (4.21), have been derived giving the self energy of an isotope, the first valid for $m \approx M$ and the second for $m \gg M$. With these two expressions the complete range of values of M can be covered for ε as large as 0.7, the connection between the two results improving the smaller the value of ε. For example, for $\varepsilon = 0.2$, (4.11) gives $\Delta E =$ (const.) 0.980 for $\eta = -0.64$ or $M = 0.36m$, whereas (4.21) gives, for the value $\xi = 0.6$ or the same value of $M = 0.36m$, $\Delta E =$ (const.) 0.980. As $M \to \infty$, $\Delta E \to$ (const.) $\{(m/m')^{\frac{1}{2}} - 1\}$ which is merely the difference in zero point energy between two oscillators because the lattice degenerates into a series of uncoupled oscillators.

In Fig. 5 the self energy is plotted as a function of (M/m) for constant m, and in Fig. 6 as a function of ε for various values of M.

TWO ISOTOPIC DEFECTS

If two isotopes of mass m' replace the two particles of mass m at the positions numbered $\pm 2l$ then the characteristic equations are

$$\cos 2N\varphi \operatorname{cosec}(2N-2l)\varphi - 2\varepsilon\cos 2l\varphi \operatorname{cosec} 2\varphi\, K_\pm(\varphi) = 0 \qquad (5.1)$$

$$\sin 2N\varphi \operatorname{cosec}(2N-2l)\varphi - 2\varepsilon\sin 2l\varphi \operatorname{cosec} 2\varphi\, K_\pm(\varphi) = 0. \qquad (5.2)$$

As in the analysis given in I and in 4(b) above, the energy of interaction V between two isotopes is given by the contour integral

$$\frac{V}{\frac{1}{2}\hbar\omega_L} = \frac{1}{2\pi i}\int_C \sum_\pm \frac{\omega_\pm(z)}{\omega_L}\frac{d}{dz}\ln\psi_\pm(z,\varepsilon)\,dz \qquad (5.3)$$

with

$$\psi_\pm(z) = 1 - \varepsilon^2 K_\pm^2(z)\sin^4(2N-2l)z\,[\tfrac{1}{2}\sin 4Nz\sin^2 z - \varepsilon\sin(2N-2l)z \cdot \sin(2N+2l)z\,K_\pm(z)]^2. \qquad (5.4)$$

As in (4.6) the contour integral reduces to the single integral

$$\frac{V}{\frac{1}{2}\hbar\omega_L} = \frac{-1}{\pi(2m+2M)^{\frac{1}{2}}} \cdot \int_0^\infty [(m^2+M^2+2Mm\cosh 2t)^{\frac{1}{2}} - (m+M)]^{\frac{1}{2}}\frac{d}{dt}\ln\psi_1(t)\,dt \qquad (5.5)$$

where

$$\psi_1(t) = 1 - \varepsilon^2 \cdot \left[\frac{\{M+m\cosh 2t - (m^2+M^2+2Mm\cosh 2t)^{\frac{1}{2}}\}\exp(-4lt)}{m\sinh 2t - \{M+m\cosh 2t - (m^2+M^2+2Mm\cosh 2t)^{\frac{1}{2}}\}}\right]^2 \qquad (5.6)$$

We can obtain an expansion for V valid for large distances by expanding the integrand as a power series in t and $\exp(-lt)$. This yields

$$\frac{V}{\frac{1}{2}\hbar\omega_L} = \frac{-2(\varepsilon^2m^2)(Mm)^{\frac{1}{2}}}{\pi(M+m)^3}\frac{1}{(8l)^3} \cdot \left[1+\frac{3\varepsilon m}{M+m}\frac{1}{4l}+0\left(\frac{1}{l^2}\right)\right] \qquad (5.7)$$

In the case $m = M$ this expression becomes

$$\frac{V}{\frac{1}{2}\hbar\omega_L} = \frac{-2\varepsilon^2}{\pi}\frac{1}{(16l)^3}\left[1+\frac{3\varepsilon}{8l}+0\left(\frac{1}{l^2}\right)\right] \qquad (5.8)$$

in agreement with I (5.3b).

An important consequence of the result (5.7) is that it proves that V is negative or the interaction between the isotopes attractive regardless of the relative magnitudes of m and M. In the more general case of isotopes of masses $(1 - \varepsilon_1)m$ and $(1 - \varepsilon_2)m$ the energy of interaction is proportional to $\varepsilon_1\varepsilon_2$ and hence is repulsive if ε_1 and ε_2 are of opposite sign. Also if one isotope is of mass $(1 - \varepsilon_1)M$ replacing a particle of mass M then in the equation (5.7) the factor $\varepsilon_1 m$ becomes $\varepsilon_1 M$. Thus for the interaction between two "M" isotopes, $\varepsilon^2 m^2$ is replaced by $(\varepsilon_1\varepsilon_2 M^2)$ and for the interaction between an "m" and an "M" isotope, the factor becomes $(\varepsilon_1\varepsilon_2 mM)$.

CONCLUSION

In a perfect alternating lattice the normal frequencies fall into two bands separated by a gap. It has been shown in the present work that, as for the monatomic lattice, localized modes can occur with discrete frequency levels out of the bands when the lattice contains defects such as isotopes. For the alternating lattice, four interesting cases arise. When one of the lighter masses "m" is replaced by an isotope "m'", then if $m' < m$ one level jumps out of the optical band into the region above, whereas if $m' > m$ one level jumps from the bottom of the optical band into the gap between the two bands. When one of the heavy masses is replaced by a lighter isotope one frequency jumps out of the top of the acoustical band into the gap while at the same time a second level jumps out of the top of the optical band into the region above. Finally, when one of the heavy masses is replaced by a heavier isotope then no frequencies emerge from the bands.

The defect level which rises out of the top of the acoustical band into the gap is of special interest. As the defect mass approaches zero the level approaches the level at the center of the gap. This level could be interpreted as due to a surface mode.

The self energy of an isotope has been computed, and the series solutions obtained, one valid for $m \approx M$ and the other for $m \gg M$, together cover the whole range of variation of the masses. The interaction energy between two isotopes is proportional to the inverse cube of the distance of separation and is attractive for two light or two heavy isotopes and repulsive for a light and a heavy isotope.

Although this paper has been concerned with only the one-dimensional lattice, the general features will be similar for the more realistic three-dimensional lattice. Thus one will expect surface modes, a phenomenon not arising in monatomic lattices. Also the attractive and repulsive character of the forces between isotopes will be of special interest in the two and three-dimensional lattices; a particle of mass intermediate between m and M will "appear" as a light isotope to one set of masses but as a heavy isotope to the others, depending on its position. The detailed analysis of the two and three-dimensional lattices will be given in a following publication.

Citius emergit veritas ex errore quam ex confusione.—FRANCIS BACON, *Novum Organum.*

MATHEMATICS.—*Numerical experiments in potential theory using orthonormal functions.* P. DAVIS and P. RABINOWITZ,[1] National Bureau of Standards.

EDITORIAL NOTE

In potential theory and vibration theory much use is made of a complete set of orthonormal solutions appropriate to the domain of the problem. The solution of the particular boundary value problem at hand is represented as a linear combination (generally an infinite series) of these orthonormal functions. One property of orthonormal expansions is that if the infinite series is approximated by its first n terms, the least square error fit is always obtained.

This approach is related to much work that has been carried out in the last generation but which has so far been limited to theoretical discussions and applications to geometrically simple domains such as circles and rectangles. In practical problems, different methods have been preferred, e.g., relaxation techniques. The numerical experiments described in the following paper show that the advent of high-speed automatic digital computing machines makes the method of orthogonal functions feasible.

INTRODUCTION

We describe in this paper three computations that were carried out on the National Bureau of Standards Eastern Automatic Computer (SEAC) and which made use of a multiple purpose orthonormalizing code recently developed for this machine [cf. Davis and Rabinowitz (*1*)]. These computations can be described briefly as follows:

(*a*) Computation of the system of orthonormal polynomials for a "bean shaped" domain (Fig. 1).
(*b*) Solution of a Dirichlet Problem for this "bean shaped" domain.
(*c*) Computation of the system of orthonormal polynomials for the square.

For the theory of orthonormal functions as applied to problems in conformal mapping, boundary value problems, etc, the reader is referred to Bergman [*2*], Szegö [*3*].

The orthonormalization code employed possesses the following features and limitations:

(1) Inner products of the type $\int_C fg\,ds$ are replaced by an integration rule

$$\int_C fg\,ds \approx \sum_{k=1}^{N} w_k f(P_k)g(P_k).$$

(2) The orthonormalization itself is carried out by the Gram-Schmidt process.

(3) The code is of single precision type. That is, the computation is carried out with 44 binary digits (11+ decimal digits).

It will be useful to specify the orthonormalization process more precisely. Let n vectors, f_i, of dimension N, have components $y_{i1}, y_{i2}, \cdots, y_{iN}$, $i = 1, 2, \cdots, n$,

TABLE 1.—LEAST SQUARES SOLUTION FOR DIRICHLET PROBLEM FOR BEAN-SHAPED REGION

Pt. No.	Abscissa	Ordinate	Weight	Boundary Value	Discrepancy		
1	.000	.110	.01414	.76089	−.0030	Boundary Value =	
2	−.050	.108	.01427	.72025	−.0031	$e^x\cos y + \log$	
3	−.100	.115	.01963	.66721	−.0032	$[(1-y)^2 + x^2]$	
4	−.160	.150	.02300	.55236	−.0034		
5	−.220	.205	.03897	.40068	−.0032	Least Square Har-	
6	−.320	.300	.02792	.17014	−.00006	monic Polynomial	
7	−.400	.358	.03324	.06949	.0044	1.0017261087	
8	−.500	.420	.01483	.02006	.0069	+.997339446	Re (z)
8	−.550	.436	.01423	.04590	.0023	−1.991187716	Im (z)
10	−.600	.430	.01505	.12037	−.0042	+1.48065453	Re (z^2)
11	−.644	.400	.01483	.22850	−.0069	−.00949996	Im (z^2)
12	−.660	.350	.01420	.33248	−.0026	+.1889575	Re (z^3)
13	−.655	.300	.02881	.41180	.0014	+.6236775	Im (z^3)
14	−.635	.200	.03043	.56168	.0038	−.355600	Re (z^4)
15	−.595	.100	.03076	.70060	.0009	+.024526	Im (z^4)
16	−.552	.000	.03311	.84177	−.0019	−.11960	Re (z^5)
17	−.500	−.105	.03175	.98915	−.0023	−.28034	Im (z^5)
18	−.440	−.200	.01809	1.12198	.0001		
19	−.400	−.250	.01998	1.19326	.0018		
20	−.350	−.300	.01882	1.26792	.0029		
21	−.300	−.344	.03140	1.33734	.0027		
22	−.204	−.400	.03450	1.44504	.0000	Discrepancies at Points	
23	−.100	−.436	.02846	1.54875	−.0025	Interior to Bean	
24	.000	−.448	.02831	1.64168	−.0017	x	Discrepancy
25	.100	−.442	.03860	1.73582	.0015	.4	+.0009
26	.230	−.400	.02431	1.85882	.0037	.3	−.0001
27	.300	−.350	.02059	1.91643	.0014	.2	−.0007
28	.353	−.300	.03566	1.95563	−.0013	.1	−.0013
29	.430	−.200	.03122	1.99206	−.0030	0.0	−.0017
30	.477	−.100	.02975	1.96611	.0004	−.1	−.0017
31	.510	.000	.02846	1.89648	.0041	−.2	−.0015
32	.522	.100	.01696	1.75623	.0030	−.3	−.0011
33	.520	.160	.02330	1.63625	−.0006	−.4	−.0010
34	.500	.240	.02102	1.41224	−.0057	−.5	−.0014
35	.456	.300	.01795	1.14765	−.0038		
36	.400	.330	.01147	.91523	.0028		
37	.360	.337	.01762	.78912	.0058		
38	.300	.320	.01648	.68785	.0054		
39	.250	.290	.01901	.66231	.0027		
40	.200	.245	.01901	.69067	−.0001		
41	.150	.200	.01809	.72694	−.0017		
42	.100	.160	.01677	.75642	−.0025		
43	.050	.128	.01501	.77202	−.0028		

[1] Now at the Weitzmann Institute, Rehovot, Israel.

and let one additional vector f have components $y_1, \cdots, y_N$.

Let

$$\begin{aligned} \phi_1 &= a_{11}f_1 \\ \phi_2 &= a_{21}f_1 + a_{22}f_2 \\ \phi_3 &= a_{31}f_1 + a_{32}f_2 + a_{33}f_3 \end{aligned}$$

where the vectors ϕ_i have components $z_{i1}, z_{i2}, \cdots, z_{iN}$ and are orthonormal in the sense that

$$(\phi_i, \phi_j) = \sum_{k=1}^{N} w_k z_{ik} \overline{z_{jk}} = \delta_{ij}.$$

The least square approximation to f is given by

$$f \sim \sum_{k=1}^{n} (f, \phi_k)\phi_k = \sum_{k=1}^{n} d_k f_k$$

where $d_j = \sum_{k=1}^{N} (f, \phi_k)a_{kj}, j = 1, 2, \cdots, n$; $a_{kj} = 0$, $k < j$. The discrepancy in this approximation is defined by

$$\delta = f - \sum_{k=1}^{n} (f, \phi_n)\phi_k$$

$$= f - \sum_{k=1}^{n} d_k f_k.$$

The input and output of the code may be indicated diagramatically as follows:

$$\begin{array}{cc} \textit{Vector Input} & \textit{Vector Output} \\ \begin{array}{cccccc} & \text{weights} & f_1 & f_2 & f_n & f \\ N\left\{\begin{array}{c} \\ \\ \\ \\ \\ \end{array}\right. & \begin{array}{c} w_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ w_N \end{array} & \begin{array}{c} y_{11} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ y_{1N} \end{array} & \begin{array}{c} y_{21} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ y_{2N} \end{array} & \begin{array}{c} y_{n1} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ y_{nN} \end{array} & \begin{array}{c} y_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ y_N \end{array} \end{array} & \begin{array}{ccccc} & \phi_1 & \phi_2 & \phi_n & \delta \\ N\left\{\begin{array}{c} \\ \\ \\ \\ \\ \end{array}\right. & \begin{array}{c} z_{11} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ z_{1N} \end{array} & \begin{array}{c} z_{21} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ z_{2N} \end{array} & \begin{array}{c} z_{n1} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ z_{nN} \end{array} & \begin{array}{c} \delta_1 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \delta_N \end{array} \end{array} \\ n\left\{\begin{array}{ccccc} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 1 & 0 \end{array}\right. & n\left\{\begin{array}{cccc} a_{11} & a_{21} & a_{n1} & -d_1 \\ 0 & a_{22} & a_{n2} & -d_2 \\ 0 & 0 & a_{n3} & -d_3 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & a_{nn} & -d_n \end{array}\right. \end{array}$$

The high-speed capacity of the code is given by the inequality $(n + N) \leq 150$.

COMPLEX ORTHOGONAL POLYNOMIALS

Let B designate a simply connected region lying in the complex z-plane whose boundary C is rectifiable. Let $w(z)$ designate a positive and continuous weight function defined on C (or on $B + C$). In the space of analytic functions which are regular in $B + C$, we may introduce the inner product,

$$(f, g) = \int_C f(z)\overline{g(z)}w(z)\, ds \tag{2}$$

and orthonormalize the powers $1, z, z^2, z^3, \cdots$ with respect to this inner product. Designate the polynomials which arise in this fashion by

$$p_n(z) = k_n z^n + \cdots; \qquad k_n > 0. \tag{3}$$

Designate by $\phi(z)$ the function which maps the exterior of C conformally onto the exterior of $|w| = 1, \phi(\infty) = \infty, \phi'(\infty) = 1$. If z is exterior to C, we shall have

$$\lim_{n \to \infty} \frac{p_{n+1}(z)}{p_n(z)} = \phi(z) \tag{4}$$

$$\lim_{n \to \infty} \frac{k_{n+1}}{k_n} = 1/c \tag{5}$$

where c is the transfinite diameter of C. These results are independent of the weight function $w(z)$.

Let $\psi(z)$ map the interior of C conformally onto the interior of $|w| = 1$. Let the weight $w(z) = 1$, then

$$\sum_{n=0}^{\infty} p_n(z)\overline{p_n(t)} = \frac{L}{2\pi}\{\psi'(z)\overline{\psi'(t)}\}^{\frac{1}{2}} \tag{6}$$

where L is the length of C. For details on these matters and for some information as to the rapidity of convergence see Szegö [3], pp. 355–366.

ORTHOGONAL HARMONIC POLYNOMIALS

If the set of harmonic polynomials 1; $\mathrm{Re}(z)$, $\mathrm{Im}(z)$; $\mathrm{Re}(z^2)$, $\mathrm{Im}(z^2)$ $\cdots$ are orthonormalized with respect to the inner product

$$(f, g) = \int_C f(x, y)g(x, y)\, ds; \qquad ds^2 = dx^2 + dy^2, \tag{7}$$

there is obtained a system of orthonormal harmonic polynomials $p_n(x, y)$ which is intimately related to the harmonic kernel function, the Greens' function, and other potential theoretic domain functions for B. See Bergman [2]. To determine a harmonic function in B with boundary data $f(x, y)$ on C (the Dirichlet problem) we may write,

$$h(x, y) = \sum_{n=0}^{\infty} \left[\int_C f(u,v) p_n(u,v)\, ds \right] p_n(x, y) \tag{8}$$

and each finite segment of (8) provides a harmonic polynomial which fits the boundary data best in the sense of least squares.

DIRICHLET PROBLEM FOR A BEAN-SHAPED REGION

A bean shaped region (see Fig. 1) was obtained from a free-hand drawing on coordinate paper. The region itself is "defined" by means of 43 points on the contour (see Table 1). These points are not distributed equally on the boundary, but somewhat more points were placed where the curvature is greatest.

Although there are certain theoretical difficulties which occur when non-convex regions are employed, we were interested in testing the process for a fairly intricate region. Since the region was not specified analytically no attempt was made to incorporate into the weights w_k (see eq. (1)) a very exact line element ds or a very exact rule of numerical integration. For this region, weights w_k were taken proportional to the distance between the successive points given on the contour. These are listed in column 4 of Table 1.

As boundary value data, we used the values of the harmonic function

$$u(x, y) = \mathrm{Re}(e^z + \log(z - i)) \tag{9}$$

at the 43 points on the boundary. These are listed in column 5 of Table 1. This boundary data was approximated by linear combinations of the 11 harmonic functions $1, \mathrm{Re}(z), \cdots, \mathrm{Re}(z^5), \mathrm{Im}(z^5)$.

The input data for this problem was accordingly, w_i = the weights of column 4, Table 1, $y_{jk} = \left\{ {\mathrm{Re} \atop \mathrm{Im}} \right. (x_k + iy_k)^p$,

$$f_k = \mathrm{Re}(e^{x_k + iy_k} + \log(x_k + iy_k - i)). \tag{10}$$

Column 6, Table 1 lists the discrepancy between the specified values and computed (least square) values along the contour. It will be seen that the highest deviation is 0.0069. If one knew that this were the greatest deviation over the whole contour then the maximum principle for harmonic functions would tell us that this is also the greatest deviation in the interior. Unfortunately, it is impossible theoretically to make such a conclusion,[2] but one feels that in the interior these deviations are also of the same order of magnitude. We have computed the deviations at ten points along the real axis in the interior of the region and have listed them in Table 1. These results bear out this feeling.

[2] For a theoretical discussion of this point see, L. E. Payne and H. F. Weinberger [4] and Nehari [5], [6].

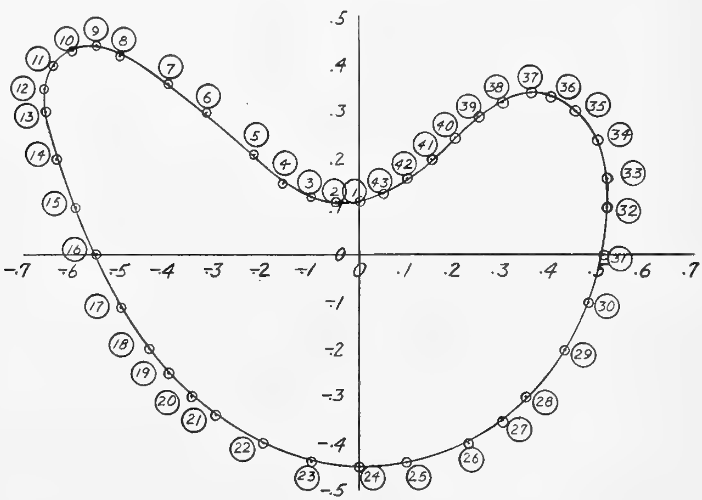


FIG. 1.—Bean-shaped region used in computation

ORTHOGONAL POLYNOMIALS FOR A BEAN-SHAPED REGION

The input data here was as follows, w_j = the weights of Column 4, Table 1, $y_{jk} = (x_k + iy_k)^j$, y = arbitrary. As part of the output data we obtained the coefficients of the orthonormal polynomials, and the values of each orthonormal polynomial at each of the 43 points on the contour. We obtained the orthonormal polynomials up to and including those of degree 21. For reasons which will be explained presently, it is not felt that the polynomials of degree greater than 11 are of great significance numerically.

TABLE 2.—DETERMINATION OF TRANSFINITE DIAMETER OF BEAN-SHAPED REGION

n	k_n/k_{n+1}
0	.485511
1	.513294
2	.503448
3	.503615
4	.506216
5	.506834
6	.508043
7	.507085
8	.507510
9	.505941
10	.508073

TABLE 3.—THE QUANTITY $\left|\frac{p_{11}(z)}{p_{10}(z)}\right|$ EVALUATED ON THE BOUNDARY OF THE BEAN

Pt. No.	$\lvert p_{11}/p_{10} \rvert$	Pt. No.	$\lvert p_{11}/p_{10} \rvert$
1	.882	23	.937
2	.906	24	1.018
3	.944	25	1.016
4	.987	26	.968
5	.999	27	1.069
6	.983	28	.985
7	.992	29	.996
8	1.017	30	1.056
9	.993	31	.940
10	.980	32	1.050
11	1.019	33	1.026
12	.989	34	.976
13	.974	35	1.034
14	1.004	36	.984
15	1.032	37	.981
16	.994	38	1.029
17	.943	39	1.057
18	1.089	40	1.033
19	1.040	41	.981
20	.930	42	.928
21	.962	43	.890
22	1.067		

Table 2 presents the ratios k_n/k_{n+1} for $n = 0, \cdots, 10$. According to (5) these ratios approach the transfinite diameter of the region. The convergence of this sequence is not too rapid, but the table suggests that we have determined this constant to two decimal places. We have computed these ratios also for $n = 11, \cdots, 20$, but have not tabulated them here. Their behavior is steady for a while and then as $n \gg 11$, they begin to increase rapidly towards one. This is the result of two things. In the first place, there is a considerable loss of significance in the coefficients of high order due to the fact that these values have to be scaled down sufficiently so as to fit on the machine. Secondly, since only crude integration rules were employed in computing $\int_C z^n \bar{z}^m \, ds$, the orthonormal polynomials themselves tend more to those corresponding to finite sum inner product as n approaches the number of points on the contour.

According to (4), the ratio $\frac{p_{n+1}(z)}{p_n(z)}$ tends to the exterior mapping function. We have tested this out for $n = 10$. The worst agreement can be expected on the boundary of the region, where a theoretical value of $|\phi(z)| = 1$, $z \in C$, should be obtained. Table 3 lists the values of $|p_{11}(z)/p_{10}(z)|$ on the contour C. A maximum error of 10% from the theoretical value of 1 was obtained. The average error appears to be about 5%. From the values of $p_{10}(z)$ on the contour it was a fairly simple matter to trace the variation in arg $p_{10}(z)$, $z \in C$, and to verify that all the zeros of $p_{10}(z)$ lie in B. Thus, p_{11}/p_{10} is regular outside of B.

As might have been foreseen from the behavior of the ratios k_{n+1}/k_n for $n > 11$, no improvement in the quantities

$$|p_{n+1}(z)/p_n(z)|$$

was observed for $n > 11$. We shall discuss in a later paragraph how these shortcomings can, in certain instances, be overcome.

We have not yet developed a code for the rapid evaluation of the interior mapping function through the use of (6) and so an estimate of the quality of the convergence of this formula cannot be given at the present time.

TABLE 4.—ORTHONORMAL POLYNOMIALS FOR A SQUARE; SIDE = 1.4; SUM OF GAUSSIAN WEIGHTS = 1.0

1.0000000000			
1.2371791483 Z			
1.4937246015 Z^2			
1.7603713248 Z^3			
2.2025044571 Z^4	+0.4230570561		
2.6608221383 Z^5	+0.7301295947 Z		
3.220657584 Z^6	+1.1572896252 Z^2		
3.905515952 Z^7	+1.7238789614 Z^3		
4.737815070 Z^8	+2.4298575834 Z^4	−.0188295964	
5.737742726 Z^9	+3.3915415979 Z^5	+.0646244543 Z	
6.949286858 Z^{10}	+4.645751758 Z^6	+.2286090195 Z^2	
8.416037589 Z^{11}	+6.274558086 Z^7	+.5137415655 Z^3	
10.19384526 Z^{12}	+8.381528538 Z^8	+.9916706683 Z^4	+.0261223727
12.34288234 Z^{13}	+11.102777658 Z^9	+1.7111406242 Z^5	+.0433444223 Z
14.94442510 Z^{14}	+14.597987726 Z^{10}	+2.782242918 Z^6	+.0869122976 Z^2
18.09361812 Z^{15}	+19.073026420 Z^{11}	+4.339843064 Z^7	+.1803740299 Z^3

ORTHOGONAL POLYNOMIALS FOR A SQUARE

For machine purposes, it is convenient to have all distances from the boundary to the origin ≤ 1, and so the side of the square was taken to be $a = 1.4$. Since the boundary of the square consists of elementary curves, it is not too difficult to employ high accuracy integration formulas in (1). In computing with the square, we selected along each of the sides a 16 point Gaussian integration formula. At the time of computation, this was the highest Gaussian formula available, though subsequently Gaussian formulas of higher order were computed. (See Davis and Rabinowitz [7]). Inasmuch as the function $z^k = (x + iy)^k$ is, along either x = const. or y = const., a polynomial in y or in x of degree k, this Gaussian integration formula will produce inner products which are completely accurate, neglecting machine roundoff, up to the terms $\int_C z^{15}\bar{z}^{15}\,ds$. No particular use of the symmetries of the square was made and the cyclic occurrence of many zero coefficients in the orthonormal polynomials served as a running check on the accuracy of the process at the machine end of the job. The orthonormal polynomials are listed in Table 4. Table 5 lists the ratios k_n/k_{n+1} which approach the transfinite diameter of the square. The theoretical value for this quantity [see Polya, Szegö (*8*), p. 252] is

$$c = 1.4\,\frac{[\Gamma(\frac{1}{4})]^2}{4\pi^{\frac{3}{2}}} = 0.826238$$

Thus, using orthonormal polynomials of degree 15, we have secured this quantity to three significant figures.

TABLE 5.—DETERMINATION OF TRANSFINITE DIAMETER OF SQUARE; SIDE = 1.4

n	k_n/k_{n+1}
0	.808290377
1	.828251169
2	.848528137
3	.799258916
4	.827753357
5	.826173559
6	.824643305
7	.824328492
8	.825728043
9	.825659214
10	.825719560
11	.825599896
12	.825888555
13	.825918846
14	.825950067

CONCLUDING REMARKS

The method of orthonormal functions for the solution of problems in potential theory is an attractive one from the point of high-speed computing inasmuch as a single all purpose code can, with suitable small modifications, be made to cover a variety of problems. The inputs for these problems are especially easy to handle.

The accuracy that has been obtained in a moderate amount (about 2 hours) of computing time on SEAC is not great; about 2 decimal places. To obtain this, one would make use of about 15 approximating functions each of which is defined by its values at about 50 points. In order to increase this accuracy, we would need to increase simultaneously the number of orthonormal functions employed and the number of points at which each function is defined. From the machine point of view, this means that we must employ double precision coding in order to retain significance in the higher harmonics. Accordingly, four place accuracy might require about 24 hours of computing time on SEAC.

The authors wish to thank the computation Laboratory of the National Bureau of Standards for carrying out certain (hand) computations necessary for the final preparation of this report.

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NOTES AND NEWS

FELLOWS OF IRE ELECTED

The Washington Section of the Institute of Radio Engineers announces the election of nine members to the grade of Fellow. Presentation of certificates will be made at the Washington Section Annual Banquet by the President of IRE to:

ALEXANDER, S. N., National Bureau of Standards. For contributions to the development and application of digital computers.

BELTZ, W. H., CAPT., USN (Ret.) For leadership in improving the reliability of military electronic systems.

CLARK, A. B. (Deceased 14 Nov. 1955.) For early development and leadership in the field of telephonic transmission systems.

CORCORAN, G. F., University of Maryland. For contributions to electrical engineering education and to the associated literature.

DAVIS, T. M., Naval Research Laboratory. For contributions in the field of military radio communication.

DINGLEY, E. N., JR., National Security Agency. For contributions in the fields of electronic guidance and detection systems.

KALMUS, H. P., Diamond Ordnance Fuze Laboratory. For contributions in the fields of electromechanical devices and electronic measurement instruments.

PAGE, C. H., National Bureau of Standards. For contributions to military electronic research and development.

RABINOW, JACOB, Rabinow Engineering Co. For contributions in the fields of electronic ordnance and automatic control.

Special recognition will be given to Wilbur S. Hinman, Jr., Technical Director of the Diamond Ordnance Fuze Laboratory, who is this year's recipient of the Harry Diamond Memorial Award

NEW MEMBER OF NATIONAL RESEARCH COUNCIL

RAY P. TEELE, a member of the Photometry and Colorimetry Section of the National Bureau of Standards, has been appointed a member of the National Research Council. He will represent the Illuminating Engineering Society in the Division of Engineering and Industrial Research for a period of three years ending June 30, 1958.

Mr. Teele has gained international recognition as a member of photometric fields. His work covers the maintenance of the national photometric units of luminous intensity (candlepower) and luminous flux; developing and maintaining standards of illumination and photometric brightness; participating in the national and international standard comparisons; and evaluating candlepowers of different colored lights by studying the luminosity factors of the human eye.

Born in Washington, D. C., in 1903, Mr. Teele came to the Bureau in 1923. He received his bachelor of science degree in electrical engineering from the University of Michigan in 1927, and his master of science degree in physics from George Washington University in 1929.

Author or coauthor of some 15 articles published in his field of research, Mr. Teele also holds a patent for a blackout automobile headlight mask and another patent for a headlamp for motor vehicles. He is a member of the Optical Society of America, the Philosophical Society of Washington, the Illuminating Engineering Society, the *Washington Academy of Sciences*, and the American Association for the Advancement of Science.

ZOOLOGY.—*The ticks (Acarina: Ixodoidea) of the J. Klapperich Afghanistan Expedition, 1952 and 1953.* GEORGE ANASTOS, University of Maryland.

This report brings together the available information on the ticks of Afghanistan and extends to 14 the number of known species from this country. None of the ticks recorded from Afghanistan are endemic but also occur in Iran, in India, and in the southern part of the U.S.S.R. The records and collections studied so far are too small and often lacking in essential data to allow any far-reaching conclusions to be drawn. Undoubtedly future collections will extend the current list considerably since scarcely any tick records are available for the extensive wild fauna known from this country.

The earlier records of ticks in Afghanistan were included only as incidental ones in studies on the tick fauna of the surrounding countries. Yakimov (1922) reported on the Ixodidae in Russia and included one record of *Hyalomma aegyptium* (Linné), 1758, from Koscha on the Russo-Afghan frontier. In a revision of the Indian Ixodidae Sharif (1928) recorded males of *Hyalomma aegyptium dromedarii* Koch, 1844 (probably *H. dromedarii* Koch, 1844), on *Erinaceus megalotis* Blyth from Afghanistan and males of *Hyalomma syriacum* Koch, 1844 (= *H. aegyptium* (Linné), 1758), from Jugdulluk on *Testudo horsfieldi* Gray. An undetermined species of *Ornithodoros* was noted by Avanesov (1938) in native dwellings in North Afghanistan and Pavlovsky (1944) later reported the occurrence of *Ornithodoros papillipes* Birula, 1895 (= *O. tholozani* (Laboulbène and Mégnin, 1882). Pomerantzev (1946, 1950) recognized the occurrence of *H. dromedarii* and of *H. aegyptium* in Afghanistan but was apparently citing the records of Sharif.

In 1954 the author reported the results of a collection from Afghanistan made by the Third Danish Expedition to Central Asia. In addition to *Hyalomma aegyptium* which had been recorded previously the following species were found to be new to Afghanistan: *Hyalomma excavatum* Koch, 1844, *H. schulzei* Olenev, 1931, *H. rufipes glabrum* Delpy, 1949, *Dermacentor niveus* Neumann, 1897, *Ixodes redikorzevi emberizae* Pomerantzev, 1950, *Rhipicephalus sanguineus* (Latreille), 1806, and *Haemaphysalis numidiana* Neumann, 1897 (= *H. erinacei* Pavesi, 1884).

In 1955 the author was fortunate to receive another collection from Afghanistan made by J. Klapperich, Bonn, Germany, in 1952 and 1953. This collection, though small, contained four species new to Afghanistan: *Argas persicus* (Oken), 1818, *Dermacentor marginatus* (Sulzer), 1776, *Haemaphysalis sulcata* (Can. and Fanz.), 1877/1878, and *Ixodes redikorzevi redikorzevi* Olenev, 1927. It also expanded the range of four species previously recorded from this area: *Dermacentor niveus* Neumann, 1897, *Hyalomma dromedarii* Koch, 1844, *H. excavatum* Koch, 1844 and *Rhipicephalus sanguineus* (Latreille), 1806. No host information was given for the ticks in this collection.

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COLLECTION DATA

Acc. No.	Species	Locality	Date	No.
EP-6	*Argas persicus*	Kandahar	18-II-53	1 adult
DM-2	*Dermacentor marginatus*	Do-Shak, Khinjan Valley, Hindu Kush	1-X-52	1 female
DM-3	*Dermacentor marginatus*	Larki, Sarekanda Valley, Badakshan	3-VIII-53	1 male
DM-4	*Dermacentor marginatus*	Walang, Salang Valley, Hindu Kush	29-IX-52	1 female
DM-5	*Dermacentor marginatus*	Walang, Salang Valley, Hindu Kush	29-IX-52	1 male
DM-6	*Dermacentor marginatus*	Sarekanda Mountain, Badakshan	31-VII-53	3 females
DM-7	*Dermacentor marginatus*	Sarekanda Mountain, Badakshan	28-VII-53	1 male, 1 female
DM-8	*Dermacentor marginatus*	Sarekanda Mountain, Badakshan	29-VII-53	1 female
DN-2	*Dermacentor niveus*	Sanglish Pass, Minjan Mountain, Badakshan	2-VIII-52	1 female
HSU-2	*Haemaphysalis sulcata*	Bashgul Valley, Nuristan	9-IV-53	1 female
HSU-3	*Haemaphysalis sulcata*	Bashgul Valley, Nuristan	8-IV-53	1 male
HSU-4	*Haemaphysalis sulcata*	Bashgul Valley, Nuristan	24-IV-53	1 male
HSU-5	*Haemaphysalis sulcata*	Pagman Mountain, 30 km. northwest of Kabul	14-VI-53	1 female
JD-1	*Hyalomma dromedarii*	Bashgul Valley, Nuristan	11-IV-53	1 female
JD-2	*Hyalomma dromedarii*	Kandahar-Kuna	22-I-53	2 females
JD-3	*Hyalomma dromedarii*	Kandahar-Kuna	28-I-53	1 female
JD-4	*Hyalomma dromedarii*	Kandahar	13-II-53	1 female
JD-5	*Hyalomma dromedarii*	Vicinity of Kabul	20-III-53	1 female
JE-3	*Hyalomma excavatum*	Kutiau, Nuristan	5-V-53	1 male
JE-4	*Hyalomma excavatum*	Vicinity of Kabul	16-V-52	1 male
JE-5	*Hyalomma excavatum*	Bashgul Valley, Nuristan	8-IV-53	1 male
JE-6	*Hyalomma excavatum*	Bashgul Valley, Nuristan	24-IV-53	1 male
JE-7	*Hyalomma excavatum*	Bashgul Valley, Nuristan	17-IV-53	1 male
IRR-1	*Ixodes redikorzevi redikorzevi*	Pagman Mountain	6-VII-52	1 female
RS-22	*Rhipicephalus sanguineus*	Bashgul Valley, Nuristan	12-V-53	1 male, 2 females
RS-23	*Rhipicephalus sanguineus*	Bashgul Valley, Nuristan	6-IV-53	1 male
RS-24	*Rhipicephalus sanguineus*	Jalabad, Nuristan	30-III-53	3 females
RS-25	*Rhipicephalus sanguineus*	Kandahar	22-II-53	1 female
RS-26	*Rhipicephalus sanguineus*	Kandahar	11-II-53	2 males, 3 females
RS-27	*Rhipicephalus sanguineus*	Kandahar	19-II-53	1 male
RS-28	*Rhipicephalus sanguineus*	Kandahar	19-II-53	3 males, 6 females
RS-29	*Rhipicephalus sanguineus*	Kandahar	13-II-53	1 female
RS-30	*Rhipicephalus sanguineus*	Kandahar-Kuna	22-I-53	1 male
RS-31	*Rhipicephalus sanguineus*	Kandahar-Kuna	1-III-53	1 female
RS-32	*Rhipicephalus sanguineus*	Vicinity of Kabul	16-V-52	1 female
RS-33	*Rhipicephalus sanguineus*	Vicinity of Kabul	16-VI-52	1 male
RS-34	*Rhipicephalus sanguineus*	Kutiau	5-V-53	1 male, 1 female
RS-35	*Rhipicephalus sanguineus*	Tchakaran, Wardush Valley	6-VII-53	1 female

BIOCHEMISTRY.—*Effect of cortisone acetate on production of liver and muscle glycogen from C-14 labeled glycine and DL-alanine.*[1] W. C. HESS and I. P. SHAFFRAN, Georgetown University School of Medicine.

It is generally considered that the glycogen formed in the liver of fasting rats, following administration of adrenal cortical hormones, is derived from protein (*1–4*). It has been shown that cortisone acetate does not increase the production of liver glycogen after feeding glycine above the additive effect of the individual actions of the two compounds (*5*). However, cortisone acetate does produce higher liver glycogen values when DL-alanine is fed (*6*). The maximum amounts of liver glycogen formed from glycine and DL-alanine, 2.6 percent in 16 hours and 3.3 percent in 6 hours, represent conversions of 30 and 25 percent, respectively, of the theoretical amounts of the carbons of the 2 amino acids into glycogen. Using glycine and DL-alanine containing tagged carbon, several investigators have reported that only 1 to 5 percent of the isotope was present in the liver glycogen (*7–9*). It would appear, therefore, that the carbons of the formed glycogen do not necessarily come from the amino acid fed, at least as far as the particular tagged carbons are concerned.

In a further study on the effect of cortisone acetate on liver glycogen formation DL-alanine and glycine tagged with C-14 in carbons 1 or 2 have been employed to determine whether there are differences in the degree of glycogen incorporation of the 2 carbons before and after the administration of cortisone acetate.

Procedure for the administration of the amino acid and estimation of liver glycogen is the same as previously employed (*5*). Rats, weighing 100 to 150 g, were fasted for 24 hours and then given either 500 mg of tagged glycine or DL-alanine and sacrificed at the end of 16 and 6 hours, respectively, the periods of maximum glycogen production for the 2 amino acids. The activity of the labeled amino acids fed ranged from 1.0 to 1.5 $\times$ 10^6 counts per minute. Activity of aliquots of the isolated glycogen was determined using a gas flow counter. In the experiments with cortisone acetate 5 mg of the hormone were given intramuscularly at the end of the fasting period, and the glycine or DL-alanine were fed 8 or 18 hours later, so that, when the animals were sacrificed at the expiration of 24 hours, the maximum effects of the amino acid and the cortisone acetate would be obtained. Muscle glycogen was also determined on aliquots of the gluteus maximus at the same time as liver glycogen.

Results.—Each experiment was conducted upon 4 to 6 rats and average values and standard deviations for each series are given in Table 1. The percent of the administered counts of the C-14 in the amino acids found in the isolated liver glycogen is given in column 2. The glycogen formed from glycine 1-C-14 accounted for 2 percent of the administered counts, while 6.1 percent were found when glycine 2-C-14 was fed. Barnet and Wick (*9*) found 1.2 and 2.6 percent, respectively, of the administered counts from glycine 1-C-14 and 2-C-14 in the liver glycogen. However, they found only 1.7 percent glycogen in the liver after 17 hours, whereas our value at the end of 16 hours was 2.6 percent. It might be noted that Mackaye, Wick, and Carne (*10*) had previously found 2.4 percent glycogen at the end of 17 hours. The lower degree of incorporation of the isotope reported by Barnet and Wick (*9*) probably reflects the smaller amount of glycogen formed. The second carbon in DL-alanine yielded a higher amount of the labeled carbon in the glycogen than did the first carbon.

Since the glycogen formed accounts for 30 percent of the carbons of the glycine fed, then if all the carbon in the glycogen comes from glycine 30 percent of the counts should have been present. The amount of labeled carbon found in the glycogen accounts for only 7 and 20 percent of the theoretical amounts of the 1-C-14 and 2-C-14 glycines, respectively. Similarly with DL-alanine where the liver glycogen formed accounted

[1] This work was supported, in part, by a contract with the Atomic Energy Commission and also by a grant from the Council on Chemistry and Pharmacy of the American Medical Association.

TABLE 1.—LIVER GLYCOGEN FOLLOWING INGESTION OF CARBON LABELED GLYCINE AND DL-ALANINE WITH AND WITHOUT CORTISONE ACETATE

Compound	1	2	3	4*	5
	Liver wt	Counts in glycogen	Total glycogen	Glycogen formed from amino acid	Counts/100 mg glycogen
	g	*percent of dose*	*mg*	*mg*	*percent of dose*
Glycine 1-C-14	4.2	2.0 ± 0.4	105 ± 10		1.9 ± 0.4†
Glycine plus CA‡	4.3	2.8 ± 0.3	172 ± 15	90 ± 15	1.6 ± 0.5
Glycine 2-C-14	4.0	6.1 ± 0.5	99 ± 7		6.1 ± 0.7
Glycine plus CA	4.4	8.8 ± 0.7	170 ± 15	86 ± 14	5.2 ± 0.8
DL - Alanine 1-C-14	4.6	1.7 ± 0.2	144 ± 14		1.2 ± 0.2
DL - Alanine plus CA	5.1	3.3 ± 0.4	270 ± 19	173 ± 8	1.2 ± 0.3
DL - Alanine 2-C-14	5.0	10.7 ± 1.1	160 ± 14		6.6 ± 0.9
DL - Alanine plus CA	4.6	19.7 ± 1.8	266 ± 20	179 ± 10	7.4 ± 1.3

* Column 4 is obtained by subtracting glycogen formed by cortisone acetate alone in 24 hours, 1.9 percent, from column 3.

† Calculation of the t value of the difference for each pair showed no significance.

‡ CA = Cortisone acetate.

TABLE 2.—MUSCLE GLYCOGEN FOLLOWING INGESTION OF CARBON LABELED GLYCINE AND DL-ALANINE WITH AND WITHOUT CORTISONE ACETATE

Compound	Rat wt	Glycogen	Total glycogen	Percent of counts in the fed amino acid
	g	*percent*	*mg*	
Fasting	133	0.60	327	
Fasting plus CA	154	0.70	467	
Glycine 1-C-14	137	0.62	341	0.5
Glycine plus CA	131	0.80	430	0.4
Glycine 2-C-14	135	0.59	330	0.6
Glycine plus CA	134	0.90	490	0.4
DL-Alanine 1-C-14	136	0.58	286	0.4
DL-Alanine plus CA	120	0.74	355	0.6
DL-Alanine 2-C-14	154	0.55	359	0.6
DL-Alanine plus CA	159	0.86	575	0.6

* CA = Cortisone acetate.

for 25 percent of the carbon in the amino acid fed the counts in the liver glycogen explained 7 and 43 percent of the theoretical amounts for the 1-C-14 and 2-C-14 positions, respectively.

When cortisone acetate was administered prior to the amino acid the liver glycogen formed represents the combined effects of the two compounds. If the amount formed by cortisone acetate alone in 24 hours, 1.9 percent (*5*), is subtracted from the total amount produced the remainder may be attributed to the amino acid. These values are given in column 4. As previously noted cortisone acetate depresses slightly the amount of glycogen formed from glycine while there is an increased glycogen production from DL-alanine (*5*). The present results are in accord with the previous ones. The increase in glycogen formation from DL-alanine induced by cortisone acetate may result from the inhibition of glucose utilization by cortisone suggested by Boutwell and Chiang (*11*). Boutwell[2] has also found that the administration of tagged alanine together with cortisone acetate produced an increase in the concentration of the tagged carbon in blood glucose over that produced by tagged alanine alone.

If the percent of the administered counts from the C-14 incorporated into 100 mg of glycogen is determined, column 5, to provide a uniform basis for comparison, no significant differences were found between the results for each labeled amino acid with and without cortisone acetate. In the experiments with DL-alanine the cortisone was in the animal for 18 hours prior to the administration of the alanine, during which period the liver formed glycogen (*5*) and the period for the joint action was 6 hours; never the less the results indicate an equal dispersion of the labeled carbon in the glycogen. It is conceivable that the amino acids are converted into glucose that enters the metabolic pool from which the liver glycogen is synthesized. The glycogen formed through the action of the cortisone would come from the same pool as the extra glycogen from the amino acid and consequently contain the same percent of the labeled carbon. Apparently cortisone acetate does not influence the incorporation of the carbons of the exogenous amino acids into glycogen. The glycogen formed by cortisone in the livers of fasting rats could come from body protein (*12*) or as suggested by Kinsell et al. (*13*) from body fat.

The results of the determinations of muscle glycogen are given in Table 2. The total glycogen is calculated from the relationship of muscle mass to body weight

[2] Personal communication.

(*14*). While cortisone acetate did produce an increase in muscle glycogen, as noted by others (*15*), neither of the amino acids was effective. On the average about 0.5 percent of the administered counts were found in the muscle glycogen and the administration of cortisone acetate did not affect the value.

Summary.—Liver glycogen formed following the feeding of glycine 1-C-14 or 2-C-14 to fasting white rats contained 2.0 and 6.1 percent of administered counts, respectively. Similar experiments with DL-alanine 1-C-14 and 2-C-14 produced 1.8 and 10.7 percent incorporation of the administered counts respectively. When cortisone acetate was injected prior to the amino acids the percent incorporation of the labeled carbon in 100 mg of the glycogen was the same as in the absence of the cortisone acetate. Cortisone acetate produced an increase in muscle glycogen; neither glycine nor DL-alanine produced any change in glycogen content either alone or in the presence of cortisone acetate; less than 0.5 percent of the administered isotopes were found in the muscle glycogen.

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NOTES AND NEWS

NEW PUBLICATION ON COLORS

Publication of *The ISCC-NBS method of designating colors and a dictionary of color names*, by Kenneth L. Kelly and Deane B. Judd, National Bureau of Standards Circular 553, 158 pages, has recently been announced by the Bureau.

The circular is designed to assist the scientist, businessman, and layman to understand the different color vocabularies used in the many fields of art, science, and industry. The dictionary serves not only as a record of the meanings of the 7,500 individual color names listed but also enables anyone to translate from one color vocabulary to another. For example, the dictionary shows that griseo-viridis (biology) = serpentine (fashion) = mint green (mass market), or in ordinary language, a light green.

The terms by which this dictionary defines color names are those of a refinement of the method of designating colors outlined by the Inter-Society Color Council (ISCC) and developed at the National Bureau of Standards. The system applies not only to the colors of drugs and chemicals, for which it was originally developed, but to the colors of all opaque, clear, cloudy, or fluorescent samples, whether viewed by reflected or transmitted light, and to microscopic structures.

The circular may be obtained from the United States Government Printing Office at $2 a copy.

FORAMINIFERA CATALOG REISSUED

The Smithsonian Institution has recently issued an offset reprint of Charles Davies Sherborn's *An Index to the Genera and Species of the Foraminifera.* This monumental reference work, long out of print, was originally published by the Smithsonian in 1893 and 1896 in two parts. It includes all species and genera of Foraminifera published to 1889, giving both the original names and any new combinations used by later authors, as well as literature citations.

Systematic work on Foraminifera during the past 40 years has received a tremendous impetus from their economic value, especially that concerned with the search for petroleum and more recently with ecologic and paleoecologic studies. Because of the daily increasing volume of published material, it is difficult to keep abreast of nomenclatural changes in current work. Recently, Dr. Hans E. Thalmann of Stanford University completed for publication an index of the Foraminifera from 1890 to 1950. This work continues the earlier work by Sherborn, bringing it up to date, but does not repeat the material of Sherborn's book. With the forthcoming publication of Thalmann's index and with the present reprinting of Sherborn's classic index, modern students will have now available an invaluable tool in their systematic work on the Foraminifera.

PROCEEDINGS OF THE SOCIETY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1379TH MEETING, MAY 8, 1953

The Society was addressed by L. MARTON, of the National Bureau of Standards, on the subject *Electron interferometry.*

The early optics of electrons was geometrical optics, the dynamic trajectories being analogous to light rays. DeBroglie introduced the wave concept of electron behavior in his famous dissertation. The contrast between photon waves and electron waves is due primarily to the fact that the electron has a rest mass, hence a rest energy, whereas the photon has mass only by virtue of moving with the speed of light.

Experimental evidence of the wave-nature of electrons was first given by the classical Davisson-Germer electron diffraction experiment. In more recent years, Fresnel diffraction has been observed at the edges of objects in the electron microscope.

Interference of light waves can be accidental, as in oil-film effects, or Newton's rings, or intentional as in various interferometers. Interferometers may produce equivalent virtual sources by wave-front splitting, as with two slits or two mirrors, or amplitude splitting, as in the half-silvered mirror of Michelson's interferometer.

Similarly, accidental interference of electron waves has been observed in thin crystal flakes, and in blisters on iodine crystals. For an electron interferometer, both wave-front and amplitude splitting have been considered. A double slit system turns out to have unreasonable dimensions, so we turn to two mirror schemes. Unfortunately, electron mirrors are not available, but we obtain a similar effect by the prismatic action of diffraction gratings. The use of three parallel gratings and suitable stops for the unwanted beams will suffice. A fraction of the incident beam goes straight through the first grating, is deflected by the second and restored to its original direction by the third grating. Another fraction of the beam is deflected by the first grating, restored in direction by the second, and passed straight through by the third. These two beams enter and emerge in the same direction, but jointly delineate a rhombus between the gratings. The optical version of the arrangement was studied by Carl Barus and lost in the literature; it was set up and demonstrated to the audience.

The electronic version has been built and operated at the National Bureau of Standards. The gratings were 100 angstrom thick gold crystals, made by the epitaxial deposit of gold vapor on the cleavage face of rocksalt crystals. The interferometer can be used for measuring the wavelengths of electrons, hence for determining Planck's constant.

Interference has been obtained with path differences of as much as 6000 wavelengths, despite the 200 wavelength limit predicted on the basis of diffraction experiments. This raises an interesting question as to the meaning of phase velocity, a quantum mechanical unobservable. It was also pointed out that free space is a dispersive medium for electron waves, since the wavelength is related to the energy, hence to the velocity.

1380TH MEETING, MAY 22, 1953

President MAHAN announced that there had been a last-minute change of program, due to the sudden illness of the scheduled speaker, that two speakers were obtained on short notice from the Naval Research Laboratory, and that the Society was grateful for such fine cooperation.

The first speaker was RICHARD TOUSEY. His subject was *Rocket spectrographs for the sun in short untraviolet and X-ray.* Rockets are needed for this work, because of the opacity of the earth's atmosphere. The lower wavelength limit of balloon and mountain observations is 2860 angstroms. Some interesting problems in the use and recovery of rocket-borne equipment were explained.

Spectrograms taken at various altitudes were shown, and the ozone density as a function of altitude deduced from the changes of absorption. Measurements down to 1900 A were made spectroscopically. At shorter wavelengths, the thermoluminescence properties of calcium sulfate and manganous sulfate were employed. These phosphors are heated after recovery, and luminesce in proportion to the amount of short-wave energy they have absorbed.

Narrow wavelength bands were explored with photon counters. Halogen filling reduces their long wavelength response, and absorption windows reduce their short wavelength response, leaving a band-pass characteristic. Soft X-rays in the 5–10 A region were measured, and the observed intensities were compatible with a coronal temperature of one million degrees Kelvin.

The second speaker was JOHN P. HAGEN, *Radio Observations of the Sun*. He discussed radio frequency measurements of the tenuous solar atmosphere lying outside the photosphere. The photosphere is transparent to visible radiation, but not to radio frequencies. Such data yield the temperature and pressure in the solar atmosphere.

Motion pictures of the 1952 Eclipse expedition were shown. Eclipses are useful in this field because radio telescopes have poor angular resolution, hence the radial brightness distribution is hard to measure. Effective resolution is obtained during an eclipse by observing the radio frequency intensity as a function of moon coverage of the sun. Theory calls for limb brightening at radio frequencies.

The 1952 expedition made measurements at wavelengths of 8 mm, 3 cm, and 10 cm. In all cases, limb brightening was observed, i.e., the sun appears to be encircled by a bright ring. From this it is deduced that the temperature rises steeply in the chromosphere, has a plateau in the corona, and then falls off. (*Secretary's abstract.*)

1381ST MEETING, OCTOBER 23, 1953

RICHARD L. PETRITZ, of the Naval Ordnance Laboratory and Catholic University, was introduced by the President and spoke on *Random processes and noise in semiconductors.*

The subject of the lecture was divided into two parts: (a) Discussion of the relationships between random processes in different fields of study, such as physics, biology, and economics; (b) application of random process theories to noise in semiconductors.

Some of the basic definitions of interesting random processes were given. Reference was made to average values, probability functions, correlation coefficients, and power spectra. The Markoff process was discussed, and the relation between branching processes in biology and atomic bomb problems indicated.

In a semiconductor the number of electrons contained in a conduction band is random. When a current is going through the semiconductor a noise is produced due to the fluctuation of the number of electrons. Noise studies permit the measure of certain parameters of the semiconductors. The speaker described some experimental methods used to determine the noise spectrum. He discussed how the shape of the noise spectrum is being related to the fluctuations of lattice temperature and to the electron mobility in semiconductors.

1382D MEETING, NOVEMBER 6, 1953

JAMES W. DAVISSON, of the Naval Research Laboratory, was introduced by the Chairman and spoke on *Electrical breakdown in crystals.*

Most phenomena in crystal physics add symmetry to the crystal symmetry itself. In the X-ray determination, the most important problem is to find out what is the symmetry of the crystal. It turns out that electrical breakdown phenomena, apart from crystal growth, are the only ones which show symmetry of crystals under all conditions. Electrical breakdown in crystals generally leads to the formation of well-defined paths. These lie in crystallographic directions which depend upon the symmetry of the crystal, the temperature, and the applied field. Both negative and positive patterns vary with the temperature. When one changes the polarity in crystals which lack a center of symmetry, the patterns are distinct and at no temperature come together. Present theory, based upon anisotropic electron scattering at the Brillouin zone borders, explains some of the qualitative features of phenomena. In metals, diamond, germanium, and silicon, there is no polarization scattering but a "nonpolar" scattering. Sulfur scattering does not vary with temperature but presents still some orienting influence. It looks as if, in sulfur, there is a new type of asymmetrical scattering not depending upon the Brillouin zone border. There is, therefore, evidence that in addition to the Brillouin zone effects there must be some other source of asymmetrical scattering.

After a discussion on the subject of the lecture, the meeting was adjourned for a social hour. Twenty-one members attended the meeting unmindful of the snowstorm which fell on Washington with complete disrespect to the Weather Bureau predictions.

1383D MEETING, NOVEMBER 20, 1953

SHIRLEIGH SILVERMAN, of the Johns Hopkins University Applied Physics Laboratory was introduced and assumed the chair for the technical portion of the meeting.

The first speaker was JOHN STRONG, Johns

Hopkins University. His subject was *Interim report on studies of infrared radiation from the moon and the planets.* Slides of the 8–14 micron infrared spectra of Venus, Mars, and the moon were shown, and surface temperatures deduced from these data were given. The ingenious experimental arrangement for comparing planetary radiation with sky background and cancelling effects of apparatus radiation, was explained. One of the experimental results was that the visually dark side of Venus is as warm as the visually bright side, hence the day-night relation being observed was sunset, rather than sunrise. No carbon dioxide was observed on Venus, implying that the observed stratosphere is above the carbon dioxide layer. The atmospheric circulation of Venus appears to be opposite to that of Earth, for the poles of Venus were found to be 6° cooler than the equator, whereas an opposite relationship is true on Earth (at high altitudes). The earth's atmospheric absorption was corrected for by an ingenious scheme. The infrared radiation from the moon can be computed in terms of the moon's temperature, in turn computed from known solar constants. Comparison with the observed lunar radiation yields the absorption in the earth's atmosphere.

The second talk was *Line width and shape in the Infrared*, given by W. S. BENEDICT, of Johns Hopkins University. This talk was centered on the Lorentz law of collision broadening of spectral lines. The predictions of this theory for line peaks, troughs between lines, and extreme wings of bands were discussed and compared with experiment. The Lorentz law is good for CO_2 except in the extreme wings, fair for CO except in the wings and troughs, and no good at all for HCl. The inadequacy for HCl is attributed to polar intermolecular forces.

The final talk was *Photo-ionization absorption spectra of negative ions*, by LEWIS BRANSCOMB, National Bureau of Standards. Negative ions have a low binding energy of only 1 or 2 volts, hence the photodetachment of the excess electron involves infrared absorption. Most atoms do not form negative ions; those that do such as hydrogen, usually have only one such state, hence do not yield a line spectrum of absorption but only a convergence limit of a continuous spectrum. These ions are of interest as a possible mechanism for storing electrons in the ionosphere. Experimentally, the weak continuous absorption is almost impossible to observe. The speaker's procedure was to observe by electrical means the detachment of electrons from a beam of known ion current. The experiments on negative hydrogen ions check with theory; negative oxygen ions are still being studied.

1384TH MEETING, DECEMBER 4, 1953

The Society was addressed by K. K. DARROW, of the Bell Telephone Laboratories, on *The Hall effect.* He quoted a statement by Maxwell that the current distribution is NOT affected by a magnetic field. Mr. Hall did not believe this statement, and devoted his doctoral thesis to an experimental proof of its falsity.

An electric current flowing through a ribbon, whose plane is perpendicular to a magnetic field, tends to be deflected against one edge of the ribbon, in the direction of the resulting mechanical force on the conductor. This transverse virtual displacement of the streamlines of the current produces a compensating transverse electric field to compensate the displacement force. The vector resultant of the applied longitudinal electric field that motivates the current and the transverse electric field of the Hall effect, makes an angle θ with the direction of the ribbon. The transverse equipotential lines are therefore also rotated through an angle θ. This angle θ is expressible as a function of the magnetic field and the charge mobility, or as a function of the field, the current, and the number of free charge carriers per unit volume. Hence the Hall effect offers a means of measuring either mobility or free charge carrier density.

If a trace of arsenic, atomic number 33, is present in germanium, 32, there are excess electrons available for conduction, even at low temperatures. As the temperature is raised, more and more of the arsenic atoms release their excess electrons, and the conductivity is increased. These effects are demonstrated by the sign and magnitude of the Hall effect.

Conversely, if the impurity is gallium, 31, there is a deficiency of electrons, and the Hall effect yields the density of apparent positive charge carriers, and shows the increase with temperature; these two types of semiconductor material are known as n-type and p-type respectively.

At sufficiently high temperatures, pure germanium becomes a so-called intrinsic semiconductor. The thermal agitation releases valence electrons, and supposedly equal numbers of negative charge carriers and apparent positive charge carriers are present. Hall effect measurements yield the ratio of the two mobilities. (*Secretary's abstract.*)

1385TH MEETING, DECEMBER 18, 1953

The Society was addressed by GEORGE GAMOW on *The arithmetic of life*. Living cells are composed of two types of material: the body of the cell is made of proteins, the small nucleus of various nucleic acids, generally abbreviated DNA. The chromosomes in the nucleus are decomposable into six building blocks; sugars, phosphates, and four complex bases. The chromosomes somehow carry the information for the synthesis of the cell proteins.

DNA comprises long chains of sugars cemented together by phosphates. To each sugar is attached one of the four bases. The bases can hook to each other in certain pairings by hydrogen bonding, thus allowing two suitable long sugar chains to be adjoined. The resulting dual chain chromosome has a helical structure, with a pitch of one turn to ten sugar molecules. Chromosome division takes place by splitting of the string of hydrogen bonds. After the splitting, each of the bases can attach a replacement from solution, and eventually restore the whole chromosome. In an excited state, some of the otherwise forbidden hydrogen bond pairings can occur. Under these conditions, the newly grown half of a chromosome may contain a few errors. Under subsequent division, this error is propagated and becomes permanent. This may be the explanation of mutations.

The proteins of the cell are decomposable into twenty different amino acids, as building blocks. It is interesting to note that although amino acids have both laevo- and dextro- forms, only the laevo-acids have been found in living organisms. Protein molecules are made of long chains of amino acid groups. The problem is to explain how the long chromosome chains of four bases control the manufacture of the long protein chains of twenty blocks. Analysis of the allowable combinations of four adjacent bases in the chromosome chains, in light of the hydrogen bonding rules, shows that exactly twenty different "diamonds" can occur. The twenty amino acids fit into these diamonds, pointing in toward the axis of the spiral, and approaching sufficiently close to each other to join and make protein. These protein molecules can then be stripped from the mold, so to speak. Further combinatorial analysis shows that the twenty diamonds cannot follow each other in arbitrary order, but still represent essentially a radix four system. The diamonds can be segregated into six classes: the first class contains four diamonds, each of which can be followed by any of fourteen, including themselves. The second class is similar. The third and fourth classes are similar, but the combining number is seven, rather than fourteen. The last two classes can each combine with only seven, and in each case this seven does not include the members of the class itself. If we represent each of the twenty diamonds by a letter we have 196 allowable pairs of letters, and each of these pairs allows only four choices of the succeeding pair. Trying to identify the various letters with the twenty amino acids is a complicated problem in cryptography. The structure of insulin is a known chain of 29 amino acids, hence represents an allowable message in our code. So far, the code has not been broken. (*Secretary's abstract.*)

1386TH MEETING, JANUARY 15, 1954

This meeting of the Society was the occasion of the retiring Presidential Address on *Some newly solved and some unsolved problems in optics*, by ARCHIE I. MAHAN, of the U. S. Naval Ordnance Laboratory. The address has been published in this JOURNAL **44:** 165–194. 1954.

1387TH MEETING, JANUARY 29, 1954

The Society was addressed by JEROME WOLKEN, director of the Biophysics Research Laboratory of the Eye and Ear Hospital, Pittsburgh, Pa., on *Cellular growth, structure, and function*. The structure of cells was described, in idealized form. A relatively new technique of electron microscopy of cells was described. The cell is first "fixed" with Osmium Tetroxide; the excess salt is then washed out with water, and a plastic allowed to diffuse in. The cell can then be sliced with a glass knife into slices of 0.03–0.05 microns thickness. One of the organisms illustrated by use of this technique was an interesting protozoon known as Euglena gracilis. This organism contains both chlorophyll and a purely animal pigment, hence can be considered as either animal or vegetable, or both. The fact that the chloroplasts can grow within the Euglena cell is shown by the fact that under suitable growth conditions, the amount of chlorophyll per cell increases with time. On the other hand, treating the cells with streptomycin or holding them at 40° Celsius will knock out the chloroplasts, but the cells will grow and divide at their normal rate.

There are about five chloroplasts per cell, on the average, and these plastids have a layer structure, about 20 "dark" layers separated by "light" layers. The light layers are mainly water and protein, the dark layers contain fat protein, and pigment, the pigment being chlorophyll in this particular case. There are about 10^9 chlorophyll molecules per plastid. These molecules are assumed to "sit" on the surface of a layer.

In a purely animal structure, the eye of the perch, the cones and rods show a similar layered or banded structure. The thickness of the bands is about the same as those found in Euglena and also in higher plants. The rod cells and cone cells also show about the same number of pigment molecules as did the plastids, even though these animal structures are much larger than those of Euglena. The apparent paradox is resolved by the observation that the visual pigments, of less molecular weight than chlorophyll, are attached to very large protein molecules in about a one-to-one ratio, whereas the chlorophyll molecules are attached to small protein molecules, still in about a one-to-one ratio. The larger animal proteins lead to the larger banded structures. Thus it is found that the dark bands in a wide range of cell types contain approximately the same number of protein molecules, or rather, of protein-pigment complexes. There is chemical evidence for the existence of a protein-pigment macromolecule; the pigments in isolated form exhibit different chemical properties than do those in cells. (*Secretary's abstract.*)

1388TH MEETING, FEBRUARY 12, 1954

The Society was addressed by HERMAN BRANSON, of Howard University, on the topic *Information theory and the structure of protein molecules.* Shannon's definition of information was reviewed, with attention to its additive properties. A table was displayed, giving the channel capacities, in bits per second, of various sensory organs, and the much slower information accepting capacity of the human brain. Information theory can be formally applied to the structure of proteins, considering the 20-odd amino acid residues as alphabetic characters, and the protein chains as words. Each possible orientation or other "complexion" of an amino residue is considered to be a different letter. The amount of information "stored" in the molecule can be taken as the difference in the Shannon entropy, or uncertainty, of the particular amino chain in question, and the maximum uncertainty that a chain of the same number of residues could have. The uncertainty is the logarithm of the number of possible "complexions". In natural proteins, the uncertainty is greater than 85 percent of its maximum possible value, in most cases. This implies little information storage. As the total number of residues, N, in the chain increases, the ratio of the uncertainty to its minimum possible value appears to be a linear, increasing function of N. (*Secretary's abstract.*)

1389TH MEETING, FEBRUARY 26, 1954

The Society was addressed by E. O. HULBURT, of the Naval Research Laboratory, on the topic *Magnetic storms, aurora, ionosphere and zodiacal light.* Magnetic measurements have indicated that the earth's magnetic field behaves as if there were a magnetic dipole at its center and a ring current of about 10^6 amperes encircling the earth in an east-west direction near the Equator. Disturbances in the earth's magnetic field may be local or world wide, the latter being referred to as magnetic storms. During a magnetic storm, the earth's field first increases, then it decreases below its normal value, and finally after a recovery period returns to its initial value. These disturbances arise from outside the earth's atmosphere and are usually associated with sun spots.

A so-called "ultraviolet light theory" has been proposed by Hulburt for explaining these magnetic storms. The theory suggests that the sun bathes the earth in a sudden flare of ultraviolet light. This light increases the ionization in the ionosphere with the result that the current in the east-west direction increases also increasing the earth's magnetic field. The ionosphere however is also heated so that an outward expansion follows. Because of the earth's magnetic field at the equator, these ions are forced into a west-east current which brings about a decrease in the earth's magnetic field. This theory has had considerable success in explaining many of these phenomena.

Abnormal ionospheric activity is also closely associated with magnetic storms, but due to a lack of sufficient data and a complete evaluation of existing data on a world wide basis, ionospheric activity has not led to a better understanding of magnetic storms. Statistical studies have been started, but the work is unfinished.

Several corpuscular theories have also been advocated for explaining magnetic storms. These theories assume that the sun projects streams of particles of like or unlike signs toward the earth, some of which enter the polar regions and produce aurora while others are trapped by the earth's magnetic field and give rise to an increased east-west current at the Equator and hence an increase in the magnetic field. These theories then make plausible the first increase in magnetic field during a magnetic storm, but the explanations of the other phases are admitted as purely speculative.

The zodiacal light and the "Gegenschein" were also discussed briefly. According to the older theories, both were explained in terms of the dust theory. Recently, however, the zodiacal light has been found to vary in brightness during a magnetic storm and this cannot be understood in terms of the dust theory. To explain these magnetic variations of the zodiacal light, Hulbert has extended his ultraviolet light theory by assuming that the atoms which reach the outer regions of the ionosphere accumulate in an oblong ring in the plane of the ecliptic which absorbs the ultraviolet light and reemits part as visible light. This light is the zodiacal light. The portion of the ring away from the sun streams away due to light pressure and when viewed on end becomes the "Gegenschein." Experiments to check these ideas are not in agreement.

1390TH MEETING, MARCH 12, 1954

The Society was addressed by HERBERT FRIEDMAN, of the Naval Research Laboratory, on *Solar X-rays, extreme ultraviolet radiation, and the ionosphere.*

Experimental data on the penetration of solar radiation into the atmosphere have been obtained primarily from rocket-borne equipment. Rocket flights reach the D, E, and F layers of the ionosphere. In the ultraviolet range, 1300 to 1700 A, the main absorber is molecular oxygen, which is dissociated by the radiation. The atmospheric absorption possesses a deep window which passes the Lyman alpha line of hydrogen at 1216 A. The 2000 to 2800 A range penetrates to about 30 kilometer altitude, where it is strongly absorbed by ozone. The Lyman alpha radiation penetrates to about 70 kilometers, which is the deepest penetration of any radiation below 1800 A.

Between 1000 and 2000 A, the spectrum is too weak for diffraction grating observations in the time available in a rocket flight. Intensity measurements in this range are therefore made at spot wavelengths with suitable photon counters. These are essentially Geiger counters with photosensitive cathodes, and special windows for filters. Such an ultraviolet counter was demonstrated. A flashlight produced absolutely no response, but the flame of a match yielded a strong signal. It was also demonstrated that glass is opaque to the ultraviolet to which this counter responded. Various photoelectron thresholds down to 1900 A are obtainable by the use of a suitable cathode. Filling the counter with the proper gas will suppress emission from the cathode, and require photoionization of the gas for response. Appropriate combinations of cathode, gas, and window material make possible counters responding to only a relatively narrow band of wavelengths. A counter was demonstrated, having a 1300 A threshold. Sapphire and lithium fluoride windows were used. Sapphire gives a pass band from 1050 to 1300 A, and allows measurement of the Lyman alpha line intensity. Ninety percent of the solar radiation in this wavelength range, below 100 kilometers altitude, is Lyman alpha. The D layer of the ionosphere is explainable by Lyman alpha absorptioe producing ionization of Nitric Oxide.

For measurement of X-rays of approximately 10 to 20 Angstroms, beryllium and aluminium windows are suitable. The major absorption of 10 to 100 A radiation is found to be in the region from 100 to 120 kilometers altitude. The resultant ionization is a reasonable source for the E layer. Measured X-ray intensities fit the known ionization density of the E layer.

The sun's corona contains highly ionized atoms, with as many as fourteen electrons removed. Recombination of these atoms with free electrons yields a continuous spectrum that is characteristic of a temperature of 1,000,000° Celsius. This supplies the 20 to 50 Angstrom energy for producing the E layer. Helium II radiation is strong at about 200 A and may contribute to the F layer. The coronal green line is attributed to Fe XIV, and is apparently a good indicator of the solar X-ray output. (*Secretary's abstract.*)

1391ST MEETING, MARCH 26, 1954

The twenty-third Joseph Henry Lecture was delivered by HENRY MARGENAU, of Yale University. His paper *Advantages and disadvantages of a causal interpretation of quantum mechanics* was published in full in this JOURNAL **44**: 265–276. 1954.

1392D MEETING, APRIL 9, 1954

The Society was addressed by A. MICHELS, of the University of Maryland and the University of Amsterdam, on the subject *Some aspects of high-pressure molecular physics.*

The classical Van der Waals picture of molecular interaction was reviewed, and its quantum mechanical explanation in terms of the interactions of electric charges. According to this model, the electronic orbits must be distorted as a substance is compressed, i.e., as the molecules are forced to be closer together. For example, if pv is strongly increased in an isothermal compression, both the total energy and the kinetic energy increase. Since the temperature is unchanged, the additional kinetic energy must be in the electronic orbits.

An interesting rough theory of high pressure effects has been worked out assuming close packed hydrogen *atoms*. Each electron is assumed to be confined to a geometrical cell centered on its proton. A computation of the electron kinetic energy increase of 5000 cal/mole for a pressure of 3000 atmospheres. This result is in approximate agreement with experimental values for a number of gases. For sufficiently high pressure, several hundred thousand atmospheres, the electron energy would exceed the ionization potential. Does this imply that hydrogen would then behave like a metal?

A similar orbit distortion verification was performed on germanium. A pressure of 3000 atmos., increases the gap between the full energy bands and the conduction bands by 3 percent, as indicated by conductivity measurements. These results are also shown by the shift in the edge of the infrared absorption spectrum.

Electron orbit distortion also shows up directly in polarizability. Measurements on carbon dioxide show a peak at about the same density for which the isothermal kinetic energy is a minimum.

Another interesting property is shown by the behavior of the vibrational absorption of molecules as the pressure is increased. The nitrogen molecule, for example, has no polar moment and its vibration is not optically active. Under 100 atmospheres pressure, the distortion produces a polar moment, and a wavelength of 4.2 microns is absorbed. In the case of hydrogen, the absorption coefficient varies as the square of the density. If, however, the compression is produced by adding argon instead of more hydrogen, the variation is linear. These results are interpreted as a linear increase due to pressure distortion, and an additional density factor arising from the increased collision rate when hydrogen alone is used. (*Secretary's abstract.*)

1393D MEETING, APRIL 23, 1954

The program was entitled "An Evening of Crystal Growth" and consisted of a set of three related lectures. PAUL EGLI, of the Naval Research Laboratory, acted as organizer and chairman.

The first topic was *The role of impurities in crystal growth*, discussed by SAMUEL ZERFOSS, of NRL. Large single crystals are grown from solution, from a melt, or by a flame melting process. Samples of these types were demonstrated. A particularly large solution grown crystal of ADP (ammonium dihydrophosphate) was exhibited and discussed. A flat seed plate was used to start the growth of a square bar, by extension of the faces, but not the edges, of the seed. The first step is to grow end-caps on the plate. This yields foggy material, but develops the equilibrium end shape, by growth along preferred planes, starting from the corners of the seed. After the endcap is developed, growth of clear crystal proceeds.

The addition of impurities to the solution modifies the growth habit of crystals, changing the preferred faces. Sometimes the modification is beneficial, as in the case of sodium chloride. This substance, in pure solution, grows too vigorously, and makes a large cubical assembly of many relatively small crystals having approximately the same orientation. The addition of lead chloride inhibits the growth on certain regions of the crystal's surface, with the end result of a large, perfect, single crystal. The lead chloride action is transient, for the resulting crystal is free of lead chloride.

The flame fusion process, familiar as the source of synthetic rubies etc., requires very pure raw materials. The residual impurities gather on the surface of the boule as a scum. This technique has been modified at NRL to allow processing in vacuo. The flame is replaced by a section of carbon pipe, heated as an induction furnace.

The second topic was *The role of dislocations in crystal growth*, presented by F. HUBBARD HORN, of the General Electric Co.

The growth rate of a crystal depends upon the degree of supersaturation of the solution. The relation is essentially linear in the supersaturation range of 25–40 percent, and in this range seems adequately explained by theory. At lower concentrations, crystals still grow well, but the theory breaks down.

It has been proposed that crystals grow readily only on edges or other discontinuities, and not on extensive perfectly flat faces. A screw dislocation would give rise to a fault line upon which growth could proceed. Analysis shows that growth on the face of such a "cliff" would propagate the cliff in a self-maintaining fashion, quasi-macroscopic feature of growth. Such spirals could also be initiated by impurity specks, or other local perturbations. Some fascinating color slides of spiral growth patterns on calcium carbide crystals were shown. (One of these could have been suitable for a necktie design.) Time lapse motion pictures, with a speed up factor of 64, convincingly demonstrated this phenomenon in other substances. It was concluded that the growth of a single crystal to appreciable size requires the presence of some type of imperfection.

The final speaker was Mr. EGLI, who used the remaining few minutes to refute the arguments of the previous speakers. His title was *The role of theories in crystal growth.* Mr. Egli showed slides of crystals that "obviously" did not grow by spirals. Their growth was not controlled by impurities but by the lattice in keeping with classical theory. The dislocation theory cannot be of major importance, because these spirals occur on the slowly growing faces, not on the fast ones. The spiral growth phenomenon may explain the existence of growth on faces that really shouldn't grow. In the case of ADP, the pyramid faces grow rapidly, while the prism faces don't grow. No theory has yet been proposed that will explain this basic fact. The state of aggregation of the molecules in solution may be involved. (*Secretary's abstract.*)

1394TH MEETING, MAY 7, 1954

The program for the meeting was entitled "History and Traditions of the Philosophical Society of Washington." Four Past Presidents were presented to the Society with a formal bow both by the speaker and President FORBUSH as was the custom in earlier years.

The first speaker was L. H. ADAMS, who served as President of the Society during 1929. Mr. Adams spoke of the early history of the Society, quoting quite frequently from W. J. Humphrey's paper *The Philosophical Society of Washington through a thousand meetings.* The Society was founded on March 13, 1871. Joseph Henry was its first president and continued to serve in this office until his death in 1878. In the beginning, the Society included all branches of science. With the years, various groups split off and formed independent societies. The first official publication of the Society was the Bulletin which was published up to 1911. After that it was discontinued and the present method adopted of publishing the Proceedings in the Journal of the Washington Academy of Sciences. Some of the early papers presented before the Society were:

Anomalies in sound signals, A. B. JOHNSON
Experiments on the photophone, A. G. BELL
Skin friction, A. F. ZAHM
Solar radiation, C. G. Abbot

Mr. Adams's membership in the Society dates from 1910, at which time he presented a paper before the Society. Mr. Adams told a few stories and then gave some personal reminiscences concerning various members whom he had known over the years.

The second speaker was L. B. TUCKERMAN, who served as President during 1932. At the beginning, Mr. Tuckerman stressed the importance of the tradition of starting the meetings on time, stating that the meeting had not started until 8:52 p.m. He also mentioned that over the years the meetings could be described as reasonably dignified. Examples of meetings were cited which were not so dignified and yet which proved to be equally interesting. Mr. Tuckerman then recalled in chronological order all the past presidents he had known, giving in each case the particular things which stood out in his memory about each one. The first was Lyman Briggs who was president in 1916. He mentioned what an inspiration Mr. Briggs had been to all who knew him. A few stories were also told about W. J. Humphreys, the most interesting of which centered about a pig which survived being struck by a ball of lightning. Mr. Tuckerman also mentioned another tradition of the Society which is falling by the wayside. This was described as the "pinning back of the ears of the retiring president", and of course refers to the frolic which is staged at the expense of the retiring president during the dinner staged in his honor. An example of these procedings cited was that of the making of a LiCl cocktail in honor of the retiring president in 1940, R. E. Gibson. The making of this cocktail was first credited to Mr. Gibson. It was later learned that this cocktail had somewhat toxic properties. Mr. Tuckerman stated, however, that no serious complications developed, for none of the members who attended that dinner are now dead.

At the close of Mr. Tuckerman's remarks, Mr. McNish asked permission from the chair to cross examine the speaker on his statement of the time of starting on the meeting. After consulting the acting recording secretary, it was finally agreed that Mr. Tuckerman had meant 8:22 p.m. instead of 8:52 p.m.

The third speaker of the evening was H. L. CURTIS, who was president of the Society in 1931. Mr. Curtis appeared in the formal attire of his period in office, tails and all, and presented a prepared address on *The development of a subspecies of the genus Homo, sapiens scientifica, who no longer adorn themselves by wearing tails*". This address has been published in full in this JOURNAL **45:** 131–132. 1955, and will not be discussed here.

The last speaker of the evening was F. G. BRICKWEDDE, who served as President during 1939. Mr. Brickwedde discussed the subject *The History and development of the Joseph Henry and Christmas lecture committees.* During the presidency of H. L. Curtis in 1931, the income of the Society began exceeding the expenses, so a committee was appointed to determine how the Society might further serve the interests of its members. This committee made the recommendation that a lecture be given each year in some field of research by scientists outside the Washington area. These lectures were not started with the idea of honoring Joseph Henry, but it was natural that this should follow, for 1931 was the centenial of the discovery of induction with which Joseph Henry was so closely associated. The first Joseph Henry Lecture Committee was composed of L. H. Adams, C. G. Abbot, and R. E. Gibson. The first Joseph Henry Lecturer was Joseph Ames, president of the Johns Hopkins University, and the lecture itself was devoted to the life work of Joseph Henry. Mr. Brickwedde then reviewed for the membership some of the outstanding contributions of Joseph Henry. The names of several of the following lecturers and their subjects were also mentioned.

Again in 1952, the Society found its income still increasing in spite of the fact that its dues per member were still fixed at $3. At this time Mr. McNish, the President, appointed another committee to determine how these funds might best be placed in the service of the Society. This committee consisting of A. Stone, L. Marton, and M. L. Henderson recommended the establishing of two demonstration lectures to be given for young people in the age range fourteen to twenty one. The first Christmas Lecture committee consisted of L. Marton, A. Stone, L. A. Wood, and A. I. Mahan. The first Christmas Lecturer was Edwin H. Land, of the Polaroid Corporation, who gave a demonstration lecture on *Two- and three-dimensional color photographs.* Last year these lectures were given by R. M. Sutton, of Haverford College, who spoke on *The world we see* and *The world we don't see.*

Several other Past Presidents and members of the Society made additional remarks. Some of these were Lyman Briggs, E. C. Crittenden, and W. G. Brombacher. At the close of the meeting, 15 past presidents assembled in front of the membership.

1395TH MEETING, MAY 21, 1954

The Society was addressed on *Quantum limitation to vision* by ALBERT ROSE, of the David Sarnoff Research Center, RCA. The well-known decrease in spatial and tonal resolution of the eye with decrease of light intensity is due primarily not to physiological factors but to effects of quantum physics. At low levels of illumination, there are just not enough photons reaching the eye to convey the desired detailed information. This quantum effect is not obvious, for there is no noticeable "granularity" to the perceived light.

Classical vision theory utilizes the bleaching of visual purple to generate nerve impulses. Quantitative studies have been made using flicker effect and dark adaptation. Adaptation to the dark results in an apparent sensitivity increase of about 10,000 to 1. This has been interpreted to mean that under the conditions of high illumination, 99.99 percent of the visual purple is bleached. This would imply that only 0.01 percent (or possibly 0.1 percent) of the incoming photons can be utilized, but it can be demonstrated that practically 100 percent must be utilized for use to see as much as we do!

A slide was shown illustrating a test pattern of various size gray and black dots photographed in such a manner that each individual photon recorded as a white spot. The smaller the spot, or the less its contrast with the background, the more photons are needed to show its presence.

In the case of a regular lattice array of spots and incident photons, a single photon is sufficient to show a dot (by being absent from the pattern of reflected photons). If the spot has a reflection coefficient of $\frac{9}{10}$, at least 10 photons are needed to make the minimum detectable difference of one photon between the dot and the background. For 1 percent contrast, 100 photons are needed, etc. This illustrates the quantum limitation to tonal discrimination.

If the array of incident photons is random, many more are needed to detect a dot—i.e., to make it obvious that a group is missing in the reflected illumination. It is found experimentally that a set of about 25 close neighbors must be missing from a random pattern to make it apparent that there is a "hole" in the pattern. For the 10 percent contrast gray dot to be detected, then, it would require an illumination density such that some 2500 photons were incident upon the dot; the 1 percent contrast dot would require 250,000 incident photons. This "square law" increase follows from statistical reasoning.

Under room illumination of 10 foot-candles, about 4×10^{16} photons are incident on each square foot each second. Allowing for the area of the iris, and the tenth-second integrating time of the eye leaves about 10^{12} photons available to the entire retina for one observation. This boils down to 10,000 per receptor, which from above is too few to detect an image of 1 percent contrast. Hence for this contrast, the quantum effect would limit resolution before receptor size would. This argument is independent of the mechanism of vision.

For a 10 percent contrast image of 1 to 2 minutes of arc extension, there are just enough photons available if 1 percent of them are used. For weak light, $\frac{1}{10}$ of the incident photons must be used to account for what we actually see. That is, in weak light, the utilization efficiency is about ten times what it is in good light. This allows only 90 percent of the visual purple to be bleached under good illumination, leaving a factor of a thousand in apparent sensitivity still to be explained.

The speaker suggested that there may be a built-in amplifying system between the retina and the nerve fibers. This is needed because the nerve impulses are more energetic than the received light. On this basis, dark adaptation is due mainly to an Automatic Gain Control in the amplifying system. The lag in adaptation can be explained by the time constant of the AGC system.

The lecture was concluded with some slides showing the image of a girl under illuminations ranging from 10^{-6} foot-lamberts to 10^{-2} foot lamberts. The granularity was quite evident at the lower levels of illumination, and the distinguishability of the image varied with level in a startling manner. (*Secretary's abstract.*)

1396TH MEETING, JUNE 4, 1954

The Society was addressed by RAYMOND J. SEEGER, of the National Science Foundation. His subject was *On natural Philosophy.*

The meaning of "natural philosophy" has changed considerably in recent generations, as has indeed the meaning of plain "philosophy." The speaker traced three eras of relationship between science and philosophy.

The first period, the age of speculative science, was typified by Plato and Aristotle. Quoting liberally from the Greek and Latin classics, Mr. Seeger illustrated his point that during this period philosophy and science were intermingled and indistinguishable.

The second period, the age of national science, saw the lives of St. Thomas Aquinas and Immanuel Kant. It was Aquinas who first distinguished between philosophy and science. Earlier writers had treated science as a part of their philosophy, not as a study in itself. Kant attempted to divorce science completely from philosophy, rather than to have it as a special branch of philosophy.

The third period is characterized as the age of experiential science, with philosophy completely missing from the picture. Physical principles are accepted on the basis of logical compatibility and experimental verification, rather than an appeal to being understandable. "Meaning" is ignored. Science absorbed metaphysics, whereas Descartes had science subordinate to metaphysics.

The speaker went on to present scattered aspects of his own viewpoint, or his philosophy about philosophy. He commented briefly on Margenau's work, and asked rhetorical questions, about "real" mass in relativity. He summed up some of the problems by quoting "The common sense of today is the uncommon science of yesterday." (*Secretary's abstract.*)

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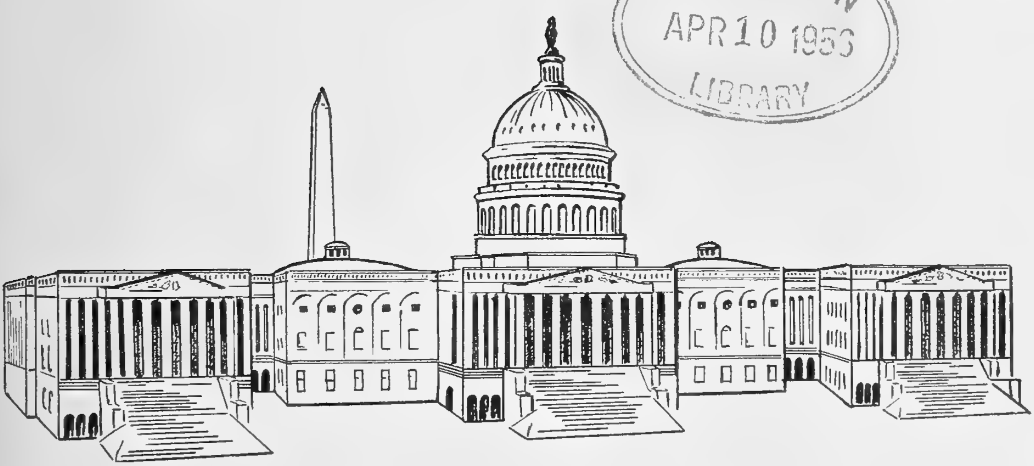

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GEOPHYSICS.—*Possibilities and significance of high-speed computing in meteorology.*[1]—François N. Frenkiel, Applied Physics Laboratory, The Johns Hopkins University.

These comments refer to the impressions from a conference on the significance and possibilities of high-speed computing in meteorology and oceanography that was organized under the sponsorship of the National Science Foundation and which met in May 1954 at the University of California in Los Angeles.[2]

Meteorological research is or at least should be of great interest not only to meteorologists but also to physicists, applied mathematicians, astrophysicists, and other scientists. Many important developments in meteorology were brought about through active cooperation between various disciplines. Modern research is often done by applying to a problem theoretical and experimental methods developed by various branches of science. Recognizing these facts, the main purpose of the Los Angeles conference was therefore to bring together meteorologists, oceanographers, mathematicians, and physicists in a round-table discussion on the possibilities as well as the limitations of high-speed computing in meteorology and oceanography. Several participants prepared in advance some comments on various meteorological problems which already are or may be investigated using high-speed computing techniques. These comments helped in leading to an extensive discussion of the applications of numerical methods in meteorology and to an exchange of ideas between the forty or so scientists representing the various disciplines.

Most of the discussion of meteorological problems was concerned with the motions of the atmosphere. The fundamental laws of air motions are based on theoretical and experimental information available from fluid dynamics studies and are applied with much success whenever the flow conditions are relatively simple, as is often the case in physics and engineering. However, in most meteorological problems, the fluid motions are extremely complex and the application of even relatively simplified laws of hydrodynamics would require long computations. The meteorologists have, therefore, of necessity, been forced to build a discipline, based partly on existing physical laws and partly on insight into atmospheric phenomena gained from long experience. While the art of meteorology was thus being continually improved, important advances were being made in fluid dynamics and in pertinent mathematical techniques. High-speed computing techniques came into being and their development opened new possibilities. With this newly acquired knowledge and facilities, a more scientific approach to problems of atmospheric motions could again be attempted. Electronic computing machines can now, within a reasonable time and without requiring thousands of human operators,

[1] Presented at the Tenth General Assembly of the International Union of Geodesy and Geophysics. Reprinted, by permission from the *Scientific Proceedings of the International Association of Meteorology, Rome, 1954*. London (Butterworths), 1955. Some references to the discussions included in the Proceedings are omitted in the present paper.

[2] The participants included F. L. Alt, J. Bjerknes, L. M. K. Boelter, J. Charney, C. Eckart, R. Fjørtoft, G. Forsythe, F. N. Frenkiel, M. R. Hestenes, E. W. Hewson, J. Holmboe, J. Kampé de Fériet, J. Kaplan, W. W. Kellogg, V. O. Knudsen, G. P. Kuiper, J. W. Mauchly, W. H. Munk, J. Namias, M. Neiburger, E. Palmén, H. A. Panofsky, E. R. Piore, G. W. Platzman, R. R. Revelle, R. J. Seeger, Z. Sekera, J. Smagorinsky, H. K. Stephenson, H. J. Stewart, J. J. Stoker, O. G. Sutton, S. Syôno, P. D. Thompson, J. von Neumann, and H. Wexler.

apply such laws to many complicated meteorological problems.

Numerical weather forecast, using high-speed computing equipment, is already an object of extensive studies, particularly in the United States, the United Kingdom, and Sweden. From known meteorological conditions over the United States, for example, the general flow pattern can already be determined, one or two days ahead, for a large part of the country. Comparisons between the numerically determined charts and those observed one or two days later appear to be encouraging. With further scientific development, predictions of large scale flow patterns, located correctly to within, say, 200 miles, will be made soon on a routine basis.

The use of electronic computers has already made great contributions to many fields of science and technology. However, their importance to meteorology is particularly significant. In such problems as weather prediction, the meteorologist does not have the time or the means to apply all those laws of fluid motion which are well known. He therefore makes a general diagnosis of the meteorological situation and determines on its basis his forecast. There is, in such a prediction, some guessing in which experience is necessary and where some luck is helpful. No two human forecasters will reach absolutely the same conclusions. Unlike the human forecaster, the electronic computing machine is completely objective; it will not guess, but it will give results corresponding to the physical laws used as a basis for the numerical forecast. An incorrect forecast will indicate to the meteorologist that his instructions or data to the machine should be improved. Thus a quantitative comparison between the effects of various possible improvements on the numerical weather predictions will be of great value. One should, however, not lose sight of the fact that an electronic computing machine does not have its own intelligence. Its lack of intelligence is responsible for its objectivity which in turn limits the ability of the machine to making relatively simple operations according to a program prepared by human operators. It is only the speed with which the machine performs these computations and the volume of the numerical information it can memorize which make it valuable to a meteorologist. Each *numerical* weather forecast must be followed by a critical interpretation of the results by a synoptic meteorologist who using it as a basis, and taking into account the humidity and temperature distributions, will prepare the *physical* weather forecast. The final weather prediction will largely depend on the experience and ability of the synoptic meteorologist. A part of his work will, however, be done using methods developed in exact sciences. One can see a certain similarity between meteorology and medicine; the electronic computing machine playing the role of such modern medical methods as, say, the determination of sedimentation rates. The diagnosis of a physician, like the diagnosis of a synoptic meteorologist will greatly improve if he uses all the available scientific tools.

The contribution of high-speed computing techniques to weather forecasting consists primarily in making possible the numerical solution of some fundamental equations of fluid dynamics which have been known for many years. However, the theoretical foundations of numerical forecasting also depend on recent contributions to the mathematical representation of atmospheric motions and to numerical analysis. There are, also, some recent advances in fluid dynamics which may, with the help of high-speed computing techniques, contribute to a better understanding of atmospheric motions. I am referring to the statistical theory of turbulence and to the related applications of probability theory. Theoretical and experimental studies of turbulence may be useful in showing where such an approach to meteorology will be of practical value.

The recent development of the statistical theory of turbulence has been influenced by the possibility of comparing the theoretical results to experimental measurements in wind tunnels. Most of these measurements were made with hot-wire anemometers with which velocity fluctuations reaching frequencies of ten thousand cycles per second can be observed. The nature of the turbulent fluctuations is determined by eliminating, with appropriate electronic equipment, the mean wind velocity and expressing the turbulence characteristics by such statistical quantities as correlation coefficients, spectra of turbulence and turbulence intensities. This electronic equipment operates, in fact, like a specialized analog computing machine determining statistical characteristics of the fluctuating wind velocity. The mean wind-tunnel velocity is well defined, and the fluctuations of the instantaneous velocity correspond to a scale of eddy sizes of the order of one centimeter or smaller. When the mean wind velocity is of at least 1 meter per second, the frequency of turbulent fluctuations is of 100 cycles per second or more. In an analog computing operation, a several second sample record is used which is sufficiently large compared to the magnitude of the fluctuation periods to give meaningful statistical results.

The turbulent energy of the atmosphere includes a certain amount of energy corresponding to eddies of the same range of magnitudes as those of wind-tunnel turbulence. It also includes eddies of several centimeters or meters observed with micrometeorological instruments as well as larger size fluctuations recorded in most meteorological stations on manographs. Eddies of a magnitude of many kilometers and cyclonic motions observed on synoptic charts may be included in the definition of the turbulent energy of the atmosphere. The spectrum of atmospheric turbulence will therefore cover a very large range of eddies. One must have, therefore, a sufficient amount of data on fluctuating wind velocities to be able to compute statistically meaningful averages. Electronic computing machines make such computations possible and enable us to apply some of the methods of the statistical theory of turbulence to atmospheric problems.

The main importance of the modern theory of turbulence is, however, its contribution to the understanding of such physical processes as the transfer of turbulent energy from large scale motion to smaller scale fluctuations and the decay of turbulence. The equations describing these physical processes are based on the laws of fluid dynamics and are known at least in some simple cases of turbulent fields. The use of the statistical description of the turbulent fluctuations is justified here by the fact that it brings these physical processes into focus and is not a means for concealing our ignorance of these processes.

The study of the relation between large-scale flow patterns and the smaller-scale phenomena, which are our local weather, must be based on a better knowledge of atmospheric turbulence. This knowledge can be acquired from extensive atmospheric data obtained under various meteorological and geographic conditions. However, the enormous amount of available data and their extreme complexity make it practically impossible for a meteorologist to digest them and to grasp fully their significance. A large number of already available measurements, therefore, remain unexploited; other significant meteorological data are not even collected because of the labor and time which would be required to analyze them. High-speed computing techniques now make possible the analysis of these data in a reasonable time.

As we have mentioned before, in a wind tunnel it is rather easy to define a constant mean wind velocity and the turbulent velocity fluctuations which depart from this mean. The averaging process is much more difficult in the case of atmospheric turbulence. The definition of a "mean" wind velocity will essentially depend on the scale at which we wish to observe the meteorological motions. There will also be some mathematical difficulties in defining appropriate averages using the experimental data but in this regard one can obtain valuable results from studies of atmospheric spectra of turbulence.

The largest scale at which one can study the atmosphere is the planetary scale. Here the main difficulty is that we cannot observe the Earth's atmosphere as a whole. One may hope that in the future meteorological observations from rockets and artificial satellites may be practicable but at present we have a general view of the atmospheric motions only for our sun and for such planets as Jupiter, Saturn, Mars, and Venus, where some cloud motions or dust storms can be seen. The view from this great distance brings out the large scale motions and averages out the smaller scale spatial fluctuations. To have an even more complete understanding of the planetary circulation one must also bring out the large-scale time trends of the flow patterns by averaging out the smaller time scale fluctuations. This can be attempted for our own atmosphere by determining an average chart from a large number of synoptic charts. The knowledge and understanding of the planetary circulation are of importance to long-range weather forecasting. In such forecasting the problem is indeed not to determine the location of individual fronts and cyclones but to predict the general trends of atmospheric behaviors over an entire hemisphere. High-speed computing techniques will be of essential importance to such studies of long-range weather forecasting. We may, however, emphasize again the need for understanding the energy transfer from large scale motions to smaller scale fluctuations to which we have referred when discussing the spectrum of atmospheric turbulence. The relation between the general planetary circulation and the large scale "turbulent motions" represented on the individual synoptic charts must also be a subject of a study based on modern fluid dynamic concepts.

Let me at this place digress to quote from the writings of one of the first meteorologists, Aristotle. In his book *Meteorologica*, he writes: "Some people, wishing to be clever, say that all the winds are one, on the ground that the air which moves is in fact one and the same whole, and only seems to differ, without differing in reality, because of the various places from which the current comes on different occasions; which is like supposing that all rivers are but one river. The unscientific views of ordinary people are preferable to scientific theories of this sort" (from an English translation by H. D. P. Lee). As you see, already 23 centuries ago there was some disagreement about the way one should look on the atmosphere. Aristotle's comments projected to our times may have some relation to the statistical considerations of atmospheric motions. It is in fact easy to disagree about the importance of a statistical approach since under the same heading many quite different viewpoints are often included. The use of statistical methods is no doubt of particular importance in meteorological studies. To bring out the planetary circulation, a statistical analysis of the data can be used to eliminate all small spatial or temporal weather fluctuations. Statistical analysis can again be used to study these fluctuations and determine a spectrum of atmospheric turbulence or a correlation curve. The significance of the shape of a spectrum of turbulence or a correlation curve would be based on the physical processes which they appear to represent. In many statistical problems, correlation coefficients are measured and in some of them their value does not add much to the understanding of the physical processes. One can compute a correlation coefficient expressing quantitatively the correctness of a weather forecast. Information theory is providing other methods for such a quantitative study which will also be of value. In many micrometeorological studies one is often concerned with another aspect of a statistical approach in which a correlation curve is significant when it has a connection with the underlying physical process.

Atmospheric pollution of an industrial area has now become a major problem in many communities. Such areas face the problem of reducing the degree of contamination without detriment to many of those human activities that produce it and that are necessary to the well-being of the population. Here again high-speed computing techniques will make possible the application of the laws of physics to the solution of a large part of the problem. The same techniques appear to be of interest to other problems related to turbulent diffusion. Serious consideration is also being given to research on evaporation as well as some problems of sand storms which are of such a great interest to the arid zones studies.

The development and trajectories of tropical cyclones are the object of several studies to which high-speed computing will be very valuable. In this problem one has to solve a system of non-linear equations with certain initial and boundary conditions which involve so many complicated numerical calculations that only electronic computing machines will be able to give practical results. Numerical forecast of the meteorological conditions leading to disastrous floods has been proven to be possible. These and other meteorological problems are of major importance in certain areas and their further study awaits the scientific developments now made possible with the assistance of high-speed computing techniques.

Since there are so many applications for high-speed computing in meteorology, one may ask the question of what is the status of electronic computing machines at present. A large number of electronic digital computers are now in operation and are used to solve meteorological problems. In the Washington area there is now a numerical computing center especially devoted to numerical weather forecast. This center located in Suitland, Md., is jointly sponsored by the Air Force, the Navy, and the Weather Bureau. Most of the meteorological problems and particularly numerical weather forecasting require digital computers of a rather large capacity with a large number of vacuum tubes and complicated electrical circuits. The size and cost of such computers with their relatively large power supplies and cooling systems often limits their availability to many meteorological organizations. There are, however, smaller computing machines which may be of great value to the study of several meteorological problems. I should also like to call attention to the possibility of using transistors in place of vacuum tubes in digital computers. A transistor is of about one tenth of the size of a vacuum tube and requires about one twentieth of its power supply. Although the use of transistors in digital computers is at present at an experimental stage one can expect that it will soon become practical. The installation of the electrical circuitry can also be considerably simplified by using printed circuits. Digital computers with transistors and printed circuits will require smaller power supplies, little or no cooling, and much less space. As a result they will no doubt become less expensive and more accessible to a larger number of meteorological organizations.

One cannot talk about the status of high-speed computing machines without thinking about the processing of data and of the instructions to the machine. I have referred before to the large amount of numerical data which can be analyzed by a digital computing machine. However, the speed with which it performs its operations is often limited by the speed with which the data can be put into the machine. Numerical weather forecasting is particularly concerned with devising techniques for an efficient processing of data to the machine and of the resulting numerical forecast back to the meteorologist.

In conclusion, let me summarize my main impressions from the discussions at the Los Angeles conference. I feel that a closer contact between meteorologists, physicists, mathematicians, and other scientists will be very profitable to the development of Meteorology as a science. High-speed computing techniques have an important role in such a development; their impact will no doubt be felt in several fields of meteorological research. I have the impression that numerical forecasting will influence synoptic meteorology in a very special way, for I believe that what is coming forward is a great development of a modern synoptic meteorology which will connect the synoptic studies to the numerical weather forecast methods. I have already referred to the fact that following a numerical forecast a synoptic meteorologist will have to prepare a physical weather forecast. But of main importance to synoptic meteorology seems to be that, in the future, numerical forecast will be used to construct general weather patterns from which one will be able to determine a weather forecast located correctly within, say, a space scale of 200 miles. These patterns will form a framework which modern synoptic meteorologists, each in his own local area, will complete at an even smaller scale taking into account the atmospheric processes particular to his area. More correct predictions of local weather conditions can be expected to follow such methods. To reach such results it is not necessary to have in each meteorological organization an electronic digital computer nor is it sufficient to have such computers in some meteorological organizations. What is more important is a proper net of data processing equipment and above all a sufficiently large number of modern synoptic meteorologists whose understanding of atmospheric processes will make possible correct predictions of local weather conditions for each area of the size of a county or a city.

MATHEMATICS.—*Commutators of A and A**.[1] T. KATO, American University, and O. TAUSSKY, National Bureau of Standards.

EDITORIAL NOTE

The commutator $(A, B) = AB - BA$ where A and B represent matrices or other not necessarily commuting operators has played an important role in quantum mechanics. The nonvanishing of the commutator of canonically conjugate operators is the root of the Heisenberg uncertainty principle.

One infers that commutability is not "purely mathematical," but of metamathematical interest. Developments in the theory of higher order commutators may some day find application in physics.

A normal $n \times n$ matrix A is one which commutes with A^*, the transposed complex conjugate of A. Four proofs are given here for the fact (Theorems 1 and 2) shown previously by C. R. Putnam [1] that the relation

$$A(AA^* - A^*A) - (AA^* - A^*A)A = 0$$

already implies that A is normal. Two of these proofs do not use the characteristic roots of the matrix and can therefore be used for more general cases. Another of these proofs is generalized for bounded operators in Hilbert space. For unbounded operators the fact ceases to be true as is shown by the matrix

$$A = \begin{pmatrix} 0 & 1 & 0 & 0 & \cdots \\ 0 & 0 & \sqrt{2} & 0 & \cdots \\ 0 & 0 & 0 & \sqrt{3} & \cdots \\ \cdot & \cdot & \cdot & \cdot & \cdots \end{pmatrix}.$$

Denoting $AB - BA$ by (A, B) it is shown that the above theorem when combined with another result of C. R. Putnam, (see [2]), implies the following more general theorem: for a non normal matrix A the commutators (A, A^*) and $(A, (A, A^*))$ do not commute.

Finally, the case $n = 2$ is examined. It is shown that the commutator

$$(A, (A, (A, A^*)))$$

is proportional to (A, A^*). If $(A, (A, \cdots, (A, A^*) \cdots))$ is called the nth order commutator if $n - 1$ brackets ( ) are used, it is shown that the fourth order commutator vanishes if A has a double characteristic root, otherwise no commutator of order >4 vanishes for a not normal 2×2 matrix.

Theorem 1. Let A be a finite matrix with elements in a formally real field or in a field with an involution $a \to \bar{a}$, *for which* $\sum a_i\bar{a}_i = 0$ *implies* $a_i = 0$. *Let* $(A, (A, A^*)) = 0$. *Then* $(A, A^*) = 0$.[2]

First proof. This theorem follows from the following more general one.

Theorem 1′. Let A and C be finite matrices satisfying the conditions of Theorem 1. Then $(A, (A^*, C)) = 0$ *implies* $(A^*, C) = 0$.

Proof of Theorem 1′. Put $B = (A^*, C)$ and assume $(A, B) = 0$. Consider trace B^*B. We obtain trace B^*B = trace $((C^*A - AC^*)B)$ = trace C^*AB − trace AC^*B = trace C^*AB − trace $C^*BA = 0$. Hence trace $B^*B = 0$ which implies that all elements of B are 0.

Theorem 1′ further implies that for non normal matrices A all "alternating" commutators

$$(A, (A^*, (A, (A^*, \cdots (A, (A^*, (A, A^*))) \cdots)))) \neq 0.$$

Second proof. From Lemma 2 of Jacobson [4], it follows that $AA^* - A^*A$ is nilpotent. Since this commutator is hermitian it is actually the zero matrix. For, let $B^r = 0$ for B hermitian. If $r = 2$ the vanishing of the elements of the principal diagonal of B^2 implies already that $B = 0$ for the type of field considered. If $r > 2$ use the relation $B^{r+s} = 0$ where $s > 0$ and $r + s$ is a power of 2. It follows again that $B = 0$.

Theorem 2. Let A be a finite matrix with

[1] This work has been supported (in part) by the Office of Naval Research.

[2] This theorem can be applied to matrices whose elements are polynomials with real coefficients of several indeterminates, e.g., group matrices (see [3]). This note arose in connection with the study of such matrices. In [3] groups with normal group matrices were characterized. Theorem 1 shows that they coincide with groups of which the 3rd order commutator of the group matrix vanishes. This can also be shown directly by group theoretical methods.

complex numbers as elements. Then

$$(A, (A, A^*)) = 0$$

implies $(A, A^*) = 0$.

First proof. The following two results are used:

1. Two matrices A and B are called quasi-commutative if[3]

$$(A, (A, B)) = (B, (A, B)) = 0.$$

Such a pair of matrices have property P, i.e., they can be transformed to upper triangular form simultaneously by a unitary similarity transformation.

2. If A and A^* have property P then A is normal (see [7]).

It is clear that $(A, (A, A^*)) = 0$ implies quasi-commutativity for A and A^*. Hence Theorem 2 follows.[4]

Second proof. Since $B = (A, A^*)$ is hermitian it can be transformed to diagonal form by a unitary similarity transformation. Since the relations $B = (A, A^*)$ and $(A, B) = 0$ are unchanged under a simultaneous transformation of A, A^* and B by the same unitary matrix, we may assume that B is already in diagonal form.

Suppose now that $B \neq 0$. Then we may assume that there is an integer m ($0 < m \leqq n$) such that the first m diagonal elements of B are equal to some $\lambda \neq 0$ while the other diagonal elements are different from λ. Then $(A, B) = 0$ implies that A has only zeros for all (i, k) elements with $i \leqq m < k$ or $k \leqq m < i$. Let A_0 be the $m \times m$ matrix composed of the first m rows and columns of A, and B_0 similarly defined. Then $B = (A, A^*)$ implies $B_0 = (A_0, A_0^*)$. This gives a contradiction, for, while the trace of (A_0, A_0^*) is zero, that of B_0 is equal to $m\lambda \neq 0$.

Theorem 3. Let A be a 2×2 matrix with complex numbers as elements and with characteristic roots λ_1, λ_2. Then

$$(A, (A, (A, A^*))) = (\lambda_1 - \lambda_2)^2(A, A^*).$$

Proof.[5] This theorem follows from the more general identity concerning any pair A, B of 2×2 matrices which can be verified by actual computation:

$$(A, (A, (A, B))) = [(\text{trace } A)^2 - 4 \det A]\,(A, B).$$

We now show how the second proof of Theorem 2 can be generalized to bounded operators.

Theorem 4. Let A be a bounded linear operator defined everywhere in a Hilbert space, and let A^* be its adjoint. Then

$$(A, (A, A^*)) = 0$$

implies $(A, A^*) = 0$.

Proof. $B = AA^* - A^*A$ is a bounded, self-adjoint operator. Let $B = \int \lambda d\, E_\lambda$ be its spectral representation. Let $\mathfrak{M}_\lambda$ be the range of the projection $I - E_\lambda$, where $\lambda > 0$. Then $(A, B) = 0$ implies that $\mathfrak{M}_\lambda$ reduces both A and A^*.[6] Let A_λ and A_λ^* be the parts of A and A^* on $\mathfrak{M}_\lambda$ respectively. It is easily seen that A_λ^* is equal to $(A_\lambda)^*$. We have $(A_\lambda, A_\lambda^*) = B_\lambda$, where B_λ is the part of B on $\mathfrak{M}_\lambda$. Hence $A_\lambda A_\lambda^* - A_\lambda^* A_\lambda \geqq \lambda I_\lambda > 0$ by construction where I_λ is the identity operator in $\mathfrak{M}_\lambda$. Let x be any vector. It follows that $\| A_\lambda x \|^2 \leqq \| A_\lambda^* x \|^2 - \lambda \| x \|^2 \leqq (\| A_\lambda^* \|^2 - \lambda) \| x \|^2$ where $\| A_\lambda^* \|$ is the bound of A_λ^*. This would lead to the contradiction $\| A_\lambda \|^2 \leqq \| A_\lambda^* \|^2 - \lambda < \| A_\lambda^* \|^2 = \| A_\lambda \|^2$ unless $\mathfrak{M}_\lambda$ is zero-dimensional. Thus we have proved that $I - E_\lambda = 0$ or $E_\lambda = I$ for $\lambda > 0$. Similarly we can show that $E_\lambda = 0$ for $\lambda < 0$. This completes the proof of $B = 0$.

Theorem 2 and Theorem 4 can be generalized by using the following theorem of C. R. Putnam (see [2]):

Let A be a bounded matrix and B be a bounded normal matrix. If $(A, B) = C$ and $(B, C) = 0$ then $C = 0$.

Using this theorem for $B = (A, A^*)$ and Theorems 2 and 4, we obtain:

Theorem 5. For a bounded matrix A in Hilbert space the commutators (A, A^*) and $(A, (A, A^*))$ commute if and only if A is normal.

[3] See [5], [6].

[4] This proof can, roughly speaking, be looked upon as the finite dimensional analogue of Putnam's proof. The concept of quasi-commutativity for operators was also studied by Halmos [8] and Kaplansky; see [9], [10].

[5] K. Goldberg assisted us in this proof. See also [11].

[6] See [12], pp. 25 and 33.

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MISCELLANY

Your Editor's mail included the following letter on a problem of general interest. The appended news items on the subject indicate encouraging progress.

A SOLUTION TO THE "SCIENTIST PROBLEM"

Since so much alarmed attention is being given to the present and future shortage of really good science teachers and, ergo, of trained scientists, this solution might be presented: a rotating supply of teachers recruited from competent scientists now working in government, industry, and the Armed Forces.

This might be organized on a one- or two-year "sabbatical leave" basis with the present employer and/or Federal Government and/or foundations continuing that part of the scientist's normal salary and expenses which the public-school system or college is unable to pay. If a man qualified to teach some phase of science is inducted into the Armed Forces, he could serve as a teacher under this plan in lieu of military service.

Since every scientist, however competent, would not necessarily be equipped to *teach* his or her subject, probably a brief period of orientation in planning, psychology, and course requirements would be necessary before entering the school system. This could be given in the form of short seminars at colleges or at central cities, by teachers "borrowed" from colleges.

Figures might be cited on the number of scientists in various fields who could contribute to such a plan. It would be intersting if statements could be quoted from leaders in government, industry, and the Armed Forces on the practical possibilities of the idea; also from educational leaders on the plan's apparent advantages (such as the value of instruction from expert "practicing" scientists and the drawing power science courses would have under such teachers), and from scientists on their willingness to participate in such a plan, their recognition of the seriousness and immediacy of the problem, and their present inability or reluctance to teach because of the financial (and, possibly, professional status) sacrifice now involved.

Opinions might be gathered concerning under what agency this could best be organized (government? one of the foundations?) and where such teaching influence is most important (high school, college, or combination of both?).

Shirley Moore
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TRAINING PROGRAM FOR SCIENCE AND MATHEMATICS TEACHERS IN SECONDARY SCHOOLS

The National Academy of Sciences-National Research Council in cooperation with the American Association for the Advancement of Science and with the encouragement of major groups in business and industry is setting up a supplementary training program for science and mathematics teachers in secondary schools. This group is considered the most important segment of the American educational system, because largely upon them depends the interest and preparation of today's students who may be tomorrow's scientists, engineers, and technicians.

Arlington County, Va., is being used as a model for a pilot study on ways and means of improving the caliber of science and mathematics teaching in public schools. Other school systems in the Washington area have been invited to participate. School boards, parent-teachers associations, and civic groups are cooperating to raise a scholarship fund which will enable teachers to take graduate-level courses and familiarize themselves with both the fundamentals and recent developments in Sciences.

Another aspect of the plan provides qualified teachers with opportunities for summer employment in local scientific and engineering organizations in both industry and government.

On October 27, representatives of The George Washington University, University of Maryland, University of Virginia, American University, Georgetown University, Catholic University, Howard University, and District of Columbia Teachers' College met at the Academy-Research Council to develop a joint program of special courses in mathematics, physics, chemistry, and biology for the summer of 1956. A committee on the improvement of science and mathematics teaching, composed of representatives of the participating universities, is being formed to help coordinate the plans for this cooperative effort.

Responsibility for the general supervision of the entire program will be assigned by the Academy-Research Council to a special board representing all areas of science, mathematics and engineering.

Shell Companies Foundation, Inc., has initiated a program of *Shell Merit Fellowships for High School Science and Mathematics Teachers.* Under the program, Shell will underwrite seminars for 60 teachers each summer. The study program will include graduate-level classes, lectures by outstanding scientists, and visits to research laboratories and industrial facilities. Cornell and Stanford Universities will operate the seminars.

Recipients of these fellowships will receive travel allowance, living expenses, tuition and fees, plus $500 to compensate other potential summer earnings.

PALEONTOLOGY.—*New families of Gastropoda.* J. Brookes Knight, Smithsonian Institution.

The writer is senior author of a manuscript for those portions of Parts I and J of the *Treatise on invertebrate paleontology* that deal with the Monoplacophora and with the Paleozoic Gastropoda. The junior authors are Dr. Roger L. Batten and Dr. Ellis L. Yochelson. It was found that a not inconsiderable number of new taxa in the familial group were needed. Although exceptions have been made, it is thought that the *Treatise* is not an appropriate place for the publication of the names of new taxa. Likewise the authors feel that names published with more than two authors place an unnecessary burden on posterity and should be avoided if possible. If new names were published in the *Treatise* it would have been necessary to cite Knight, Batten, and Yochelson as authors, unless recourse was had to the always clumsy and often confusing expedient of citing authorship for individual names of new taxa different from that of the paper as a whole.

These considerations have led the joint authors to agree that the senior author, Knight, publish the new taxa of most of the familial group in advance of the appearance of the *Treatise*. Since the full systematic treatment and full diagnoses of these taxa will appear within the year and since diagnoses are not requisite for validity of familial names, though recommended (Follett, 1955, p. 5 [38, 42]), they are omitted here.

Certain other names for new families, new genera, and new species will also be published separately in advance of the *Treatise* by the junior authors and by two others, Dr. Stephen S. Winters and Dr. Arthur J. Boucot, both of whom have papers in preparation containing taxa important to the *Treatise*. In the following list names ending in -acea apply to superfamilies, in -idae to families, in -inae to subfamilies, and in -ides to tribes.

Familial name	*Type genus*
Agnesiinae	*Agnesia* Koninck, 1883.
Archinacellidae	*Archinacella* Ulrich and Scofield, 1897.
Coelozoninae, Coelozonides	*Coelozone* Perner, 1907.
Elasmonematidae	*Elasmonena* Fischer, 1885.
Euphemitinae	*Euphemites* Warthin, 1930.
Gyronematinae	*Gyronema* Ulrich, 1897.
Hypseloconidae	*Hypseloconus* Berkey, 1898.
Liospirinae	*Liospira* Ulrich and Scofield, 1897.
Luciellidae	*Luciella* Koninck, 1883.
Meekospiridae	*Meekospira* Ulrich, 1897.
Knightitinae	*Knightites* Moore, 1941.
Neilsoniinae	*Neilsonia* Thomas, 1940.
Ophiletinae	*Ophileta* Vanuxem, 1842.
Palaeotrochacea, Palaeotrochidae	*Palaeotrochus* Hall, 1879.
Pelagiellacea, Pelagiellidae	*Pelagiella* Matthew, 1895.
Phanerotrematidae	*Phanerotrema* Fischer, 1885.
Plagiothyridae	*Plagiothyra* Whidborne, 1892.
Planitrochidae	*Planitrochus* Perner, 1903.
Planozonides	*Planozone* Perner, 1907.
Platyschismatinae	*Platyschisma* M'Coy, 1844.
Progalerinae	*Progalerus* Holzapfel, 1895.
Rhaphischismatidae	*Rhaphischisma* Knight, 1936.
Ruedemanniinae	*Ruedemannia* Foerste, 1914.
Tropidodiscinae	*Tropidodiscus* Meek and Worthen, 1866.
Tubinidae	*Tubina* Owen, 1859.
Turbonellininae	*Turbonellina* Koninck, 1881.

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PALEONTOLOGY.—*Some new pleurotomarian gastropods from the Permian of west Texas.*

Roger L. Batten, University of Wisconsin. (Communicated by John B. Reeside, Jr.)

Five new genera and two new families of upper Paleozoic gastropods have thus far been recognized by the writer during a study of Permian pleurotomarians from west Texas and New Mexico. The purpose of this present paper is to make available the resulting new names for the forthcoming *Treatise on invertebrate paleontology*, since no new names can be included in that work. The new genera and families will be treated and illustrated in greater detail in a paper to appear shortly.

Portlockiellidae Batten, n. fam.

Description.—Characterized by dominant, usually rather coarse spiral ornament and a selenizone low on the whorls; shell shape ranging from globose to turreted; ornament on parietal surface resorbed or covered by a very thin inductura.

Tapinotomaria Batten, n. gen.

Type species.—*Tapinotomaria rugosa* Batten, n. sp.

Description.—Turbiniform pleurotomarians with rounded to steplike whorls and dominant spiral ornament separated by concave interspaces; collabral ornament forms rounded to elongated nodes at intersections with spiral ornament; selenizone defined by a thread with a spiral cord above this thread and commonly with a gap between the cord and the next cord above it; slit shallow.

Tapinotomaria rugosa Batten, n. sp.

Holotype.—U.S.N.M. no. 125281, U.S.N.M. Locality 702d, Leonard formation, Glass Mountains, Texas.

Description.—Whorl profile even and convex to selenizone; spiral and collabral ornament form nodes varying in degree of emphasis; 4 to 6 spiral cords above the selenizone and 4 to 14 spiral cords on the base.

Phymatopleuridae Batten, n. fam.

Description.—Discoid to moderately high spired, highly ornamented pleurotomarians with a selenizone located at or slightly above the periphery; the outer whorl face vertical or sloping and may be narrow compared to upper whorl surface; selenizone convex to concave and usually strongly bordered; there may be basal sinuses; ornament in the parietal lip resorbed.

Callitomaria Batten, n. gen.

Type species.—Callitomaria stanislavi Batten, n. sp.

Description.—Turreted pleurotomarians with dominant spiral ornament and step-like whorls, moderately wide selenizone situated about midway on an almost vertical outer whorl face; outer whorl face generally narrower than upper whorl surface; a spiral thread or cord present between suture and upper selenizone margin and one just above selenizone margin; collabral ornament variable in development from suture to base; shallow slit; thin shell.

Callitomaria stanislavi Batten, n. sp.

Holotype.—A.M.N.H. no. 27953, A.M.N.H. Locality 512, Getaway formation, Guadalupe Mountains, Texas.

Description.—Collabral ornament coarse and variable, may be very strong forming nodes above selenizone or on base only or both; spiral elements equally well developed above and below selenizone.

Discotomaria Batten, n. gen.

Type species.—Discotomaria basisulcata Batten, n. sp.

Description.—Discoid to low spired pleurotomarians with a concave selenizone depressed beneath the surface of an almost vertical outer whorl face; upper whorl surface concave with dominant collabral cords; upper edge of outer whorl face unornamented or with nodes and threads; outer whorl face concave, ornamented by collabral elements except for selenizone and a narrow trough just beneath the selenizone; labral sinus complex and moderately deep and slit narrow; trough on outer edge of base with sinus; columellar lip with sinus at upper end.

Discotomaria basisulcata Batten, n. sp.

Holotype.—U.S.N.M. no. 125280, U.S.N.M. locality 702, Leonard formation, Glass Mountains, Texas.

Description.—Early whorls are flat and unornamented; upper whorl surface with very strong collabral cords that form strong nodes at upper edge of outer whorl face; a flat collabrally ornamented shelf forms upper surface of the large, rounded and reticulate lower edge of outer whorl face.

Family Eotomariidae Wenz, 1938

Subfamily Eotomariinae Wenz, 1938

Tribe Ptychomphalides Wenz, 1938

Description.—Turbiniform to trochiform pleurotomarians with dominant collabral ornament and the selenizone situated on the periphery or slightly above it; pronounced cords restricted to a few species only; depth of the slit is variable; selenizone margin complex consisting of several components in some species closely or widely spaced, the lower selenizone margin tending to be wider and more complex.

Shwedagonia Batten, n. gen.

Type species.—Shwedagonia elegans Batten, n. sp.

Description.—Characterized by a very deep, narrow slit extending about eight-tenths of a whorl in depth; selenizone located just above a shallow trough above the periphery; shell shape varies from straight-sided to concave-sided; dominant collabral ornament, usually more pronounced above the selenizone; a flat area just under selenizone bordered below by a turned up margin similar to the upper margin of selenizone; base is smooth to coarsely ornamented; umbilicus wide and with deep sutures.

Shwedagonia elegans Batten, n. sp.

Holotype.—U.S.N.M. no. 125279, U.S.N.M. Locality 703b, Leonard formation, Glass Mountains, Texas.

Description.—Well developed collabral ornament usually more strongly developed above selenizone; spiral ornament consists of fine threads both above and below selenizone; shell shape extremely variable, ranging from very low spired concave sided to moderately high spired straight sided.

Eirlysia Batten, n. gen.

Type species.—Eirlysia exquisita Batten, n. sp.

Description.—Globose trochiform to moderately spired pleurotomarians with a relatively wide selenizone just above periphery; whorls inflated and smooth to selenizone; collabral ornament may be dominant above selenizone but spiral ornament frequently present and weakly developed; slit shallow, selenizone defined by two sharp cords, which may be composed of multiple elements; a trough is usually developed just below selenizone, lower edge of outer whorl face a cord separating it from flat to flatly rounded base; parietal inductura thin; narrowly to widely phaneromphalus; reflexed columellar lip.

Eirylsia exquisita Batten, n. sp.

Holotype.—U.S.N.M. no. 125282, Princeton University locality 3, Bone Spring formation, Sierra Diablo, Texas.

Description.—Relatively low spired forms with globose whorls; dominant collabral cords from suture to selenizone; selenizone relatively wide and selenizone margins sharply defined; spiral threads are visible both above and below selenizone; lower edge of outer whorl face is sharply defined; narrowly phaneromphalus.

PALEONTOLOGY.—*New Permian gastropod genera from eastern Arizona.* STEVEN S. WINTERS, Florida State University. (Communicated by J. Brookes Knight.)

The following generic names and diagnoses are published so that they might be available for the *Treatise on invertebrate paleontology*, part I. Full discussion with illustrations will be forthcoming at some later date as part of a stratigraphic-paleontological study of the Permian in eastern Arizona. The three new genera, *Apachella*, *Cibecuia*, and *Kinishbia*, are based on silicified material collected from the Fort Apache limestone (Permian) in eastern Arizona on the Fort Apache Indian Reservation.

Family PLEUROTOMARIIDAE Swainson, 1840
Apachella Winters, n. gen.

Type species.—*Apachella translirata* Winters, n. sp.

Description.—Small, moderately high spired turbiniform, less commonly pupiform gastropods with wide, steeply sloping selenizone and flatly rounded, anomphalous, or narrowly phaneromphalous base; initial whorl planospirally coiled; selenizone above peripheral carina flat to concave, generated by a wide slit of moderate depth; aperature ovate to circular; outer lip trending obliquely backward to slit, then with slight forward convexity to nearly vertical columellar lip; parietal inductura thin; parietal tooth in some species extends down from top of aperture; upper whorl profile in some species modified by subsutural shoulder, various revolving carinae and lirae common to all species; transverse ornamentation, when present, limited to upper whorl surface.

Apachella translirata Winters, n. sp.

Holotype.—A.M.N.H. no. 27999/1: 1.

Description.—Turbiniform gastropods with well-developed subsutural shoulder; initial whorl planospirally coiled; whorl profile below subsutural shoulder sloping outward to steeply sloping selenizone carine, then turning to vertical, concave flank, which rounds smoothly into flatly rounded, minutely phaneromphalous base; shallow sinus; columellar lip slightly reflexed; ornament 9 to 10 strong, revolving carinae on base bordering selenizone and well-developed transverse, rounded and closely spaced lirae on subsutural shoulder; first three whorls without ornamentation.

Family MURCHISONIIDAE Koken, 1896?
Cibecuia Winters, n. gen.

Type species.—*Cibecuia cedarensis* Winters, n. sp.

Description.—Small, high-spired, many-whorled conical gastropods with wide, flat selenizone located about midway between upper suture and peripheral keel marking basal angulation; first four whorls smooth; base flatly rounded, anomphalous; outer lip thin, with sinus culminating in notch of unknown depth at midwhorl face; outer lip curves backward with forward convexity above selenizone; below selenizone curves gently forward with forward convexity to keel and across base to thick inner lip, smoothly concave outward; parietal inductura thin or absent; ornament parallel grooves bordering selenizone, with peripheral keel and revolving lirae on base; transverse nodes when present on upper whorl face only.

Cibecuia cedarensis Winters, n. sp.

Holotype.—A.M.N.H. no. 28007/2: 1.

Description.—Small, high-spired, many-whorled, conical gastropods with straight, gently tapered silhouette; sutures incised and impressed below peripheral, keeled angulation separates whorl face from flatly rounded, slightly extended, anomphalous base; outer lip thin, with sinus culminating in notch of unknown depth at mid-whorl face generating a wide, flat selenizone; revolving ornament of a pair of grooves delimiting selenizone, a faintly noded peripheral keel and 3 or 4 lirae on base; transverse ornament rounded nodes on upper part of whorl face beyond fourth whorl extending downward with slight backward obliquity.

Family Loxonematidae Koken, 1889

Kinishbia Winters, n. gen.

Type species.—*Kinishbia nodosa* Winters, n. sp.

Description.—Small to medium, high-spired, many-whorled conical gastropods with smooth extended base and narrow umbilicus; outer lip thin, columellar lip thick and nearly vertical, parietal lip nearly horizontal; shallow anterior notch; earlier whorls developing concave profile of tapered spire; strongly developed, rounded transverse costae on upper whorl face of all but first four smooth whorls.

Kinishbia nodosa Winters, n. sp.

Holotype.—A.M.N.H. no. 28011/1: 1.

Description.—Gastropods with whorl profile convex or gently shouldered in upper half, flat and sloping slightly inward in lower half to slight keel separating whorl face from smoothly rounded, somewhat flattened base; outer lip thin with broad, very gentle sinus on flank, crossing base with slight forward convexity to shallow anterior notch; inductura absent; pleural angle varying from 22° to 31°; ornament of transverse costae on upper whorl face and at keel.

PALEONTOLOGY.—Labridens, *a new Permian gastropod.*[1] Ellis L. Yochelson U. S. Geological Survey. (Communicated by James S. Williams.)

Examination of the large collections of fossils from the Permian of western Texas in the U. S. National Museum has revealed a new genus of gastropods. The gastropod, here named *Labridens*, has one unusual character that distinguishes the genus and suggests some interesting implications as to phylogeny.

Labridens is similar to genera placed in the Subulitacea in possessing a siphonal notch and folds on the inner lip and is referred to that superfamily. *Labridens* differs from other subulitaceans and from other Paleozoic gastropods in possessing a lira on the inner surface of the outer lip. As the shell grew, this lira moved forward and formed a spiral ridge inside of the shell.

Lirae and elaborate thickening on the inner surface of the outer lip and throughout the shell are important characteristics of the Nerinacea. This group is common in the Jurassic and Cretaceous, but is unknown elsewhere in the geologic record. Although the shell form of many nerinacean genera is different from that of *Labridens*, a few genera, for example *Brouzetia* Cossmann, approach it. Most nerinaceans have a short canal and at least one columellar fold.

[1] Publication authorized by the Director, U. S. Geological Survey.

The available evidence does not necessarily indicate relationship of the Nerinacea with the Subulitacea, but it is suggestive. Should further evidence of relationships between the Subulitacea and Nerinacea be found, certain major changes in phyletic interpretation will be required, as the Nerinacea are presently classed in the order Mesogastropoda (subclass Prosobranchia) by Wenz (1938, p. 46), and the Subulitacea are classed in the order Archaeogastropoda by Wenz, (1938, p. 44) and in the order Neogastropoda by Knight (1944, p. 477).

Class Gastropoda

Order Neogastropoda

Superfamily Subulitacea

Family Subulitidae

Labridens Yochelson, n. gen.

Type species.—*Labridens shupei*, Yochelson, n. sp.

Diagnosis.—Turbinate gastropods with a strong lira on inner surface of outer lip and one or more columellar plications; whorl profile simple, with gently inflated whorls; without ornament; a strong, sharp lira developed on the inner surface of outer lip; inner lip with basal notch, probably functional as a siphon, and one or more folds above.

Labridens shupei Yochelson, n. sp.

Description.—Moderately high-spired, turbinate, anomphalous gastropods with two folds on inner lip and a lira on inner surface of the outer lip; earliest whorls not certainly known, but probably simple and smooth; suture shallow, but distinct; outer whorl surface flattened, very gently inflated between sutures; surface smooth, ornamented only by exceedingly obscure growth lines; base of columella with a siphonal notch; inner lip with a distinct groove for a short distance above siphonal fold, limited above by a fold extending outward as a flange, the lip above this flange with a wide, shallow groove in turn limited by a second, less distinct, plication, the inner lip above this plication being gently convex above to juncture with outer lip; inner surface of outer lip bearing a low, strong lira approximately across from higher plication on inner lip.

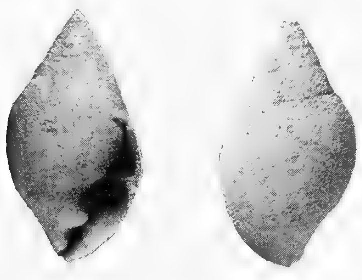

Fig. 1.—*Labridens shupei*, n. sp.: *a*, Apertural view showing folds of inner lip and lirae on inner surface of outer lip; *b*, adapertural view. The tip of the siphonal fold has been broken so that it appears as a notch. ×3.

Discussion.—The outer lip is broken back on all specimens examined but the revolving ridge is fully developed at a point probably no more than one-eighth of a whorl behind the unbroken aperture. The upper plication on the inner lip is obscure near the aperture, but is somewhat more distinct one-half whorl back. Examination of broken specimens indicates that the ridge on the outer lip is not resorbed; similar observation could not be made on the columellar plications.

Labridens shupei is known from a dozen specimens found at three localities in the upper part of the Leonard and lower part of the Word formations of the Glass Mountains. The holotype (U.S.N.M. no. 119556) and an unfigured paratype (U.S.N.M. no. 119557) were collected at U. S. National Museum locality 703. This locality is in a platy limestone in the first limestone member of the Word formation, near the top of a slope half a mile southwest of road forks just northeast of the old Word Ranch House, Hess Canyon quadrangle, Brewster County, Tex.

The species is named for Nelson W. Shupe, U. S. Geological Survey, Paleontology and Stratigraphy Branch, who for many years has contributed superb photographs of fossils to the reports of Geological Survey paleontologists.

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Wenz, Wilhelm. *Handbuch der Paläozoologie* (Herausgegeben v. Schindewolf), Bd. 6, *Gastropoda*, Teil 1, Allgemeiner Teil und Prosobranchia (pars). Berlin, 1938.

PALEONTOLOGY.—Gyrospira, *a new genus of bellerophontid (Gastropoda) from Bolivia.*[1] A. J. Boucot, U. S. Geological Survey. (Communicated by G. Arthur Cooper.)

Class Gastropoda

Order Archaeogastropoda

Family Bellerophontidae

Subfamily Carinaropsinae

Gyrospira Boucot, n. gen.

Type species.—*Gyrospira tourteloti* Boucot, n. gen. and n. sp.

Diagnosis.—Widely disjunct bellerophontid Gastropoda; aperture flaring widely both posteriorly and laterally, lacking apertural plate, but bearing median carina internally on posterior face; revolving ornament lacking; possessing median carina, the locus of deep slit.

Comparison.—Genus has flaring aperture, phaneromphalous spire, and posterior, internal carina that characterize members of the Carinaropsinae.

Carinaropsis is most closely related to *Gyrospira*, but the former is more closely coiled. *Gyrospira* is more openly coiled and lacks the revolving ornament that characterizes both *Bucanopsis* and *Phragmosphaera*. *Gyrospira* has less

[1] Publication authorized by the Director, U. S. Geological Survey.

lateral flaring of the aperture and it lacks the apertural plate of *Phragmosphaera*. *Phragmosphaera* lacks the internal carina characteristic of *Gyrospira*. *Sphaenosphaera* possesses an incipient apertural plate and is also more closely coiled than *Gyrospira*.

Gyrospira tourteloti Boucot, n. sp.
Figs. 1–5

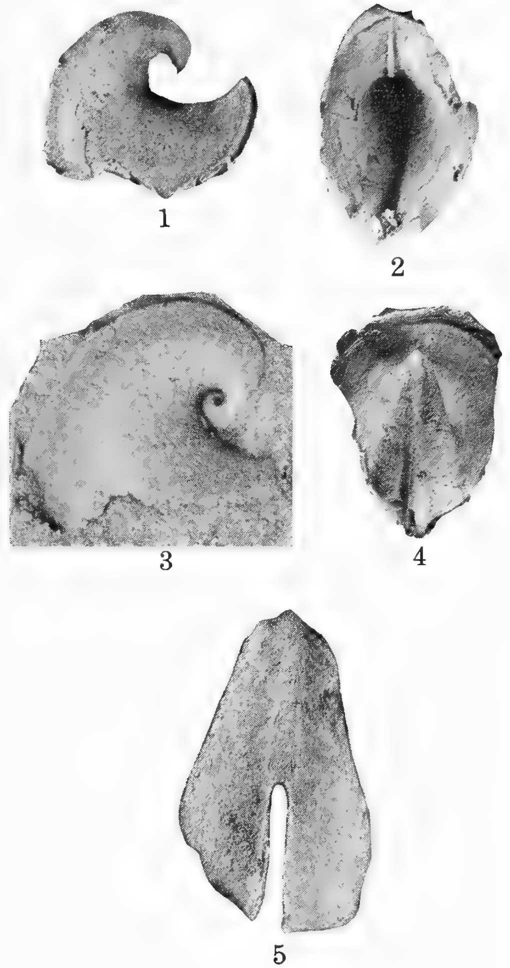
Description.—Medium-sized, openly coiled, widely phaneromphalous, spiral gastropod with wide flaring of posterior and anterior portions of aperture, deep slit in anterior lip culminating in carina; slit about one-third of whorl in depth. Whorl profile on either side of median carina steep, convex over lateral slopes and rounded in open umbilicus; surface with obscure collabral undulations; nucleus and first whorl barely in contact; apertural margin with no anterior flaring but flaring widely posteriorly and moderately on lateral portions of the aperture; posterior median carina on interior of shell (this carina not caused by impression of earlier whorl as whorl is free); ornamentation of undulating concentric growth lines which interrupt otherwise smooth surface of shell; shell moderately thick, its structure unknown.

Occurrence.—The following locality description was provided by H. A. Tourtelot: Measured stratigraphic section (bed 8) beginning at Chacorillo farm and extending nearly a kilometer to the west. Chacorillo farm is about 6 kilometers north of Kilometer 65 of the Potosí-Sucre road; Kilometer 65 is about 15 kilometers east by road from the village of Betanzos, which is 50 kilometers from Potosí, Province of General de Saavedra, Department of Potosí, Bolivia. This locality is U.S.G.S. Silurian and Devonian catalog #3137. Addition material was collected from nearby float (U.S.G.S. Silurian and Devonian catalog no. 3139).

The specimens are preserved as casts and molds in rusty weathering, brown sandstone.

Geologic range.—Carinaropsids have a known range of Middle Ordovician to Devonian. Prof. Harry Whittington, of Harvard University, who kindly examined the associated trilobites, reports (comm. 1955) the presence of *Leiostegina inexpectons*, which suggests to him a correlation with beds of Caradoc age (Black River and Trenton). Dr. David Nicol, of the U. S. National Museum (written communication, 1955), considers that the associated pelecypod material indicates a Middle Devonian age based on the presence of *Parallelodon*, *Modiomorpha*, *Ctenodonta*, and *Grammysia*. The one fragmentary brachiopod present in the material indicates a post Early Ordovician age.

Inasmuch as the trilobites of early Paleozoic age are better known than the pelecypods it seems to the writer that a Middle Ordovician age is the most reliable assignment that can be made under the circumstances.



Figs. 1–5.—*Gyrospira tourteloti* Boucot, n. gen. and n. sp.

1, Latex impression of exterior (holotype) (×1). Note the widely disjunct coiling and the posteriorly flaring aperture, and the obscure collabral undulations. U.S.N.M. no. 125457.

2, Latex impression of interior (×1). Note the prominent ridge on the posterior portion of the aperture. U.S.N.M. no. 125458A.

3, Latex impression of exterior (×2). Note the nucleus in contact with the first whorl. U.S.N.M. no. 125458C.

4, Latex impression of exterior (holotype) (×1) (dorsal view). Note the prominent median carina on the anterior margin. U.S.N.M. no. 125457.

5, Latex impression of anterior margin and slit (×2). Note the deep slit and raised selenizone. U.S.N.M. no. 125458B.

Holotype.—U.S.N.M. no. 125457.

Figured paratypes.—U.S.N.M. nos. 125458 A-C. *Unfigured paratypes.*—U.S.N.M. nos. 125459, 125460 (U.S.G.S. Silurian and Devonian catalog no. 3139).

ENTOMOLOGY.—*Gall midges associated with cones of western forest trees (Diptera: Itonididae).*

RICHARD H. FOOTE, Entomology Research Branch, United States Department of Agriculture.

For a number of years, personnel of the former Bureau of Entomology and Plant Quarantine, now of the U. S. Forest Service, U. S. Department of Agriculture, have been studying all phases of the biology and control of forest insects. An extensive collection of gall midges, together with associated biological data, has accumuluated during this investigation and has recently been made available to me. The present paper provides names and descriptions for a number of species occurring in cones and seeds of western conifers; their biological characteristics will be published in a forthcoming manual of the insects associated with these trees in western United States.

Throughout the work I have omitted morphological descriptions of immature stages. Almost without exception, larvae in this collection were so poorly mounted that detailed examination under a compound microscope was not possible. Even in those few cases in which most larval characters were visible, I have preferred to postpone publication of descriptions until concepts of species differences in the larval stage have been clarified. Associations of larva and adults have been made largely on the basis of the available biological information, aided in a few cases by incomplete morphological details.

I wish to thank F. P. Keen, California Forest and Range Experiment Station, for making this collection of gall midges available to me and for encouraging my efforts. I am also grateful to Dr. A. Earl Pritchard, University of California, for making preliminary identifications of a number of the species included herein.

Specimens deposited in the U. S. National Museum are indicated below by the initials USNM; those in the California Insect Survey at Berkeley by CIS.

Genus **Rübsaamenia** Kieffer

Rübsaamenia Kieffer, 1894, Ann. Soc. Ent. France **63:** 333 (type, *Asynapta pectoralis* Winnertz; by original designation); 1913, Gen. Ins., fasc. 152: 278; Felt, 1911, Journ. New York Ent. Soc. **19:** 40; 1916, New York State Mus. Bull. 180: 129; 1925, New York State Mus. Bull. **257:** 140.

To my knowledge no previous mention of the occurrence of this genus in North America has been made. The species assigned to it may be recognized by the presence of the base of vein Cu_1 (this vein obsolete basally in the closely related North American genus *Holoneurus*) and by the long slender recurved abdomen, which separates it from the North American genera *Asynapta* and *Clinorhytis*. *Rübsaamenia* runs to *Porricondyla* in Pritchard's (1953) key to California genera of Porricondylini; it may be separated from that genus by the recurved abdomen and by the fact that vein Cu_1 is present to the base of the wing. It is represented in the United States by the single species described below.

Rübsaamenia keeni, n. sp.

Fig. 1, a–g

Male.—Head as wide as high from anterior view, eye bridge about 12 facets wide. Scape of antenna subtriangular, length about 2.5 times width at apex; pedicel roughly rectangular, 0.7 as wide as apex of scape, not narrowed apically; flagellum with 12 to 24 segments, those of the smallest individuals with the fewest segments, segments decreasing in length from base to tip, apical segment 1.5 times as long as subapical and narrowed to a blunt point at apex; fifth flagellar segment (fig. 1*g*) 2.0 times as long as wide; stem with subapical expansion, equal in length to node, which is as wide as long, slightly narrower at base than at tip; circumfilum a simple, tightly fitting ring encircling node at proximal third. Palpus (Fig. 1*c*) of four segments, proportions 1:1.2:2.1:3 (average of type series); second segment widest, third and fourth successively narrower; setae longer than width of third. Wing (Fig. 1*b*) 2.3 times as long as wide; membrane with fine microtrichia; R_1 ending in costa at basal 0.4; R_s nearly parallel with costa; R_5 bending posteriorly to meet and terminate costa at or very slightly before wing tip; M_{3+4} visible from wing base to margin; Cu_2 terminating at middle of posterior margin of wing. Hind femur slightly longer than tibia; first tarsal segment with a short, blunt apicolateral projection on all legs; proportions of hind tarsal segments 1:8.3:4.6:2.6:1.4 (average of type series); fore, mid, and hind claws (Fig. 1*d*) each with a long basal tooth; each pulvillus very slightly shorter, equal to, or slightly longer than claw. Terminalia (Fig. 1*a*) longer than wide (viewed dorsally); length of basistyle about 2.3 times its greatest width, with an inner apical lobe obscured in some mounts by the dististyle; inner surface of lobe covered by a patch of short, slender spines; dististyle 2.0 times as long as wide at base, bluntly rounded distally, with an even, dense row of blunt, stout spines along distal third or fourth of inner margin, this comb terminated by two heavy, blunt teeth at apex. Tenth sternite and tenth tergite bilobed, the former distinctly shorter than the latter and less deeply incised at center line; aedeagus truncate, with a shallow central notch and a small projection on distal margin midway between central incisure and lateral margin; proximally, aedeagus with a curved arm on each side connecting with the basistyle, and a slender median arm tapering to a sharp point, on each side of which there is connected an irregular, sac-shaped structure.

Female.—Head, eye bridge, scape, and pedicel as in male. Flagellum with 10 to 26 segments, the smallest individuals with the fewest segments; first flagellar segment longest, remaining segments decreasing in length from base to tip, apical segment somewhat elongated and narrowed to blunt apical point. Fifth flagellar segment (Fig. 1*f*) with node 1.3 times as long as wide; stem short, 0.25 as long as node; circumfilum a simple, tightly fitting ring as in male, encircling middle of node. Palpus of four segments, proportions 1:1.3: 2.6:3.3 (average of type series), similar in general appearance to that of male. Wing and legs as in male. Terminal abdominal segment (Fig. 1*e*) with paired, elongate appendages, each about 2.5 to 3.0 times as long as wide; in addition, a flat, bilobed plate nearly covering basal half of each appendage and attached thereto, similar in shape to tenth sternite of male; a sclerotized internal spermatheca with paired lateral arms also present.

Holotype.—♂, Butte County, Calif, 29-IX to 7-X, 1953, Calif. Div. Forestry, reared from cones of *Abies magnifica*, Hopkins no. 32738e. U.S.N.M. no. 63027.

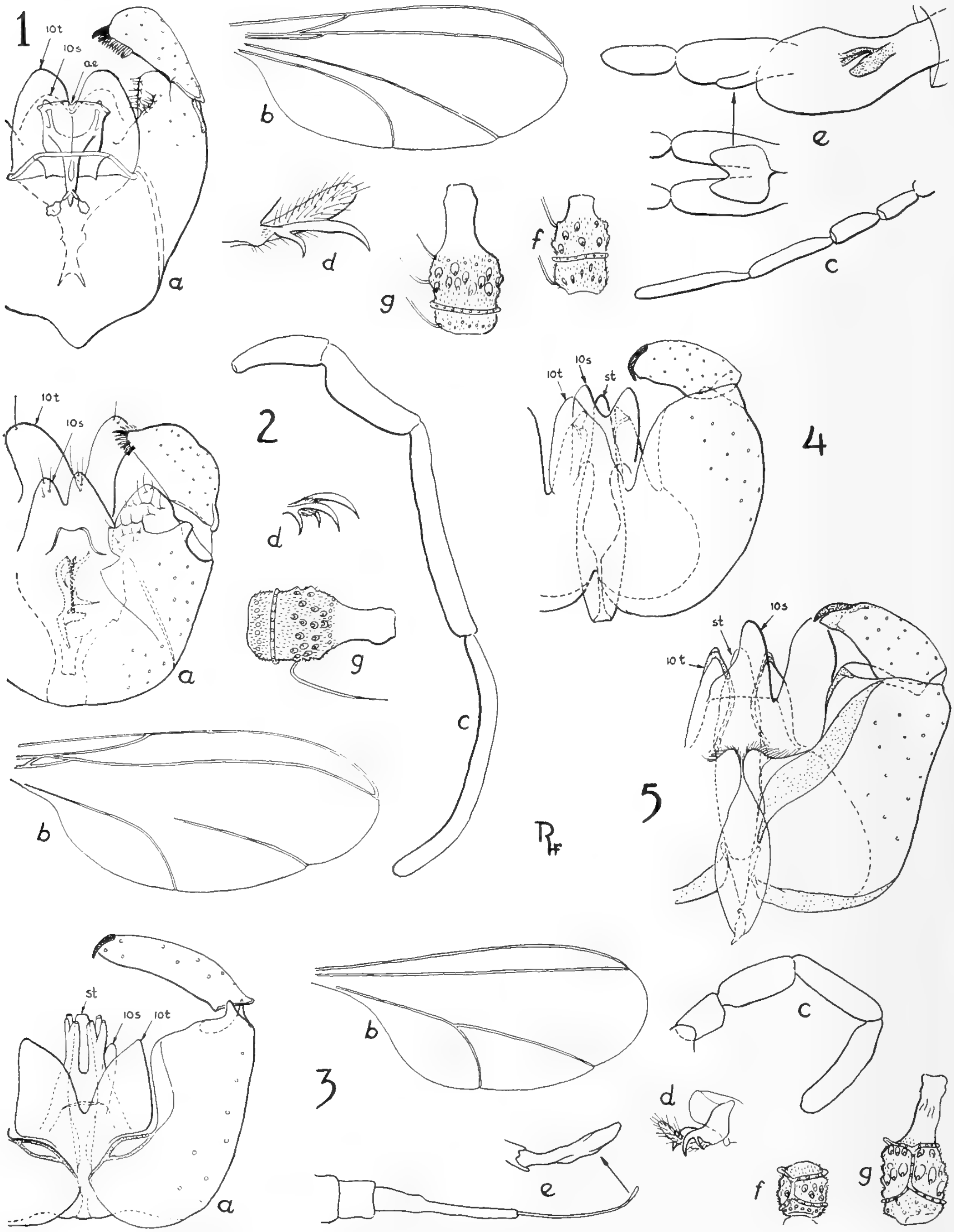
Paratypes.—7 ♂♂, 14 ♀♀, same data as holotype, Hopkins nos. 32737, 32737e and 32737h. 3 ♂♂, 3 ♀♀ (CIS); remainder (USNM).

Additional material examined.—CALIFORNIA: 24 ♂♂, 44 ♀♀, 38 larvae; Crescent City, Gasquets, General Grant National Park, Kyburz, McKinney Creek, Mono National Forest, Sequoia National Park, Mount Shasta City, Six Rivers National Forest, Yosemite National Park. COLORADO: 2 ♀♀, 18 larvae; Cheyenne Mountain, N. Cheyenne Canyon, Manitou, Williams Canyon. NEW MEXICO: 3 ♂♂; Pecos Mountains. OREGON: 65 ♂♂, 61 ♀♀, 50 larvae; Ashland, near Lamb's Mine (Ashland), Clover Creek, Colestin, Jenny Creek, La Pine, Netart's Beach, Palmerlee's Ranch, Waldo. Taken from cones of *Abies concolor*, *A. grandis*, *A. magnifica shastensis*, *Picea englemanni*, *P. contorta* var. *latifolia*, *Pinus jeffreyi*, *P. lambertiana*, *P. ponderosa*, *P. ponderosa* var. *scopulorum*, *Pseudotsuga menziesii*, and *P.* sp. from February 17 to November 26, 1913–1954.

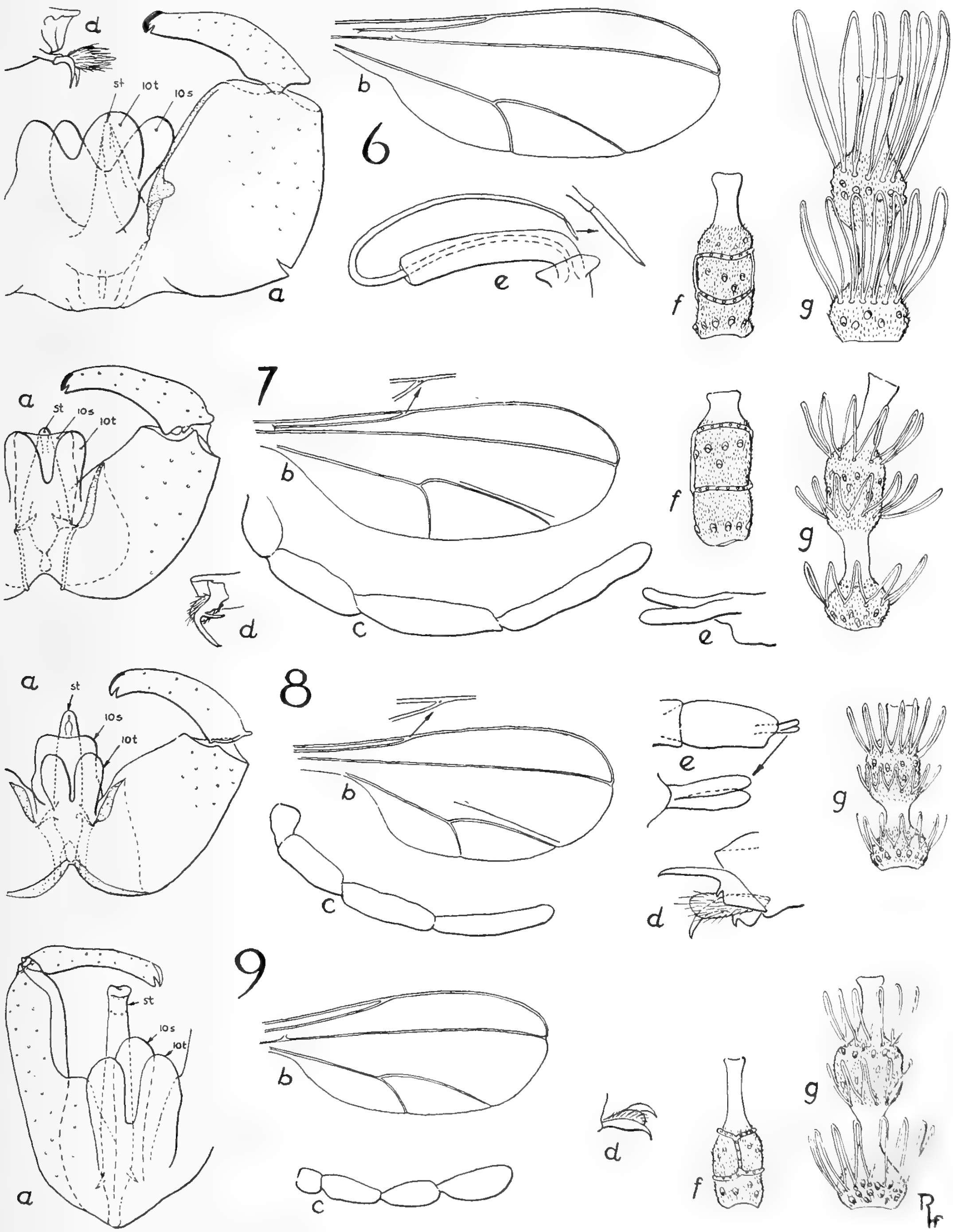
Discussion.—This species may be distinguished from all other members of the Porricondylini by the generic characters given above, and by the characteristic features of the male terminalia (Fig. 1*a*).

Holoneurus strobilophilus, n. sp.
Fig. 2, a–d, g

Male.—Head as wide as high from anterior view, eye bridge 8 to 10 facets wide. Scape of antenna subtriangular, length about equal to width at apex; pedicel subglobular, as wide as long and about 0.7 as wide as apex of scape; flagellum of 21 or 22 segments, which decrease only very slightly in length and width from base to apex; terminal segment longer than subterminal, with the apical nipple; fifth flagellar segment (Fig. 2*g*) with a proximal node 1.2 times as long as greatest width and a distal stem 0.7 as long as node; circumfilum a simple, closely fitting ring encircling node at proximal third. Palpus (Fig. 2*c*) of four segments, proportions 1:1.4:2.4:3.3 (holotype only), second segment widest, third and fourth progressively narrower, setae short and scattered. Wing (Fig. 2*b*) 2.3 times as long as wide, R_1 ending in costa at basal 0.4; R_s nearly parallel with costa and appearing to be a continuation of R_5; R_5 bending posteriorly to meet and terminate costa slightly before wing tip; M_{3+4} straight except at extreme apex, visible to base of wing; Cu_2 curved to meet posterior wing margin at basal 0.45 of wing. Hind femur slightly longer than tibia; proportions of hind tarsal segments 1:8.0:5.0:2.5:1.2 (one leg of holotype only); fore, mid and hind claws each with a long basal tooth; each pulvillus about 0.5 as long as claw. Terminalia (Fig. 2*a*) slightly longer than wide



FIGS. 1–5.—1, *Rubsaamenia keeni*, n. sp.; 2, *Holoneurus strobilophilus*, n. sp.; 3, *Dasyneura abiesemia*, n. sp.; 4, *Phytophaga carpoghaga*, Tripp, male terminalia; 5, *Janetiella siskiyou* Felt, male terminalia. (a, male terminalia; *b*, wing; *c*, male palpus; *d*, hind claw, male; *e*, terminal segments of female ovipositor; *f*, fifth flagellar segment, female; *g*, fifth flagellar segment, male. Abbreviations: 10t = tenth tergite; 10s = tenth tergite; ae = aedeagus; st = style.)



FIGS. 6–9.—6, *Contarinia oregonensis*, n. sp.; 7, *Mycodiplosis conicola*, n. sp.; 8, *Mycodiplosis coryloides*, n. sp.; 9, *Lestodiplosis taxiconis*, n. sp.; (*a*, male terminalia; *b*, wing; *c*, male palpus; *d*, hind claw, male; *e*, terminal segments of female ovipositor; *f*, fifth flagellar segment, female; *g*, fifth flagellar segment, male. Abbreviations: 10t = tenth tergite; 10s = tenth sternite; st = style.)

(viewed dorsally); length of basistyle about 2.0 times its greatest width, with a rounded inner apical lobe and a truncate apical lobe ventral to it, both lobes noticeably more densely haired than basistyle itself; length of dististyle 2.1 times its greatest width, outer margin with a heavy subterminal seta, inner margin straight, an apical comb of many even, short spines and two or three longer stouter spines more widely spaced; style short, slender, rodlike; an irregularly shaped structure lying beneath and to one side of style, as if turned on its side as a result of slide mounting; tenth sternite bilobed, each lobe about as wide at base as high; tenth tergite bilobed, each lobe about 1.5 times as long as wide at base.

Female.—Unknown.

Holotype.—♂, Butte County, Calif., 29-IX to 7-X, 1953, Calif. Div. Forestry, reared from cones of *Abies magnifica*, Hopkins no. 32737. U.S.N.M. no. 63028.

Paratypes.—4♂♂, same data as holotype. 2♂♂ paratypes (CIS), remainder (USNM).

Additional material examined.—CALIFORNIA: 6♂♂, Sequoia National Park. OREGON: 1♂, Colestin. From cones of *Abies concolor*, August 22 to September 24, 1914.

Discussion.—Felt (1915) keys the North American species of *Holoneurus* principally by the use of color characters. The comparatively long distal narrowed portion of the fifth flagellar segment will separate *H. strobilophilus* from the only two species, *multinodus* Felt and *photophilus* Felt, possessing over 20 flagellar segments. The terminal armature of the dististyle (Fig. 2*a*) will further distinguish this species from others in the genus. The genus is not included in Pritchard's (1953) key; it runs to *Porricondyla* there, from which it may readily be distinguished by its simple vein Cu_2.

Dasyneura abiesemia, n. sp.

Fig. 3, a–g

Male.—Head suboval (viewed anteriorly), widest slightly below the center; eye bridge about eight facets wide. Scape of antenna nearly square in outline, very slightly longer than wide; pedicel similar in shape and very slightly smaller than scape; flagellum of undetermined number of segments, some of the distal ones lost, but those that are present not decreasing noticeably in length or width from base to apex of flagellum; first two flagellar segments completely fused; fifth flagellar segment (Fig. 3*g*) with proximal node 1.2 times as long as wide; distal stem 0.9 as long as node; circumfilum consisting of one irregular ring encircling node on basal third and another nearly at apex, these two rings connected on opposite sides of node by short extensions of the rings; the segment rather lopsided, with stem emerging more or less from one side of node apex, the circumfilum on the opposite side loosely applied to the segment and extending some distance away from its surface. Palpus (Fig. 3*c*) of four segments, proportions 1.0:1.5:1.9:2.2 (one palp only), proximal segment widest, other segments progressively narrower. Wing (Fig. 3*b*) 2.5 times as long as wide; R_1 close to costa and joining it at basal third, the entire area between costa and R_1 somewhat darker than remainder of wing; R_5 nearly straight, bending posteriorly only very slightly at outer fourth to meet and terminate costa distinctly proximad of wing tip, M_{3+4} not visible in slide mounts; Cu straight, branched distinctly apicad of juncture of R_1 with costa; Cu_1 as long as Cu, nearly straight; Cu_2 curved posteriorly and ending at middle of posterior margin of wing. Legs thickly set with narrow, pointed scales; hind tarsal segments shrunken in all slide mounts so that proportions are not measurable; claws (Fig. 3*d*) not bent at right angles; fore, mid and hind claws each with a long, narrow ventral tooth which is 1.5 to 1.75 times as long as claw. Terminalia (Fig. 3*a*) wider than long (viewed dorsally); basistyle 2.0 times as long as wide, with a prominent inner apical, broadly rounded prominence and a more proximal shoulder in which a darkened, ringlike structure appears; length of dististyle 4.0 times greatest width, narrowing gradually distally and tipped with a narrow, sclerotized plate which appears as spur in slide mounts; style widest at middle, narrowing slightly to a rounded-truncate tip distally and narrowing more strongly toward the base, which is provided with a foot-shaped expansion; style surrounded ventrally and laterally by a deeply incised plate with three short terminal appendages on each side; tenth sternite consisting of two extremely narrow, widely separated lobes, only one of which is shown in the figure; tenth tergite completely filling the space between inner borders of basistyle and about as long as these, the incision deeper than one-half the length of plate, each lobe gently, then more abruptly tapered on inner margin to a narrow, rounded point.

Female.—Head, eye bridge, scape, pedicel and first two flagellar segments as in male. Flagellum of 14 segments, the second segment the longest, the more distal segments becoming slightly narrower; fifth flagellar segment (Fig. 3*f*) 1.4 times as long as wide, with inconspicuous stem, circumfilum as in male. Wing, legs, claws, and pulvilli as in male, proportions of hind tarsal segments 1.0:8.0:4.2:2.4:1.3 (average of type series). Ovipositor (Fig. 3*e*) retractile, at least twice as long as abdomen when fully extended, terminated by a single lobe of variable shape about 6.0 times as long as wide.

Holotype.—♂, Palmerlee's Ranch, Oreg., 8-IX-1915, P. D. Sergent and J. E. Patterson, bred from cones of *Abies magnifica shastensis*, Hopkins no. 14200c. U.S.N.M. no. 63029.

Paratypes.—3♂♂, 4♀♀, same data as holotype. One ♂, 2♀♀ (CIS), remainder (USNM).

Additional material examined.—CALIFORNIA: 5♂, 3♀, 56 larvae; Butte County, Crescent City, General Grant National Park, McKinney Creek, Sequoia National Park. OREGON: 3♂♂, 11♀♀, 7 larvae; Applegate River, Ashland, Colestin. Taken from cones of *Abies concolor*, *A. grandis*, *A. magnifica*, and *A. magnifica shastensis*, July 18 to October 7, 1914–1953.

Discussion.—Pritchard (1953) states that three species of *Dasyneura* occur in California; *D. abiesemia*, the fourth, is the only one forming gall pockets in seeds and cone scales of *Abies* in California forests. In Felt's (1915) key to United States species, it falls within the series having a nearly straight vein R_5 and 14 flagellar segments; within this group it is the only species in which the female has a nearly sessile, subglobular fifth flagellar segment, and in which the proportions of the palpal segments are as shown in Fig. 3*c*.

Phytophaga carpophaga Tripp

Fig. 4

Phytophaga carpophaga Tripp, 1955, Can. Ent. **87:** 261.

A comparison of males collected as shown in the "Material examined" section below with a male paratype of *carpophaga* sent to the National Museum by the Canadian Department of Agriculture leaves no doubt that *carpophaga* is represented on the west coast. Most of Tripp's material is from Ontario and was collected from white spruce, *Picea glauca*.

I am including an illustration (Fig. 4) of the male terminalia of this species drawn from a Colorado specimen, since Tripp's photograph omits certain details which may eventually become important for the separation of *carpophaga* from other members of the genus.

Material examined.—CALIFORNIA: 9♂♂, 2♀♀, Crescent City. COLORADO: 7♂♂, 2♀♀, 3 larvae, Glenwood Springs, Manitou, Mountain View. Taken from cones of *Picea englemanni* and *P. sitchensis*, August 17 to October 25, 1913–1916.

Janetiella siskiyou Felt

Fig. 5

Janetiella siskiyou Felt, 1917, Journ. New York Ent. Soc. **25:** 194; Pritchard, 1953, Bull. California Ins. Survey **2**(2): 139.

Felt originally described larvae and females from the Siskiyou National Forest in California; his description of the females is based primarily on color characters, but since this midge appears to be quite host-specific for seeds of *Chaemocyparis*, there appears to be no need to repeat Felt's information or to add to it here.

A description of the terminalia is given below. Unfortunately, the single male available to me had been hardened in alcohol for such a long period of time that the regular mounting method obscured much of the detail; remaining parts of this specimen were nearly destroyed in the mount. No recently collected material was available for this study.

Male.—Terminalia (Fig. 5) stout, slightly longer than wide (dorsal view). Basistyle with overall width equal to overall length, entire proximal margin and almost entire inner margin with broad sclerotized bands, a lobe at inner apex with a band of sclerotization at its own inner edge, and a narrowly pointed lobe attached to inner margin at widest portion of basistyle; length of dististyle about 2.1 times greatest width, both inner and outer margins gently curved from base to join each other at apex, here provided with a single sharp, stout tooth; style bluntly rounded distally and proximally, its center portion obscured in the mount, proximal portion with a subtriangular plate ending proximally in a broadened expansion resembling an arrow-head; tenth sternite bilobed, a deep incisure separating the broadly pointed lobes; tenth tergite with two medially expanded lobes which are lightly sclerotized on their inner margins and separated by a cleft, the bottom of which is not visible in the mount.

Material examined.—Oregon: 4♀♀, 1♂;

Siskiyou National Forest, Waldo. Taken from cones of *Chaemocyparis lawsoniana* March 28, 1919, and August 15, 1914.

Contarinia oregonensis, n. sp.

Fig. 6, a, b, d, e, f, g

Male.—Head 1.2 times as high as wide from anterior view; eye bridge 12 to 14 facets wide. Scape of antenna subtriangular, length equal to distal width; pedicel subglobular, length equal to greatest width, 0.6 to 0.7 as wide as apex of scape; flagellum of 12 segments, the first two fused, their point of junction indicated by a narrow hyaline area, remaining segments approximately equal in size, terminal segment with distal stem reduced to a short nipple; fifth flagellar segment (Fig. 6*g*) with two nodes, the proximal one 0.8 as long as the distal; length of proximal stem 1.1 times proximal node; length of distal stem equal to that of distal node; two series of circumfila, one on each node, the loops of that on proximal node attaining middle of distal node, those of distal node attaining middle of proximal node of succeeding segment. Palpus of four segments, proportions 1.0:1.5:2.5:2.8 (holotype only), the second segment widest, third and fourth successively narrower; with sparse, scattered setae longer than width of second segment. Wing (Fig. 6*b*) 2.5 times as long as wide; R_1 entering costa at basal 0.4; R_5 curving posteriorly at distal third to meet and terminate costa only very slightly before wing tip, with a cross vein at basal 0.12 extending halfway to R_1 and ending midway between the two veins; Cu straight; Cu_1 gently curved throughout its entire length; Cu_2 terminating in posterior border of wing just apicad of point of origin. Legs long; hind femur 1.1 times as long as tibia; proportions of hind tarsal segments not recognizable because of damage to specimens; fore, mid, and hind claws (Fig. 6*d*) simple, each shorter than the pulvillus. Terminalia (Fig. 6*a*) wider than long (viewed dorsally); length of basistyle 1.4 times its greatest width[1] with a dark, thickened sclerotized area at center of inner margin, no inner lobe present; length of dististyle 3.5 times its greatest width, with an inner, subterminal notch. Style 3.5 times as long as wide, bluntly pointed apically, with two ill-defined membranes nearly attaining tip of style and lying in a different position in each mount; tenth tergite bilobed, width of each lobe at base about equal to length; tenth sternite bilobed, with central incisure slightly deeper than that of tenth tergite, length of each lobe about 1.2 times proximal width; style and tergites terminating at approximately the same level.

[1] In flattened-out holotype; other males in type series have shriveled basistyles.

Female.—Head, eye bridge, scape, pedicel and palpus similar to those of male. Flagellum of 12 subequal segments; first two segments fused, with a narrow hyaline area in some specimens indicating the juncture; fifth flagellar segment (Fig. 6*f*) with proximal node 2.0 times as long as wide; distal stem 0.5 as long as node; two irregular circumfila encircling node and connected at opposite sides of node as shown. Wing and legs as in male. Ovipositor (Fig. 6*e*) retractile, about 0.6 as long as abdomen, terminating in a lightly sclerotized lobe which is the side view of the scissorslike terminus of ovipositors usually found in this genus.

Holotype.—♂, Mistletoe, Oreg., 25-VIII-1916, P. D. Sergent and J. E. Patterson, reared from cones of *Pseudotsuga menziesii*, Hopkins no. 14280e. U.S.N.M. no. 63030.

Paratypes.—8 ♂♂, 10 ♀♀, same data as holotype. Three ♂♂, 5 ♀♀ paratypes (CIS), remainder (USNM).

Additional material examined.—4 ♂♂, 4 ♀♀, same data as holotype. (USNM). These badly damaged specimens have little value for comparative purposes.

Discussion.—Felt (1917) employs the color of live specimens and antennal characters for the separation of males but does not attempt to key females. This is the only species of *Contarinia* known to occur in the Western United States, and the only United States species associated with conifers. Antennal and palpal characters of *Contarinia oregonensis* closely resemble those of *C. perfoliata* Felt and *C. agrimoniae* Felt; characters of the male terminalia (Fig. 6*a*) will distinguish *oregonensis* from the other two. The genus, although previously recorded from California, will run in Pritchard's (1953) key to *Thecodiplosis*, but may be distinguished by the invagination of the wing margin at the termination of vein R_5.

Mycodiplosis conicola, n. sp.

Fig. 7, a–g

Male.—Head suboval from anterior view, widest slightly below center; eye bridge 8 to 10 facets wide. Scape of antenna subtriangular, length equal to greatest width; pedicel subglobular, as long as wide, the same width as scape;

flagellum of 12 segments, the first two completely fused with only a narrow subhyaline area indicating the junction, the remaining segments about the same length as the fifth but with narrower stems, twelfth segment with a long terminal nipple; fifth flagellar segment (Fig. 7*g*) with two nodes, the proximal one 1.1 times as wide as long, the distal one 1.7 times as long as wide and 1.7 times as long as proximal node; proximal stem equal in length to proximal node; distal stem 0.9 as long as distal node; three circumfila, the proximal on proximal node, its loops attaining basal half of proximal stem, middle at base of distal node, its loops attaining basal 0.6 of its node, the distal on distal portion of node, its loops attaining basal two-thirds of distal stem. Palpus (Fig. 7*c*) of four segments; proportions of segments 1.0:1.5:2.1:2.5 (one palp of holotype), first segment 1.5 times as long as wide, remaining segments successively narrower. Wing (Fig. 7*b*) 2.6 times as long as wide; R_1 ending in costa at basal 0.4; two sensory pores very close to the juncture as in figure; R_5 nearly straight but bent gently at distal fourth to meet and terminate costa at wing tip; M_{3+4} obsolete basally but visible to posterior margin of wing; Cu branching at level of junction of R_1 with costa; Cu_1 slightly curved, shorter than Cu; Cu_2 curved sharply at base and bent at nearly right angles to horizontal axis of wing. Each leg covered by very narrow scales which are longer and darker at ends of tibiae and tarsal segments 1 to 4; proportions of hind tarsal segments 1.0:6.5:4.0:3.0:1.8 (average of two legs on one paratype); four, mid, and hind claws (Fig. 7*d*) each bent sharply near base, nearly straight beyond, with a long delicate ventral tooth before the bend; each pulvillus 0.5 as long as claw. Terminalia (Fig. 7*a*) wider than long (viewed dorsally); basistyle stout, length 1.7 times greatest width; dististyle rather stout, length 3.0 times greatest width, basal third of outer margin bulging with a darker area as shown, apical third somewhat darkened and with a single tooth; style triangular, connected at base with inner surface of basistyle by a triangular extension, this continuous with a lateral footlike piece without a distinct termination in the mounts; style terminating proximally in two narrow extensions. Tenth sternite and tenth tergite about equal in length, both only very slightly shorter than style; tenth sternite truncate with rounded corners and very shallowly emarginate; tenth tergite deeply emarginate, the resulting lobes about 1.7 times as long as width at base.

Female.—Head, eye bridge, palpus, scape and pedicel as in male. Flagellum of 12 segments, the first two fused as in male, the distal segments becoming successively shorter with shorter stems, apical segment 2.0 times as long as wide, narrowing from distal half outward to rounded point; fifth flagellar segment (Fig. 7*f*) with proximal lobe 2.1 times as long as wide; distal stem 0.2 as long as proximal node; circumfila of two closely adhering rings, the basal encircling the node at basal 0.4, the distal at the extreme tip of node, the two rings connected on opposite sides of the segment. Wing and legs as in male. Ovipositor (Fig. 7*e*) about 1.5 times as long as abdomen, retractile, terminated by simple paired lobes.

Holotype.—♂, Butte County, Calif., 29-IX to 7-X, 1953, coll. Calif. Div. Forestry, reared from cones of *Abies magnifica,* Hopkins no. 32737. U.S.N.M. no. 63031.

Paratypes.—10 ♂♂, 29 ♀♀, same data as holotype. 5 ♂♂, 5 ♀♀ (CIS), remainder (USNM).

Additional material examined.—Oregon: 2 ♀♀; Ashland, Colestin. Reared from cones of *Abies concolor*, August 22 to October 23, 1914.

Discussion.—*Mycodiplosis conicola* is closely related by morphological characters to *M. alternata* Felt and *M. hudsoni* Felt, both of which have been recorded only from eastern United States, the former on *Podophyllum* and the latter on *Acer*. *M. conicola* and *M. coryloides* are the only species associated with the cones of western forest trees; *conicola* may be distinguished from *coryloides* by the shape of the proximal portion of the style and by the longer narrowed portions of the flagellar segments. See also discussion of *coryloides*, p. 56.

Mycodiplosis coryloides, n. sp.

Fig. 8, *a–e*, *g*

Male.—Shape of head from anterior view and width of eye bridge not visible in mounts available. Scape of antenna only very slightly longer than wide, widest slightly beyond the middle; pedicel subglobular, greatest width about 0.7 greatest width of scape; flagellum with terminal segments missing in all specimens, the segments not appreciably narrowed or shortened toward distal end of flagellum, first two flagellar segments fused, without a trace of a division between; fifth flagellar segment (Fig. 8*g*) with two nodes, the proximal one 0.8 as long as greatest width, which is at about middle; proximal stem 0.4 as long as proximal node; distal node 1.1 times as long as wide and 1.4 times as long as proximal node; distal stem 0.6 as long as distal node; three circumfila, one on proximal node and two on distal, the proximal one with loops attaining basal half of proximal stem, middle one with loops attaining apical two-thirds of distal node, distal one with loops barely exceeding apex of distal stem. Palpus (Fig. 8*c*) of four segments, proportions 1.0:2.2:3.0:3.8 (average of type series), first segment about as long as wide, second widest, third and fourth successively narrower. Wing (Fig. 8*b*) 2.2 times as long as wide; R_1 ending in costa at basal 0.4 with a single sensory pore just before the junction; R_5 nearly straight, bending slightly at distal fourth to meet and terminate costa at wing tip or just beyond; M_{3+4} obsolete basally, visible only from branching of Cu to near posterior margin of wing; Cu straight, branching at about the level of R_1-costa junction; Cu_1 slightly curved, shorter than Cu; Cu_2 curved and ending in posterior margin slightly beyond point of origin. Leg scales so narrow as to be almost hairlike; hind femur slightly longer than tibia; proportions of hind tarsal segments 1.0:7.3:4.2:3.0:1.8 (average of type series); claw (Fig. 8*d*) on each leg bent sharply near the base, nearly straight beyond; fore, mid and hind claws each with an inconspicuous ventral basal tooth; pulvillus 0.6 as long as claw. Terminalia (Fig. 8*a*) wider than long (viewed dorsally); basistyle stout, length 2.0 times greatest width, with a diagonal strip of sclerotization at base; dististyle 0.6 as long as basistyle, length 4.0 times greatest width, curved and somewhat tapered to tip, with a distal tooth as in illustration; style stout, narrow at extreme base but widening rapidly on basal fourth or third, where it forms lateral triangular arms attaching to inner margin of basistyle, gradually narrowing on distal fourth to a blunt, rounded tip; tenth sternite rounded-truncate distally with the mere suggestion of a median invagination; tenth tergite bilobed, the incisure attaining the base of the lateral arms of the style, each lobe rounded apically.

Female.—Head, palpus, scape and pedicel as in male. Flagellum of 12 segments, the first two fused without any indication of a division, segments becoming slightly shorter toward apex of flagellum, the terminal segment 2.0 times as long as wide, narrowed to a point from distal half outward; fifth flagellar segment with proximal node 2.1 times as long as wide; distal stem 0.1 as long as node; two closely adhering circumfila in the form of irregular rings which are connected to each other at opposite sides of the segment. Wings and legs as in male. Ovipositor (Fig. 8*e*) fleshy, retractile, length not measurable in available specimens, terminated by simple paired lobes.

Holotype.—♂, Butte County, Calif., 29-IX to 7-X, 1953, Calif. Div. Forestry, reared from cones of *Abies concolor*, Hopkins no. 32738f. U.S.N.M. no. 63082.

Paratypes.—3♂♂, 5♀♀ same data as holotype. One ♂, 2♀♀ paratypes (CIS), remainder (USNM).

Additional material examined.—CALIFORNIA; 1♂, 2♀♀; Plumas National Forest (Quincy). OREGON: 1♂; Jenny Creek. From cones of *Abies magnifica* and *Pseudotsuga menziesii*, October to November 26, 1930–1938.

Discussion.—The two new *Mycodiplosis* species discussed here, *conicola* and *coryloides*, are very closely related and are the only species of the genus associated with cones of Western forest trees. *M. coryloides* may be distinguished from *conicola* by the narrower style and the more slender dististyle, and from *Mycodiplosis coryli* Felt, to which it is also closely related, by the longer claws and wider style flanges. Adults of several species of this genus have been reared from mycophagous larvae, but it is not known whether the mycophagous habit is common to the genus as a whole.

Lestodiplosis taxiconis, n. sp.
Fig. 9, *a–d, f, g*

Male.—Head nearly round from anterior view; eye bridge 9 to 10 facets wide. Scape of antenna 1.25 times as long as wide, slightly narrower at base than at apex; pedicel subglobular, slightly wider than long, rounded at apex; flagellum of unknown number of segments, the first two completely fused, appearing as a single segment with four nodes; remaining segments progressively shorter, apical segment narrowed and rounded at apex; fifth flagellar segment (Fig. 9*g*) with two nodes, the proximal 0.55 as long as wide and separated from distal node by a stem 1.5 times as long as proximal node; distal node as long as wide at greatest width, also somewhat flask-shaped; distal stem equal in length to distal node; proximal node with a single circumfilum, loops of which nearly attain base of distal node; distal node with two circumfila, the proximal one very close to base of node and with loops nearly attaining greatest width of node; distal one situated very close to distal margin of node and with loops nearly attaining apex of distal stem. Palpus (Fig. 9*c*) of four segments proportions 1.0:2.6:2.6:3.1 (average of type series); first segment subsquare in outline, second and third slightly wider, fourth suboval and only very slightly wider than second and third. Wing (Fig. 9*b*) without markings, about two times as long as wide; R_1 ending in costa at basal 0.4; the suggestion of a crossvein, not distinctly connected with R_1, present near base of R_5; R_5 nearly straight for most of its length, meeting and terminating costa at wing tip; Cu straight, forked at outer 0.4; Cu_1 gently curved; Cu_2 likewise gently curved and terminating in posterior margin of wing just apicad of termination of R_1. Legs densely covered by very narrow scales; hind femur slightly longer than tibia; proportions of hind tarsal segments 1.0:5.6:2.4:1.3:1.0 (average of type series); fore, mid and hind claws (Fig. 9*d*) simple, not sharply curved; each pulvillus 0.8 as long as claw. Terminalia (Fig. 9*a*) longer than wide (viewed dorsally); basistyle slender, length nearly three times greatest width, with a distinct shoulder on inner dorsal margin at the middle; dististyle 0.5 as long as basistyle, 4.5 times as long as greatest width, swollen on basal fourth, remainder slender, slightly curved inwardly, only very slightly enlarged distally and with a distal slit; style nearly as long as basistyle, narrow proximally and expanding to its greatest width at proximal fourth where it is provided with inconspicuous lateral projections, thence gradually narrowing to tip which is very slightly expanded and truncate; tenth tergite bilobed, the bottom of the incision almost square, each lobe 1.5 times as long as wide and evenly rounded at tip; tenth sternite slightly shorter than tergite and considerably shorter than style, rounded at tip (not divided into lobes).

Female.—Head, eye bridge, palpus, scape, and pedicel as in male. Flagellar segments with single nodes, the first two completely fused; fifth flagellar segment with length of node 1.6 times the greatest width; distal stem 0.9 as long as node; circumfila not distinguishable in the poorly mounted specimen. Wing as in male. Hind tarsal segments missing; terminal abdominal segments fleshy; ovipositor not retractile.

Holotype.—♂, Colestin, Oreg., 30-VI-1914, J. E. Patterson, reared from cones of *Pseudotsuga taxifolia*, Hopkins no. 12535g. U.S.N.M. no. 63033.

Paratypes.—4♂♂, same data as holotype; 2♂♂ (CIS), remainder (USNM). Eleven ♂♂, 3♀♀, near Lamb's Mine, Ashland, Oreg., 17-II-1915, F. P. Keen and P. D. Sergent, reared from cones of *Pseudotsuga menziesii*, Hopkins no. 13209e-3 through e-8; 6♂♂, 1♀ (CIS) remainder (USNM).

Additional material examined.—1♂, 1♀, same data as Hopkins nos. 13209e-3 through e-8 (CIS). These specimens are badly damaged and have little value for comparative purposes.

Discussion.—Males of *Lestodiplosis taxiconis* may be distinguished at once from all other North American species of *Lestodiplosis* by the relatively short, narrowed portions (length 2.5 times width vs. length 3.5 times width) of the fifth flagellar segment, and by the fact that this species is associated with cones of Western forest trees.

Felt's (1921) key to the North American species of *Lestodiplosis*, based almost entirely on color and characters of the male antennae, is almost impossible to use for alcoholic or slide-mounted material. The genus needs extensive revision. Pritchard (1953) does not list the genus as occurring in California. In his key, *Lestodiplosis* runs to *Retinodiplosis* or to *Itonida*, from which it may be separated by the presence of a lobe on the inner surface of the basistyle (Fig. 9*a*).

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HERPETOLOGY.—*The herpetofauna of Harford County, Maryland.* CLYDE F. REED, Baltimore, Md. (Communicated by Doris M. Cochran.)

One of the most varied geographical areas in Maryland is Harford County. It is bounded on the east by Susquehanna River, on the southeast by Chesapeake Bay, and on the west and south by Little Gunpowder River. To the north there is no definite geographic boundary with Pennsylvania. The largest inland streams are Deer Creek, Broad Creek, Rock Run, and Bynum Run.

The lower southeast eighth of the county is below the Fall Line, thus providing coastal situations along lower Susquehanna River, Chesapeake Bay, and Bush River. The Little Gunpowder runs along the western and southern boundary of Harford County, separating it from Baltimore County. Many deep rocky ravines are exposed along its course, down to the Fall Line, where the river flattens out into a tidal river, like Bush River and the lower Susquehanna River. Deer Creek also exposes extensive rock formations in the northern and central portions of the county, especially near The Rocks, near Kalmia, and below Darlington, where Deer Creek enters the Susquehanna River just below Conowingo Dam. Most of the rock formations in Harford County are acidic in nature, there being a few calcareous regions in the southwest portion of the county. These areas afford a variety of habitats for amphibians and reptiles, thus accounting for the large number of species found in the county.

Some of the areas in Harford County have been quite extensively studied. The most frequented area is the Broad Creek area where there is a Boy Scout Camp. Other areas well studied are the regions of The Rocks, Conowingo, Lapidum along the Susquehanna from Conowingo to Havre de Grace along the rocky slopes, the region about Aberdeen, and the regions about Bel Air, Churchville, Kalmia, Webster, Hickory, Fallston, Whiteford, Jarrettsville, Shawsville, Norrisville, Edgewood, and Magnolia.

The distribution of the species of plants and animals to be found in Harford County follows the geographical boundaries very closely. Species that are typically of Piedmont distribution are: *Diadophis punctatus edwardsii*, *Lampropeltis triangulum triangulum*, *Natrix septemvittata*, *Clemmys insculpta*, and *Clemmys muhlenbergii*; species that are typically coastal reaching up into Harford County are: *Eumeces fasciatus*, *Eumeces laticeps* (?), *Carphophis amoena amoena*, *Opheodrys aestivus*, *Lampropeltis getulus getulus*, *Storeria dekayi*, and *Sternotherus odoratus*; the other species are found in both regions.

Many of the following records are additions or new records to the herpetofauna of Harford County. Since several of these records are additions to McCauley's *The reptiles of Maryland*, 1945, the following annotated list of species is presented. All records and annotated specimens have been collected by the author unless otherwise noted. The collection numbers refer to specimens in the herpetological collections of the author. A total of 43 species are listed from Harford County, 18 of these species are either new records or extend the known range of the species in this county.

1. *Diemictylus viridescens viridescens* (Rafinesque): NEWT or RED EFT. The Rocks (in meadow pools, May 1954); Broad Creek (in swamp 2 miles north of Broad Creek Camp); Rock Run (in swamp and edge of stream, spring 1953); Churchville (eft stage).

2. *Desmognathus fuscus fuscus* (Green): DUSKY SALAMANDER. The Rocks, Rock Ridge Road (April 10, 1954, #789–791); Broad Creek (common under rocks along streams, May 12, 1953, #127); Lapidum (April 25, 1953, #129–130; April 9, 1953, #146–154); Shures Landing below Conowingo Dam (September 20, 1953, #18–24; March 20, 1954, #569–572); Susquehanna River at Schweers Landing (April 9, 1953, #186–192); Deer Creek near Darlington (April 9, 1953, #273); Kalmia (in a spring, May 1955).

3. *Plethodon cinereus cinereus* (Green): WOOD SALAMANDER; RED-BACK SALAMANDER (red and black phases). Broad Creek (common under rocks and logs); Deer Creek at Route 1, north of Bel Air (Oct. 15, 1954, #995–1007); Deer Creek near Darlington (September 20, 1953, #28–35, 85; April 19, 1954, #144; April 9, 1953, #267–272); along Rock Run near Susquehanna River at Schweers Landing (April 9, 1953, #166–185, 193–202); Lapidum (April 9, 1953, #647–650; April 25, 1953, #99–102); Deer Creek at Susquehanna River (April 25, 1953, #155–165; summer 1953,

#131–139); Shures Landing below Conowingo Dam (March 20, 1954, #524–527).

4. *Plethodon glutinosus glutinosus* (Green): Slimy Salamander. Deer Creek near Darlington under rocks on hillsides (April 9, 1953, #103–108; #274–275; September 20, 1953, #26; April 25, 1953, #114–125, including Deer Creek at Susquehanna River); Deer Creek at Route 1, north of Bel Air (October 15, 1954, #977–978); Broad Creek. Many of the specimens from the Deer Creek and Susquehanna River areas have no spots; they are solid black.

5. *Pseudotriton ruber ruber* (Sonnini): Red Salamander. Rock Run near Schweers Landing (April 25, 1953, #112–113); Broad Creek (in old spring house near swamp; under logs); Dublin; Deer Creek near Darlington (April 19, 1953, #145); Shures Landing below Conowingo Dam; The Rocks (in spring house, April 1954); Edgewood; Churchville (in old well).

6. *Eurycea bislineata bislineata* (Green): Two-lined Salamander. Broad Creek (May 12, 1953, #128, edge of streams); Shures Landing below Conowingo Dam (April 9, 1953, #126; September 20, 1953, #17); Susquehanna River near Schweers Landing (common); Rock Run.

7. *Eurycea longicauda longicauda* (Green): Long-tailed Salamander. Shures Landing below Conowingo in seepage (September 20, 1953, #14–16); Broad Creek (in spring house).

8. *Bufo terrestris americanus* Holbrook: American Toad. Broad Creek; Bush River; Churchville; Havre de Grace (common in all localities); Lapidum.

9. *Bufo woodhousii fowleri* Hinckley: Fowler's Toad. Churchville; Broad Creek; Lapidum.

10. *Acris gryllus crepitans* Baird: Cricket Frog. Rock Run; Broad Creek; Churchville (frequent); along Susquehanna River in canal, Conowingo to Havre de Grace.

11. *Hyla crucifer crucifer* Wied: Spring Peeper. Havre de Grace; Churchville; Broad Creek; woods, 2 miles north of Havre de Grace (October 6, 1955, #1024).

12. *Hyla versicolor versicolor* LeConte: Common Tree Frog. Broad Creek.

13. *Rana catesbeiana* Shaw: Bull Frog. Bush River (in swamps); Havre de Grace; Aberdeen; Broad Creek (in swamps near camp); Hickory north of Bel Air.

14. *Rana clamitans* Latreille: Green Frog. Churchville (April 25, 1953, #501); Broad Creek; Bel Air; Hickory; Susquehanna River near Glen Cove (May 12, 1953, #284).

15. *Rana sylvatica* LeConte: Wood Frog. Deer Creek at Darlington (September 20, 1953, #25); Shures Landing below Conowingo Dam (March 20, 1954, #567); Broad Creek (in nearby swampy areas); Deer Creek at Susquehanna River; Schweers Landing along Susquehanna River (October 6, 1955, #1025).

16. *Rana pipiens* Schreber: Leopard Frog. Chruchville (April 25, 1953, #502–503); Broad Creek; Bel Air.

17. *Rana palustris* LeConte: Pickerel Frog. Broad Creek; woods along Route 1 at Deer Creek (October 6, 1955, #1023); Lapidum (October 6, 1955, #1027).

18. *Chelydra serpentina serpentina* (Linnaeus): Snapping Turtle. Havre de Grace; Webster; Edgewood; Deer Creek near Kalmia (April 30, 1955, #980); Broad Creek, in Broad Creek Lake (seen up to 30 pounds; many juveniles caught in streams leading to lake); The Rocks; Churchville (frequent in ponds and swamps).

19. *Clemmys guttata* (Schneider): Spotted Turtle. Broad Creek (behind dam, in swamp next to creek, 5 collected); Bush River; Darlington; along Susquehanna River near Conowingo Dam.

20. *Clemmys muhlenbergi* (Schoepff): Muhlenberg's Turtle. Broad Creek, in swampy area near pipe drain at Broad Creek Scout Camp (4 collected in three years). New to Harford County.

21. *Clemmys insculpta* (LeConte): Wood Tutle. Roberts Island; Broad Creek (below dam, 2 collected along creek); Havre de Grace (USNM 14582).

22. *Terrapene carolina carolina* (Linnaeus): Box Turtle. Havre de Grace; Webster; Aberdeen; Emmorton; Bel Air; The Rocks; Broad Creek; Rock Run.

23. *Sternotherus orodatus* Latreille: Musk Turtle. Along Little Gunpowder River, in Harford County, near Fork.

24. *Chrysemys picta picta* (Schneider): Painted Turtle. Havre de Grace; along Susquehanna River near Darlington; Conowingo Dam; Broad Creek (around lake and in streams); Aberdeen; Churchville. New to Harford County.

25. *Graptemys geographica* (LeSueur): Map Turtle. Havre de Grace (USNM 17833); Susquehanna River at Darlington (Roger Conant).

26. *Kinosternon subrubrum subrubrum* (Lacépède): Mud Turtle. Bush River (CMP 8035).

27. *Sceloporus undulatus hyacinthinus* (Green): Northern Fence Swift. The Rocks (RHM); Broad Creek (collected near nature lodge). Ex-

tending the range north and east in Harford County in Maryland.

28. *Eumeces fasciatus* (Linnaeus): FIVE-LINED SKINK. Bush River (CMP 8379); Broad Creek (seen near rocks where copperheads stay; collected by nature lodge). Extending range northward about 20 miles to Pennsylvania line.

29. *Natrix septemvittata* (Say): QUEEN SNAKE. Along Susquehanna River above Havre de Grace; near Edgewood; Broad Creek (frequent along streams on overhanging branches); Schweers Landing along Susquehanna River (ZSP 385); Van Bibber (USNM 36087). Extending range northward along Susquehanna River to Pennsylvania Line.

30. *Natrix sipedon sipedon* (Linnaeus): COMMON WATER SNAKE. The Rocks, along Deer Creek; Havre de Grace; Dublin; Carsens Run; Churchville; Broad Creek (common along streams and on overhanging branches).

31. *Thamnophis sauritus sauritus* (Linnaeus): RIBBON SNAKE. Near Aberdeen; Broad Creek (some observed with part of tail missing); The Rocks (2 specimens observed and let go, July 1954); Bush River (CMP 8374); Edgewood Arsenal (MNHS); The Rocks (RHM). Extending range north and east to Susquehanna River near Pennsylvania line.

32. *Thamnophis sirtalis sirtalis* (Linnaeus): GARTER SNAKE. Shures Landing below Conowingo Dam (March 20, 1954, #565); Broad Creek; Havre de Grace; The Rocks; Churchville. Extending range north and east to Pennsylvania line.

33. *Haldea valeriae valeriae* Baird and Girard: EASTERN GROUND SNAKE. Broad Creek (under old plant stalk, embedded in ground); Prospect; north of Bradshaw, along Little Gunpowder. New to Harford County.

34. *Heterodon platyrhinos platyrhinos* Latreille: HOG-NOSED SNAKE. Broad Creek (5 collected in year, near fence posts and in dead logs); near Magnolia (DOR, May 1952); Aberdeen (Robert Duppstatt). Extending range north and east to Pennsylvania line.

35. *Diadophis punctatus edwardsi* (Merrem): RING-NECKED SNAKE. Deer Creek at Susquehanna near Darlington (September 20, 1953, #27); Broad Creek (under rotted logs and flat rocks). New to Harford County.

36. *Storeria dekayi* (Holbrook): DEKAY'S SNAKE. Churchville. New to Harford County.

37. *Opheodrys aestivus* (Linnaeus): ROUGH GREEN SNAKE. Aberdeen (climbing over shrubs). New to Harford County.

38. *Carphophis amoenus amoenus* (Say): WORM SNAKE. Conowingo; Broad Creek. New to Harford County.

39. *Coluber constrictor constrictor* (Linnaeus): BLACK SNAKE, BLACK RACER. Broad Creek; Deer Creek at Susquehanna River (Spring 1953, in woods). New to Harford County.

40. *Elaphe obsoleta obsoleta* (Say): PILOT BLACK SNAKE. Broad Creek; Churchville; along Little Gunpowder River; Bel Air; The Rocks. New to Harford County.

41. *Lampropeltis doliata triangulum* (Lacépède): MILK SNAKE. Havre de Grace (USNM 9284); Broad Creek (collected in ruins of old building). Extending range northward to Pennsylvania line.

42. *Lampropeltis getulus getulus* (Linnaeus): EASTERN KING SNAKE. Along Little Gunpowder River, northwest of Fallston; near Aberdeen (Robert Duppstatt). Extending range well into Harford County.

43. *Ancistrodon contortrix mokeson* (Daudin): COPPERHEAD. The Rocks (on boulders sunning, 1946); Kalmia (1954); Broad Creek (on rocky ledges below dam; some killed at camp site above lake); Deer Creek (Fowler, 1925); near Darlington; on rocky ledges along Susquehanna River just above Havre de Grace. Widens the range in Harford County.

Although the following species of amphibians have not been collected in Harford County, to the best of my knowledge, they do occur just below the Conowingo Dam on the Cecil County side of the Susquehanna River. Since they all show aquatic or semiaquatic tendencies, there is no reason why they might not be found in Harford County.

Ambystoma maculatus (Shaw): Low ground between the Octoraro River and Port Deposit, #38–41, March 18, 1953; just below Conowingo Dam, #48, September 20, 1953.

Ambystoma opacum (Gravenhorst): Under logs just below Conowingo Dam, #47, September 20, 1953; low woods between Octoraro River and Port Deposit, #37 and 37a, March 18, 1953.

Hemidactylium scutatum (Schlegel): Under logs just below Conowingo Dam, #46, September 20, 1953.

Cryptobranchus alleganiensis (Daudin): Collected in the Octoraro River many years ago; common farther north in the Susquehanna River and its tributaries in Pennsylvania.

ZOOLOGY.—*A new genus and two new species of amphipods from Dry Tortugas, Florida.*

Clarence R. Shoemaker, U. S. National Museum.

While collecting in the shallow water around Loggerhead Key, Dry Tortugas, in 1926, I discovered some small amphipods living among the coral sand and rocks. These proved to be a new genus, herein named *Hoplopheonoides.*

A number of amphipods found clinging to the exterior of a large spider crab taken by Dr. Waldo L. Schmitt south of Tortugas in August 1931, have been found to be a new symbiotic species of *Stenothoe.*

Family Amphilochidae

Hoplopheonoides, n. gen.

Antennae short, subequal in length, flagella much shorter than their peduncles, accessory flagellum absent. Eye rather small. Mandible, molar well developed, cutting edge well toothed, spine row of several spines, palp absent. Maxilla 1, inner plate narrow and rather long, outer plate with 9–11 spines, palp 1-jointed. Maxilla 2 both plates narrow, inner the shorter. Maxillipeds normal. Coxal plates 1 and 2 rudimentary, 3 and 4 very large. Gnathopods 1 and 2 subchelate. Peraeopods 1 and 2 slender; peraeopods 3 and 4, slender with second joint linear; peraeopod 5, slender with second joint slightly expanded. Metasome segments normal. Urosome segment 1 long, with a high dorsal crest or lamella; urosome segments 2 and 3 very short and not coalesced. Uropods normal. Telson horizontal and entire.

Hoplopheonoides obesa, n. sp.

Fig. 1

Male.—Head as long as the first two body segments combined. The specimens examined having been in alcohol for a considerable time, the eyes were distorted so that their correct outline could not be determined. Antenna 1, peduncle rather stout, the joints decreasing consecutively in length; flagellum, a little longer than the last peduncular joint, the first joint being as long as the succeeding four joints combined. Antenna 2 a little shorter than 1 and comparatively slender; fourth joint a little longer than the fifth; flagellum as long as the fifth peduncular joint and composed of one long joint and four short joints. Upper lip bilobed. Mandible without palp; molar well developed; cutting edge rather broad and well toothed; spine row of six or seven spines, as well as could be determined. Maxilla 1, inner plate narrow and rather long and apparently without setae; outer plate with nine or eleven spines; palp 1 jointed and bearing distal spines. Maxilla 2, both plates narrow and slightly curved, inner plate the shorter, and each bearing one apical seta. Maxilliped, inner plate longer than the outer and reaching forward nearly as far; outer plate reaching nearly to the end of the first joint of palp; second joint of palp short and widened distally; third joint with a narrow distal lobe reaching nearly to the middle of the fourth joint.

Gnathopods 1 and 2 slender. Gnathopod 1 shorter than 2; second joint not quite as long as the fifth and sixth combined; fifth joint with lower lobe produced forward beneath the sixth; sixth joint over twice as long as wide, palm transverse and rather deeply incised; seventh joint slender, curved, much longer than the palm and bearing minute spinules on inner margin. Gnathopod 2 second joint longer than the fifth and sixth combined; fifth joint a little longer than the sixth; sixth joint expanding slightly distally, palm transverse, concave, having a small tooth near the seventh joint, and defined by a tooth bearing two spines; seventh joint slender, strongly curved, extending a little beyond the palm and armed on the inner margin with five spinules and a small forward-pointing tooth. Peraeopods 1 and 2 slender, alike, and about equal in length. Peraeopods 3 and 4 alike, but 3 the shorter (Fig. 1*a*). Peraeopod 5 about as long as 3, second joint slightly expanded but not produced below. The fourth joint of all peraeopods slightly expanded and very little produced below. The seventh joint of all peraeopods slender and little curved.

Coxal plates 1 and 2 rudimentary and nearly hidden by the greatly expanded coxal plate 3. Coxal plate 4 greatly expanded and reaching back to the end of coxal plate 5.

The body of the animal viewed from above widens rather abruptly toward the fourth segment which is the widest and which bulges out laterally over the central coxal plates. The body then tapers off to the posterior end which is very narrow.

Metasome segments evenly rounding below and without angles. Urosome segment 1 about three times longer than segments 2 and 3 combined, and expanded dorsally into a thin vertical crest or lamella which is produced behind over segments 2 and 3. Urosome segments 2 and 3 very short, and apparently not coalesced. Uropods decreasing in length consecutively, all biramous, the outer ramus being the shorter. The upper margins of all rami bearing very fine, closely set spinules. Telson entire, with lateral margins converging to a narrow apex, and reaching nearly to the end of the peduncle of uropod 3. Length 2.5 mm.

Female.—Those specimens which are believed to be females are like the males, and are of the same size.

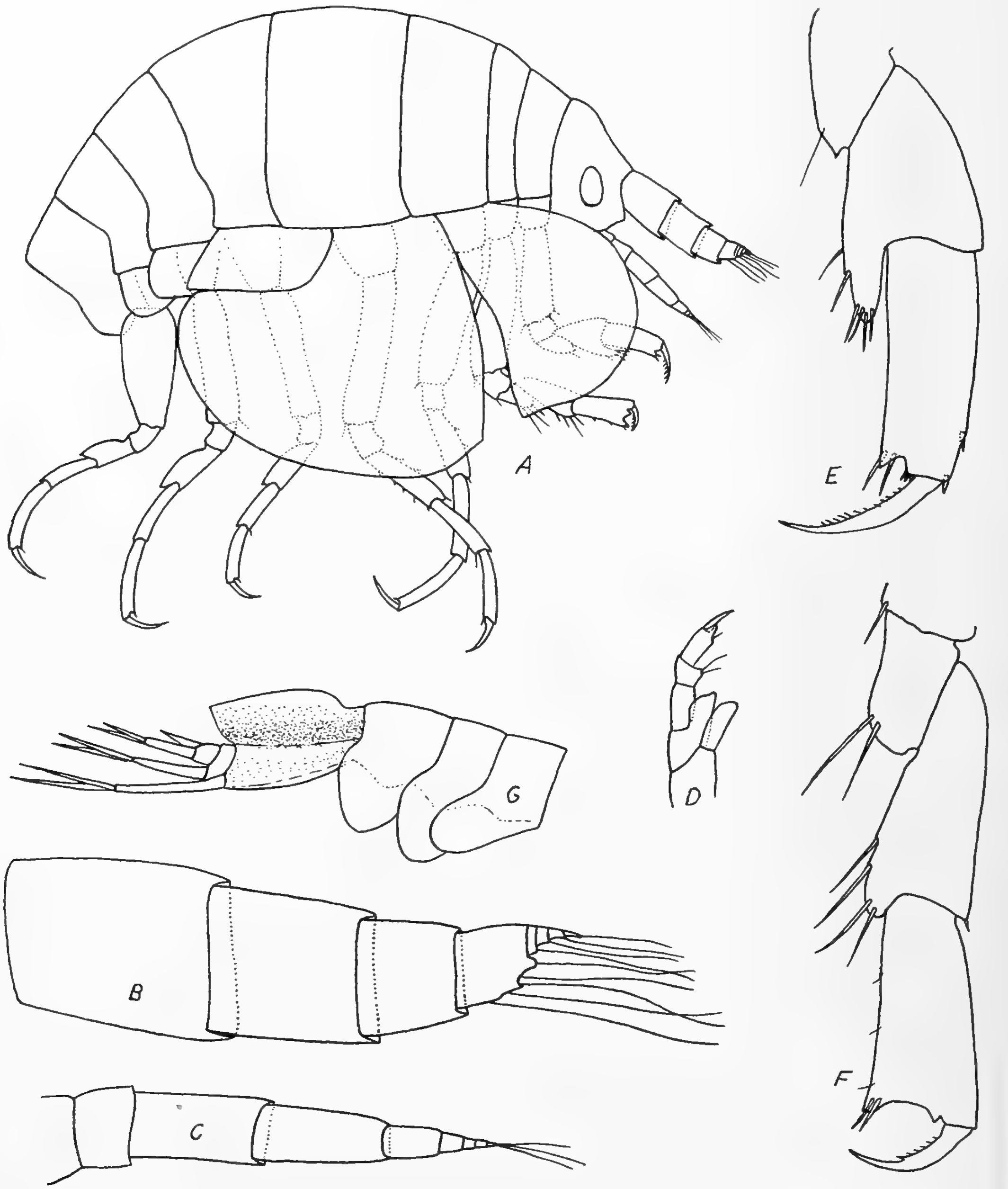

FIG. 1.—*Hoplopheonoides obesa*, n. gen. and n. sp., male: *a*, Front part of animal; *b*, antenna 1; *c*, antenna 2; *d*, left maxilliped; *e*, end of gnathopod 1; *f*, end of gnathopod 2; *g*, hind part of animal.

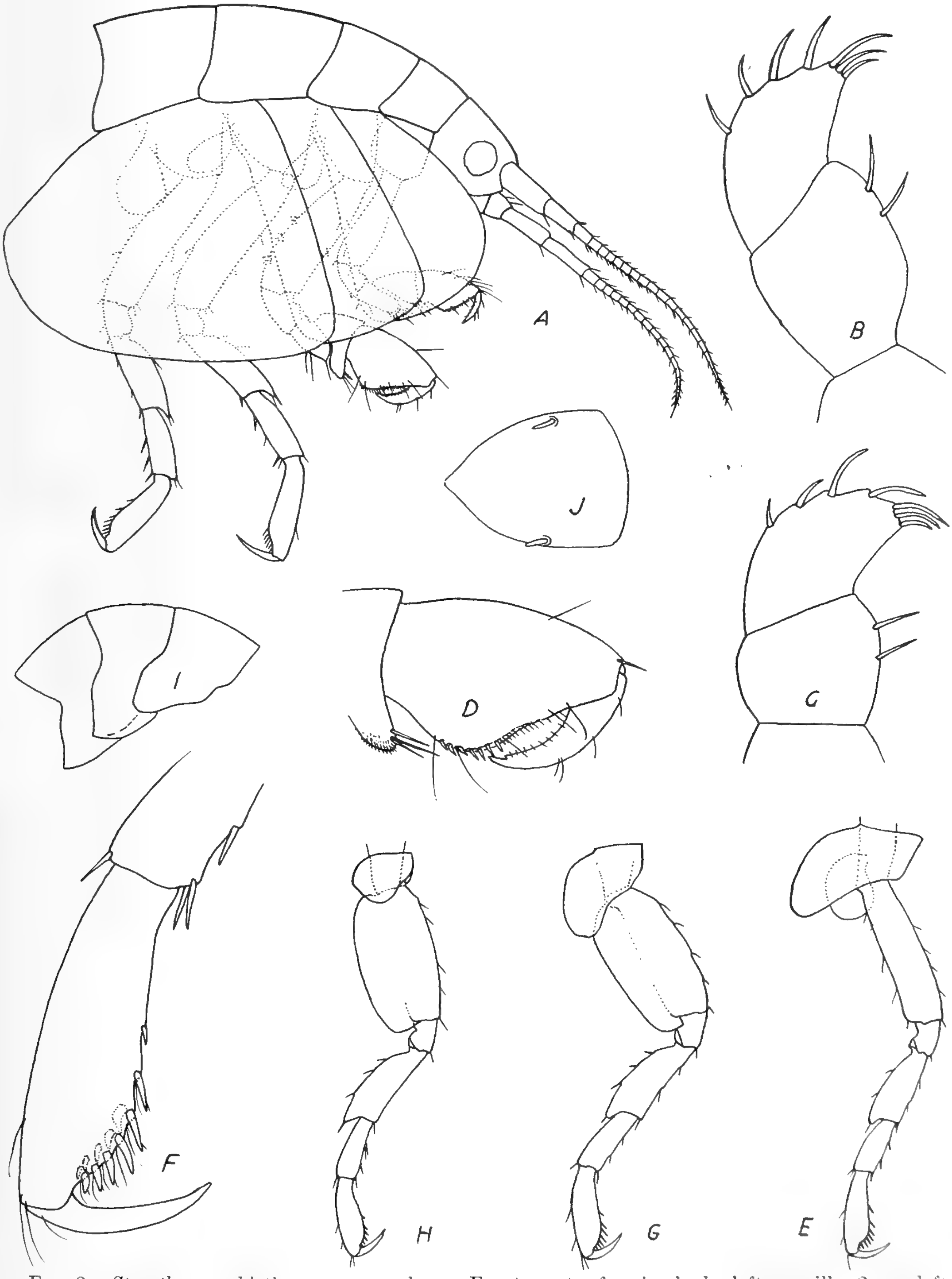

Fig. 2.—*Stenothoe symbiotica*, n. sp., male: *a*, Front part of animal; *b*, left maxilla 2; *c*, left maxilla 2 of another specimen; *d*, end of gnathopod 2; *e*, peraeopod 3; *f*, end of peraeopod 3 enlarged; *g*, peraeopod 4; *h*, peraeopod 5; *i*, metasome; *j*, telson.

Type.—A male, U. S. Nat. Mus. no. 96465, taken off the northern end of Loggerhead Key, Tortugas, Fla., in 15 feet of water, among sand, rocks, and marine growths, August 4, 1926, by Clarence R. Shoemaker.

Remarks.—This amphipod possesses characters belonging to several of the genera of the Amphilochidae, but the combination of these characters does not agree with that of any of the established genera of the family; it, therefore, appears necessary to create a new genus to receive it.

In life the animal is heavily mottled with greenish brown, yellowish green, and white, which give it an effective protective coloring for its native habitat amongst the coralline sands and rocks.

Specimens of this species were taken at a number of localities in the shallow water around Loggerhead Key.

Stenothoe symbiotica, n. sp.

Fig. 2

Male.—Head with lateral lobe angular, but not acutely so. Eye rather large, nearly round, and light straw color in alcohol. Antenna 1 a little longer than 2, penduncular joints decreasing in length consecutively; flagellum nearly twice as long as the peduncle, and composed of about 19 or 20 joints. Antenna 2, fourth and fifth joints equal in length; flagellum longer than the peduncle, and composed of about 16 joints.

Right mandible, cutting edge broad, with five coarse teeth; accessory plate broad with very finely toothed edge, spine row of about 12 spines; palp absent, but indicated by a small, pointed, conical protuberance. Left mandible, cutting edge broad with more and much finer teethn in tha right mandible; accessory plate broad with coarser teeth than in right plate. Maxilla 1, inner lobe small with one seta; outer lobe with six spine teeth; palp 2-jointed, the rounding distal margin and inner margin with spines. Maxilla 2, inner lobe absent; outer lobe bearing seven spines. Maxilliped, inner lobes very small, but separate; outer lobes entirely absent. Inner distal end of the third joint of the palp and the inner margin of the fourth joint bearing a brush of fine setae.

Gnathopods 1 and 2 very much alike, but 2 much the larger. Gnathopod 2, second joint not much expanded and as long as the fifth and sixth joints combined; fifth joint a little over half the length of the sixth, and with prominent lower lobe; sixth joint about one-third longer than wide, widest in the middle; palm very oblique, slightly concave, provided throughout with very short spinules, without defining angle, and merging into the joint by a broadly rounding curve which bears a row of seven stout spines; seventh joint stout, curved and bearing a row of fine spinules on inner margin.

Peraeopods 1 and 2 slender and alike, fourth joint little expanded; sixth joint longer than fifth, expanded distally, and provided on the oblique distal end with two rows of stout spines, thus, with the opposing seventh joint, forming a subchelate clasping organ. Peraeopods 4 and 5, second joint moderately expanded, and the third to seventh joints like those of peraeopod 3. Coxal plates 2 and 4 broadly expanded and much deeper than their body segments. Metasome segment 1 evenly rounding below. Metasome segments 2 and 3 slightly produced below, but not sharply so.

Uropod 1 extending a little farther back than 2. Uropod 3 extending a little farther than 2 and about as far as 1. All uropods with very few small spines. Uropod 3, peduncle not quite as long as first joint of ramus, which is longer than the second joint and bears one or two central and several distal spines on upper margin. Telson not reaching the end of the peduncle of uropod 3, lateral margins each bearing one spinule and converging to the narrow rounding apex. Length about 7 mm.

Female.—The female is very much like the male. The antennae are a little shorter. The coxal plates are not so deep. The gnathopods are smaller and weaker, but structurally the same as those of the male. The female is a little smaller than the male.

Type.—A male, U. S. Nat. Mus. no. 96464, taken from the exterior of a large spider crab caught in 50 fathoms south of Loggerhead Key, Tortugas, Fla., August 7, 1931, by Waldo L. Schmitt. A considerable number of these amphipods were taken from the crab, where they were apparently living symbiotically. Several specimens were taken in an otter trawl at Tortugas. A single specimen was taken by the steamer *Albatross* December 12, 1919, in an otter trawl, in 62–110 fathoms, at station 20037 off South Carolina.

NOTES AND NEWS

SIX DISTRICT AREA SCIENTISTS RECEIVE ACADEMY AWARDS

The Board of Managers of the Washington Academy of Sciences announce the 1955 winners of the awards given annually to scientists under 40 years of age in recognition of distinguished scientific achievements in the Biological, Engineering, and Physical Sciences, and to a secondary-school teacher for excellency in Teaching of Science. The selections were made by a committee of 25 leading scientists in the various fields represented.

The President of the Academy, Dr. Margaret Pittman, of the National Institutes of Health, presented the awards at the Annual Dinner Meeting of the Academy, held on January 19, 1956, at the Kennedy-Warren.

BIOLOGICAL SCIENCES

Dr. Clifford Evans and Dr. Betty J. Meggers, of the Smithsonian Institution, a husband-wife team, were selected to receive jointly an award in the Biological Sciences in recognition of their outstanding contributions to the prehistory and human ecology of Lowland South America. They were pioneers in archeology in the Amazon area. They lived and worked in the rain forests where no one previously had been willing to work, and there uncovered evidence that has necessitated drastic revision of previously held views of native culture in northeastern South America. Their field work has been in Peru, Lower Amazon, British Guiana among the Wai Wai Indians, and in coastal Ecuador.

Dr. Evans was born in Dallas, Tex., and received his Ph.D. from Columbia University in 1950. He joined the staff of the Smithsonian Institution in 1951 as associate curator, Division of Archeology, U. S. National Museum.

Dr. Meggers was born in Washington, D. C., and received her Ph.D. from Columbia University in 1952. Since 1954 she has been an honorary research associate at the Smithsonian Institution.

Lt. Col. Robert Traub, formerly chief of the Department of Entomology of the Walter Reed Army Institute of Research and now commanding officer of the U. S. Army Medical Research Unit in Malaya, was selected for a Biological Science Award in recognition of his outstanding work on ectoparasites, fleas and mites. He made outstanding contributions during World War II to the control of mite-borne scrub typhus in the Malaya area and during the Korean War to the control of hemorrhagic fever. Hemorrhagic fever, the greatest scourge of that area, is now almost a medical curiosity.

Dr. Traub was born in New York, N. Y., and received his Ph.D. from the University of Illinois in 1947. He has been with the United States Army since 1943.

ENGINEERING SCIENCES

E. Arthur Bonney, of the Johns Hopkins University Applied Physics Laboratory, Silver Spring, Md., was selected for the Engineering Science Award for his outstanding contributions in the field of supersonic aerodynamics. He has played a leading role in elucidating the problems of interactions among the wings, body, and tails of a supersonic missile. Specifically, his analysis and wind-tunnel tests have led to a fairly complete understanding of the aerodynamic and aeroelastic effects of a structure in regions of flow ranging from subsonic to high Mach numbers. His work has fundamental application in the design of air-borne missiles and rockets.

Mr. Bonney was born in Waltham, Mass. He received his master of science degree from New York University in 1942. He has been at the Applied Physics Laboratory since 1945.

PHYSICAL SCIENCES

Dr. Terrell Leslie Hill, of the Naval Medical Research Institute, Bethesda, Md., was selected for the Physical Science Award in recognition of his outstanding contributions to physical and biological chemistry. He has made significant advancements in the statistical mechanics of the behavior of assemblies of particles, molecules, and atoms and in the applications of statistical mechanics to problems of general chemistry, for example; the behavior of molecules at interfaces (gas bubbles in liquids, gases adsorbed on charcoal, etc.). His study of electrical properties of molecules has contributed to the understanding of the chemical behavior of cells, one example of which is muscle contraction.

Dr. Hill received his Ph.D. from the University of California in 1942. He has been on the staff of the Naval Medical Research Institute since 1948.

TEACHING OF SCIENCE

Helen Nale Cooper (Mrs. C. L.), of Bethesda, Md., was selected for the Teaching of Science Award for her distinction in fostering ability and enriching the perspective in mathematics. She has been an effective teacher for a number of years. Mathematics is presented so skillfully that even the slower learners are not scared away from mathematics while the faster learners are challenged to do extra work. Her students have won science fair prizes. She has helped many students decide on an engineering or mathematical career by constantly stressing the need for mathematicians and engineers. She is also active in teacher association projects.

Mrs. Cooper received her A.B. from West Virginia University. She has taught in the Montgomery County Schools since 1946 and in North Bethesda Junior High School since September 1955.

NEW DIRECTOR OF NAVAL RESEARCH

Dr. Oscar Theodore Marzke, associate director of research for materials at the Naval Research Laboratory, has been appointed director of research at NRL. He succeeds Dr. Edward O. Hulburt, who has retired from Civil Service to become the senior scientist for the United States National Committee for the International Geophysical Year of the National Academy of Sciences.

A native of Lansing, Mich., Dr. Marzke received his B.Sc. degree in 1929 from Michigan State College and his Sc.D. degree in Metallurgy in 1932 from the Massachusetts Institute of Technology; he was a Swett scholar. During part of the time he was taking his postgraduate work he served at NRL as a laboratory technician.

From 1933 to 1946, Dr. Marzke was a metallurgist with the American Steel and Wire Co., doing both research and plant metallurgical work, his last position with the company being that of works metallurgist at the Waukegan, Ill., plant beginning in 1942. He joined the Naval Research Laboratory in 1946 as superintendent of the Metallurgy Division and became the first associate director of research for materials in 1954. During the period 1951–53, he was also head of the Metallurgy Branch of the Office of Naval Research and was Development Coordinator for ONR from January to August 1955.

Dr. Marzke is a member of the American Society for Metals, the American Institute of Mining and Metallurgical Engineers, the American Welding Society, Tau Beta Pi, the Research Society of America, the British Institute of Metals, the British Iron and Steel Institute, and the **Washington Academy of Sciences.**

ELECTRON TUBE INFORMATION SERVICE

The National Bureau of Standards has established a tube information service for accumulating and disseminating technical data on both domestic and foreign radio tubes. At the present time nearly 10,000 cards, filed by tube type number, are appropriately referenced to manufacturers' source material. In addition, about 10 percent of these cards, selected mainly from the high-use miniature and subminiature types, have been coded on punched cards for mechanical sorting.

With this unique service, it is possible to find (1) information about any particular tube, (2) all tube types whose electrical characteristics, bulb sizes, or base configurations fall within particular ranges, and (3) domestic tubes that can be substituted for unavailable foreign tubes. Recently, junction diodes and transistors have been added to the Bureau's program. The program began about seven years ago as a service to NBS personnel. It has since been extended to all scientists and engineers in Government and industry who have legitimate requests. This continuing service is being carried out by C. P. Marsden and J. M. Moffitt of the Bureau's electron tube laboratory.

The NBS tube information service was established to meet the ever-increasing number of requests for information that was not readily available on little-known tubes or tubes of foreign manufacture. As the service grew, it included more and more detailed information on larger numbers of tubes. Recently the Bureau has begun punched-card coding for automatic selection in order to process requests more rapidly. The goals of the service are to include the latest technical data on all domestic and foreign tube types and to have all such information coded.

The service includes all such data on electron tubes and semiconductor devices as electrical characteristics, bulb size and base configurations, ambient operating conditions, and where possible, construction details. The main source of this information is the manufacturer's brochure or handbook. While the major companies automatically furnish the information through their distribution lists, numerous new and small companies must be queried directly whenever preliminary information on their products is gathered from advertisements, articles, and brochures. Special attention to these scattered sources has been required to maintain current the file on crystal diodes and transistors. The NBS files include products of about 80 domestic and 15 foreign manufacturers. In general, foreign data have been limited to Western European sources.

So far the Bureau has received requests for tube information mainly from other Government agencies, the military services, foreign governments, and local private industries. Most of the inquiries have been for information about the electrical characteristics of a particular tube type or the selection of a domestic tube for replacement in foreign equipment. Although this sort of request is easily met, questions on cathode operating temperature or contact potentials must be answered in general terms because these quantities vary with the manufacturer. Queries on tube types with specified electrical, mechanical, or geometric characteristics are usually answered by a combination of machine card sorting and reference research. Clearly, only general information can be coded on punched cards; after machine selection of several tubes that meet the specifications of the inquiry, reference research is required to supply the more specific information. In general, coding is on the basis of operating voltages, transconductance, etc.; and the tube types machine-selected are those within the ranges specified by the inquiry.

While the coding on punched cards has been completed only for the miniature and subminiature tubes with bulb sizes up to T6½, the Bureau plans to proceed as rapidly as possible with the coding of all other tube types. The semiconductor devices are being coded as soon as the information becomes available.

The Bureau's service is open to all who have legitimate requests. Inquiries may be made by telephone if desired. However, they should contain as much factual information as possible to expedite the reference research and should include background information where appropriate. The service cannot undertake to answer queries on tube applications in circuits; complex or highly detailed questions that may require laboratory research can be answered only on the basis of data available. Address inquiries to C. P. Marsden, chief, Electron Tubes Section, National Bureau of Standards, Washington 25, D. C.

DR. CURTIS CELEBRATES 80TH BIRTHDAY

Dr. HARVEY L. CURTIS, one-time member of the staff of the National Bureau of Standards and still an active physicist, was honored by his junior NBS colleagues on the occasion of his 80th birthday on December 14.

Dr. Curtis, who is internationally known for his work in absolute electrical measurements, was presented with a bound volume of letters from many of his former scientific associates congratulating him on his birthday.

Until his retirement in 1946, Dr. Curtis was chief of the Bureau's Inductance and Capacitance Section, a part of the Electricity Division. In this capacity Dr. Curtis supervised the maintenance and continued development of the national standards of reference for determining the two basic electrical quantities, inductance and capacitance. His work on the measurement of current and resistance in absolute units brought him into contact with renowned scientists in other national laboratories and made him an appropriate NBS representative at the International Electrical Congress at Paris in 1932.

In addition to the basic work on absolute electrical measurements, he inaugurated fundamental researches on the properties of dielectrics, particularly rubber and petroleum. During World Wars I and II, he directed extensive programs in ballistic research for the Navy.

Since his retirement Dr. Curtis has maintained an active association with the Bureau, coming to his desk almost daily. His continued interest in ballistics is shown by the publication in 1948 of a paper entitled "An Instrument for the Rapid Production of a Decimal Series of Potentials and its Application to Ballistics Measurements," of which he was coauthor with Howard S. Roberts. He also published a paper in 1950 on the "Determination of Curvature by an Osculometer." His continued interest in absolute electrical measurements led to publication in 1949 of a paper on that subject in the Scientific Monthly.

He has long been concerned with science education, and his retirement permitted him to prepare, after a lapse of over 40 years, a historical paper on the establishment of accredited graduate courses at the National Bureau of Standards. This paper was published in this JOURNAL in 1949. In 1906, the year before Dr. Curtis joined its staff, the Bureau had established a system of courses at the graduate level—the first such courses in government. Dr. Curtis was soon asked to serve as chairman of the committee which arranged this curriculum. His studies as a postgraduate student at NBS helped qualify him for his own doctorate.

Since retiring, Dr. Curtis founded a unique organization, "The Fossils." These retired Government workers hold weekly meetings for fellowship and for discussions of subjects of mutual interest. They also make trips to places of historical and National interest around Washington.

Dr. Curtis was born December 14, 1875, on a farm near Lansing, Mich. He received his bachelor of philosophy degree from the University of Michigan in 1900 and his master of arts degree in 1903. He became a physics instructor at the Michigan Agriculatural College in 1903 and held the post of assistant professor there until he joined the National Bureau of Standards in 1907. He took his doctorate at the University of Michigan in 1910. In 1915, after demonstrating his ability for making electrical measurements with high precision, Dr. Curtis was appointed a section chief to direct part of the Bureau's electrical work. He continued to serve as a section chief until his retirement.

During his active career he gave generously of his spare time to scientific societies. He has served as president of the Philsophical Society of Washington and of the Washington Academy of Sciences and was chairman of the Washington section of the American Institute of Electrical Engineers. He is an honorary member of the American Society for Testing Materials, having served as chairman of Committee D-9 on Electrical Insulating Materials and as chairman of American Standards Association Technical Committee C-59 which is sponsored by ASTM. As a Fellow of the American Institute of Electrical Engineers, he was active in the National Affairs of that organization and also the American Physical Society. Dr. Curtis was made an honorary Phi Beta Kappa when the chapter was established at the University of Michigan in 1930. He is at present hard at work on his memoirs.

DR. HERBERT FRIEDMANN, curator of the Division of Birds, U. S. National Museum, Smithsonian Institution, has been awarded the 1955 Leidy medal of the Academy of Natural Sciences of Philadelphia. The medal is awarded every three years for the best publication, exploration, discovery, or research in the natural sciences in such particular branches thereof as may be designated.

Dr. Friedmann is being honored for his research in ornithology, his study of the biology of parasitic birds, the monographic works he has published dealing with them, and the discovery of wax digestion by honey guides. His study of these small birds, which lead men and animals to nests of bees, may provide a new means of attacking the tubercle bacillus.

It may be noted that Dr. Friedmann is the author of the first number in the Academy's monograph series, *The Parasitic Cuckoos of Africa.*

OLIVER H GISH has been appointed visiting professor of physics at Southern Illinois University for the academic year 1955–56. From 1922 until his retirement in 1948, Gish was on the staff of the department of terrestrial magnetism of the Carnegie Institution of Washington, first as physicist and later as chief of the section of terrestrial electricity and as assistant director of the department. Since his retirement, he has been part-time consulting physicist to the U. S. Air Force and the U. S. Navy Mine Defense Laboratory.

R. N. DOETSCH, associate professor of bacteriology at the University of Maryland, has been appointed a 1956 fellow of the John Simon Guggenheim Foundation at the Rowett Research Institute, Bucksburn, Aberdeenshire, Scotland. He will work with A. E. Oxford on some aspects of rumen microbiology.

SHIRLEIGH SILVERMAN, of the Applied Physics Laboratory, Johns Hopkins University, has taken a year's leave, effective November 1, to serve as director of the Physical Sciences Division, Office of Naval Research.

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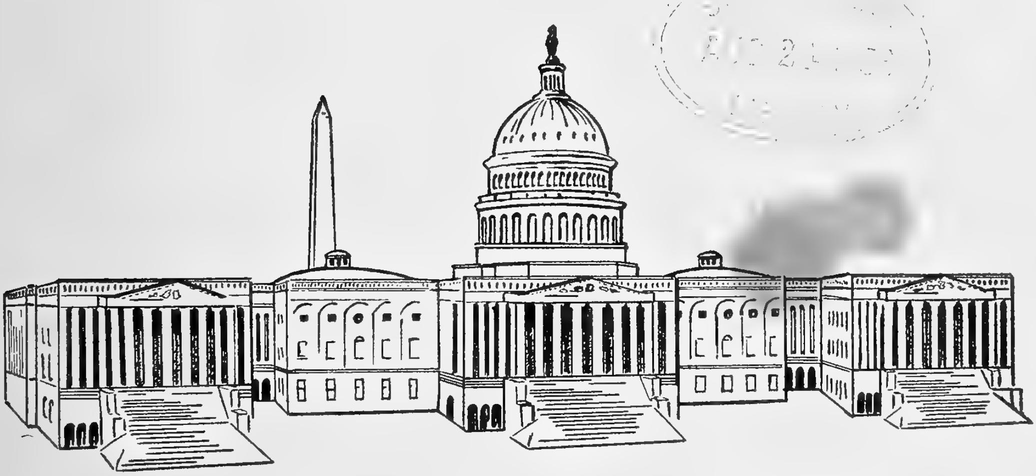
JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES



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PHYSICS.—*The basis for standards for radiation protection.*[1] LAURISTON S. TAYLOR, National Bureau of Standards.

In the broad sense, radiation protection is a problem that will touch the lives of most of us more and more as time goes on, whether it be in connection with nondestructive testing, with radiology, or with the production of nuclear power. The uses of radiation-producing machines and the use of radioactive materials will undoubtedly increase as time goes on, and radiation as such will become an increasingly important part of our national economy. It will also become a part of our political economy because, with the widespread uses of radiation, there is an increasing tendency to endeavor to control its hazards through legislative means. Legislation can be good or bad; whether it is one or the other will depend to a considerable extent upon the action and interest of our scientific and technical organizations.

Today, radiation rules, laws, and regulations are being developed rapidly. With any law or regulation, restriction is apt to follow. This can be harmful if such restrictions are allowed to interfere materially with the normal progress of science and industry. These problems will undoubtedly come to your attention more and more. I want to emphasize the importance of keeping a close watch on these developments, and when necessary, being willing to devote some of your time and energy to assure that regulations are sensible, useful, and yet at the same time nonrestrictive.

The term "radiation-protection standards" is used somewhat loosely, and yet at the same time there is probably very little real uncertainty as to the broad meaning of the term. One normally thinks of a standard as being something rather firm, rather well understood, inflexible, accurately known, and reproducible. When a standard is mentioned one immediately thinks of something like the standard meter-bar, carefully locked away in a vault and resistant to the changes of time; or of some accurately measurable quantity, such as the ohm or volt.

However, in the field of radiation protection standards, there are many unknowns and many uncertainties. They involve a great many assumptions that may have to be changed from time to time. In fact, it would not be oversimplifying the case to state that our protection standards are essentially protection goals or objectives. Where it is possible to develop numbers to assign to some of the standards, these numbers are really more in the nature of a means to achieve some goal than the goal itself. Even the goal itself is difficult of definition. It is primarily to determine the limits of radiation exposure to which the individual, or whole population, can be exposed without encountering risks incommensurate with the benefits to be expected from its use. Standards of safety go back directly to the individual who will be exposed to radiation. For this it is necessary to determine how much radiation he can absorb without injury to himself or to his progeny. Knowing the complication of the human being as an organic structure, and the great difference in sensitivity between individuals, it is very easy to see why such a determination immediately becomes an extremely difficult problem. To point up the difficulties, it may be helpful to review rather briefly some of

[1] This paper is the substance of the Lester Honor Lecture, delivered before the Society for Non-Destructive Testing and published in full in the journal of that Society. Their permission to reprint this part is acknowledged with appreciation.

the early background and philosophy leading to the development of standards of radiation protection. Much has been written on this subject and therefore only the high spots will be touched upon (*1*, *2*, *3*, *4*).

Radiation was recognized as a potential hazard to health soon after its discovery. Serious efforts to understand and curtail radiation exposure to individuals were not begun seriously until the 1920's. One should bear in mind that it was not until 1928 that the world had a uniform and acceptable unit of radiation dose, namely the roentgen. Consequently, radiation-protection efforts and protection standards were, of necessity, on a purely qualitative basis. Until 1928, most radiation treatments were expressed in terms of fractions of erythema dose—the amount of radiation that would cause a defined reddening of the skin. This in itself was a very uncertain factor, since it depended upon the energy of the radiation, the time over which it was delivered, the size of the irradiated field, and the amount of backscattering, not to mention the individual's idiosyncrasy with regard to radiation sensitivity. It was not until the mid-thirties that stray radiation exposure was measured quantitatively, making it possible to put radiation-protection standards on a reasonably firm quantitative basis. Interestingly enough, later efforts proved that these early standards were not grossly wrong.

The first protection standards, if such they could be called, were in terms of thicknesses of lead that were required to be interposed between a radiation source and an individual to assure his safety (*5*). Graded thicknesses of lead were recommended on the basis of the voltage applied across the X-ray tube. No account was taken of the hardness of the radiation, distance factors, origin and history of the scattered radiation, time of exposure, etc. The standard barriers were based on supposedly "average" conditions. The following of this principle of protection, while a substantial achievement, nevertheless resulted at times either in underprotection or costly overprotection.

One could venture the suggestion that if there is any basic standard of radiation protection it would be what is now referred to as the maximum permissible dose, or maximum permissible exposure of an individual. By maximum permissible exposure is meant the amount of radiation to which the whole body of an individual can be subjected over the period of his adult lifetime, without producing in that individual any detectable harmful effects (*6*). For the occupational exposure of an individual to radiation, such a standard might be adequate, but as explained below in more detail, there should be an additional basic standard relating to the average exposure of the entire population; for genetic reasons.

Parenthetically, it should be remarked that the old term "tolerance dose" that prevailed for many years is a complete misnomer. There is no such thing as a "tolerable dose of radiation." No radiation effects, other than for the treatment of disease, are known to be beneficial to man. Any radiation exposure received by man must be accepted as harmful. Therefore, the *objective should be to keep man's exposure as low as possible and yet at the same time, not discontinue the use of radiation altogether*.

The big problem is to obtain some quantitative idea as to the amounts of radiation that can harm the human being.

As already mentioned, early permissible exposures were expressed in terms of the erythema. This followed as a result of a very few observations on a very few people who had been overexposed to radiation, under conditions where there was some crude idea as to the amount of radiation involved (*7*). As a result of this, numerous proposals were made, and for a time served a useful purpose. For example, Mutscheller proposed as a "tolerance dose," $\frac{1}{100}$ of an erythema dose in 30 days (*8*). Others reduced this to $\frac{1}{1000}$ of an erythema dose in 3 days. Sievert independently proposed $\frac{1}{10}$ of an erythema dose per year (*9*), which was not appreciably different from Mutscheller's value.

Various attempts were made to place the erythema dose on a sound physical basis. Glocker and Kaupp (*10*) described a tolerance dose as that radiation level which would give just barely visible fluorescence observable in a completely darkened room by dark-adapted eyes. They also described it as barely visible blackening of a "duplitized" X-ray film after an exposure to radiation of one hour. Mutscheller's formula, a simple but very inaccurate one for computing erythema doses, was developed for a given distance from the X-ray tube for the direct beam. The number of erythema doses was given by the number of milliampere minutes, divided by 25 times the square of the distance.

Knowing as much as we do now about radiation, these standards look pathetic indeed and yet they marked important milestones leading to our more accurate understanding of the problem. When one realizes that, on the basis of today's knowledge, an erythema dose under given conditions may vary from 270 to 1,000 roentgens over a range of 100 to 1,000 kilovolts, some visualization of the vast uncertainties in the early work might be had (*11*).

By the early 30's such works as just mentioned were correlated and reconciled by the free use of safety factors—or just factors. Germany proposed the first quantitative expression of a permissible dose measured in roentgens, arriving at a figure of 10^{-5} roentgen per second as their so-called tolerance level of radiation. In 1934 it was possible, for the first time, for the International Commission on Radiological Protection to express permissible exposure in terms of roentgens (*12*). The value then chosen was $\frac{2}{10}$ roentgen per day. In the United States in 1936 a somewhat lower level, namely, $\frac{1}{10}$ roentgen per day was adopted (*13*). This lower value was in part a result of the belief that there was not an adequate safety factor in the international recommendations.

It will be noted that the permissible exposures mentioned above were integrated over varying lengths of time, ranging over a period of 1 second to one year. Although precise information on radiation recovery is lacking, it is undoubtedly true that a given dose of some roentgens received in a period of a few minutes is probably more harmful to the individual than the same dose distributed evenly over a year's period of time. Therefore, while the various proposals for permissible exposure appear to reduce numerically to the same quantity, they were not, in fact, biologically equivalent.

Additionally, there is a serious administrative problem involved, when one compares the integration of a dose given over a few seconds or over a year. For example, according to the early German proposals, if at any time an individual is exposed to more than 10^{-5} roentgens in any one second, he would have exceeded his permissible dose rate even though this might only occur once in a year. This, of course, is nonsense. On the other hand, the problem of integrating a dose over a year's time could also present serious difficulties, depending upon the particular technique used. A person might be heavily overexposed during an early period in a year, yet this might not be detected until it was too late. It was through consideration of such reasons as these, that integration over a period of one day was adopted in the mid-thirties.

In 1946 the National Committee on Radiation undertook an intensive review of the whole problem of permissible dose. This review was instigated by the fact that, during the Manhattan District days, a tremendous amount of experimental and biological research had been carried out for the purpose of assuring safety to radiation workers; new biological data had become available. It was quickly realized that the value of $\frac{1}{10}$ roentgen per day, as used in this country, provided only marginal protection. There was increasing evidence leading the committee to believe that the value should be lowered. At the same time it was decided to review the question of the period over which the dose would be integrated. For technical, as well as administrative reasons, it appeared that integration over one day was unnecessarily restrictive. Integration over about 1 month appeared to be more reasonable and a compromise was finally reached at one week. The committee arrived at the recommendation of $\frac{3}{10}$ roentgen per week as the permissible whole-body exposure to gamma rays and moderate and medium energy X-rays. This value has since been adopted internationally (*16*).

It might be pointed out that integration over a week still presents an occasional source of administrative difficulties, particularly in large nuclear industry operations. In such operations the situation occasionally arises where a person may be exposed to more than his weekly allowance, and yet would not receive any serious additional exposure for many weeks thereafter. It seemed improper to penalize either the worker or the work because of such occasional over-exposure. Therefore, a modified standard was recommended to take care of such situations.

According to this, under special circumstances, a person's exposure may be integrated over a period of 13 weeks (or $\frac{1}{4}$ of year) during which period he may be allowed a total exposure equal to that which might have been received at the normal maximum rate for 10 weeks. Thus the 13-week integration carries with it a penalty of about 23 percent. In other words, if a person receives his total dose for the longer period all at once, his permissible dose for that period is only $\frac{10}{13}$ of what it would otherwise be. There is little quantitative foundation for this concept, other than the general belief, as already mentioned, that a dose distributed over some appreciable time is less harmful than the same dose taken all at once.

Thus far the problem of radiation exposure to the individual has been considered only under essentially occupational conditions. There are a number of other conditions that have to be considered. These will be enumerated briefly and some of them will be taken up in more detail later. Radiation effects on human beings may be more or less significant depending upon many factors. For example, there is increasing evidence that irreversible genetic damage may result from exposure of the gonads to *any* amount of radiation. All such exposure is cumulative. This implies that an exposure that may not produce any harm to the individual himself, may be passed on through the genetic chain to the descendants of this individual. It is impossible to neglect the possibility that such damage may occur.

It also appears that individuals are more susceptible to radiation damage during their embryonic stage. For this reason it is considered advisable to restrict as far as possible the exposure of pregnant women, especially during the first few months of pregnancy.

Exposure of children under 18 years of age should also be held to a minimum, although there is no positive evidence that they are more susceptible to radiation damage than an adult. On the other hand, the permissible exposure for adults takes into consideration the possible genetic damage during their lifetime prior to the conception of their children. To allow children under 18 to receive the same exposure would start them at a disadvantage were they later to go into radiation work and then to receive the maximum permissible exposure.

As far as a potential parent is concerned, the important period of his life with regard to radiation exposure is that time up to the conception of his last child. On the average this would not be higher than the age of 45 years. For this reason the permissible exposure to persons over 45 years of age may be doubled. This might provide some degree of flexibility in certain industrial operations, but some say that the differentiation of people under 45 and over 45 years of age is an administrative headache.

An additional problem, and one that will be dwelt upon in more detail later, concerns the exposure of large population groups. Take for example, a large city supplied by a single source of water. If this water becomes contaminated by radioactive waste, a very large number of people might receive a small but continuing dose of radiation. Depending upon the nature of this contamination, the radiation might reach the gonads. In this situation a small genetic damage might result to a large number of people where the possibility of crossbreeding is large. This could be deleterious to the well-being of a considerable number of people. Hence standards for the protection of a large population group may have to be substantially different from these for a relatively small number of radiation workers, each receiving individually higher doses of radiation.

Thus far the discussion has dealt, in the main, with the standards of protection from sources outside of the body. When the radiation sources get into the body the problem is vastly more complicated and the overall difficulty of reaching our standards is much greater. Here again the basic protection standard relates back to the maximum permissible dose of $\frac{3}{10}$ roentgen per day. However, in the case of internal emitters, one must consider the particular organ, or organs, that may be sensitive to the radiation. This involves an intimate knowledge of what happens to every chemical element, once it is inside the body. For example, certain elements such as radium, plutonium, and strontium are what is known as bone seekers.

By one means or another a fraction of the material entering the body eventually ends up firmly fixed in the bone where it can create damage. Another material, such as iodine, will tend to concentrate in the thyroid. Generally speaking, there are definite organs in the body which are more susceptible than others to radiation damage, both because of the nature of the organ and the tendency for that organ to concentrate radioactive material.

Depending upon the nature of the material, and its means of entry into the body, varying fractions will be eliminated by normal processes, while the remainder is taken up by the body organs. It is necessary to determine these relative proportions. The degree of damage to an organ by a given quantity of radioactive material also depends upon the biological half-life which in turn includes the physical half-life of the material. By biological half-life is meant the time that it takes to reduce the quantity of the material in the body to one-half of its initial value through the process of body elimination and radioactive decay. Thus an isotope that has a short half-life, and is also quickly eliminated from the body, is relatively non-hazardous. Such an isotope is sodium-24. On the other hand radium and plutonium are both elements having extremely long half-lives, and at the same time a low elimination rate, together with a tendency to concentrate in the bone. The former (sodium-24) is relatively non-hazardous, whereas the latter are very hazardous.

In arriving at permissible exposure levels for radioactive elements within the body, the following factors, among others, have to be taken into consideration.

1. Quantity of radioactive material taken into the body.
2. Initial body retention.
3. Fraction of material going from blood to critical body tissues.
4. Radiosensitivity of tissue.
5. Size of the critical organ.
6. Essentiality of the critical organ to proper function of the body.
7. Biological half-life.
8. Physical half-life.
9. Energy of the radiation produced by the isotope.
10. Specific ionization and the attenuation of that energy in tissue.

Once all the biological and physical factors are known, it is then possible to work backwards to determine the concentrations of radioactive material in air or in water that may be taken into the body without resulting in damage to the critical organ or tissue. By this means it has been possible to develop a series of values for the maximum permissible concentrations for radioactive isotopes in air and in water, which can be described as standards of radioactivity level. Such levels for about 100 radioactive isotopes have been worked out and agreed upon by the National Committee on Radiation Protection and have since been adopted internationally (*14*).

A slightly different problem, resulting in a different series of standards, develops when one considers the possibility of a single or occasional intake of radioactive material during a lifetime, and where little or no other exposure to radiation has been received. For these circumstances, very much larger quantities of radioactive material may be taken into the body without serious harm. For situations of this nature, it is possible to group the radioactive elements into four categories that are representative of their single-dose hazard. The elements may be placed in these categories depending on the amount of safe single dose of say 1, 10, 100, or 1,000 microcuries (*15*).

This has also been found to be a convenient grouping for legislative purposes. Since there is obviously little point in trying to control and regulate a quantity of radioactive material that is not harmful if taken in its entirety, there is no reason why it should not be exempted from control. Unrestricted use of the established quantities should be allowed in accordance with the groupings just mentioned.

Standards necessary for the control of the disposal of radioactive wastes, present still a different problem. Having once decided what would be a safe permissible concentration in air and water, the next problem is to determine the conditions under which such concentrations may occur, in situations where the air or water may be taken into the human system.

An additional complication arises, because of the possibility that radioactive wastes may by some means or another enter into our food chain. For example, radioactive wastes discharged into the air or river may be taken up and concentrated by animal or plant life and eventually get back into the human system by way of the food supply. In spite of the extensive studies made of this problem, it is still necessary to provide very substantial safety factors with regard to the permissible amounts of radioactive material that may be discharged into the public domain. It must also be borne in mind that once radioactive material has been dumped outside of a controlled area, its future from there on is largely beyond the control of man. To allow for such uncertainties, permissible concentrations of radioactive wastes are not allowed to exceed $\frac{1}{10}$ of those allowed for continuous occupational exposure (*15*, *16*). This probably represents a very conservative standard of protection, except under the most exceptional circumstances. It is, of course, the single exceptional circumstance that dictates caution.

Additionally, for regulatory purposes it is necessary to establish standards of contamination that will apply under conditions that can be subject both to the control of the user and to inspection by an enforcing agency. This may at times lead to seemingly harsh requirements but from a legal or regulatory point of view, one does not see any easy way of avoiding the situation.

For example, in one early proposed regulation it was specified that the radiation level at any point outside of an installation could not exceed 30 milliroentgens per week, or $\frac{1}{10}$ of the level that is allowed for continous occupational exposure for 25 years of a person's lifetime. The argument here is reasonable to the extent that the point of discharge is the last point at which the installation can control its discharge. Once the material is outside the installation, it is beyond their control and probably even beyond the ability of an inspection agency to evaluate. The possibility exists, however remotely, that by some quirk the material may become dangerously concentrated at some point in the chain of events leading to human consumption.

It is for such reasons that standards for radioactive contamination in uncontrolled areas, namely the public domain, must not be allowed to exceed $\frac{1}{10}$ the maximum permissible amounts for continuous exposure. This applies particularly to situations where large population groups may be exposed to radioactive contamination under conditions which are completely and totally beyond their control (or for that matter any control). The situation is somewhat ameliorated in the recommendations of the National Committee on Radiation Protection by allowing such population exposures to be integrated over a year instead of a week (*6*, *15*).

Thus far the discussion has covered a whole series of standards for radiation protection, namely, protection of the whole body or parts of the body from external radiation sources, protection for occupational workers, continuing exposure to radiation either internally or externally, protection of individuals against large single internal doses of radiation, protection of large populations, standards for animal and vegetable life, for persons over 45 and under 45 years of age, for persons under 18 years of age, and for pregnant women. It is very clear from this sketchy outline that the problem is not a simple one and it is further clear that the standards discussed here must be subject to change—and probably frequent change. Radiation is unquestionably here to stay with us, and it is important that we learn how to use it under conditions which are both safe and economical. The price for unnecessary safety is high, but this is the price that will have to be paid until the problem is better understood.

There is however, one large outstanding problem in standards of radiation protection that has only been touched upon, namely, the genetic problem and the exposure of large population groups. This problem directly influences our whole philosophy with regard to radiation protection, in that the genetic effects of low-level exposures of a large fraction of the population may be the prime determining factor in deciding upon the permissible dose for all persons. As already indicated, the chief consideration up to this point has been in deciding upon the maximum permissible dose of radiation to the individual.

The current maximum level of permissible exposure for the individual rests on the philosophy that exposure at this level throughout his adult lifetime is believed unlikely to cause him detectable bodily injury at any time during his lifetime. Based on this major premise, the present permissible exposure levels are acceptable both from the plant and the individual's viewpoint. They do not appear to involve an unreasonable working risk. Such levels are, however, also based on the additional premise that only a small portion of the world population will be so exposed up to the close of the reproductive lifetime of any individual.

On the other hand, where large population groups may be exposed, the preservation of the genetic balance of the population may require that the exposure per individual, averaged over the whole population, be limited to only a very small fraction of the individual occupational exposure. Up to the present, most of the pertinent data is from animal rather than human experiment, yet we are forced to tentatively accept the animal data and apply it to man.

For purposes of discussion, consider Muller's statement that an exposure of 80 roentgens to the gonads would double the natural mutation rate and that such exposure repeated generation after generation might seriously upset the genetic equilibrium (*17*). Presumably this would be genetically unacceptable in view of the doubly-heavy genetic load thrust upon the unexposed population, and in view of the present trends in reproductive practices. Muller suggests a maxium exposure per individual per reproductive lifetime of 20 roentgens, again averaged over the whole population. This would result in an increase in the mutation rate of only 25 percent. Other authorities have arrived at figures as low as 3 roentgens as a permissible average "lifetime" exposure. Either figure is much lower than the presently accepted individual occupational exposure limit which may be as high as about 400 roentgens in a lifetime.

If we are to adhere to the 20 roentgens averaged for the whole population, not more than 5 percent of the people could be permitted to receive a full occupational exposure of 400 roentgens to the gonads. For the United States this would be some eight million persons—a figure unlikely to be attained for many years to come. One should also consider that most radiation workers do not receive exposures over periods as long as 25 years, and that in fact only a very small number receive more than about one-third of the permissible exposure. On the other hand, there must be added to this, the medical and diagnostic exposures wherein radiation may reach the gonads.

Before facing the problem of determining how much additional radiation may be received by nonoccupational population groups, it is essential to make a careful evaluation of existing exposure patterns. Since the prime consideration will be genetic effects, such exposure evaluation should be limited to the gonads of persons before the close of their reproductive lifetime.

Concurrent with such a study should be certain sociological investigations. Reproduction habits will play an important role, and these will vary markedly depending upon such factors as race, education, inbreeding within certain geographic limits, etc. In averaging the exposure of population groups, erroneous results might be obtained by equal weighting of, say, the population of New York City and the population of the rest of the state, of which a considerable portion is rural.

Since the size, distribution, and nature of a population group may influence the pattern of crossbreeding, it may be worthwhile, even within a single country such as the United States, to consider very different average expcsures for different parts of the country. Such differentiation might present almost impossible administrative problems because of population movements, yet there are relatively large and different population groups between which crossbreeding is negligible. This same consideration, however, will be likely to necessitate lowering of average exposures in some areas where inbreeding is high within a population group that remains somewhat static in location. There will undoubtedly be special problems of this sort in certain areas and it might be worthwhile to treat them specially, rather than inflict unnecessarily low permissible exposures over the country as a whole. Analysis of individual situations, while costly to perform, may nevertheless be sound economy in the end.

We have to face the high probability of an enormous growth in the uses of nuclear energy. It is doubtful whether anyone can accurately predict this for the next 20 or 100 years. Looking backward, the enormous changes in our civilization brought about by technological advances in the past four or five generations, indicate the futility of planning ahead in detail for a similar range of time. This does not imply, however, that we should stand passively by and let nature take its course. There is much that can be done in preparation for the future.

As the invention of the internal combustion engine revolutionized the world's economy, so may we expect controlled nuclear energy to do so again. The engine has brought vast improvements into our material way of life. One wonders, had it been anticipated in 1910 that the engine would be responsible in less than half a century for the deaths of over a million people on United States highways alone, if there would have been a hue and cry to curtail its further use. In spite of the fact that we somehow accept this carnage, we might have been able to hold it down had the problem been attacked while automobiles were in their infancy. But who in 1910 could have predicted today's automobile industry?

With nuclear energy the situation is even more complicated—and vastly different. We know a great deal about its potential hazards and to some extent how to cope with them. In addition, we have some time in which to solve the special problems. However rapid the growth in the use of nuclear energy, there is still some leeway that will allow us to proceed with technological developments before we outrun our practical limits in the methods of protection. The greatest and most serious limitation is that imposed upon us by genetic considerations. Our most substantial advances in knowledge of genetics have been within the past two or three decades—a very short time. The results of this knowledge have been a major consideration in the discussions leading to our present concepts of permissible dose, yet we have avoided any attempts to rigorously define the genetic limitations. (It is presumed that, to be safe, the geneticists, from whom we get our information, assume the most pessimistic conditions.)

At some time, but probably not within the immediate future, man will be faced with making an inescapable decision. At what point may the advantages of atomic energy be offset by the disadvantages to the future man? And who will have the abundant wisdom to recognize that point and do something about it? Will it be known, in time for such a decision, just what radiation may do to man's future? I believe that at some point a decision involving an educated gamble with man's future will have to be made, and history of the past indicates that such a decision may be made on the less—rather than the more—conservative side. That decision does not need to be made tomorrow or probably for some years. In the meantime, our present pace can be continued with relatively little risk. But in that same meantime, we should start to condition our thinking for a change in philosophy with regard to radiation exposure. On the basis of today's knowledge of ourselves, we may be expected to show a willingness to accept more rather than less radiation exposure insofar as its effects 10 or 20 generations hence may be felt.

In this same time, we should also devote our every energy to keeping radiation exposure of persons to the minimum compatible with reasonable progress and good sense. Through education and the dissemination of wisely chosen information, much can be done to improve the present situation in matters of radiation protection, without at the same time fettering a source of great benefit to mankind. The better the ordinary job of protection is done today, the longer is the fateful decision on man's future postponed.

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NBS-AF PANORAMIC X-RAY MACHINE

Research at the National Bureau of Standards has produced an X-ray machine that rapidly takes a single panoramic X-ray picture of the entire dental arch. Developed by the Bureau in cooperation with the U. S. Air Force Dental Service and the USAF School of Aviation Medicine, the panoramic X-ray machine should be particularly useful to the armed forces in making full-mouth dental X-ray surveys of inductees on entering and leaving the service. It will save much of the time required by present techniques, in which up to 14 small films are exposed separately for a full-mouth survey. The device should find application wherever large numbers of people are examined for dental defects, and its principles can be applied to radiography of other parts of the body.

In the NBS-AF panoramic machine, the film is placed outside the patient's mouth and is exposed by passing a narrow beam of X-rays through his head from the rear. A panoramic X-ray picture of all the teeth and associated structures is obtained on a single 5 x 10-inch film in about 40 seconds. Thus the problem of handling many small film packets during exposure and processing is eliminated. At the same time more comprehensive radiographs are produced, giving more general diagnostic information than do conventional full-mouth X-ray surveys.

For several years investigators in both the United States[1,2] and Finland[3] have been seeking to develop a rapid, practicable method for making panoramic X-rays of the entire dental arch. However, the procedures that have been tried have been rather cumbersome—they required rotation of the patient or fitting films inside the mouth. Because of the large number of full-mouth surveys that must be made of military personnel, particularly at induction stations, a rapid, dependable method was needed to replace conventional radiographic techniques. Funds for research in this field were therefore provided by the Air Force. As a result, a more flexible and simple panoramic machine was developed by Col. D. C. Hudson, NBS guest worker from the U. S. Air Force Dental Service, and J. W. Kumpula of the Bureau staff, with the cooperation of members of the NBS electronic instrumentation laboratory.

In this machine, an X-ray source and film holding device follow semicircular paths on opposite sides of the patient's head. The film holder travels in front of the patient, the X-ray source behind him. Movement of source and film is so coordinated that only those structures of the dental arch desired in the finished film are sharply projected while other overlying structures are not.

The X-ray source and film holder are suspended from opposite ends of a horizontal arm that rotates about a central vertical axis. A narrow beam of X-rays emerges from a slit in the exit cone of the X-ray source, passes through the subject's head, and enters a corresponding slit in the film holder just beyond his teeth. Meanwhile, the film, in a carrier within the holder, travels horizontally in a direction opposite to that of the holder and at such a rate that an X-ray shadow of each successive tooth falls on successive areas of the film.

[1] U. S. Patent 2476776, issued to H. Smathers.
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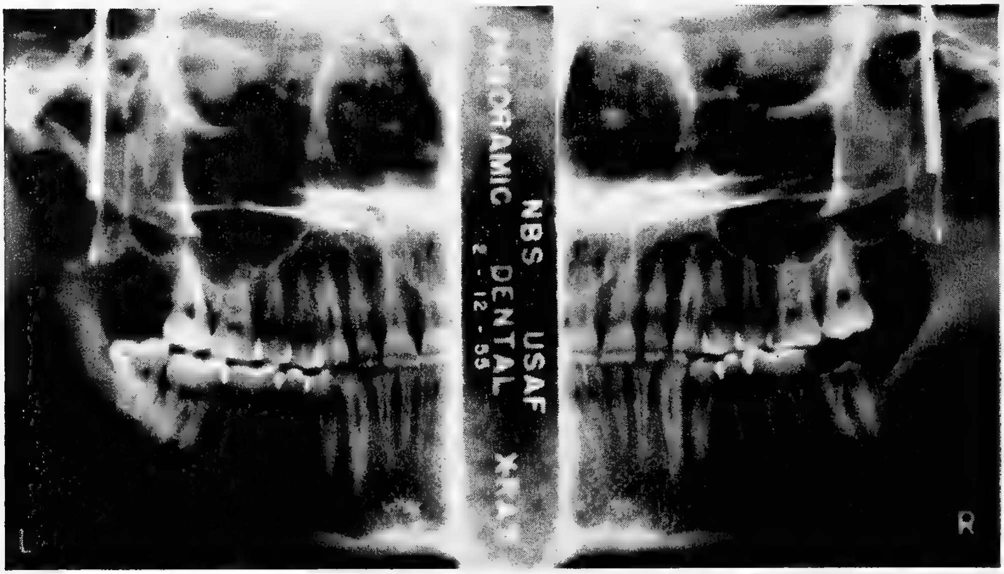

Fig. 1.—Typical X-ray photograph of the human dental arch produced by the NBS-AF panoramic X-ray machine. Parts of the nasal sinuses and other bony structures of the head can also be observed. This radiograph was made on a wax phantom head. The strip in the center normally carries the patient's name and date.

To avoid unwanted X-ray shadows from overlying bony structures, the X-ray beam is made to enter the patient's head largely through the soft tissue between the vertebral column and the bone of the jaw—first from one side, the from the other. As the system rotates, the axis of rotation of the X-ray beam is in this soft tissue, which is much more transparent to X-rays than are the harder structures. Thus, since the X-ray beam is in constant motion, shadows cast by intervening bone and other tissue between the point of entry and the dental arch move across the film too rapidly to obscure detail in the exposure. As a result, clearer lateral jaw radiographs can be obtained than with conventional techniques.

A simple mechanical system automatically varies the rate of film travel to conform to the size and shape of the human dental arch. This device consists of a cable wound about a cam which is curved in the shape of an average dental arch. The free ends of the cable are connected through pulleys to the film carrier. As the horizontal arm rotates at constant speed, the film moves at a rate determined by the curvature of the cam surface at the point where the cable is leaving the cam. The cam is fixed at the axis of rotation, while an electric motor rotates the arm supporting the X-ray source and film holder. A central panel controls the motor as well as X-ray voltage and current.

The first model of the panoramic X-ray machine is now undergoing performance studies. In this model the patient sits in a dental chair beneath the rotating arm and is positioned by means of a chin support pivoted from a stationary point on the machine. The chin support serves to steady the head and to place the dental structures in the proper position for best projection onto the moving film. Future models may be so constructed that the subject need not sit but may be radiographed in a standing position. This will further reduce the time needed for a dental survey.

With the cooperation of the Naval Medical Research Institute, a study[4] was made of the radiation levels produced by the panoramic X-ray machine at points in and about a phantom head constructed of tissue-equivalent wax molded upon an adult human skull. By the use of small ionization chambers—about 30 mm^3 in volume—it was found that the panoramic device produces lower radiation levels than the conventional 14-film intraoral technique produces at corresponding points. The reduction in radiation received by the patient is due to the small area covered by the beam of X-rays during panoramic exposure and the fact that no overlapping occurs.

[4] *Ionization chambers for radiation data during dental x-ray exposure*, by D. C. Hudson and J. W. Kumpula, Armed Forces Med. Journ. **6:** 1131. August 1955.

ENGINEERING.—*The influence of space flight on engineering and science.*[1] Milton W. Rosen, Naval Research Laboratory. (Communicated by C. H. Page.)

Within the past few years many scientists have predicted seriously and confidently that human beings from the earth would, in the foreseeable future, travel to the moon and the nearer planets. The ranks of those who would dispute this prospect are diminishing rapidly. Although much of the progress is still guarded by military necessity, space flight is emerging as an activity in its own right—one that can command the efforts of many engineers and scientists.

In the United States the exploration of the upper atmosphere, the frontier to space, is a vigorous and continuing activity. Pilots of rocket aircraft have experienced conditions approximating those in free space, if only for a few minutes. The effect of space flight upon the human organism is being investigated—the U. S. Air Force maintains a Department of Space Medicine.

There is an international organization devoted to the promotion of space travel and there are space flight societies in 23 countries. Numerous journals exist wholly or in part for the publication of papers on astronautics and its allied fields—notable among these for the quality of its articles is the Journal of the British Interplanetary Society.

I shall try here to explain how the present state of affairs came about and also to forecast what might be the future influence of man's effort to travel in outer space.

The ancients, except for a few rare individuals with greater insight, conceived of the world as an enclosure; they stood upon the earth at the bottom and gazed upward at a blue ceiling upon which a multitude of lights, a few great and many small, seemed to move under the influence of an unseen hand. The atmosphere filled this enclosure and it was believed that if man had wings he could fly to the ceiling and determine the source of the lights. If a few philosophers guessed more nearly at the truth, certainly the average man had no better conception of the universe than the fanciful picture just described. There could be no valid idea of space flight until Copernicus, Kepler, and Galileo placed the earth in its true relation to the universe and at the same time gave dimensions to space.

When at last the moon and the planets were found to be material bodies not unlike our earth, it was possible to ponder whether the immense separating distances could be traversed by man or any man-made device. The situation was made even more discouraging when, in 1686, Newton (*1*) defined the nature and the magnitude of gravitational attraction. If previously there had been some fanciful hope of visiting celestial bodies, now surely it appeared that man was destined to remain forever a prisoner of his own planet. In view of the great distances, it seemed unlikely that the atmosphere could extend through interplanetary space, and any suspicion that it might was laid to rest when Torricelli's barometer was carried to a mountaintop and taken aloft by the early balloonists.

Although Newton brought man face-to-face with one formidable aspect of the problem, namely gravity, he also provided, in his three laws of motion, the key that would unlock the door to space. The fundamental equation of rocket action in free space and hence of space flight:

$$V_b = C \cdot \log_e \frac{M_o}{M_b}$$

where V = velocity of rocket at end of burning
C = velocity of exhaust jet
M_o = initial mass of rocket
M_b = mass of rocket at end of burning

is derived by integrating Newton's third law of motion. Nevertheless, more than two centuries would pass before anyone performed the integration or realized that the simplest embodiment of Newton's third law, a rocket, is the only machine capable of propelling itself in a vacuum.

While science gave no solution, and, indeed, many scientists despaired of finding one, the dream of travel to celestial bodies

[1] A lecture delivered before the Washington Society of Engineers, November 16, 1955.

was kept alive in fiction. One of the earlier references to rockets for propelling a space ship is found in the writings of Cyrano de Bergerac (*2*), but it is doubtful that Cyrano understood the rocket's essential role. Perhaps the most famous novel about space travel is Jules Verne's *From the Earth to the Moon* (3). Although Verne had expert scientific advice, he chose an impossible means of projecting his space ship—it was fired from a long cannon sunk in the ground. Probably Verne knew that no human could survive the acceleration of his projectile and that the projectile itself would disintegrate under the tremendous forces imparted to it. Yet, millions of readers believed his story; many thought it had actually been accomplished—so great was his art—and he created a myth that had to be destroyed before any scientific progress could be achieved. In his novel *The first men in the moon* H. G. Wells (*4*) felt no necessity for scientific rigor, and he conjured up a gravity-defying substance which he called "cavorite."

By the beginning of the twentieth century the physical sciences had advanced to the point where it was inevitable that someone would develop a valid theory of rocket action and would apply the theory to the problem of escape from the earth. The task was accomplished by three men working independently in three different countries. The three had much in common—they were teachers, one at a small university, the other two in secondary schools.[2] Each one pondered the problem for many years before committing his findings to publication. But what is most important, all three were motivated by the desire to explore interplanetary space and presented their findings with conviction, even though they were regarded by most of their contemporaries as prophetic dreamers. The men and their works are now well known. They are:

ZIOLKOVSKY—*The exploration of cosmic space by reaction machines*, 1903.

GODDARD—*A method of reaching extreme altitudes*, 1919.

OBERTH—*The rocket into interplanetary space*, 1923.

[2] One, Oberth, became a teacher after his fundamental work had been completed.

Any one of these three publications, had it been widely read and accepted, would have sufficed to lay the groundwork for space travel, because each man clearly understood and asserted the following fundamental concepts:

1. That escape from the earth is possible by the application of a moderate acceleration over a substantial period of time—at least several minutes.

2. That such acceleration can be produced in a vacuum by a rocket.

3. That the rocket must (a) have high thermal efficiency (i.e., high velocity of the ejected matter) and (b) consist mainly of propellant material (i.e. have a high ratio of fuel weight to total weight).

4. That high thermal efficiency would be obtained most readily from the chemical combustion of liquid fuels.

Ziolkovsky (*5*) started by examining Jules Verne's cannon and also the balloon as a means of reaching very high altitudes. Both approaches died quickly under mathematical analysis. He proceeded next to the rocket and developed the fundamental equation previously noted. Realizing that energetic fuels were required, he determined from thermochemical calculations the heat release of various liquid combinations. When he computed the velocity that could be attained, in theory at least, he realized it was sufficient for escape from the earth.

Goddard (*6*), alone of the three, proceeded from experiment to theory. Using smokeless powder in a heavy-walled steel combustion chamber he produced a jet velocity of almost 8,000 feet per second, a sevenfold improvement over ordinary rockets and the highest velocity of matter attained up to that time outside of electrical discharge tubes. Also, he proved by tests in a vacuum that a rocket does not produce its force by pushing on the air behind it, a fact he knew from basic physics, but that he felt had to be demonstrated. He observed correctly that the jet velocity was greater in a vacuum, but he attributed it erroneously to more efficient ignition. Although Goddard did not turn to liquid fuels until after his basic paper was published, he achieved the first flight of a liquid rocket, an event that took place on March 16

1926. Goddard (*7*) continued his experiments for more than two decades during which time he developed, in rudimentary form, almost every component of modern rocketry. Not one of his components would be considered reliable by present-day standards; realizing the prodigious task he had set out to accomplish, he would repeatedly add a new component before perfecting the previous one. In retrospect, it appears that Goddard was attempting, single-handed, to encompass the entire field of liquid-rocket development, a task that would eventually tax the abilities of thousands of engineers and scientists.

Oberth (*8*), in his treatise, gave the most complete theoretical analysis and carried it farther into the realm of space travel than either of the others. He stated at the outset the four propositions he would attempt to prove:

1. Considering the present state of science and technology, it is possible to build machines that could rise beyond the atmosphere.
2. After further development these machines will be able to attain such velocities that, left undisturbed in the depths of outer space, they will not fall back to the earth and will even be able to leave the zone of terrestrial attraction.
3. These machines could be constructed so as to transport human beings, probably without damage to their health.
4. Under certain economic conditions the construction of such machines might be profitable.

Oberth began by developing the theory of the liquid-rocket and describing its construction. He proceeded to discuss applications of the rocket, first as a high-altitude sounding vehicle, then as an earth satellite, and finally as a space-ship for interplanetary travel. He developed the concept of synergic (minimum energy) ascent trajectories. Without doubt, almost every later book on space flight owes much to Oberth's encompassing study.

Whereas the first quarter of this century provided the theoretical background for space flight, the second 25 years may be viewed as the period of experimental preparation. It saw the liquid-fueled rocket develop as a practical engine for the propulsion of aircraft and guided missiles. Many fuels and oxidizers were explored—a few saw widespread use. An assortment of auxiliary hardware—pumps, turbines, valves, and regulators—was developed to feed and control the rocket motor. The steering of a large rocket vehicle was mastered by means of gyroscopes and jet controls. Great progress was made in the aerodynamics of supersonic flight, in structural design, and in the use of high temperature materials.

Of the early experimenters three groups were most noteworthy. The work of Goddard as an individual has been referred to previously. In Germany the Verein für Raumschiffahrt, fired by Oberth's monumental work, undertook to develop a small workable rocket called, appropriately, minimum-rakete (Mirak—for short) (*9*). In the course of several years they made hundreds of static firings and numerous brief flights. The American Interplanetary Society drew its inspiration largely from abroad, so secretive was Goddard about his experiments. Indeed, when in May 1933, the Society finally achieved a first liquid-rocket flight, they were unaware that Goddard had progressed far beyond his first flight seven years before. It is unfortunate that the British Interplanetary Society was prevented from experimenting with rockets, a situation frequently lamented by its founder, Philip Cleator (*10*).

The V-2, whose development started in the middle of this period, was the largest single engineering advance in the field of rocketry. By applying thousands of engineers and scientists in a concerted effort, the German government was able in six years to transform the liquid-fueled rocket from a small, sputtering vehicle, capable of ascending a few hundred feet, into a giant projectile with a range of 200 miles and a velocity of one mile per second. The V-2 was a material embodiment of Oberth's ideas and, although he conceived the liquid rocket as a vehicle for space travel, he also foresaw its possible use as a bombardment weapon. Actually, he hoped that the rocket missile would be a deterrent to rather than a tool of war.

After the war the major activity leading to space flight took place in the United States in the form of upper-air research with instruments carried in rockets. In a continuing program, scientists from government laboratories and universities explored the upper atmosphere using at first captured V-2 rockets and later, as they became available, Aerobees and Vikings. Both Viking and Aerobee were designed specifically for probing the atmosphere in the region between 50 and 150 miles above the earth. A few of the more important accomplishments of this program are noted. Knowledge of the pressure, temperature, density, and ionic content of the atmosphere has been extended up to 135 miles by direct measurements. The solar spectrum has been recorded in the far ultraviolet. X-rays have been detected in solar radiation and their role in the formation of the ionosphere has been postulated. The number and the mass distribution of primary cosmic rays have been recorded in emulsions carried aloft in rockets. Small animals, monkeys and mice, were sent aloft and their physiological reactions observed during a period of weightlessness. For nine years man had been exploring the frontier of space as a prelude to flight beyond the atmosphere.

It is always tempting to draw parallels and it might appear, at first glance, that the advance toward space flight parallels the progress of aviation, with the latter preceding in time. The same elements of progress are evident in both fields, but one can not fail to note the differences and contrasts.

Although much theoretical work had been done on fluid mechanics and experiments performed in wind tunnels and with gliders, there was at the time of the first mechanical flight no adequate theory to explain the lift of a winged vehicle (*11*). We knew that the Wright brothers' plane flew, but we could not explain why or how it flew. By contrast, the motion of a rocket, as we have seen before, was well understood before Goddard's first flight attempt. This is no paradox—it is apparent that the mathematical treatment of flight within the atmosphere is much more difficult than the analysis of flight in free space.

In both fields there was a period when development was nourished mainly by amateurs; in aviation it was the first decade of this century, for rocketry the late twenties and early thirties. In both cases the advance was given great impetus by a war; the first World War for aviation, the second for rocketry. But I doubt if there is in the history of aviation any single step forward comparable in magnitude to the creation of the V-2. Aviation has been characterized by gradual, steady development, fostered to a large extent by its economic returns as well as its military advantages. There have been several significant milestones; one of the most noteworthy was the development by Major Whittle and others of the turbojet engine, which in the short space of a dozen years has completely displaced the piston-driven propeller in high speed military aircraft and may soon dominate the field of commercial aviation.

In pursuing this rather loose parallelism I have tried to estimate what period in the history of aviation corresponds to the present status of space flight. It seems to me that we are now at a point roughly corresponding to the period before Lindbergh's historic flight across the Atlantic. The significant event we are awaiting is the first orbital flight of a manned earth satellite.

In both cases, at the time being considered, the vehicle had been developed to a reasonable degree of reliability and many flights of shorter range and duration had been made. But again, there is a significant difference. Aviation has always implied manned flight—in rocketry most of the progress thus far has been made in unmanned, automatically-controlled vehicles. Our technology has advanced to the point where we need not risk human life in experimental rocket-flights—on the road to space, instruments will always go first and will point the way for men to follow.

Prior to establishing the first manned satellite two important techniques will have to be mastered. First, there will be a period of experimentation with unmanned, instrumented satellites during which time problems of propulsion, staging, and navigational control will be worked out. The environmental hazards—cosmic radiation, meteors, solar heat (and the absence of it), and possibly weightlessness—can be evaluated.

Worldwide realization that this first problem is being attacked vigorously came when, on July 29, 1955, President Eisenhower announced that the United States would launch small instrumented satellites during the International Geophysical Year (1957–1958). By their statements in support of the President's announcement, many noted scientists attested to the feasibility and usefulness of the instrumented satellite. It is significant, also, that the United States invited international cooperation and offered to make its scientific findings available to all nations.

The second problem is the one of safe return to the earth's surface. The relative speed of roughly five miles per second between the orbiting vehicle and the earth's surface must be brought to zero. Obviously, this will be done by allowing the satellite to transfer its energy to the atmosphere. But this process must be controlled with great precision, lest the satellite absorb too much of the energy in the form of heat. Much will be learned by observing the return of instrumented satellites, but the final preparatory steps will probably involve manned flights at gradually increasing re-entry speeds.

I have placed Lindbergh's flight and the first manned satellite in juxtaposition because one has and the other will, I believe, so excite the world's imagination that future progress will be greatly accelerated. One can not say when the desired event will take place—much hard work remains to be done—but it is not uncommon for scientific achievements to precede their predicted arrival. The mechanical components, engines of sufficient power and controls of requisite precision, are within sight. If it is argued that the human hazards are great and, at present, poorly understood, let it be remembered that the first orbital flight need only be brief—a matter of several hours. In this respect the ordeal may be less prolonged than Lindbergh's flight, but certainly no less demanding upon the pilot's judgment and courage.

We have seen that although space flight is yet to be achieved, its prospect has had, in the last fifty years, an appreciable influence upon science. The greater influence by far lies in the future. The advances in our technology necessary to achieve manned flight in space and those required to exploit it can be readily delineated. But a more important result will, I believe, be the impact of space flight upon scientific thought and education.

In America today we are faced with a serious shortage of engineers and scientists even though the demand is great and the remuneration is ample. Almost every prospective technical graduate of our universities is showered with offers of employment and our newspapers and magazines are filled with advertisements for men with technical training. The most appalling aspect of this situation is that it is likely to continue for many years. A recent survey shows that the study of physics in our public high schools has been declining for more than half a century. Whereas in 1895 more than 95 percent of high-school graduates had taken a course in physics, by 1952 only 21 percent of graduates had ever studied it (*12*). For many years the increase in high-school enrollment more than offset the decrease of specialization in physics, but now the waning interest is taking its toll. Today only about half of the public schools offer a course in physics, and a quarter of these have no laboratory facilities. There is a critical shortage of science teachers, due in part to the attractions of industry, but more so to the lower status and wages accorded the teaching profession. But these factors can be remedied with sufficient effort—a deeper and more serious cause is the lack of interest on the part of our youth. Why do they turn away from a career in science? We can only grope for the answer. Perhaps they sense, better than their elders, that too much of our scientific talent is engaged in the unproductive task of developing weapons for war. Is there much inspiration to devote one's life to this end, especially when we are rapidly approaching the borderline of total destruction?

I believe that space flight might serve in no small measure to turn men's minds toward a more appealing scientific goal. As the exploits of Cabot, Drake, and Davis inspired many generations of Englishmen to turn to the sea, so may the first astronauts reawaken our youth to the romance of scientific exploration.

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NATIONAL ACADEMY MEDAL AWARDED TO DR. WATTS

The James Craig Watson Medal of the National Academy of Sciences has been awarded to Dr. Chester B. Watts (WAS), of the United States Naval Observatory, in recognition of his outstanding contributions to astronomical research. The Medal will be presented to Dr. Watts during the Annual Meeting of the Academy to be held in Washington, April 23–25, 1956.

Dr. Watts, who is director of the Six-Inch Transit Circle Division of the Naval Observatory, has been engaged during the greater part of his 45 years at the Observatory in determining positions of the sun, moon, planets, and stars. Such measurements provide the basic data for the study of the motions of celestial bodies both within the outside the solar system. Since 1934 Dr. Watts has been chiefly responsible for the Six-Inch Transit Circle. With a judicious combination of mechanical, optical, photographic and electronic techniques, he has brought the instrument to a higher state of perfection than any other of its kind. He recently designed and supervised the construction of a new Nine-Inch Transit Circle at the Observatory. In spite of his skill in perfecting his instruments, Dr. Watts remained dissatisfied with the precision of his measurements, which are based on observations of the edge of the moon's disk. The edge that we see is always irregular because of the high mountains and low valleys on the moon's surface. Also, a slightly different aspect of the edge of the moon is seen from time to time. These factors have limited the precision with which measurements could be made. About 11 years ago, Dr. Watts undertook to survey that part of the moon's surface (comprising some 18 percent) that presents itself on the edge of the moon, and to make this survey of a surface some quarter of a million miles away accurate to within about 50 feet. His survey is now virtually complete. The work required some thousands photographs of the moon, the invention and construction of an automatic photoelectric machine for tracing the profile of each photograph and drawing it on a strip of paper 30 feet long, the design and construction of analogue computers for analyzing the profiles and translating them into numerical form, the devising of means for integrating the profiles into a representation of the surface of the moon in the vicinity of the edge, and finally the development of the most readily usable form for publication of the results. The completed work will be published shortly.

The Watson Medal was established in 1874 by the bequest of James Craig Watson, a member of the Academy and Director of the Washburn Observatory of the University of Wisconsin. He provided in his will that the medal should be awarded "to any person in any country who shall make any astronomical discovery or produce any astronomical work worthy of special reward as contributing to our science."

Is there any thing whereof it may be said, See, this is new? it hath been already of old time, which was before us.—Ecclesiastes i:10

BIOCHEMISTRY.—*An observation on pufferfish toxin.*[1] ROBERT D. MACOMBER, School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, Calif. (Communicated by Bruce W. Halstead.)

Many workers have observed that the skin of pufferfish contains a considerable amount of toxin. Tani (Teikoku Tosho Kabushiki Kaisha **2** (3): 1–103. 1945) reported that some skin samples extracted and assayed contained as much as 20 percent of the total toxicity of the fish. Routine screening tests in our laboratory have also demonstrated puffer skin extracts to be strongly positive.

MATERIALS AND METHODS

With the foregoing facts in mind, it was suggested that the water used in thawing frozen puffer specimens for preservation be assayed. A mouse was injected intraperitoneally with 1 cc of the water used to thaw a frozen Japanese puffer, *Fugu pardalis* (Temminck and Schlegel). It was found that the water contained sufficient toxin to kill a mouse in about 5 minutes.

After this chance observation, the experiment was set up as follows: From another frozen pufferfish of the same species, samples of flesh, liver, gonad, and skin weighing 7 grams each were assayed to determine the toxicity of various parts of the fish. For the assay, the samples were homogenized in a Waring blender with 2 cc distilled water being added per gram of samples; the skin sample being tough and leathery, was cut in small pieces with the shears prior to homogenizing. Samples were then centrifuged 20 minutes at 2,000 rpm and the supernatant liquid decanted for injection of mice, following the procedure routinely used by Halstead (Copeia (1): 1–11. 1954.)

The skin extract assayed 3.4 mouse units of toxin per gram of sample. (A mouse unit, as recommended by H. Sommer and K. F. Meyer, Arch. Path. **24** (5): 568–570, 1937, in their work on paralytic shellfish poison has been adopted for fish bioassays. The mouse unit is defined as the amount of toxin required to kill a 20-gram mouse in 15 minutes.) From data on the other samples, it was estimated that the skin contained roughly 14 percent of the total toxicity of the fish.

For the second part of the experiment another sample of skin weighing 7 grams was then removed from the fish from an area adjacent to that of the first sample. This second sample was washed thoroughly on the exterior surface with methyl alcohol. A cotton swab wet with the solvent was used to remove all traces of mucus and the skin was scraped lightly with a razor blade. The alcohol wash and scrapings were combined and evaporated to dryness under vacuum. The residue was made up to a volume of 14 cc with distilled water for assay and the residue insoluble in water was not removed. The skin, free from all signs of mucus on the exterior surface, was extracted with water and assayed.

RESULTS

The skin extract showed toxic symptoms in the mice but they all recovered. The water suspension of the residue from the alcohol wash assayed 3.05 mouse units of toxin per gram of skin sample. The alcohol wash solution, then, contained approximately 90 percent of the amount of toxin that had been present in the homogenized sample of skin extracted with water.

The results are tabulated as follows:

Water extract of skin	3.4 MU/gm of sample
Alcohol wash of exterior skin surface	3.05 MU/gm of sample
Water extract of skin sample previously washed with alcohol to remove mucus	Weakly toxic

SUMMARY

The major portion of the toxin present in the skin of the Japanese puffer, *Fugu pardalis* (Temminck and Schlegel), appears to be in the superficial layers of the skin or sufficiently near the surface to be removed with solvent wash.

[1] This investigation was supported in part by a research grant awarded to Dr. Bruce W. Halstead from the Division of Research grants, National Institutes of Health, Public Health Service, grant No. RG-(2366)C5.

BOTANY.—*An evaluation of* Benjaminia *Martius ex Benjamin.* LYMAN B. SMITH, U. S. National Museum, and J. MURÇA PIRES, Instituto Agronômico do Norte, Belém do Pará, Brazil.

Among the aquatic plants that float on the still waters of the lakes in the campo regions, there is a small species of the family Scrophulariaceae which is rather common, especially in the campos of Bragança in northeastern Pará and in the Brazilian territory of Amapá. Its roots are buried in the soil, while its stems spread over the water and bear pale rose corollas, the whole plant being entangled in a mat of other aquatics like *Pontederia*, *Salvinia*, and *Cabomba*. In the process of identifying this species as *Bacopa reflexa* (Benth.) Edwall, we were struck by its close resemblance to the genera *Benjaminia* and *Naiadothrix*, which supposedly belong to different families. To clear the title of this species it was necessary to evaluate both genera, and the situation was so confused that it seems worth while to record our findings here.

The genus *Benjaminia* Martius ex Benjamin was validly published in the Flora Brasiliensis (**10:** 255. 1847) with a single species, *B. utriculariiformis* Martius ex Benjamin, based on a single collection, *Gardner 4347*. Under it as a synonym was listed "Quinquelobus Benj. Mss."

In the same year Benjamin published *Quinquelobus* (Linnaea **20:** 316. 1847) with this note immediately after the name: "(Benjam. in Mart. et Endl. Fl. Bras. Fam. Utric. adhuc ined.)." The note would indicate that *Quinquelobus* was the earlier name and subsequent authors, notably Beck (Engler & Prantl, Die Nat. Pflanzenfam. IV. **3b:** 123. 1895) and Dalla Torre and Harms (Genera Siphonogamarum 586. 1906), evidently have jumped to this conclusion without further investigation. The evidence of priority is just as strong for *Benjaminia*, but the whole question of priority is irrelevant because the first publication of *Quinquelobus* is invalid. There is no description of the genus itself as required by Article 48 of the International Code of Botanical Nomenclature of 1952, nor can it be considered valid as a monotype according to Article 50 because it is based on four species. The four species are also invalid according to Article 51 because they were published in an invalid genus, although all but the first have descriptions.

A year after the publication of *Benjaminia* and *Quinquelobus*, Bentham (London Journ. Bot. **7:** 567. 1848) pointed out that *Benjaminia* not only did not belong to the Utriculariae (Lentibulariaceae) but was identical with his *Herpestes reflexa* of the Scrophulariaceae. Furthermore, it was based on the same collection, *Gardner 4347*. He also indicated that the four species under *Quinquelobus* belonged to three different genera of Scrophulariaceae.

Bentham's identification of *Benjaminia* has been reenforced recently by Prof. G. Erdtman, who informs us that there is no apparent similarity between its pollen and those in the Lentibulariaceae, but that there is a resemblance to certain types in the Scrophulariaceae.

Owing to the later misconceptions of Beck and Dalla Torre and Harms, the clarification of Bentham was overlooked by recent authors. Thus Pennell in making *Naiadothrix* as a segregate from *Bacopa* (Mem. Torrey Bot. Club **16:** 105. 1920) transferred *Herpestis reflexa* Bentham to it without realizing that *Benjaminia* was already available. Consequently, anyone who believes that this taxon is a distinct genus must make the appropriate combinations under *Benjaminia*. We are not taking this action because we agree with Pennell's final stand in reducing all segregates to *Bacopa* in the broadest sense (Proc. Acad. Nat. Sci. Philadelphia **98:** 83–98. 1946). Our findings may be summarized briefly thus:

Bacopa Aubl. (1775) Section **Chaetodiscus** Subsection **Naiadothrix** (Pennell) Pennell, Proc. Acad. Nat. Sci. Philadelphia **98:** 98. 1946.

Benjaminia Mart. ex Benj. in Mart. Fl. Bras. **10:** 255. 1847.

Quinquelobus Benjamin, Linnaea **20:** 316. 1847, nomen invalidum.

Naiadothrix Pennell, Mem. Torrey Bot. Club **16:** 105. 1920.

ETHNOLOGY.—*An investigation of the early bands of the Saone group of Teton Sioux.*

Harry Anderson, St. Albans, N. Y. (Communicated by John C. Ewers.)

Although little, if any, investigation has been made into the condition of the Saone bands of the Teton Sioux during the years shortly before and after the beginning of the 19th century, two sources are available, which provide an excellent foundation for such a study. These are the statistical tables prepared by Lewis and Clark and printed in the *American State Papers, Indian Affairs*, volume 1,[1] and *Tabeau's Narrative of Liosel's Expedition to the Upper Missouri*, edited by Anne H. Abel.[2] The term Saone was used extensively on the Upper Missouri during the period 1800–1850, when referring to the five tribes of northern Tetons, the Minneconjous, Sans Arcs, Two Kettles, Hunkpapas, and Blackfeet Sioux.

Lewis and Clark and Tabeau were on the Upper Missouri in 1803 and 1804, recording data on the Saones at a time when these tribes were beginning the process of their development into distinct political structures. Some, like the Minneconjous, had already assumed the stature of a separate tribe containing three subbands, while others like the Two Kettles and Blackfeet can not be recognized as such, and only conjectures can be made regarding their stage of development at that time. The products of such an investigation are many. In some cases, enough facts are available to permit definite conclusions to be formed, while other situations merely invite strong suppositions, and still others result in unanswerable and frustrating puzzles. Yet, the positive products greatly outweigh the negative, for in providing a clearer understanding of the beginnings, customs, and structures of these Teton tribes, we are far better able to evaluate many of their actions in later periods of their history.

The origin and meaning of the name Saone is not definitely known, for during the 1880's when the missionaries were making their inquiries concerning the Teton bands, the name had then gone out of common usage, and little reliable information could be obtained from the Sioux regarding its meaning.[3] The first known use of the name was by Truteau, who recorded in his journal that a Sioux band called "Chahony" was expected to arrive at the Arikara village late in the summer of 1795 for the purpose of trade.[4] The best study to date on Saone origins, based upon the available sources, can be found in Hyde's history of the Oglalas. It is his conclusion that the name was given originally to the northern Teton group by the southern Tetons, the Oglalas and Brules, and in some manner referred "shooting in the trees", or living and hunting in wooded areas.[5]

Both Lewis and Clark and Tabeau list the bands of the Minneconjous separately rather than including them under the general heading of Saones. This is significant in view of the fact that other material on Teton bands prepared during the 1800–1850 period classified the Minneconjous as Saones. The earliest of these, the reports and treaties submitted by the Atkinson-O'Fallon Commission of 1825, lumped the Minneconjous together with the tribes now commonly known as the Sans Arcs and Two Kettles, and had the chiefs of these three groups sign a single treaty.[6] In 1840 S. R. Riggs, the Sioux missionary, visited Fort Pierre and recorded much valuable information regarding the Tetons obtained from the fur traders. Riggs also classified the Minneconjous as "Sanoni."[7] From this and other information, it clearly appears that the Minneconjous were a part of the Saone group, but at the time of the writings of

[1] Pp. 712–715. This information can also be found in the *Original journals of the Lewis and Clark expedition, 1804–1806*, edited by Reuben G. Thwaites, **6**: 97–99. New York, 1905.

[2] Norman, Okla., 1939, pp. 103, 104.

[3] See the *History of the expedition under the command of Lewis and Clark*, edited by Elliott Coues, **1**: 101. New York, 1893.

[4] *Journal of Jean Baptiste Truteau among the Arikara Indians in 1795*, South Dakota Hist. Coll. **7**: 473.

[5] Hyde, George E. *Red Cloud's Folk*: 12–13. Norman, Okla., 1937.

[6] The Atkinson-O'Fallon report can be found in House Document *no. 117*, 19th Congress, 1st Session; the signers of the Saone treaty in the Statutes at Large, **7**: 254.

[7] Riggs, Stephan R. *Journal of a tour from Lac-Qui-parle to the Missouri River.* South Dakota Hist. Coll. **13**: 340.

Lewis and Clark and Tabeau, they were so numerically superior to the other Saone bodies that they were given a separate listing.[8]

A second significant factor appears after a careful examination of the Minneconjou material; of the three bands which made up the tribe around 1800, none can be recognized in the Minneconjou tribal circle obtained by J. Owen Dorsey some 80 years later.[9]

THE MINNECONJOUS

Lewis and Clark	*Tabeau*
Min-na-kine-az-zo	Minican-hojou
Wan-nee-wack-a-ta-o-ne-lar	Tacohiropapais
Tar-co-eh-parh	Waniwacteonilla

The first group, the Min-na-kine-az-zo of Lewis and Clark, or the Minican-hojou of Tabeau, is undoubtedly the parent body of this tribe, the Original or True Minneconjou band. According to the explorer's list, the chief of this band was Wock-ke-a-chauk-in-dish-kah or Thunder Ring (*wakinyan*, thunder and *cangleshka*, a hoop or wheel, something round). An explanation to an entry in the High Hawk winter count[10] confirms that the Minneconjous had a prominent head man named Thunder Ring shortly before the end of the 18th century. Because of his leadership over the parent band, he is named by Lewis and Clark as being the head chief of the Minneconjous.

Unfortunately, no detailed list of Sioux bands is available for the period between Lewis and Clark's and that of Thaddeus Culbertson's, dated 1850.[11] By the author's own admission, the Culbertson list is not complete, and no mention is made on it of the True Minneconjous. However, the material collected by F. V. Hayden in 1859–60[12] reveals that this band was still very active, and also supplies a valuable clue as to the reason it was not found on the Dorsey list of 1880. The Hayden information states that the True Minneconjou chief was "The Elk That Whistles Running,"[13] another name for the powerful old Minneconjou chief, Lame Deer. One of the most hostile of the Sioux leaders during the Sioux War of 1876, Lame Deer's band took part in all the fighting against the United States troops during that conflict. A report from the hostile Sioux camp near Slim Buttes in September, 1876, identifies portions of the Minneconjous in the camp as those of the "Grandmother" band led by Fast Bull.[14] The use of the term "grandmother" is difficult to explain, unless it referred to the parent group of the Minneconjous. There would be little basis for a contention that this "Grandmother" band and the True Minneconjous were one and the same were it not known that the "Grandmother's" chief, Fast Bull, was Lame Deer's son. Actually Lame Deer was still the bands' chief, but during the hostilities, the war leaders, or head soldiers such as Fast Bull, were afforded more notoriety than the older council chiefs.

During the winter of 1876–77 the Sioux were hard pressed by the Army, and nearly all of the hostiles surrendered or fled to Canada with Sitting Bull. Lame Deer's band was the only group that attempted to continue to roam freely in the Powder river country of Montana. On May 7, 1877, troops under Colonel Nelson A. Miles attacked and destroyed the True Minneconjou camp on the upper reaches of the Rosebud. Lame Deer was among those who were killed.[15] Survivors of the camp, led by Fast Bull, straggled into Red Cloud Agency in September and surrendered. During the following year many of the surrendered hostiles became dissatisfied with their existence at the Sioux agencies and sought refuge in Canada. Large numbers fled from the Red

[8] Lewis and Clark gave the Minneconjous 100 lodges, 250 warriors, and 750 people, and the combined Saone groups, 120 lodges, 300 warriors, and 900 inhabitants.

[9] Dorsey, J. Owen. *Siouan sociology*, 15th Ann. Rep. Bur. Amer. Ethnol.: 220. 1897.

[10] Curtis, E. S. *The North American Indian* **3:** 168. New York, 1907–1930.

[11] Culbertson, Thaddeus, *Journal of an expedition to the Mauvaises Terres and the Upper Missouri in 1850*, Bur. Amer. Ethnol. Bull. 147: 135, 136. 1952.

[12] Hayden, F. V. *Contributions to the ethnography and philology of the Indian tribes of the Missouri Valley:* 375, 376. Philadelphia, 1862.

[13] Other places it is written "The Elk That Bellows Walking," but the meaning intended is probably Noisy Walking Elk.

[14] Lt. Col. George P. Buell to the Assistant Adjutant General, General Terry's Column in the field, September 9, 1876, Record Copy of Letters Sent, Post at Cheyenne River Agency, Records of the War Department, National Archives.

[15] Report of the Secretary of War for 1877: 498.

Cloud and Spotted Tail groups during the relocation of those agencies on the Missouri during the late fall of 1877.[16] Numerous small groups left at other times. The definitely hostile attitude of the True Minneconjous would make it almost a certainty that the survivors of that band were among those who joined Sitting Bull north of the border. When the Sioux returned from their Canadian exile in 1881 and were sent back to their respective agencies a year later, the True Minneconjous had ceased to exist as a distinct band. Apparently lacking the strong leadership of the Lame Deer type, the remainder of the camp had either become absorbed by the other Minneconjou bands, or had followed relatives and friends into the camps of the Oglalas and Hunkpapas while in Canada.

Examination of the material available dealing with the second band on the Lewis and Clark list, the Wan-nee-wack-a-ta-o-nelar (Tabeau lists it third, as Waniwacteonilla) reveals that by 1880 it was no longer a Minneconjou band, and as a group was nearly extinct because of its wild and hostile activities. Although the name is difficult to translate because of the differences in the Sioux words of 1800 and those of more recent vintage,[17] this band is the one mentioned intermittently throughout Sioux history as the Broken Arrows. It had its origins among the Minneconjous, later became part of the Brules, and finally is last mentioned as living with the Oglalas on the Pine Ridge reservation.

The Broken Arrows remained with the Minneconjous until at least the mid 1830's. The Atkinson-O'Fallon expedition met the camp near the Missouri in 1825. One member of the party recorded in his journal that this band was "not well looked upon by the other bands of Sioux, being considered rather refractory and ungovernable."[18] On the treaty negotiated by the Atkinson-O'Fallon party with the Saone group, which included the Minneconjous, one of the signers was a leading warrior of the Broken Arrow camp, *Chante Wahneecha*, or No Heart. This was the name given to the chief of the Broken Arrows by Lewis and Clark, but since the warriors leaders were invariably younger men, Atkinson and O'Fallon's No Heart was probably the son of the Lewis and Clark chief. Several years later, George Catlin was on the Upper Missouri and painted a number of portraits of prominent Sioux around Fort Pierre, including two Broken Arrow leaders, *Shonka*, the Dog, and No Heart.[19]

It was not long after Catlin's visit that Broken Arrows appear to have migrated, perhaps forcibly, from the Missouri to join the Brules living between the White river and the Platte. Actually the evidence points to a split in the band, with the majority joining the Brules and only a small number staying with the Minneconjous. The No Heart family, definitely identified as Broken Arrows, remained on the Missouri and were known as leaders of the Minneconjous up through the reservation period.[20] Culbertson's band list of 1850 does not refer to the Broken Arrows among the Minneconjous,

[16] Hyde, *op. cit.*: 299–301.

[17] The Dorsey material (1884) calls the band *Wan-nawega*, Broken Arrows. This is phonetically very different from the band's early identity. See also footnote 22.

[18] *Journal of the Atkindon-O'Fallon Expedition*, edited by Russell Reid and Clell Gannon, North Dakota Hist. Quart. **4**(1): 21. Oct. 1929.

[19] Catlin, George. *Illustrations on the manners, customs, and conditions of the North American Indian*, **1:** 223; **2:** 190, 192. Catlin's description of *Shonka* fits into the general pattern of remarks we have concerning the whole Broken Arrow band: "an ill-natured and surley man—despised by the chiefs of every other band . . ." While Catlin was at Fort Pierre, *Shonka* shot and killed a noted warrior of the Hunkpapa tribe, Little Bear, and had to flee to the Black Hills to escape the vengeance of the dead man's relatives. Although Catlin distinguishes between Shonka's band, the Caz-a-zhee-ta (Bad Arrow Points), and No Heart's Wah-nee-watch-to-nee-nah (Broken Arrows), we know from later evidence that both men were leaders in the same camp. This is only another instance of the artist's careless distortion of the Teton band names, a situation which makes his material difficult to work with.

[20] The Black Hills treaty of 1876 was signed for the Minneconjous by a No Heart and an "Old Man No Heart." The latter could have been Catlin's chief, for his son was born in 1844. The younger No Heart was often referred to as Little No Heart to distinguish him from his father. Little in this case alluded to age rather than size. High Hawk, who was a Brule, recorded in his winter count that in 1838 there was a fight among the members of the Broken Arrow band. This may have been the date of the separation between the *Shonka* and No Heart portions of the camp, or perhaps refers only to an incident among *Shonka's* people after they had joined the Brules.

but does list a "Bad Arms" band among the Brules. Rufas B. Sage located the Broken Arrows on the Platte prior to the date of Culbertson's information,[21] and the name "Bad Arms" (referring to weapons-arrows, rather than body extremities) cannot be associated with any group belonging to the Brules proper. Hayden's list of 1859, in some ways more complete than Culberton's, alters the Brule's Broken Arrows to the "Band with Poor Guns or Bows." This source also places a group among the Minneconjous translated very vaguely as "The Band That Kills No People." At first glance this does not appear to be the old No Heart portion of the Broken Arrows, but examination of the Sioux word, *Waktonila*, from which Hayden gets the name reveals that it is an incomplete form of the name recorded by Lewis and Clark and Tabeau, Wan-nee-wack-a-ta-o-ne-lar or Waniwacteonilla.[22]

After the date of Hayden's information there is little mention made of the Broken Arrows.[23] They were known to have been in the hostile camp in the Powder river country in 1866 which supplied the warriors for the siege of Fort Phil Kearney, the Fetterman fight, and the other actions comprising the Red Cloud War.[24] When J. Owen Dorsey made his inquiries for his study of the Teton bands, none of his informants mentioned the Broken Arrows as being a Brule group. In fact, even his early information on the Minneconjou groups omitted the Broken Arrows. However, Dorsey made subsequent inquiries among the Minneconjous and was told by a member of the No Heart family that the Broken Arrows belonged in the Minneconjou tribal circle, but at that time (1884) they were nearly extinct.[25] From this it appears that there was a camp of Broken Arrows still in existence, but it was not living with the other Minneconjou bands attached to the Cheyenne River Agency. No Heart knew of the camp while the other Minneconjou informants did not, probably because of the old ties his family had with it.

Fortunately, Phillip Wells, a long-time Army scout, interpreter, and Indian service employee, recorded before his death, a number of his experiences among the Sioux.[26] One of these supplies us with enough information to locate the remnants of the Broken Arrow camp. In 1892, when Wells was an agency farmer on the Pine Ridge reservation, the so-called Two Sticks Raid took place which culminated in the killing of several cowboys in the Pine Ridge beef camp. Wells wrote that the Two Sticks camp was the last of the old Broken Arrow band. He said the Broken Arrows had always been a renegade group, containing many a Sioux who had been disgraced in his own band and was invited by the Broken Arrows to join them. They ignored tribal law, custom, and religious beliefs.

According to the Wells manuscript, the people in the Two Sticks camp claimed the earliest Broken Arrow chief which they could remember was *Shonka*, the Dog. This was the headman whose portrait Catlin painted at Fort Pierre in 1832. It was shortly after Catlin's visit that the Broken Arrows split up, with one portion leaving the Missouri. The Two Sticks camp was the remains of this group. Their memory of *Shonka* as their chief strongly suggests that it was his following in the band that left, or was driven out by the Minneconjou

[21] Sage, Rufas B. *Wild scenes in Kansas and Nebraska:* 68. Philadelphia, 1855.

[22] Catlin's phonetic vocabulary (1832) has arrow as *wonhee*. The exact translation of *waktonila* is not known, but at one time it apparently referred to something broken. By coincidence there is a more modern Teton word sounding somewhat similar; *wa-cin-ko-ke-la*, meaning easily made angry. From what we know of the Broken Arrows this could be one general description of them.

[23] During the early 1850's the Oglala and Brule Sioux on the Platte were involved in several brushes with troops stationed at Fort Laramie. These events, which led to Gen. W. S. Harney's campaign against the Sioux in 1855 and 1856, included the firing upon a military skiff crossing the Platte in 1853 and the so-called Grattan "massacre" a year later. In both instances, official reports state that a wild band of Minneconjou troublemakers, otherwise unidentified, were in some way responsible for the hostilities. There is every reason to assume that these troublemakers were the Broken Arrow camp.

[24] See the Col. Henry B. Carrington papers in Senate Document no. 32, 50th Congress, 1st Session, p. 29.

[25] Dorsey, *op. cit.*: 220.

[26] The Wells material is owned by his daughter, Miss Flora Wells, of Pine Ridge, S. Dak., who recently lent it to George E. Hyde. My information on the Broken Arrow references comes from correspondence with Hyde. Some Wells accounts were published in 1948 in North Dakota Hist. **15**(2–4), but these omitted some of the more important Broken Arrow material.

leaders, and migrated to the White river country of the Brules. No Heart, the other Broken Arrow leader identified by Catlin, remained near the Missouri, and he and his small following were absorbed by the other Minneconjou camps.

The remaining band on the Minneconjou lists, the Tar-co-eh-parh or Tacohiropapais is not mentioned in any of the available sources written after the date of the Lewis and Clark report. They either ceased to exist as a distinct band, or were known down through later chapters of Sioux history under another name. While the scattered and inconclusive evidence affords no concrete proof for such a contention, it is believed that the Tacoropas did not dissolve as a tribal band, but became more familiarly known as the *Oohenompa* or Two Kettle Tetons.

The earliest mention of the Tacoropas was recorded by Jean Baptiste Truteau in a portion of his journal kept while residing in the Arikara village during the summer of 1795. In June of that year two men from the Tacoropa camp brought a warning that three "villages" of Sioux were assembling a force of 500 warriors for an attack upon the Arikara village. Later on, in July of the same summer, the entire Tacoropa camp, said by Truteau to number "80 huts", came on a trading trip to the Arikaras.[27] Truteau's evidence shows that these Tacoropas were friendly with the Arikaras at a time when very few of the other Teton bands were on good terms with that tribe. This fact is important in attempting to connect them with the later-day Two Kettles, for it is known that the Two Kettles were the friendliest of the Teton tribes, often managing to maintain amicable relations with other tribes, and the whites as well, with whom the Tetons were then at war. In addition, the Two Kettles also undertook several attempts at farming on their own prior to the reservation days. Their agricultural knowledge and training could easily have come from their association with the Arikaras, who depended upon the raising of crops for a good part of their food supply.

Truteau's statement that the Tacoropa village numbered 80 lodges seems to be an error, for ten years later, Lewis and Clark gave the entire Minneconjou tribe only 100 lodges. Whether the latter figure includes the Tacoropa camp is not clear. The explorers failed to record the name of this band's chief (they had such information for every other Sioux band), and this gives rise to a suspicion that their information regarding these people was very vague. The figures of Truteau and Lewis and Clark can perhaps be reconciled by the suggestion that it was the entire Minneconjou tribe, and not just the Tacoropas that visited the Arikara village on July 20, 1795. The name Minneconjou, meaning "those who plant by the water" indicates that this tribe was at one time agriculturally inclined. Some tribal traditions say that the water near which they planted was the Missouri, perhaps under the guidance of the Arikara. But, why then didn't Truteau write Minneconjous instead of Tacoropas?

In the midst of all these suppositions and conjectures regarding the Minneconjous, Tacoropas, and Two Kettles, one known fact stands out which clearly links them together. Four Bears, a Two Kettle leader of the reservation period, related to E. S. Curtis, when the latter was collecting material for his work on the Sioux, a tribal tradition which Curtis used as an explanation for one of the entrys in the High Hawk winter count.[28] High Hawk, and the Baptiste Good winter counts as well,[29] recorded that in 1791 "The White Men Came and Carried the Flag Around the Nation". The Four Bears account related that when the Sioux were living "in the eastern forest", a party of whites came to a large camp of Minneconjous, Two Kettles and Sans Arcs, and pursuaded four of the chiefs to return with them to the white settlements.

Four Bears was born in 1834, and his grandfather, Two Lance, was among the chiefs who were selected to make the trip. Thunder Ring, listed by Lewis and Clark as chief of the True Minneconjou band, also went with the white party. The fact that this event took place in the spring ("the time of greening grass"), plus the reference to the "eastern forest" indicates that the Minneconjou-Two Kettle-Sans Arc camp was at-

[27] Truteau, *op. cit.*: 454, 473.

[28] Curtis, *op. cit.*: 168.

[29] 10th Ann. Rep. Bur. Amer. Ethnol.: 310. 1893.

tending one of the annual trading fairs held on the upper reaches of the St. Peter or Minnesota river.[30] In addition to the various groups of Sioux, the Tetons from the Missouri, the Minnesota bands, and the Yanktons from the Des Moines River, these fairs were regularly attended by British fur traders from Canada. The traders, in taking the chiefs to their posts and presenting them with medals and other gifts, were trying to retain the allegiance of the western Indians after the close of the Revolutionary War. The trip was evidently a long one, for the Teton chiefs did not return to their people until the following winter.

Combining the evidence contained in the Four Bears account with the known conditions of the time regarding the Sioux trading fairs and the activities of the British among the western Indians, it certainly appears that the tradition could be dated anytime between 1785 and 1795. The year of the winter count entry, 1791, is as good a selection as any.

The important fact to be noted here is that Two Kettle tradition, handed down to the time of Four Bears, discloses that in 1791 elements of that band roamed together with the future Minneconjou and Sans Arcs groups in one large Saone camp. By 1803 the Minneconjous had emerged into a distinct tribe, containing three subbands, while the Sans Arcs as well were a recognizable group on the Tabeau and Lewis and Clark lists. It does not seem too unreasonable to suggest that the Two Kettle portion of the old Saone camp was still with the Minneconjous as the mysterious sub-band of that tribe called the Tacoropas. We are able to follow the progress of the other two Minneconjou bands, the true Minneconjous and the Broken Arrows, through subsequent pages of Sioux history, but after 1803 the Tacoropas disappeared, and almost corresponding with their disappearance came the advent of this new group, the Two Kettles.

THE SAONES

Tabeau	*Lewis and Clark*
Tatchindi-chidja	Sah-one
Hitasiptchone	Tack-chan-de-see-char
Hont-papas	Sah-o-ne-Hont-a-par-par

[30] Hyde, *op. cit.*: 21. For this period, Hyde has located the Sioux trading fairs on the headwaters of the Minnesota river.

The group easiest to identify are the Hontpapas or Sah-o-ne-Hont-a-par-par, which clearly were the later-day Hunkpapa Sioux, the wild and warlike people made famous by the leadership of Sitting Bull. Lewis and Clark reveal that their chief was Long Dog (Shark-ka-has-car—*Shunka*, dog, *hanska*, long), a name borne by one of the more hostile Hunkpapa chiefs during the 1870's.[31] At the time of the explorers' visit, the Hunkpapas are said to have roamed on both sides of the Missouri to the north of the Minneconjous located on the Cheyenne river.[32] On the west side of the Missouri this would place them in the region of the Moreau, Cannonball, and Heart rivers, which at that time was claimed by the Arikaras. It is suspected that the Hunkpapas spent most of their time east of the Missouri, crossing the river only to hunt buffalo and to trade with (and steal from) the Arikaras. It was not until some 20 years later, when the power of the Arikaras was broken by a combination of disease, Sioux hostility, and their own stupidity, that the Hunkpapas could move across the Missouri and lay any sort of substantial claim to the lands west of the river.

Tabeau's second Saone band, Hitasiptchone (Itazipcho to modern ethnologists), is far better known by its French translation, Sans Arcs. It is a combination of the Sioux words *itazipa*, meaning bow and *cho*, an abbreviation of *chodan*, or without. For some unknown reason this name did not appear on the Lewis and Clark list. Perhaps it was not commonly used and the band was known by another name. After examining Tabeau's first band, Tatchindi-chidja, and Lewis and Clark's Tack-chan-se-see-char, it would seem that these names also refer to the group eventually to become known as the Sans Arcs. Lewis and Clark received much of their original information regarding the Sioux from Tabeau, and were able to check and rearrange it on the basis of material obtained from Hugh Heney, a Sioux trader, and from other informants at the Mandan village.[33] It is very possible that Heney told them that the Sans Arcs were better known as the Tack-chan-de-see-char band, thus account-

[31] Report of the Secretary of War for 1876: 481, 483.

[32] Thwaites, *op. cit.*: 97, 98.

[33] Tabeau, *op. cit.*: 101, 102.

ing for the omission of Tabeau's Hitasiptchone from their list.

While the meaning of the name Tatchindichidje (Tack-chan-de-see-char) is not perfectly clear, it is fairly obvious that it refers in some manner to the weapon, the bow. This, however, is not the only reason for believing that this band was the fore-runner of the later-day Sans Arcs. Again the name of the band's chief as supplied by Lewis and Clark aids in its identification. They write it as War-mun-de-o-pe-in-do-tar, the best translation of which may be Red Tailed War Eagle. There was a leading chief of the Sans Arcs by this name during the 1850's and '60's. He signed the Sans Arcs treaty of 1865 and his name was then written almost exactly the same phonetically as was Lewis and Clark's chief.[34]

There are three possible translations of the band name, Tack-chan-de-see-char or Tatchindi-chidja. The first, and not necessarily the best, would be "bows from the heartwood of the willow": tack (tat) from *iTAZipa* or bow, chan-de (chandi) from *chante* or heart, and see-char (chidja) from the ending of *choh-wan-zhi-cha* meaning willow. A second choice, somewhat similar to the first, can be obtained by substituting the word *schicha* meaning bad, for see-char or chidja. This would result in something like "bad bows from the heartwood". The third possibility would be "a bow, the back of which is overlaid with sinew". Here the work *takan*, meaning the sinews taken from the backs of deer and buffalo and used extensively in making bows, would be combined with *itazipa* (bow) to form Ta-kan-i-ta-zi-pa.

Regardless of what the true translation may be, one thing is evident from the inclusion of this name on both the Saone band lists; that the name Itazipcho (without bows) signifying the Sans Arc Sioux had its origin not too many years before the first Teton contact with the whites on the Missouri. It certainly appears that Tack-chan-de-see-char (Tatchindi-chidja), whatever its exact meaning, was the earliest of the names applied to what we know today as the Sans Arcs. Of the five tribes making up the Saone faction, the Sans Arcs grew to be the third largest (after the Minneconjous and Hunkpapas) and were certainly living among the Tetons on the Missouri at the time of the visits by Tabeau and Lewis and Clark. Unless perhaps they were recognized by the sub-heading Sah-one by Lewis and Clark, the Tack-chan-de-see-char group can be the only name on their list which refers to the Sans Arcs. As has been mentioned, perhaps the Hitasiptchone included on Tabeau's list along with the Tatchindi-chidja was another, newer name for the band and was imitted from the Lewis and Clark list upon consultation with Heney or someone else. It also may be that the Hitasiptchone was an offshoot of the parent Tatchindichidja group, for already the Tetons or Bois Brules had four subbands and the Minneconjous three. The fact that this offshoot grew and prospered while the parent group, the Tatchindi-chidja, disappeared from any later references is not unusual. Examination of the Minneconjou band lists obtained in the 1880's fails to disclose the parent group of that tribe, the True Minneconjous, which was listed by both Tabeau and Lewis and Clark.

There remains then only one name on the two lists which thus far has not been identified, the Sah-one sub-group of Lewis and Clark. It is impossible to even guess with any degree of accuracy what this name made reference to. There are two Teton tribes, the Two Kettles and the Blackfeet Sioux, that are not mentioned in any recognizable way by Lewis and Clark, and it may be that one of these is the Sah-one band. It is felt, however, that the Two Kettles were more closely associated with the Minneconjous and possibly, at that date, were the mysterious Tacoropa band. It also does not seem likely that the Blackfeet were the group referred to by Lewis and Clark, for Tabeau provides a clue which strongly suggests that the Blackfeet were then part of the Yankton tribe. On his list, under the heading of "The Yinctons of the South" living on the James river, is a band called Seascapé, a name almost identical to Sihasapa or Blackfoot (*siha*, foot and *sapa*, black). It is known that the Blackfeet were the last of the Teton tribes to cross the

[34] The first signer for the Sans Arcs at Fort Sully on October 20, 1865, was Wah-mun-dee-o-pee-doo-tah, or The War Eagle with the Red Tail. *Wahmundee* or *Wambili*, eagle or war eagle, and *duta* or *luta*, red. Actually *luta* means scarlet, but it was commonly translated as red.

Missouri, for even as late as 1825, the Atkinson-O'Fallon treaty commission met them on the east bank of the river, while the other Teton groups, including the Hunkpapas, were all treated with on the west bank.[35] The delayed arrival of the Blackfeet in the regions west of the Missouri could very well have been caused by the time-consuming break with their old ties among the Yanktons and a gradual movement northward up the Missouri to where they contacted the Hunkpapas and crossed westward.

[35] The Commission's report states that the Saones were divided into two groups which roamed on both sides of the Missouri. One group, the Minneconjous, Sans Arcs, and Two Kettles, signed a treaty at the mouth of the Teton (Bad) river on July 12, 1825, and were the Saones who generally inhabited the country west of the Missouri. On July 12, the Commission concluded a treaty with the Saones of "Fire Heart's band" at Camp Hidden creek. This was on the east bank. Fire Heart's band were the Blackfeet-Sioux. The Fire Heart family were long-time leaders of that tribe.

NEW BOOK ON AQUARIUM FISHES YIELDS DISTRIBUTION DATA

There are 40,000 kinds of fishes—species and subspecies—in the world. This is the most recent estimate of Dr. Leonard P. Schultz, Smithsonian Institution curator of fishes. The fishes can be divided roughly into inhabitants of eight world zones, by far the richest of which is the tropical Indo-Pacific area. This is the region extending from the head of the Red Sea to Easter Island. Within this region are found approximately 9,000 species.

The number of kinds in other regions, as estimated by Dr. Schultz, is as follows: Australia, 1,500; North America, 4,500; South America, 6,500; Africa, 6,500; deep seas all over the world which have their own characteristic forms of fish life, 2,500; Europe, Asia, and India, 6,500; various island groups, 3,000.

These estimates are contained in a Handbook of Tropical Aquarium Fishes suitable for the home aquarium written by Dr. Schultz in cooperation with Herbert R. Axelrod. However, among all these fishes fewer than 500 kinds are common in aquaria.

All over the world, Dr. Schultz points out, fishes have evolved into a remarkably diverse group to fit various habitats and to follow various ways of life. Some fly, but not like birds; others leap, walk, and burrow as well as swim. Some swim as fast as a locomotive—60 miles an hour for the swordfish, 50 for the bonito, 44 for the tuna. Some, like the bass, hardly can speed up beyond about 12 miles an hour.

Some of their varied ways of life are shown by the bettas and the paradisefish, both of which blow bubble nests at the water surface where they cradle their eggs and babies. Others, like the male of the black-chinned mouthbreeder, incubate the eggs and young in the mouth. More remarkable is the seahorse, the male of which has a pouch, much like that of a kangaroo, where the eggs are placed by the female and where they are incubated for a few weeks before birth occurs.

Dr. Schultz has carried on special studies of fish flight on South Pacific marine flyingfishes. "Anatomically," he says, "flyingfishes do not possess muscles that could possibly help the fins to flap like the wings of birds. Instead the fins are used as glider wings. Although some of the oceanic flyingfishes can sail for over 30 seconds at about 35 miles an hour, the freshwater flyingfishes of South America can sail only a few yards. These little aquarium fishes are thin as a wafer and shaped like a hatchet."

Walking, Dr. Schultz points out, is well developed among some fishes. The lower rays of one of the fins are separated from one another and are controlled by special muscles so that they propel the fish along the bottom in a fashion very similar to the walking of a mammal on land. The fish that can "walk" best on land is a common aquarium fish, the walking or climbing perch, but it does not have the separate fin rays. It does have an extra air chamber above the gills that aids it in staying alive for several hours out of water. This walking perch has been known to travel at least 300 feet over dry land, in a space of 30 minutes in going from one pool to another.

Nearly all fishes, Dr. Schultz says, are well equipped with special sense organs to acquaint them with their immediate environment. Connected with a highly developed sense of touch is the so-called "lateral line," which enables a fish to detect low frequency vibrations in the water, such as would be set up by the movements of another fish. In sharks, for example, this is so highly developed that they can tell whether the movements are made by a healthy or an injured fish.

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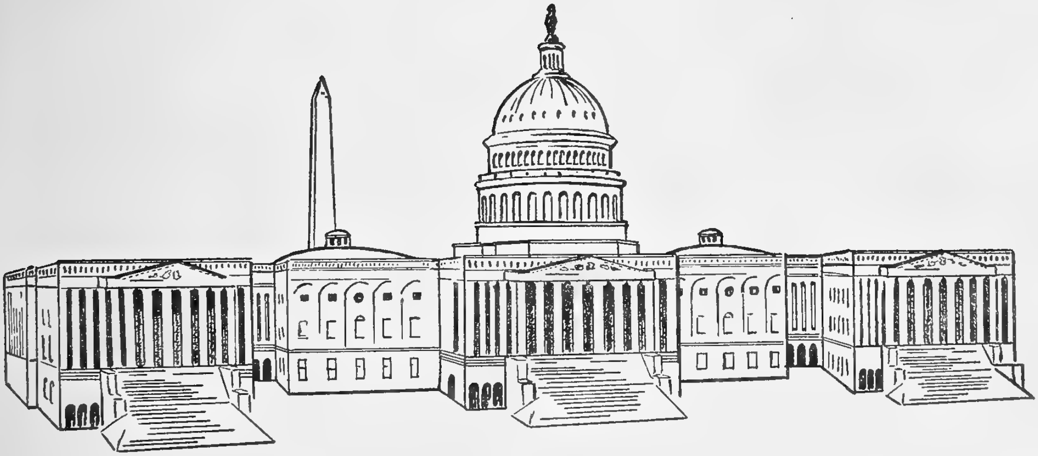

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PALEONTOLOGY.—*A late Triassic terebratellacean from Peru.*[1] Francis G. Stehli, California Institute of Technology. (Communicated by D. H. Dunkle.)

The brachiopod fauna of the present oceans consists predominantly of representatives of the Terebratuloidea. In this group the relation of the soft parts to the skeleton is relatively well known. For this reason they offer the most promising group within the Brachiopoda for purposes of evolutionary study. An excellent study (Cloud, 1942) of the basal terebratuloid stocks and their initial radiation during the late Silurian and Devonian furnishes a foundation for further work. In connection with studies undertaken for the *Treatise on invertebrate paleontology* the writer has completed a revision of Mississippian, Pennsylvanian, and Permian terebratuloids (unpublished). In combination these two studies reveal with reasonable clarity the major course of terebratuloid evolution during the Paleozoic.

Studies of recent forms have been carried back through the Tertiary (Thompson, 1927, and others), and many living genera are known to extend into the Cretaceous and some perhaps into the Jurassic as well. The main gap in our knowledge of terebratuloid phylogeny may be seen therefore to fall in the Triassic-Jurassic interval. As it happens it is during this interval, particularly the Triassic portion, that great innovations appear. Chief among these is the origin of the dominant modern superfamily, the Terebratellacea.

The recognition of Mesozoic terebratellaceans is frequently difficult. This difficulty arises principally in distinguishing them from other groups having long adult loops. The basic feature permitting separation of the terebratellaceans from these other groups is the metamorphosis of the loop during ontogeny and its intimate relation to the median septum. More or less complete ontogenetic series are therefore necessary for confident recognition.

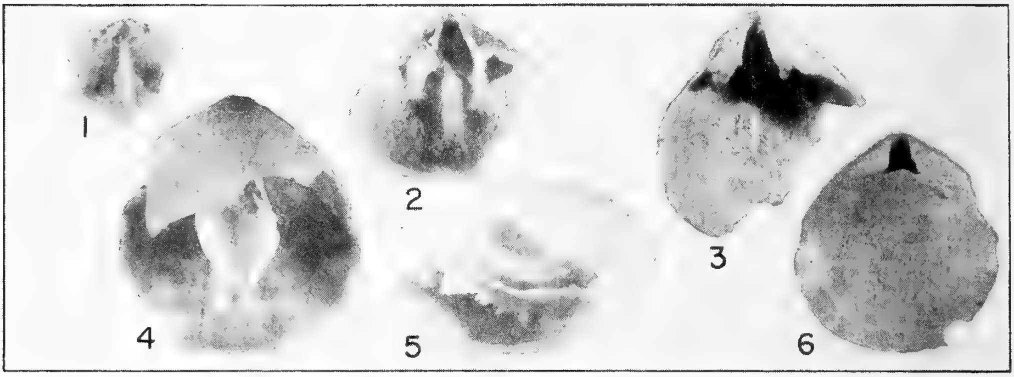
The earliest definitely known terebratellacean reported in the literature appears to be *Hamptonina* of the Middle Jurassic. Particular importance therefore attaches to an undoubted terebratellacean species recently recognized in a collection of silicified material from the late Triassic of Peru. The importance of this form as the earliest known member of the superfamily and its evolutionary significance has prompted the description which is presented below.

PRESENT MATERIAL

The species here in question is represented by at least twenty fragmentary silicified specimens. They have been freed of the matrix by acid etching. The fragments present abundant internal detail, but the external form of the shell is incompletely known. All specimens are believed to represent juvenile individuals because of the immature beak characters displayed and the presumably incompletely metamorphosed loop. All individuals are of about the same size and suggest that a high degree of sorting was effected during their transportation to the burial site. Because it appears undesirable to me to propose a name for immature specimens which cannot now be identified with any adult, the species is merely described and may await naming when more complete material becomes available.

All specimens were obtained from lot 74 of the Jenks collection of Peruvian Triassic from the Cerro de Pasco region. They are housed in the American Museum of Natural History in New

[1] California Institute of Technology, Division of the Geological Sciences, Contribution No. 768.



Figs. 1–6.—An unnamed late Triassic terebratulloid brachiopod: 1, Interior of a fragmentary brachial valve showing the heavy median septum and the medially sessile cardinal plate with which it is connected; 2, interior of a fragmentary pedicle valve showing the open delthyrium and the dental plates; 3, interior of fragmentary pedicle valve showing the open, perhaps juvenile nature of the delthyrium; 4, more or less complete specimen showing the loop in place; 5, lateral view of the same specimen; 6, brachial interior of the same specimen.

York City. The strata from which lot 74 was collected have been dated on the basis of other fossils as late Triassic (Haas, 1953) and are part of the Pucara group.

DESCRIPTION

Shells small, the most complete specimen is 7.5 mm long, 7 mm wide, and appears to have been about 4 mm in thickness. The outline is slightly ovate; the pedicle valve is longitudinally and transversely convex; no fold or sulcus appears to be present, pedicle beak nearly straight; pedicle foramen unrestricted by deltidial plates, so that the delthyrium is open, and not transgressing on the apex of the beak. Brachial valve longitudinally and in general transversely convex but seemingly developing a shallow sulcus anteriorly.

Pedicle interior with short strong dental plates and a low myophragm dividing the muscle field and extending from the anterior margin of the rostral cavity to about midlength, muscle scars poorly impressed. Brachial interior with the cardinal plate medially concave and supported by a low, broad septum which extends anteriorly past midlength to a union with the loop; crura arising from the inner margins of the socket plates; crural points small; main bands extend forward in an essentially centronelliform fashion and unite with the median septum and the remainder of the loop; recurving band consisting of two more or less vertically disposed plates which are concave inward and united at the apex of each concave surface; each plate arises from the median septum with which it is broadly joined by becoming gradually free at the lower margin; above their union with each other the two plates diverge only to be united posteriorly by a narrow transverse band which is not,

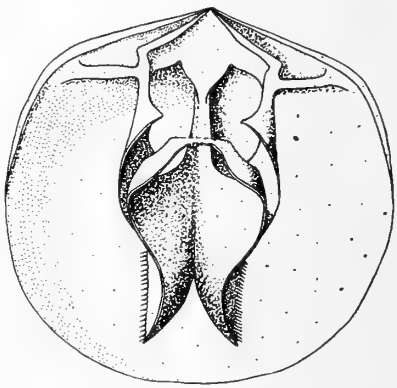


Fig. 8.—Diagrammatic reconstruction of the loop.

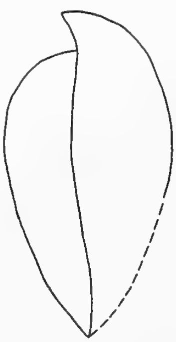


Fig. 7.—Profile of partly reconstructed individual.

unfortunately, preserved in any specimen; the anterior extremities of the recurved band extend much farther forward than the main bands and bear spines as does the lateral margin of the main band; the positions of the muscle insertions cannot be determined.

DISCUSSION

The stage of loop development seen in this form does not closely resemble any stage in the development of the three major types distinguished by Elliott (1953) among modern forms. It most nearly approaches, however, the early stages of dallinid loop development. It seems probable that this form, if it can truly be referred to any modern family, should be placed in the Dallinidae. The principal basis for this conclusion is the general resemblance of the loop to that of the adult loop of the Cretaceous genus *Kingena*.

If these specimens are, as they seem to be, juveniles, this may account for the difficulty encountered in relating them to preexisting forms. Should they actually represent adults, the problem is even more difficult, for they do not closely resemble any known Paleozoic or Triassic genus. One possibility is that neoteny, an important feature in terebratuloid evolution, has intervened, obscuring relationships. Probably little more can be determined of the true relationships of this form until a comprehensive study of Triassic forms is carried out.

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BIOLOGICAL STUDIES AT POINT BARROW

The Eskimo birth rate is increased as much as threefold when the Arctic people eat "white man's food" instead of their traditional pure-animal diet of whale, fish, and seal. This is the observation of Prof. G. E. MacGinitie, of the California Institute of Technology, in a report recently published by the Smithsonian Institution on his biological investigations at the Navy's Arctic Research Laboratory at Point Barrow, on Alaska's Arctic coast.

"When hunting was the only means of subsistence," he writes, "Eskimo women became pregnant only once in several years, but with the new diet they bear a baby about every year. What will happen when outside support is shut off is an important and serious problem. Some few fathers are training their boys in hunting and other Eskimo skills, but most of them are content to let the future take care of itself. The situation is fast becoming a problem difficult of solution."

Of primary importance in the old Eskimo culture, Professor MacGinitie points out, is the bowhead whale. "Several," he says, "are taken in the spring of each year and the flesh is stored underground in cellars where it remains edible for three or four years. The whales feed on euphasiids, mysids, pteropods, and copepods, which are so abundant that the great blue whale can attain a weight of 60 tons in two years. Baleen whales probably lead the easiest life of any mammal. These enormous creatures have only to swim slowly through water, which has about the same specific gravity as themselves, opening and closing their mouths and swallowing food. To an Eskimo the most delectable food is whale muktuk, which consists of whale skin with about an inch of underlying blubber. After freezing, the muktuk is cut into small pieces and eaten raw. It has a nutty flavor and is really quite good.

"Perhaps next in importance in the native economy is the bearded seal. This marine animal, which reaches a weight of 500 to 600 pounds, feeds almost entirely on amphipods, using its whiskers for sweeping them from the underside of the ice. The teeth are very small and are of little use for holding or masticating food.

"In winter these seals are hunted in offshore leads. They float when shot, and so can be taken easily. In summer they are hunted in boats. Then they sink when shot and, if not immediately harpooned, are lost. On one summer hunt on which I accompanied my two boatmen, eleven seals were shot and seven were lost."

PALEOBOTANY.—*New items in Cretaceous and Tertiary floras of the western United States.* Roland W. Brown, U. S. Geological Survey.

The fossil plant collections in the United States National Museum continue to enlarge as deposits are made by U. S. Geological Survey expeditions and by gifts from private individuals and institutions. Some of these increments come from localities and formations already known and exploited; but others are from strata not yet named and, therefore, contribute toward the dating of the strata as well as to a clearer concept of the species the plants represent. Rather than postpone their description to an uncertain time when monographic studies might be published they are presented now for such significance as they may have.

Gleicheniaceae

Gleichenites repenningi Brown, n. sp.

Fig. 14

Frond forked three times, but no arrested buds at the forks as in normal species of *Gleichenia*. Ultimate pinnules narrow, entire, rounded at the tips and separate almost to the rachis. Venation relatively simple, usually once but sometimes twice forked. No fruiting specimens found.

Although the general appearance of the frond and the venation of the pinnules suggest that the affinity of this fern is with the Gleicheniaceae, the assignment must be considered tentative.

The species is named for Charles A. Repenning, of the U. S. Geological Survey, who discovered the locality.

Occurrence.—In the Mesaverde group (Upper Cretaceous) at Black Mountain, about 40 miles southeast of Kayenta, Ariz. Collected by R. W. Brown et al., 1955.

Schizaeaceae

Schizaeopsis dentata Brown, n. sp.

Fig. 13

Frond deeply incised, almost digitate, showing a kind of repeated dichotomy, the ultimate divisions narrow, but the tips not seen. Margin inconspicuously and remotely dentate. Venation forked, with a vein running into each marginal tooth. No fruiting structures found.

The reference of this fern to the Schizaeaceae must be regarded as tentative. In some features it may be compared with the living *Schizaea elegans* (Vahl) Swartz, of the American Tropics, and the epiphytic *Platycerium alcicorne* Desvaux, of East Africa. Neither of these, however, has marginal teeth. In the latter respect *Dipteris conjugata* Reinwardt of the East Indies, is somewhat comparable, but the main venation is more open and has numerous prominent cross-connections, which are absent in the fossil.

Perhaps the most striking resemblance of this fern is to specimens called *Pseudogingko bohemica* Velenovsky and Viniklar (1926, p. 8, pl. 5, figs. 1–15) from the Upper Cretaceous of Bohemia. The latter, however, lacks marginal teeth. That the present specimen and *P. bohemica* represent gymnosperms may well be questioned. Such uncertainty about even the higher rank allocation of fossils illustrates the frustration to which paleontologists are sometimes subject when definite clues are lacking.

Occurrence.—In the Mesaverde group (Upper Cretaceous) at Black Mountain, about 40 miles southeast of Kayenta, Ariz. Collected by R. W. Brown et al., 1955.

Leguminosae

Bauhinia wyomingana Brown, n. sp.

Fig. 1

Upper half of a leaf, evidently originally at least 10 cm long, deeply incised making a rounded sinus and two lobes. Only the top of the midrib present. Secondary veins strong, curving upward in the direction of the margin, the uppermost pair entering the apical lobes.

No pods were found with this leaf, but large pods, not yet identified, have been found at about the same stratigraphic level at neighboring localities in Wyoming, where, however, no leaves recognizable as those of *Bauhinia* occur. The deep sinus and bilobed feature of this leaf, together with the venational details, leave no doubt about its identification. It is the first species of *Bauhinia* to be reported from the Paleocene strata of the western States. One doubtful species, *B. pseudocotyledon* Cockerell, was described from the Oligocene lake beds at Florissant, Colorado. Several species have been identified in the Cretaceous and Eocene deposits of the Atlantic and Gulf coasts.

This leaf resembles those of several living species, of which there are about 150. They include

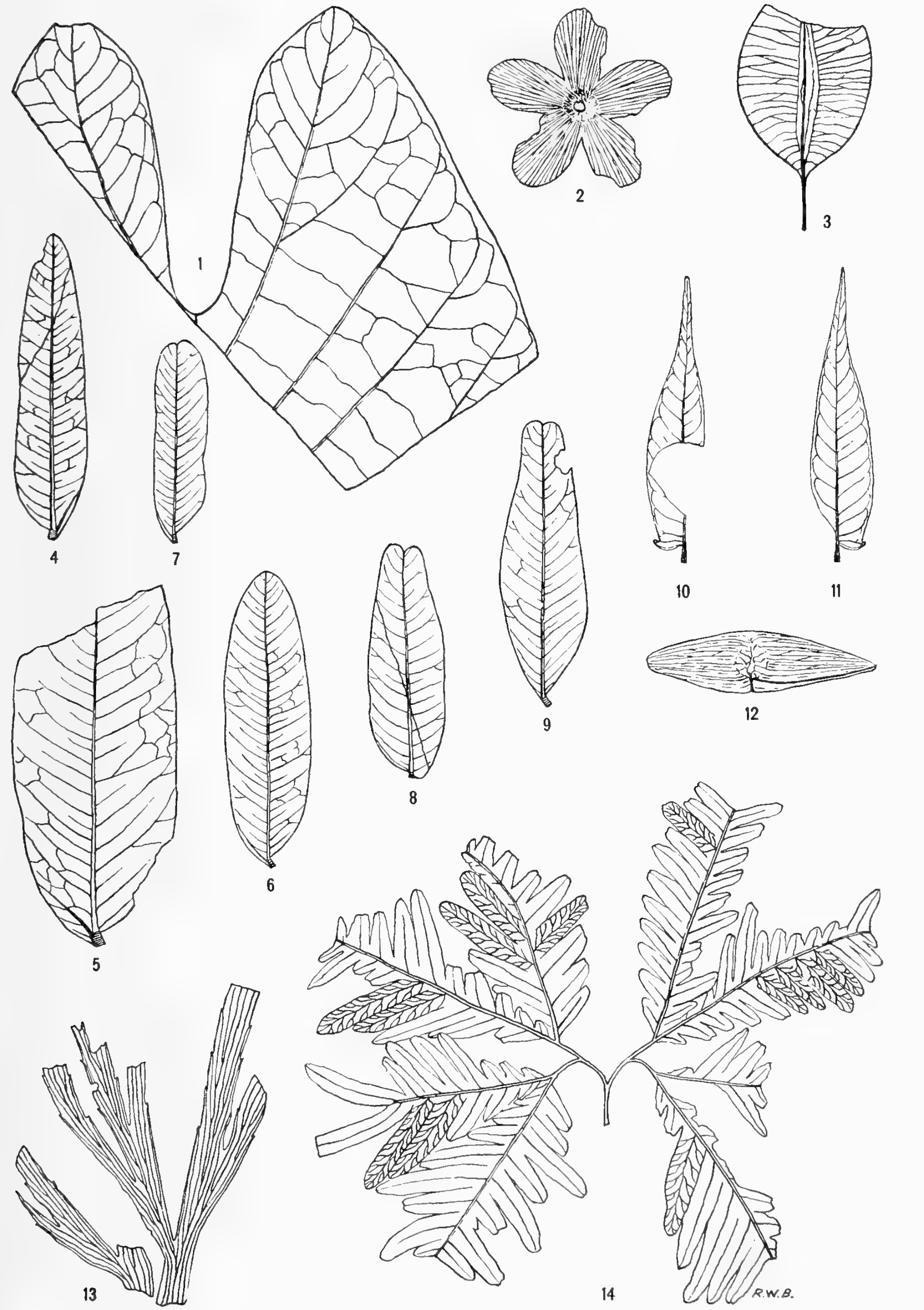

Fig. 1.—*Bauhinia wyomingana* Brown, n. sp. Fig. 2.—*Antholithes wellsi* Brown, n.sp. *Koelreuteria annosa* Brown, n. sp. Figs. 4, 5, 6.—*Caesalpinia pacifica* (Knowlton) Brown, n. comb. Figs. 7, 8, 9.—*Caesalpinia pecorae* Brown, n. sp. Figs. 10, 11.—Counterparts of *Ailanthus eureka* Brown, n. sp. Fig. 12.—*Ailanthus lesquereuxi* Cockerell. Fig. 13.—*Schizaeopsis dentata* Brown, n.sp. Fig. 14—*Gleichenites repenningi* Brown, n. sp. All figures natural size.

trees, shrubs, and vines, closely allied to the redbuds, *Cercis*, and are found in the tropics and subtropics around the world. Some species have been introduced successfully as showy ornamentals in southern Florida and southern California. *Bauhinia wyomingana*, therefore, adds a bit of further evidence to that of palms, breadfruit, figs, and others, indicating warm climatic conditions in early Paleocene time in parts of the Rocky Mountain region.

Occurrence.—In lower lignitic strata of the Fort Union formation (Paleocene), sec. 14, T. 57 N., R. 85 W., 2¼ miles northwest of Monarch, Wyo. Collected by T. E. Williard, 1907.

Caesalpinia pacifica (Knowlton) Brown, n. comb.

Figs. 4, 5, 6

Quercus pacifica Knowlton, U. S. Geological Survey 20th Ann. Rept., pt. 3, p. 43, pl. 1, figs. 9, 10, 1900.

Asymmetric leaflets, 4 to 8 cm long with short, glandular, cross-wrinkled petioles. Apex in general rounded, only exceptionally emarginate. Base rounded. Secondary veins numerous, regular, with short intersecondaries and some reticulation. The lowermost basal secondary noticeably thickened.

This species differs from *Caesalpinia pecorae* chiefly in having leaflets with rounded rather than emarginate apexes. Otherwise, the resemblance is so striking as to suggest very close affinity or even identity. It is significant that both species are from formations regarded reliably as being not older than middle Eocene in age.

I have also collected this species from an Eocene sequence exposed in cuts along the Southern Pacific Railroad one to two miles north of Comstock, Oreg. Sanborn (1937), although reporting two species of *Lonchocarpus* from large collections at the same locality, has no other legumes and especially nothing definitely comparable to *Caesalpinia pacifica*.

Occurrence.—Knowlton's specimens from yellowish sandstone, NE ¼ sec. 16, T. 38 S., R. 1 E., about 5 miles north of Ashland, Oreg. Collected by J. S. Diller, 1898. Figs. 4, 5, 6, from an Eocene lignitic sequence near the Hansen coal mine, SW ¼ sec. 3, T. 37 S., R. 1 W., about 4 miles northeast of Medford, Oreg. Collected by R. W. Brown et al., 1940.

Caesalpinia pecorae Brown, n. sp.

Figs. 7, 8, 9

Asymmetric leaflets, 3 to 4 cm. long, with short, glandular, cross-wrinkled petioles. Apex in general emarginate, only exceptionally rounded. Base rounded. Secondary veins numerous, regular, with short intersecondaries and some reticulation.

Emarginate leaflets, such as these, occur in many species of living and fossil legumes, notably in *Acacia*, *Cassia*, *Eysenhardtia*, *Mimosa*, *Pithecellobium*, *Robinia*, and *Sophora*. Assignment of them to a given genus must, therefore, be considered tentative until confirmatory evidence like pods and seeds is found at the same localities. In the meantime *Caesalpinia* is perhaps as good a label as any. The genus has about 30 living species distributed in the tropics and subtropics around the world.

The species is named for William T. Pecora, of the U. S. Geological Survey, to honor his leadership, friendliness, and cooperation in solving the stratigraphic and paleontologic problems of the Bearpaw Mountains, Montana.

Occurrence.—Figs. 7, 9. In the upper strata of the Green River formation (middle Eocene) on the east side of the Bonanza to Watson road, 2.2 miles north of Watson, Utah. Collected by R. W. Brown, 1941. Fig. 8. In tuffaceous middle Eocene strata, SE ¼ NW ¼ sec. 11, T. 28 N. R. 14 E., in the western foothills of Centennial Mountain, Bearpaw Mountains, Mont. Collected by R. W. Brown et al., 1954.

SIMARUBACEAE

Ailanthus eureka Brown, n. sp.

Figs. 10, 11

Leaflet notably asymmetric, lanceolate, 4 cm long and 8 mm wide. Apex long attenuate. Lower half of rounded base with one prominent glandular tooth, the margin otherwise entire. Secondary veins more or less straight to the area near the margin where they curve upward to join the the secondary above. Few short intersecondaries present. Petiole 2 mm long.

This leaflet, so far as I am aware from perusal of the literature, is the first unequivocal fossil foliage of *Ailanthus* to be reported. Its finding marks the end of a long search. Hitherto, the assignment of leaflets to the same species as well recognized seeds from the same localities has left much to be desired in that none of the leaflets so assigned has clearly shown the characteristic basal, glandular teeth (Brown, 1940, p. 351; 1946, p. 350). All the features of this leaflet, however, but particularly the glandular tooth, are consonant with those seen in most species of living *Ailanthus*, the one exception being *A. excelsa* Roxburgh, which has toothed leaflets without glands.

No samaras were found with this leaflet. Its associates, however, are species of leaves and fish like those found in the middle Eocene Green River formation in Colorado, Utah, and Wyoming, thereby attesting its Eocene age. On the other hand, the beautiful samaras of *Ailanthus lesquereuxi* Cockerell (Fig. 12) from the Green River formation at Fossil, Wyoming, although found with many other species of leaves, fruits, and seeds, are not accompanied by leaflets clearly assignable to *Ailanthus*. As the samaras of *Ailanthus* found in many western Tertiary deposits from the Eocene to the Miocene epochs are very similar in features, they cannot well be distinguished as separate species; but a number of such species have been described. The question now arises: Should the present leaflet be called *A. lesquereuxi* or should it be a new species? I choose the latter alternative, pending the finding of samaras at the same locality, or the finding of similar leaflets in the Green River formation, that may show its true relationship to *A. lesquereuxi*.

The leaflet is relatively small as compared with those of living species. Perhaps it is abnormal and not typical of its species. The finding of recognizable *Ailanthus* leaflets in the Green River and other Tertiary floras is, therefore, an eventuality earnestly hoped for.

Why are these leaflets rare in the fossil record? I can suggest in reply only the implications hinted at in my observation of the leaves of *Ailanthus altissima* (Miller) Swingle, the common Asiatic tree-of-heaven, planted or escaped in many parts of the north temperate zone. When the large compound leaves fall they disintegrate quickly, the leaflets remaining intact for only a few days. On the ground they become fragile and crumble easily. Unless, therefore, such leaflets fortunately fall into water and are speedily buried in bottom sands and muds, there is little chance that they will be preserved as fossil specimens.

Species of *Ailanthus* in the Tertiary record of the western States, like those of *Cercidiphyllum*, *Ginkgo*, *Keteleeria*, *Koelreuteria*, *Metasequoia*, *Pseudolarix*, and many others, indicate a former widespread distribution in the North Temperate zone of entities whose remaining relatives are now restricted to indigenous Asiatic floras. The presence of any one of these in a fossil flora from the American west prompts an inspection of the living Asiatic flora for possible matches to other specimens seemingly unidentifiable in terms of local or neighboring species.

Occurrence.—In tuffaceous middle Eocene strata, SE ¼ NW ¼ sec. 11, T. 28 N., R 14 E., in the western foothills of Centennial Mountain, Bearpaw Mountains, Mont. Collected by R. W. Brown et al., 1954.

Sapindaceae

Koelreuteria annosa Brown, n. sp.

Fig. 3

Capsular valve, 2.7 cm long and 1.8 cm wide. Elliptic in outline, with apex missing. Peduncle 5 mm long. Venation relatively simple, with a few forks and anastomoses.

No foliage assignable to *Koelreuteria* was found with this characteristic capsule. In size it is somewhat smaller than that of *K. nigricans* (Lesquereux) Brown (Brown, 1946, p. 350) from the middle Eocene Green River formation, to which, on account of its geographic contiguity, it might have been closely related. *K. annosa*, however, is from lignitic strata near the top of the Fort Union formation (Paleocene) northeast of Point of Rocks, Wyo.

Several species of *Koelreuteria* have been recorded from the Tertiary rocks of the western States, but this is the first from the Paleocene series. It belongs with a group of species of other genera whose living descendants or relatives are now restricted to Asiatic habitats. One species, *K. paniculata* Laxmann, the so-called goldrain-tree, an exotic to the parks of the United States, makes a showy display with its mass of golden flowers and its Chinese lanternlike seed pods.

Occurrence.—In the upper lignitic strata of the Fort Union formation (Paleocene), NW ¼ SW ¼ sec. 36, T. 21 N., R. 100 W., about 7 miles northeast of Point of Rocks, Wyo. Collected by William P. Severn, 1954.

Uncertain affinity

Antholithes wellsi Brown, n. sp.

Fig. 2

Five-parted calyx or corolla, the parts united at the base. Diameter 2 cm. Central area depressed to form a shallow cup. No evidence of stamens or pistils.

Although numerous leaves were found associated with these flowers, no definite suggestion of relationship or identity has developed from their study.

The species is named for Francis G. Wells, of the U. S. Geological Survey, to honor his long labors in elucidating the geology of Oregon.

Occurrence.—In an Eocene lignitic sequence near the Hansen coal mine, SW ¼ sec. 3, T. 37 S., R. 1 W., about 4 miles northeast of Medford, Oreg. Collected by R. W. Brown, 1954.

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DR. JOHN G. THOMPSON RETIRES

Dr. John G. Thompson, chief of the Metallurgy Division of the National Bureau of Standards, has retired after more than 35 years of Government service.

Born in Eau Claire, Wis., in 1894, Dr. Thompson attended Cornell University, receiving his bachelor of chemistry degree in 1915 and his doctor of philosophy in 1921. His association with the National Bureau of Standards began in 1921 when he became a member of the Chemistry Division. From 1924 to 1929 he was employed as a chemist and metallurgist at the Fixed Nitrogen Laboratory of the Department of Agriculture on problems in connection with the synthesis of ammonia. He returned to the National Bureau of Standards in 1929 as a research associate for the Cerro de Pasco Copper Corporation and the following year was appointed chief of the Chemical Metallurgy Section. He was appointed chief of the Metallurgy Division in 1946.

Dr. Thompson has made outstanding contributions in fields of research pertaining to the preparation of pure metals, the evaluation of their properties, gases in metals, special refractories, corrosion, and powder metallurgy, and is the author of more than 35 technical publications. The results of his studies of bismuth and bismuth alloys paved the way for industrial development of fusible alloys containing bismuth. Dr. Thompson was instrumental in developing a process that involved chemical purification of an iron salt and its subsequent conversion into oxide, sponge, and melted ingots. By the use of this process, he was successful in 1938 in producing an iron of 99.99 percent purity, the highest established purity to that time in this country or abroad. His book *The Metal—Iron* (co-authored with H. E. Cleaves) is an exceptionally valuable reference and was the basic volume of the series of monographs on alloys of iron sponsored by the Engineering Foundation. He was successful in extending the slip-casting process to the preparation of thin-wall crucibles of alumina, beryllia, and other special refractories that lacked the property of plasticity. Slip-cast beryllia crucibles were used in preparing the "super-pure" ingots of iron. The results of his work served as the basis for the production of slip-cast crucibles of special refractories by other laboratories.

Dr. Thompson was the leader of an international cooperative study that established the accuracy of the vacuum-fusion method for determining oxygen in the plain carbon steels, either as aluminum-killed, silicon-killed, or rimmed. He recommended procedures for obtaining optimum results by this method and subsequently extended its usefulness for determining oxygen in alloy steels. The vacuum-fusion method is now extensively used, not only as a tool for research but commercially, as the "standard" for determining the oxygen content of steels and other metals. During World War II he conducted researches on beryllium-aluminum alloys under the auspices of the War Metallurgy Committee; this work received an award from the Office of Scientific Research and Development. His study of the metallurgy of beryllium and uranium for the Manhattan Project was also recognized by an award from the War Department.

Since World War II Dr. Thompson has been honored by service as a Presidential appointment member of Annual Assay Commission for 1950, U. S. Mint, Philadelphia; member of the Materials Advisory Board of the National Research Council; member of Advisory Committee on Revision of New York State Industrial Code No. 21; chairman, Washington Chapter, American Society for Metals; and conferee, First World Metallurgical Congress, 1951. He has served on many technical committees of various engineering societies. He is an active member of the American Society for Metals, American Institute of Mining and Metallurgical Engineers, American Society for Testing Materials, National Association of Corrosion Engineers, British Iron and Steel Institute, British Institute of Metals, WASHINGTON ACADEMY OF SCIENCES, Sigma Xi, and the Cosmos Club.

BOTANY.—Calamochloa: *A Mexican grass.* Ernest R. Sohns, U. S. National Museum. (Communicated by Agnes Chase.)

The genus *Calamochloa* was described by Fournier (1877). His brief description was based on the single collection by the French mineralogist Pierre Virlet d'Aoust, no. 1461, from San Luis Potosí, Mexico, without precise locality. Other than the type specimen in the Paris Museum and a fragment and photograph brought to the U. S. National Herbarium in 1922 by Mrs. Chase, the genus remained unknown from 1877 to 1954, when I collected it at three stations in the Sierra de Guadalcázar, between Charco Blanco, Aguaje de Garcia and the Minas de San Rafael (Figs. 18, 19), on Cretaceous limestone outcrops.

The original description of the genus by Fournier (1877) was very brief, as follows [translated]:

Glumes subequal, the lower shorter; flowers 3, of which 2 are pilose around the base, the summit less so; lemma 5-lobed, lateral and intermediate lobes subulate, palea 2-toothed, panicle ovate, influorescence 4–5 spicate.

The glumes of this genus have the same structure as several of those in the Chlorideae, notably those of the section *Heterostega* of the genus *Atheropogon*, but the location of the lemma with respect to the rachis removes the genus from the Chlorideae. The hairs of the rachis and its appearance, suggests *Calamagrostis*, among [the species of] which one would, at first view, try to place *Calamochloa filifolia*.

The short description of the genus, quoted in the second and third paragraph, was used again by Fournier (1886). In this work he described *C. filifolia* as follows [translated]:

Culms strict, sheaths striate, glabrous; ligule pilose; blades linear, glaucous, convolute; panicle ovate and terminal; glumes subequal, the upper broadly mucronate, median nerve prominent; lemma 5-lobed [as in] *Polyschistidis*, palea truncate, plicate, obscurely 2-dentate, ⅓ shorter, base and margin villous.

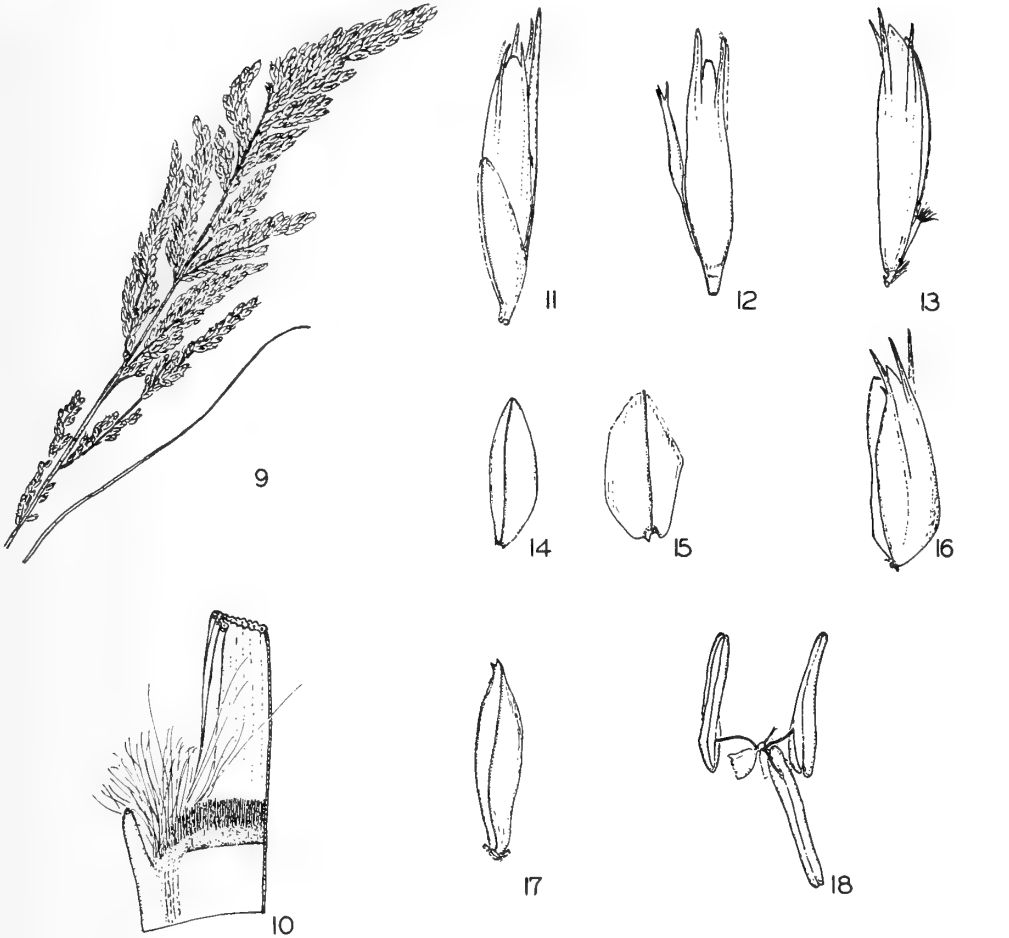
The rather inadequate description and the fact that the species was represented only by the type specimen, consisting of the upper portions of two or three culms and their pistillate inflorescences, led to uncertainty about the genus and its tribal affiliation. Hackel (1887, 1890) put the genus in the tribe Festuceae, subtribe Pappophoreae. Bews (1929) keys the genus in the Festuceae, lists the author and the single species in Mexico. Rozhevits (1937) included the genus in the tribe Pappophoreae along with *Scleropogon*, *Cathestecum*, *Enneapogon* and other genera. Conzatti (1946) put the genus in the tribe Chlorideae between the genera *Tripogon* and *Leptochloa*. The origin of the generic name is given in addition to the known information about the genus. Pilger (1954) placed the genus in the tribe Festuceae, subtribe Festucinae with the notation, "Doubtful genus," and in the tribe Aveneae, subtribe Aveninae with the statement: "Genus of doubtful position."

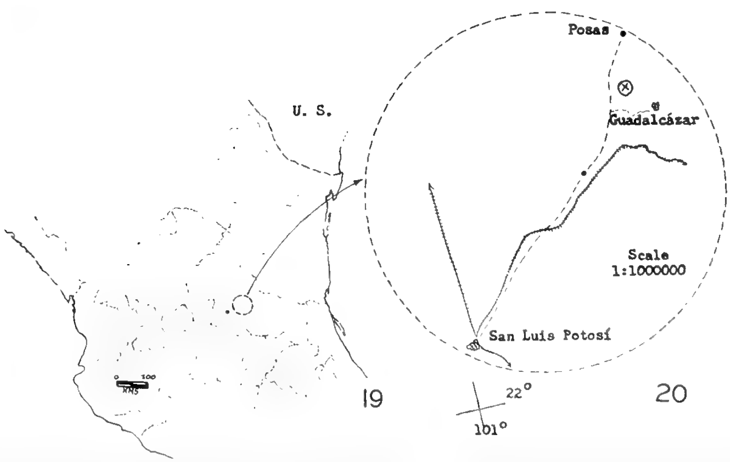
After a study of the type material and the specimens collected in the Sierra de Guadalcázar, it is concluded that the genus belongs in the tribe Pappophoreae (Rozhevits (1937) and Hubbard (1934)).

Calamochloa Fournier—Emended. Plants dioecious. Staminate spikelets 3–5 flowered, the rachilla glabrous and not disarticulating between the florets; glumes about equal in length, 2.8–4.1 mm long, 3-awned, the awns short; palea as long as the lemma or slightly shorter; stamens 3, large, well-developed; pistil rudimentary; lodicules 2, membranaceous. Pistillate spikelets mostly 3-flowered; rachilla disarticulating tardily, the florets usually falling together; glumes about equal, 3.5–7 mm long, 1-nerved, glabrous except slightly scaberulous on the keel toward the tip and over the back; lemma (first floret) to 7 mm long, pilose on the margins and on each side of the median nerve from about 1 mm above the base to the base of the central awn, 3-awned, the awns prominent, subulate and diverging at maturity; callus pilose; palea as long as the lemma or very slightly shorter; pistil well-developed; stamens 3, rudimentary; lodicules 2, membranaceous. Tufted perennials forming tough clumps in dry soil, with long, flat blades which become flexuous and involute on drying. Inflorescences spreading in anthesis, later becoming narrow and compact. Name presumably from *kalamos*, cane and *chloa*, grass.

Calamochloa filifolia Fournier—Emended. Staminate plants: Perennial, densely tufted, the old bases persistent, 30–100 cm tall; culms from

FIGS. 1–8.—*Calamochloa filifolia* Fournier: *1*, Habit sketch of pistillate plant, × ½; *2*, ligule, with portion of blade and sheath (median longitudinal section); *3*, spikelet (from type specimen, Virlet, no. 1461); *4*, lower floret (from type specimen, Virlet, no. 1461); *5*, lower floret; *6*, palea with rachilla joint and pistil; *7*, pistil and stamens of lower floret; *8*, pistil, stamens and lodicules of second floret. (Figs. 2–8, × 7; all figures, except 3 and 4, drawn from Sohns, nos. 1352 and 1506.)





FIGS. 9–20.—*Calamochloa filifolia* Fournier: *9,* Inflorescence of staminate plant, × ½; *10,* ligule with portion of blade and sheath (median longitudinal section); *11,* spikelet; *12,* second and third florets; *13,* first floret with rachilla joint; *14,* first glume; *15,* second glume; *16,* lemma of first floret; *17,* palea; *18,* stamens, rudimentary pistil and lodicules of first floret; *19,* outline map of northern Mexico; *20,* approximate locality of *C. filifolia* (marked by an "x" in a circle). (Figs. 10–18, × 7; drawn from Sohns, no. 1406; fig. 20 based on 1938 edition of a map of the State of San Luis Potosí prepared by the Dirección de Geografía Meterología e Hidrología, Mexico.)

slightly short pubescent to densely pubescent and short appressed pilose below the nodes; blades 10–36 cm long, flat in living specimens, involute when dry, antrorsely scabrous on both surfaces; sheaths glabrous, longer than the internodes; ligule a ciliate rim, 0.7–1 mm long, pilose on the margins near the junction of the blade and sheath, auricles sometimes present as a straight upward prolongation of the margin of the sheath; inflorescence 7–20 cm long, axis and branches pubescent, branches spreading in anthesis, contracted later, short pubescent in the axils; spikelets 5 to 9 mm long, 3–5-flowered, spreading slightly at maturity; rachilla joints short pilose below the floret (base of callus and rachilla joint), otherwise glabrous; first glume 2.8–3.4 mm long, glabrous, 1-nerved, the median nerve often projecting beyond the tip 0.1–0.2 mm; second glume 2.8–4.1 mm long, otherwise as the first glume; lemma of the first floret 5–5.5 mm long, glabrous, 3-awned from below the summit, the awns 1–2 mm long and slightly exceeding the lemma, antrorsely scabrous; palea as long as the lemma or slighty shorter, with a slight membranous wing on each keel; lodicules 2, membranaceous; stamens 3, pollen grains large and well-developed; pistil rudimentary, 0.2–0.5 mm long.

Pistillate plants: Perennial, cespitose, forming hard persistent clumps, 40–100 cm tall; blades 18 to 40 cm long, flat, flexuous, becoming involute and curled when dry, antrorsely scabrous on both surfaces; culms finely pubescent and short appressed-pilose, especially at the nodes; sheaths glabrescent, longer than the internodes, sometimes with an auricle, especially on the lower sheaths; ligule a ciliate rim 0.8 to 1 mm long; hairs abundant at the margins of the ligule on the collar, up to 2.5 mm long; inflorescence 8–21 cm long, axis pubescent, branches spreading at anthesis, later appressed, pubescent and short-pilose; panicle branches short-pilose in the axils; spikelets mostly 10–12 mm long, 3-flowered, the uppermost rudimentary; rachilla joints short and glabrous; first glume 3.5–6.5 mm long, 1-nerved, scaberulous on the keel toward the tip and over the back; second glume 4.7–7 mm long, otherwise like the first glume; lemma of the first floret about 7 mm long, pilose on the margins and on each side of the median nerve from about 1 mm above the base to the base of the diverging central awn; 3-awned, the awns subulate, antrorsely scabrous and diverging at maturity; palea as long as or slightly shorter than the lemma; lodicules 2, membranaceous; stamens 3, 0.2–0.3 mm long, apparently non-functional; pistil well-developed; stigmata plumose. Mature caryopses were not found.

The emended description is based on these specimens in the U. S. National Herbarium:

San Luis Potosí (staminate plants): In the Sierra de Guadalcázar between Charco Blanco and Aguaje de Garcia; alt. 1100–1600 m; September 20, 1954, *Sohns* 1340 and 1352a; September 24, 1954, *Sohns* 1460a. On the northeastern slopes of hills near Aguaje de Garcia in the Sierra de Guadalcázar; alt. 1800 m; October 1, 1954, *Sohns* 1487 and 1498. Near the Minas de San Rafael in the Sierra de Guadalcázar; alt. 1900–2100 m; October 3, 1954, *Sohns* 1506a.

San Luis Potosí (pistillate plants): In the Sierra de Guadalcázar between Charco Blanco and Aguaje de Garcia; alt. 1100–1600 m; September 20, 1954, *Sohns* 1352; September 24, 1954, *Sohns* 1460. On the northeastern slopes of hills near Aguaje de Garcia in the Sierra de Guadalcázar; alt. 1800 m; October 1, 1954, *Sohns* 1488. Near the Minas de San Rafael in the Sierra de Guadalcázar; alt. 1900–2100 m; October 3, 1954, *Sohns* 1506.

SUMMARY

Calamochloa filifolia Fournier, a rare genus of one species is redescribed and illustrated. The species, collected in the Sierra de Guadalcázar after a lapse of 77 years, is dioecious and apparently a highly restricted endemic. The genus belongs in the tribe Pappophoreae.

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BOTANY.—*Studies of South American plants, XVI.* A. C. Smith, U. S. National Museum.

A recent collection of plants made in Peru and Ecuador by Dr. Werner Rauh, Botanisches Institut, Heidelberg, and his associate Dr. Gerhard Hirsch, has disclosed three species of the family Vacciniaceae not previously described. The material upon which the following descriptions are based is deposited in the U. S. National Herbarium.

Sphyrosperum venustum, sp. nov.

Frutex gracilis terrestris ad 50 cm altus, ramulis glabris elongatis 1.5–3 mm diametro basis versus foliorum valde confertorum conspicue incrassatis; stipulis pro genere egregiis binis intrapetiolaribus filiformibus 2–4 mm longis mox caducis; petiolis inconspicuis haud 1 mm longis canaliculatis glabris; laminis in sicco papyraceis fusco-viridibus forsan in vivo carnosis, elliptico-obovatis, 12–16 mm longis, 4–7 mm latis, basi obtusis, apice rotundatis, margine incrassatis leviter recurvatis, juventute ubique minute puberulis mox glabratis, costa et nervis in sicco utrinque paullo elevatis inconspicuis, nervis secundariis utrinsecus saepe 3 adscendentibus, rete venularum obscuro immerso; inflorescentia axillari 1-flora quam foliis breviore, rhachi subnulla, bracteis sub floribus paucis, 2 intimis lanceolatis circiter 1 mm longis acutis obscure ciliolatis, pedicellis haud 0.5 mm longis superne incrassatis apicem versus obscure glanduloso-pilosis (pilis fuscis ad 0.2 mm longis); calyce pilis paucis obscuris limbo et loborum margine exceptis glabro sub anthesi circiter 3 mm longo et 2 mm diametro, tubo cupuliformi obscure 10-gono circiter 1 × 1 mm limbo suberecto papyraceo 5-lobato, lobis deltoideis acutis circiter 1 mm longis et latis, sinibus rotundatis; disco annulari-pulvinato glabro; corolla glabra tenuiter carnosa cylindrico-urceolata sub anthesi circiter 8 mm longa et medium versus 3 mm diametro, basi valde contracta, lobis 5 deltoideis acutis circiter 1 mm longis; staminibus 5 quam corolla paullo brevioribus, filamentis ligulatis circiter 2.5 mm longis supra medium gradatim angustatis et superne intus minute pilosis, extus glabris, antheris circiter 4.8 mm longis; thecis longitudine tubulos subaequentibus basi rotundatis, tubulis gracilibus per rimas ovales circiter 1 mm longas dehiscentibus; stylo gracili corollam fere aequante, stigmate minuto.

Type in the U. S. National Herbarium, no. 2180834, collected between Chimborazo and Guaranda, Province of Bolívar, Ecuador, alt. 3,000 m, in upper zone of the "ceja de la montaña," September 20, 1954, by W. Rauh & G. Hirsch (no. 388).

The graceful species here described is remarkably isolated, but *Sphyrospermum* seems to be the best generic position for it. The crowded leaves, the branchlets conspicuously swollen at the leaf bases, and the peculiar filiform stipules are striking characteristics. The small, elliptic-obovate, rounded leaf blades and the solitary subsessile flowers with only five stamens further separate the new species from its congeners. The reduced number of stamens occurs elsewhere in *Sphyrospermum*, as well as in the related genera *Themistoclesia* and *Eleutherostemon,* but no species with this character are suggestive of *S. venustum.*

Ceratostema callistum, sp. nov.

Frutex epiphyticus 30–50 cm altus, ramis tubere magno ad 20 cm diametro enatis, ramulis subteretibus copiose canescente-hispidulis (pilis gracilibus 1–2 mm longis eglandulosis ad apices ramulorum cum pilis graciliter clavatis glandulosis aequilongis intermixtis); stipulis intrapetiolaribus binis e basi incrassata subulatis 3–5 mm longis ut ramulis hispidulis; petiolis incrassatis rugulosis 4–5 mm longis pariter hispidulis; foliorum laminis subcoriaceis in sicco brunneo-viridibus ovatis, 6–9 cm longis, 3.5–5 cm latis, basi cordatis, in acuminem callosum 1–1.5 cm. longum gradatim angustatis, margine planis paullo incrassatis, supra molliter pilosis (pilis haud 0.3 mm longis) ac etiam parciore glanduloso-pilosis (pilis ad 0.8 mm longis) demum glabrescentibus, subtus pariter pilosis sed pilis longioribus (ad 1 mm) et persistentibus, pinnatinerviis, costa supra leviter impressa subtus elevata, nervis lateralibus utrinsecus plerumque 3 inconspicuis curvatis subplanis, nervis intimis cum costa 1–2 cm concurrentibus, rete venularum immerso; inflorescentiis apices ramulorum versus axillaribus racemosis ut videtur 4–8-floris breviter pedunculatis, rhachi pedicellisque pilis debilibus pallidis 0.4–0.8 mm longis molliter pubescentibus ac etiam pilis anguste clavatis glandulosis aequilongis parciore ornatis, rhachi subtereti ad 5 cm longa; bracteis sub floribus papyraceis lanceolatis 5–8 mm longus extus ut pedicellis pubescentibus intus glabris, pedicellis sub anthesi 10–18 mm longis cum calyce articulatis medium versus bibracteolatis, bracteolis bracteis similibus; calyce sub anthesi 22–25 mm longo apice circiter 15 mm diametro ubique ut pedicellis glanduloso- et eglanduloso-pilosis sed pilis brevioribus, tubo cupiliformi circiter 5 mm longo et diametro, limbo suberecto papyraceo reticulato-nervato profunde 5-lobato, lobis lanceolatis 14–17 mm longis; disco cupuliformi glabro crenulato-marginato; corolla tenuiter carnosa cylindrica circiter 45 mm longa et basim versus 6 mm diametro, superne paullo angustata, extus ut calyce molliter pilosa sed tantum superne glandulosa, intus glabra, profunde 5-lobata, lobis subulato-lanceolatis circiter 10–12 mm longis; staminibus 10 sub anthesi leviter exsertis, filamentis membranaceis glabris circiter 7 mm longis in tubum cohaerentibus, antheris circiter 40 mm longis thecis conspicue granulatis circiter 11 mm longis basi mucronulatis et incurvatis, tubulis circiter 29 mm longis gracillimis (superne haud 0.15 mm diametro) per poros ovales subapicales circiter 1 mm longos dehiscentibus; stylo filiformi leviter exserto, stigmate minuto.

Type in the U. S. National Herbarium, no. 2180858, collected near the Hacienda Taulis, near Chiclayo, Valle Río Saña, Department of Lambayeque, Peru, alt. 2,500 m, October 13, 1954, by W. Rauh & G. Hirsch (no. 2186).

Dr. Rauh states that there is a beautiful forest composed chiefly of *Podocarpus* near the Hacienda Taulis, this being the only substantial wooded section in the entire region. The new species is a frequent epiphyte here, its branches arising from a large tuber up to 20 cm in diameter. The corolla is said to be carmine-red without and greenish within.

This very distinct species of *Ceratostema,* compared with my recent key to the 16 known species (in Mem. New York Bot. Gard. **8:** 57. 1952), is seen to be closely related only to *C. peruvianum* Gmel. and *C. pensile* (A. C. Sm.) A. C. Sm., from both of which it is at once distinguished by its narrowly lanceolate calyx lobes. From *C. peruvianum* the new species further differs in its more copious and often glandular indument, its less deeply cordate leaf blades, which are acuminate rather than obtuse at apex, and in its terete rather than costate calyx tube. Our plant is obviously distinct from *C. pensile* in its more copious foliar indument and in its narrowly lanceolate rather than broadly ovate inflorescence bracts and bracteoles.

Ceratostema callistum is the only species of the genus positively known to occur in Peru, although it is probable that some of the Ecuadorian species actually extend southward.

Thibaudia rauhii, sp. nov.

Frutex 0.3–1 m altus ut videtur epiphyticus et tubere magno enatus, ramulis subteretibus gracilibus apices versus 1.5–2 mm diametro, partibus juvenilibus copiose pilosis (pilis albidis circiter 1 mm longis) mox glabrescentibus; stipulis intrapetiolaribus subulatis circiter 2 mm longis pilosis evanescentibus; petiolis leviter canaliculatis 3–3.5 mm longis ut ramulis pubescentibus, laminis subcoriaceis in sicco viridibus oblongo-ovatis, 3–4 cm longis 1.3–1.7 cm latis, basi anguste rotundatis, apice obtusis, margine integris anguste recurvatis, utrinque molliter pilosis (pilis albis 0.3–0.8 mm longis supra evanescentibus subtus persistentibus) ac etiam subtus parce nigro-glanduloso-pilosis, costa supra leviter impressa subtus prominente, nervis secundariis utrinsecus plerumque 2 adscendentibus utrinque inconspicue elevatis, rete venularum immerso; inflorescentia subfasciculata 2–4-flora pilis albis 0.5–1 mm longis ubique copiose molliter pilosa, basi bracteis paucis deltoideo-lanceolatis ad 3.5 mm longis circumdata; pedicellis teretibus sub anthesi 6–9 mm longis basim versus bibracteolatis, bracteolis lanceolatis circiter 5 mm longis caducis; calyce sub anthesi 7–7.5 mm longo et apice diametro, tubo cupuliformi circiter 3 mm longo et diametro, limbo erecto-patente quam tubo manifeste longiore 5-lobato, lobis late deltoideis circiter 1 mm longis acutis; disco annulari-pulvinato glabro; corolla rubra tenuiter carnosa subcylindrica sub anthesi 15–16 mm. longa et medium versus circiter 6 mm diametro, extus praeter basim versus copiose pilosa, intus glabra, lobis breviter deltoideis obtusis; staminibus 10 circiter 10 mm longis, filamentis glabris in tubum circiter 3 mm longum laxe connatis, antheris circiter 8 mm longis, loculis basi incurvatis, tubulis gracilibus 2.5–3 mm longis (quam thecis brevioribus), rimis elongatis; stylo quam corolla breviore, stigmate parvo peltato.

Type in the U. S. National Herbarium, no. 2180848, collected in the valley of the Río

Marcapata, near Cuzco, Department of Cuzco, Peru, alt. 2,800 m, May 22, 1954, in "ceja de la montaña," by W. Rauh & G. Hirsch (no. 1329).

The new species is closely related only to *T. regularis* A. C. Sm., of southern Peru, and *T. densiflora* (Herzog) A. C. Sm., of Bolivia. It differs from both of these in its somewhat smaller and inconspicuously nerved leaf blades, which are rounded at base and obtuse at apex, and in its subfasciculate few-flowered inflorescences, with short pedicels, comparatively large and copiously pilose corollas, and longer stamens.

NOTES AND NEWS

ROGER G. BATES RECEIVES HILLEBRAND AWARD

The 1955 Hillebrand Award was given to Roger G. Bates (WAS), of the National Bureau of Standards. The citation is for his studies of the thermodynamic properties of electrolytic solutions and standardization of the pH scale.

The Hillebrand Award was established in 1925 in honor of William F. Hillebrand, chief chemist of the National Bureau of Standards from 1908 to 1925. Dr. Hillebrand was an authority on analytical chemistry and famous for the development of systematic methods for the complete analysis of rocks and ores. The award is made each year to a member of the Chemical Society of Washington who has made a notable and original contribution to chemistry during the preceding five years.

FURTHER NOTES ON TEACHER TRAINING

A new and unique program to assist secondary schools in science teaching has been announced by the Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn. The program, which is jointly sponsored by the National Science Foundation and the U. S. Atomic Energy Commission, and administered by the Institute, will enable a selected group of high-school teachers to undergo a three-month course of training in Oak Ridge and then spend nine months in traveling about the country giving lecture demonstrations in science classes at individual high schools. The results of this experiment will be used by the NSF for program planning and for considering future support of this method of attack on increasing the number of highly able young people in science and engineering.

The program is the latest of several developed by ORINS to stimulate interest in science and science education as a means to help in meeting the steadily increasing demand for scientifically trained personnel in all fields of research and development. The Institute is a nonprofit educational corporation owned by 34 Southern universities, operating under direct contract with the AEC.

The new teaching program, which is administered by the ORINS University Relations Division, will operate generally as follows:

A group of eight to ten secondary-school science teachers will be selected on a national basis by ORINS with the recommendation and advice of a selection committee which will include, among others, high-school teachers and administrators. Beginning with the summer of this year, this group will receive leaves of absence from their respective schools for the academic year only, returning to their normal teaching positions in September of 1957.

The Oak Ridge program will begin with the group's participation in a four-week institute to be held at the ORINS Special Training Division in Oak Ridge. This institute, similar to one held in the summer of 1955 under NSF sponsorship, is designed to provide its participants with up-to-date reviews of scientific developments, classical and modern, stressing that science should be taught as a whole, rather than as a series of highly specialized and unrelated technologies. Both lecture and laboratory work will be included in the curriculum; the topics to be covered include classical and modern physics, chemistry, matehmatics, engineering, science experiments, science-teaching methods, and radioisotope techniques. A number of outstanding authorities in various fields of physical science will assist the ORINS staff in presenting the institute, which will include other secondary-school science teachers, to bring the total enrollment to 48.

During the four weeks following the institute, which will end early in July, the selected group will participate in a program designed to acquaint its members with modern laboratory techniques and experiments. This period will include visits to specific laboratories, work with demonstration equipment, supervised self-training, and some practice teaching.

The third phase of the program will send the teachers "on the road." Each one will be provided with a station wagon and demonstration equipment consisting of easily transportable classroom aids in physics and chemistry. Until the end of May 1957 the teachers will spend their working days visiting high schools in the areas assigned to them, giving classroom demonstration lectures at the sophomore-junior level. It is anticipated that each teacher will spend one week at a single high school, where he may give two to three lectures per day three to five days during the school week. The teacher might also be available for consultation with other science teachers or school administrators.

It is estimated that the total number of high schools reached by this program in one academic year will be between 200 and 250.

A particularly pleasant feature of the program will be the assignment of each teacher to a district where he may use his home town as a base of operations, thus enabling him to spend his week ends and possibly many evenings with his family. The touring portion of the program will end late in May 1957. From then until June 15, the teachers will prepare individual reports on the program and will participate in an evaluation study. It is also planned that, at the conclusion of the program, the demonstration equipment will be presented to the science departments of the high schools whose representatives participated in the program.

During the academic year, the touring teachers will receive a stipend at least equal to their regular teaching salaries. In addition, it is planned to provide a travel allowance to cover expenses while the various schools are being visited. The stipends and travel expenses will be paid by the NSF.

The traveling-teacher program, in common with other programs of the Oak Ridge Institute of Nuclear Studies, is designed to help overcome the distressing disparity between the nation's need for well-trained science teachers and scientifically trained personnel and the present and future supply of such personnel as indicated by enrolments in science courses in our universities, colleges, and secondary schools. The urgent need for implementing our present science-education programs has been strongly stressed in recent speeches by Lewis L. Strauss, chairman of the U. S. Atomic Energy Commission, Dr. Alan T. Waterman, director of the National Science Foundation, and other outstanding leaders in research and education. It is hoped that the new program will act as an educational "chain reaction" to stimulate interest in all phases of science on the part of our nation's high-school students, and at the same time provide an ever-increasing supply of science teachers capable of supplying up-to-the-minute information in science to their pupils.

It is also true that man sees more of the things themselves when he sees more of their origin; for their origin is a part of them and indeed the most important part of them. Thus they become more extraordinary by being explained. He has more wonder at them but less fear of them; for a thing is really wonderful when it is significant and not when it is insignificant.—G. K. Chesterton, *St. Francis of Assisi.*

ZOOLOGY.—*A new crayfish of the genus* Procambarus *from South Carolina (Decapoda: Astacidae).* Horton H. Hobbs, Jr., Samuel Miller Biological Laboratories, University of Virginia. (Communicated by Fenner A. Chace, Jr.)

The first specimen of the species described here was collected on February 4, 1934, by L. M. Mace from near Barnwell, Barnwell County, S. C. Since that time a number of attempts have been made to secure a series of specimens on which to base the description of the species as well as to ascertain the extent of its range. These attempts have met with only slight success, for at the present there are but 118 specimens available from seven localities. On the basis of these collections it may be said that *Procambarus echinatus* occurs in the Salkehatchie River and in the headwater streams of the Edisto River in Bamberg, Barnwell, and Aiken Counties, S. C.

The closest relative of *Procambarus echinatus* appears to be *Procambarus dupratzi* Penn (1953: 1), which is reported to occur in eastern Texas and western Louisiana. These occupy, respectively, the most eastern and western limits of the range of the Spiculifer Group, and with *Procambarus natchitochae* Penn (1953: 5), the range of which appears to be confined to southern Arkansas and northern Louisiana, probably represent more nearly the ancestral stock of the group than do the remaining species. Consequently, it appears that the more "primitive" members are occupying the periphery of the range of the group.

Because at present Dr. George H. Penn is conducting a study of speciation in the Spiculifer Group, no attempt is made to summarize the ranges of the other species: *P. spiculifer* (LeConte, 1856: 401), *P. versutus* (Hagen, 1870: 51), *P. vioscai* Penn (1946: 27), *P. penni* Hobbs (1951: 273), *P. suttkusi* Hobbs (1953a: 173), and *P. raneyi* Hobbs (1953b: 412).

I wish to acknowledge with thanks the kindness of Dr. Penn in lending me two lots of specimens from the Tulane Collection and of Dr. G. Robert Lunz, Jr., formerly of the Charleston Museum, who lent me the first specimen of this new species I had seen. Also I express my appreciation to the following who have aided me in securing specimens of this new species: Dr. R. D. Suttkus, Dr. W. R. West, E. A. Crawford, and T. R. Bello.

Procambarus echinatus,[1] n. sp.

Diagnosis.—Rostrum with lateral spines; acumen spiculiform and constituting 41.6–52.0 percent of the total length of the rostrum; postorbital ridges terminating in spines; suborbital angle absent; lateral surface of carapace with two or more spines present just caudad to cervical groove; areola 2.5–4.2 times longer than broad and constituting 21.3–27.4 percent of entire length of carapace. Simple hooks present on ischiopodites of third and fourth pereiopods that extend proximad of distal end of respective basipodites, neither of the latter of which bears an opposable tubercle. First pleopod of first form male (Figs. 1, 5) terminating in four parts: mesial process subspiculiform with only the tip corneous; cephalic process corneous, slender and lying laterad of the central projection; caudal element represented by a truncate poorly defined caudal knob from which arises the subacute, scalelike, corneous caudal process; central projection, the most conspicuous of the terminal elements corneous, subacute and directed at an angle of about 70° to the main shaft of the appendage. Annulus ventralis (Fig. 12), slightly movable and partially concealed by the underhanging multituberculate sternum lying immediately cephalad of it, more than twice as long as broad; a transverse cephalically situated ridge is interrupted by a longitudinal median furrow which continues caudally as the sinuous sinus almost to the midcaudal margin of the annulus; the fossa lies near the median line immediately caudad of the transverse ridge.

Holotypic male, form I.—Body subovate, slightly compressed laterally; abdomen shorter than carapace (59.2–64.0 mm). Height and width of carapace subequal in region of caudodorsal margin of cervical groove (30.0–29.5 mm).

Areola relatively broad and short, about 4.2 times as long as wide with nine fine punctations

[1] *Echinatus*, Latin, set with prickles, prickly. Chosen because of the well-developed spines on the carapace and cheliped of this species.

in narrowest part. Cephalic section of carapace about 2.5 times as long as areola (length of areola about 28.3 percent of entire length of carapace).

Rostrum long with acumen extending beyond peduncle of antennule, excavate; sides convex and terminating at base of acumen in acute cephalolaterally directed spines. Acumen longer than half the remainder of rostrum (10.1 mm). Margins of rostrum not swollen or conspicuously elevated. Upper surface with a few minute punctations. Subrostral ridges poorly developed and not evident in dorsal aspect.

Postorbital ridges prominent, tuberculate, grooved dorsolaterad, and terminating cephalad in acute spines. Suborbital angle absent; branchiostegal spine well developed. Each side of carapace with a row of seven to nine tubercles and spines immediately caudad of cervical groove; upper surface of carapace punctate and lateral surface very strongly granulate.

Cephalic section of telson with two spines in each caudolateral corner. Epistome with a small cephalomedian spine (see fig. 3).

Antennules of the usual form with a strong acute spine present on ventral side of basal segment.

Antennae broken (see description of allotype and morphotype). Antennal scale long, moderately broad; widest slightly proximad of midlength; outer distal margin with a moderately strong spine.

Chela somewhat depressed with the palm somewhat inflated; outer margin of hand slightly concave at base of immovable finger. Hand entirely tuberculate. Inner margin of palm with a row of eight tubercles; a row of four tubercles immediately above this row and a single tubercle below it near distal end; a moderately prominent knoblike tubercle present on lower surface of palm at base of dactyl. Opposable margin of dactyl with a row of 20 knoblike tubercles, fourth from base largest but not forming a distinct emargination; upper surface of dactyl with no distinct longitudinal ridge but with tubercles proximad and setiferous punctations distad; mesial margin of dactyl with a row of 10 tubercles that diminish in size distally; lower surface of dactyl similar to upper surface. Opposable margin of immovable finger deeply concave with an upper row of 19 tubercles, the fifth from base largest, and a distal lower row of six of which the second from base is largest; minute denticles between the tubercles of each row and between the two rows; upper surface of immovable finger with a distinct submedian longitudinal ridge flanked proximally by tubercles and distally by setiferous punctations; lateral surface of immovable finger convex (i.e., distal two-thirds of finger bent mesiad) with tubercles along basal one-third, and distal two thirds with a row of setiferous punctations; lower surface of finger similar to upper surface.

Carpus of first right pereiopod with a broad longitudinal depression flanked on each side by tubercles in poorly defined rows; submedian furrow interrupted distally by a small tubercle near distal margin of podomere. Mesial surface with one large submedian tubercle with a few smaller ones at base and one large one on upper distal margin; below the large submedian tubercle just mentioned are four somewhat smaller ones; lower distal margin with the usual two large tubercles with a row of three small ones proximad of the more mesial tubercle; lateral surface with punctations and a few scattered tubercles.

Merus of first right pereiopod with a few small tubercles and scattered punctations on lateral surface; upper surface with tubercles along entire length, except near distal extremity, with two of the more distal ones larger than the others; mesial surface with a few tubercles distally and somewhat excavate along middle three-fifths, producing a longitudinal furrow near lower margin. Lower surface with two rows of spikelike tubercles, an outer one of 5 and an inner one of 13; two or three additional small tubercles present between and to the sides of these two rows.

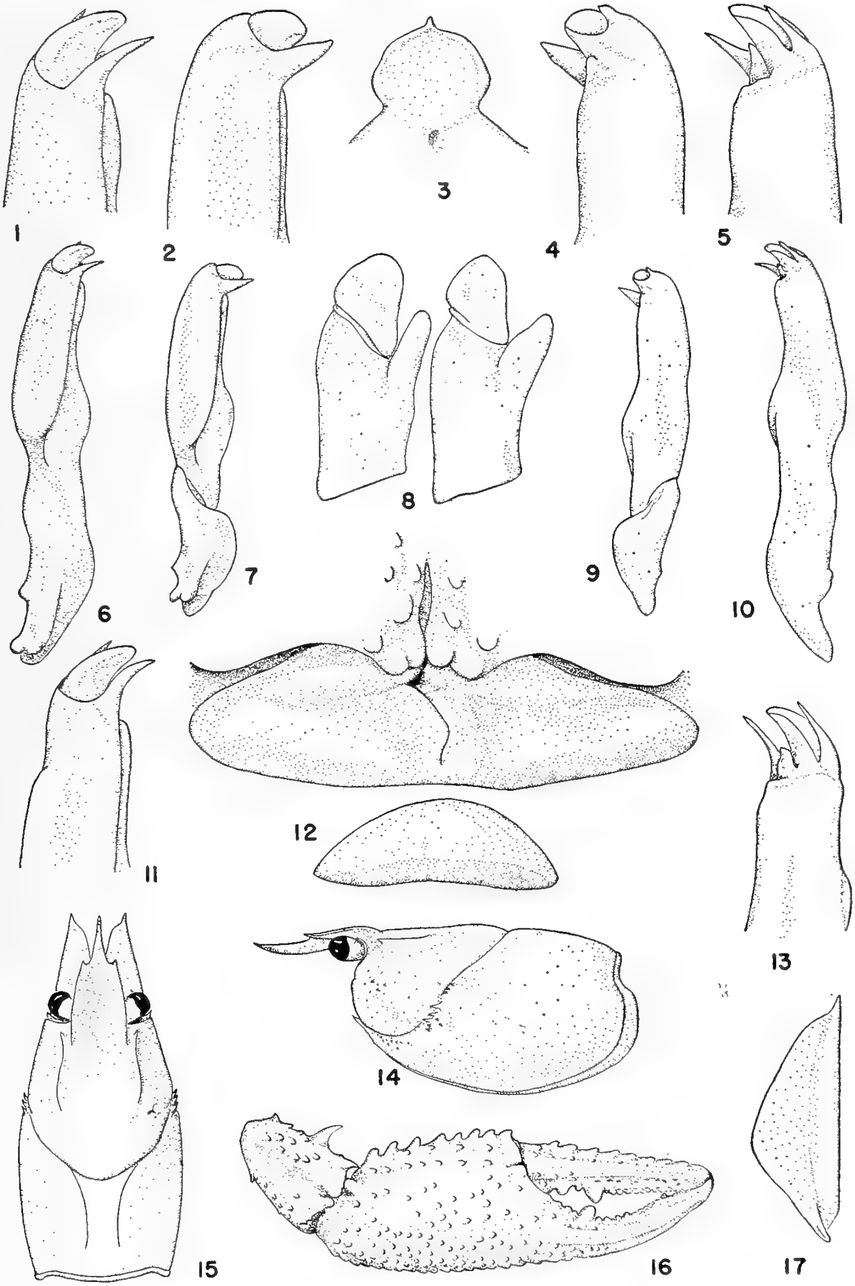
Ischiopodite of first right pereiopod with a row of four tubercles continuing from the lower mesial row on merus.

Basipodite of first right pereiopod without tubercles.

Coxopodite of first right pereiopod with no cephalically projecting spine but with a small caudally projecting one on caudomesial angle.

Hooks present on ischiopodites of third and fourth pereiopods; hooks simple and extend proximad of distal end of their respective basipodites; basipodites bear no opposable tubercles. Coxopodites of fourth and fifth pereiopods with caudomesial projections: that on fourth knoblike, that on fifth more compressed and more sharply defined.

First pleopod reaching coxopodite of third



Figs. 1–17.—*Procambarus echinatus*, n. sp. (pubescence removed from all structures illustrated): 1, Mesial view of distal portion of first pleopod of holotype; 2, mesial view of distal portion of first pleopod of morphotype; 3, epistome of holotype; 4, lateral view of distal portion of first pleopod of morphotype; 5, lateral view of distal portion of first pleopod of holotype; 6, mesial view of first pleopod of holotype; 7, mesial view of first pleopod of morphotype; 8, basipodites and ischiopodites of third and fourth pereiopods of holotype; 9, lateral view of first pleopod of morphotype; 10, lateral view of first pleopod of holotype; 11, mesial view of distal portion of first pleopod of first form male from Aiken County, S.C.; 12, annulus ventralis of allotype; 13, lateral view of distal portion of first pleopod of first form male from Aiken County, S.C.; 14, lateral view of carapace of holotype; 15, dorsal view of carapace of holotype; 16, distal podomeres of cheliped of holotype; 17, antennal scale of holotype.

pereiopod when abdomen is flexed. Tip terminating in four distinct parts (Figs. 1, 5). Mesial process spiculiform and directed caudodistad. Cephalic process, lying laterad of central projection, acute, corneous, and directed caudodistad. Caudal element represented only by the small corneous, laterally compressed caudal process. Central projection prominent, corneous and directed caudodistad similarly as the cephalic process.

Allotypic female.—Differs from the holotype in the following respects: Each side of carapace with a row of seven or ten tubercles and spines; antenna extends caudad to last abdominal segment; row of tubercles on palm above marginal row consists of six; opposable margin of dactyl with a row of 14 tubercles, fourth from base largest; mesial margin of dactyl with a row of 11 tubercles; opposable margin of immovable finger with a row of 11 tubercles, third from base largest, and entire finger only slightly bent mesiad; fewer tubercles present on carpus of chela but major ones situated as in holotype; mesial row of tubercles on lower surface of merus with only 12 tubercles.

Annulus ventralis partially obscured in ventral aspect by multituberculate prominences which extend caudad from sternum immediately cephalad of annulus. Annulus spindle shaped with the greatest length in the transverse axis; cephalic half with an irregular transverse ridge, and caudal half with a median prominence; sinus originates near median line on caudal surface of cephalic ridge and forms a sinuous line which extends caudad almost to midcaudal margin of annulus (see Fig. 12).

Morphotypic male, form II.—Differs from the holotype or allotype in the following respects: Antenna extends caudad almost to caudal margin of telson; opposable margin of dactyl with 16 tubercles; opposable margin of immovable finger with an upper row of 17 tubercles and a lower distal one of four; ischiopodite of first pereiopod with three or four tubercles; secondary sexual characters as in holotype but much reduced in size.

First pleopod with all processes represented, although none corneous, and while less well defined are all similarly situated as in holotype but directed more caudad (see Figs. 2, 4).

Measurements.—As follows (in millimeters):

	Holotype	Allotype	Morphotype
Carapace—height	30	24.8	25.7
width	29.7	25.2	26.0
length	64.0	54.5	54.9
Areola—length	18.1	14.5	15.0
width	4.3	4.4	4.2
Rostrum—length	22.5	19.2	19.3
width	9.9	8.5	8.5
Right chela—			
length of inner margin of palm	21.4	9.7	13.0
width of palm	21.0	9.7	12.7
length of outer margin of hand	59.5	29.0	37.0
length of dactyl	32.1	16.3	20.7

Type locality.—Salkehatchie River, 1.9 miles south of Barnwell, Barnwell County, S. C., on State Highway 3. Here the stream varies from 10 to 100 feet across with a sand and mud bottom. The water is dark brown, with little silt suspension, and in many places flows with a moderate current through dense growths of *Vallisneria* and *Saururus cernuus.* My specimens were taken after dark resting on eel grass in the swifter reaches of the stream and on submerged roots near the surface of the water.

Disposition of types.—The holotypic male, the allotypic female, and the morphotypic male are deposited in the United States National Museum (nos. 99180, 99181, 99182, respectively). The following paratypes are retained in my personal collection at the University of Virginia: 9-349-7a—type locality (1 ♀), W. R. West and H.H.H., coll.; 4-1955-6a—type locality (1 ♀, 4 juv. ♂♂, 1 juv. ♀), E. A. Crawford, T. R. Bello and H.H.H., coll.; 9-349-6a—Georges Creek, 9 miles southeast of Barnwell on State Highway 64 (1♂II, 3 juv. ♀♀), W. R. West and H.H.H., coll.

Specimens examined.—In addition to the types mentioned above, the following specimens from the Edisto River system in Aiken County, S. C., are available: 6-749-2—trib. s. fork of Edisto River, 11.2 mi. n. of Aiken (1♂II), R. D. Suttkus, coll.; 8-1952-2a—creek, 10.7 mi. n. of Aiken on U. S. Rt. 1 (5♂♂II, 13♀♀, 3 juv. ♂♂, 4 juv. ♀♀), H.H.H., coll.; 4-1955-4a—Bridge Creek, 10.6 mi. n. of Aiken on U. S. Rt. 1 (1♂I, 4♀♀II, 8♀♀, 13 juv. ♂♂, 12 juv. ♀♀), E. A. C., T. R. B., and H. H. H., coll.; 4-1955-5, south fork of Edisto River, 12.3 mi. n. of Aiken on U. S. Rt. 1 (2♀♀, 1 juv. ♂), E.A.C., T.R.B., and H.H.H.; 9-1355-1a, same as preceding (1♂I, 3♀♀II, 3♀♀, 2 juv. ♂♂, 4 juv. ♀♀), H.H.H., coll.; 4-1955-3a—Shaws Creek, 16.1 mi. sw. of Wagener on St. Rt. 215 (4 juv. ♂♂, 1 juv. ♀) E.A.C., T.R.B., H.H.H., coll.; Tulane University (T.U.) 3311-17.5 mi. s. of Batesburg on St. Rt. 391 (1♂II, 8 juv. ♂♂, 4 juv. ♀♀), G. H. Penn and J. B. Black, coll.; T.U. 3312—5.7 mi. ne. of Aiken on St. Hy. 391 (1♂II, 3♀♀, 1 juv. ♂, 4 juv. ♀♀), G.H.P. and J.B.B., coll.

Color notes.—Carapace olive-green dorsad, fading ventrally into creamy white with ridges edged in black. In addition to the ground color of carapace the cephalic region is marked by a broad distinctly U-shaped black yolk following the contour of the cervical groove; however, base of U not continous but broken between attachments of mandibular muscle. Thoracic portion of carapace with a similarly disposed and broken U-shaped black marking—the broken portion occurring at caudal end of areola. Abdominal segments greenish with caudal portion bright blue bearing reddish-purple and vivid red markings. Chela reddish black with white tubercles; distal portion of fingers red but fading at the extreme distal ends into the yellow corneous spines.

Variations—While there are a considerable number of variations from specimen to specimen, none of these, including ratios of body parts, has been demonstrated to be correlated with any of the several local populations represented. Indeed, there is almost as much variation between individuals collected from the type locality as there are between any one of them and specimens taken elsewhere. Only in the number of spines along the cervical groove and in minor details of the first pleopod of the male may specimens from the Edisto drainage be distinguished from those from the Salkehatchie. Specimens from the latter all have from three to five spines on each side of the carapace, whereas those from the Edisto usually have only two, although as many as four are present on one side of two of the specimens examined. There are so few first form males available, one from the Salkehatchie and two from the Edisto, that it is not known how much variation does exist; for this reason the first pleopod of specimens from both drainage systems are figured (cf. Figs. 1 and 11; 5 and 13).

Relationships.—*Procambarus echinatus* has its closest affinities with *Procambarus dupratzi* (Penn) but may readily be distinguished from the latter by the absence of a carina on the rostrum and by the form of the caudal element of the first pleopod of the first-form male.

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Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labor in the minute sifting of numerical results.—LORD KELVIN, *Report of the British Association for the Advancement of Science* **41:** 91. 1871.

ZOOLOGY.—*A new entoniscid (Crustacea: Isopoda) from the Pacific coast.* LEONARD MUSCATINE, University of California, Berkeley. (Communicated by Fenner A. Chace, Jr.)

The occurrence on the American west coast of an entoniscid isopod has been recognized for some time, although the only known printed reference is that of Menzies and Miller in Light et al. (1954), p. 141. There they report that "a genus closely related to *Portunion*" is parasitic on *Hemigrapsus oregonensis* in the San Francisco Bay region. On the basis of the systematic arrangement of the 11 known genera of the family which is included in the work of Shiino (1942) on the Entoniscidae of Japan, the form mentioned by Menzies and Miller has been established as a member of the genus *Portunion* and, further, has been found to be an undescribed species. The description below follows the terminology of Shiino throughout.

This problem was suggested to me by Dr. Cadet Hand, of the Department of Zoology, University of California, Berkeley, and I am grateful to him for much kind advice and criticism.

Genus **Portunion** Giard and Bonnier, 1886

Female with two ventral and a pair of anterodorsal ovarian processes. Marsupium complete; ascendant lamellae of first pair of oöstegites entirely covered by second pair. First four abdominal segments have folded pleural lamellae. Male cephalon fused with, or distinct from, first thoracic segment. Abdomen bears ventromedian hooks. Sixth peraeopod of epicaridium neither prehensile nor longer than others; propodus with simple process at its tip and rudimentary dactylus. (From Shiino.)

Portunion conformis, n. sp.

Female (Fig. 1A, B, E): From hood to tip of posterior medioventral ovarian process ca. 15 mm long; abdomen ca. 8 mm long in the largest specimen. Marsupium, when full of ova, yellowish; full of epicaridian larvae, brown to dark brown; ovary whitish to yellow; abdomen white. Exopodite of maxilliped broad, surface wrinkled, edges frilled and thicker than central portion; coxopodite egg-shaped, smaller than exopodite; endopodite lamellar, lying beneath the coxopodite with medial border exposed. Cephalon a pair of spheres separate from the thorax. Two pairs of antennae inserted on the cephalon dorsal to the maxillipeds in the form of parallel ridges; the external antenna slightly smaller than the internal. Dorsal ovarian processes arise from middle of thorax and incline anteriorly; of the two ventral processes, the anterior is shorter and arises vertically from the thorax, forming a right angle with the posterior which projects backwards except in gravid females where the processes are somewhat displaced. Thorax cylindrical, bearing five pairs of oöstegites (Fig. 1B); first pair inserted under maxillipeds and each divided into ascendant, transverse and recurrent lamellae (Fig. 1E); ascendant lamellae project anteriorly over the cephalon and continuous with the transverse lamellae which curve laterally; both somewhat thickened and supported by a vein at their inner margin; recurrent lamellae extend posteriorly the length of the thorax and curve around the posterior ventral ovarian process; these lamellae relatively thin and supported by a vein running down the center with numerous branches to the outer margins. The second pair of oöstegites curves anteriorly over the cephalon, covering the first pair and forming the hood; members of this pair meet on median ventral line forming a conspicuous inpocketing, but do not fuse. The three remaining pairs of oöstegites inserted laterally on the thorax and closely applied to the host membrane; they overlap medially in young specimens and may overlap one another longitudinally without fusing, thereby remaining easily distinguishable; fifth pair slightly larger than third and fourth owing to an antero-posterior elongation of the distal border. In mature specimens, all oöstegites meet their fellow on the opposite side, enclosing the recurrent lamellae of the first pair, and forming the brood pouch. The lateral protuberances of the thorax are irregularly-shaped bodies which occur in pairs (Fig. 1B); the larger usually spherical while the smaller is curved or peduncular. The second to fifth peraeopoda mentioned by Shiino and earlier authors are difficult to discern in this species.

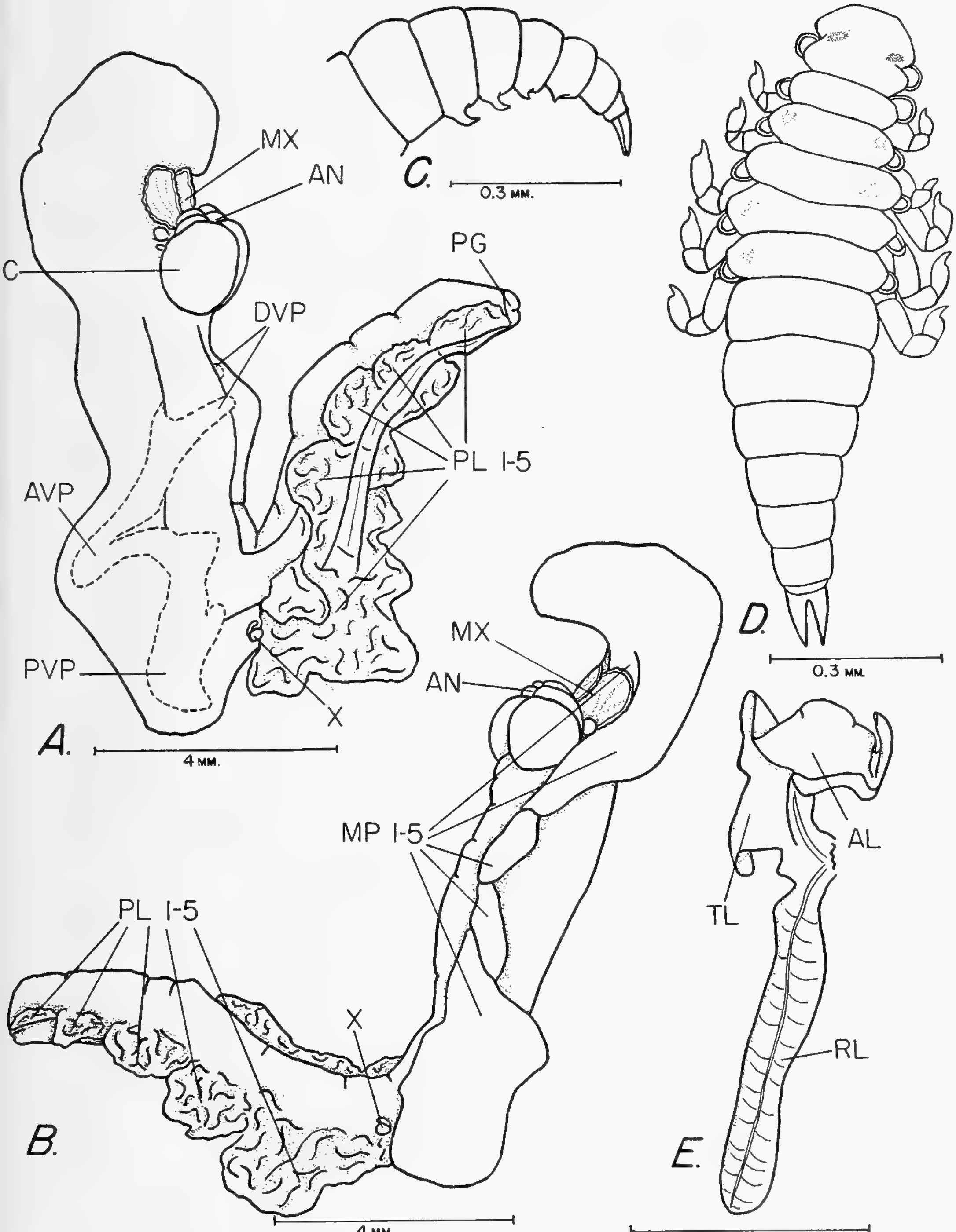

Fig. 1.—*Portunion conformis*, n. sp.: A, ♀ with thorax enclosed in host membrane; B, young ♀ with host membrane removed; C, ♂ abdomen; D, dorsal view of mature ♂; E, oöstegite I. (Abbreviations: *al* ascendant lamella, *an* antenna, *avp* anterior medio-ventral ovarian process, *c* cephalon, *dvp* dorsal ovarian process, *mp* oöstegite, *mx* maxilliped, *pg* pygidium, *pl* pleural lamella, *pvp* posterior medio-ventral ovarian process, *rl* recurrent lamella, *tl* transverse lamella, *x* lateral protuberance of thorax.)

They seem to be represented by thickenings of the anterior border of the last three oöstegites and the peduncular member of the lateral protuberance of the thorax; of these the latter is most conspicuous and corresponds to the seventh peraeopod described by Shiino in *P. flavidus.* The abdomen bears five pairs of pleural lamellae (Fig. 1A, B); the first pair much larger than the remaining pairs and with a highly crispate margin; the rest become pro-

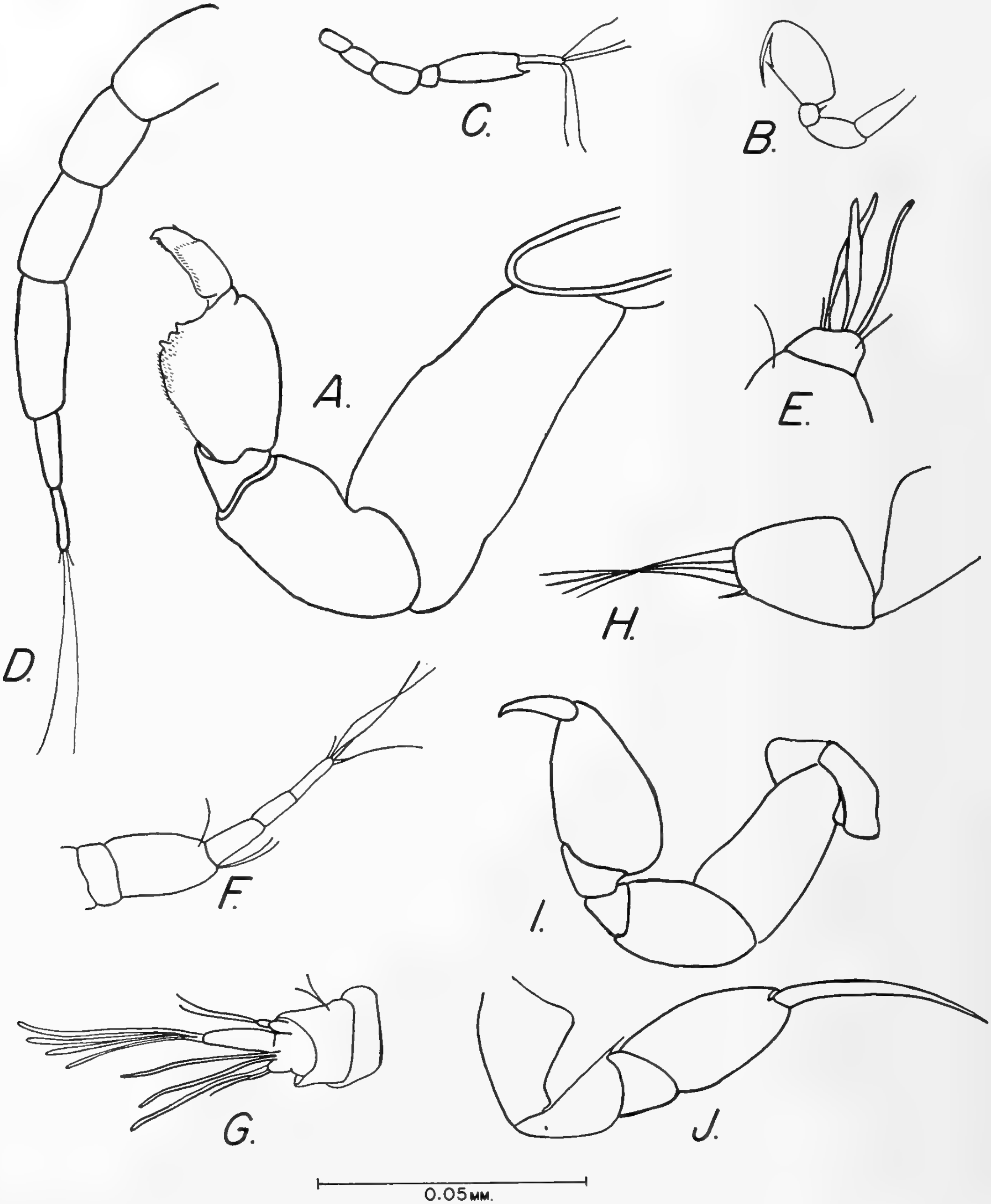

FIG. 2.—*Portunion conformis*, n. sp.: A, ♂ peraeopod IV; B–E, epicaridium (B, paraeopod I; C, peraeopod VI; D, antenna; E, antennule); F–J, cryptoniscium (F, antenna; G, antennule; H, pleopod; I, peraeopod I; J, peraeopod VII).

gressively smaller from front to back and the complexity of the marginal folds lessens; the fifth is a simple triangular lamella. The pleopoda uniramous and overlap their members on opposite sides. The pygidium small, bifurcated and curved slightly ventrally. The third abdominal segment often bulges on its dorsal surface, indicating the position of the heart.

Male (Fig. 1C, D): 1.1 mm long and at fourth thoracic segment 0.3 mm wide with scattered brown to dark brown pigment patches. Cephalon fused with first thoracic segment but distinguishable ventrally and laterally. Antennules rounded bosses bearing many small setae. Antennae absent. Oral cone bears styliform mandibles. Lateral parts of thoracic segments slightly attenuated except last segment which has a truncate margin. Coxal plates well developed and projecting laterally. Peraeopoda 5-jointed; carpopropodus and dactylus clad with rows of spinules; distal margin of carpopropodus bears blunt processes (Fig. 2A). Ventral spines on first three abdominal segments hooklike with pointed tip (Fig. 1C); that of fourth reduced; other segments lacking spines. Bifid ends of last segment straight, inclined ventrally at tips and more or less smooth (Fig. 1C, D).

Epicaridium (Fig. 2B–E): 0.26 mm long and 0.11 mm wide. First five peraeopoda 6-jointed with propodus bearing a short process at lateral end of distal margin and merus with small seta on its external margin (Fig. 2B). Sixth peraeopoda with dactylus straight and surmounted by a crown of long setae; propodus ends in a short pointed process (Fig. 2C).

Cryptoniscium (Fig. 2F–J): 0.5 mm long and 0.16 mm wide. Body wider anteriorly than posteriorly. General pigmentation brown in scattered patches; eye pigments darker than other pigments and well defined. Antenna 6-jointed, basal three parts larger than distal three; third bears three short hairs and sixth ends in a bundle of long hairs (Fig. 2F). Antennule 4-jointed; second joint with short setae on anterior margin; third narrower and bearing three bundles of short hairs, the outer two bundles arising from jointed tubercles; fourth still narrower, surmounted by two rami, each of which ends in long hairs (Fig. 2G). Peraeopoda 6-jointed (Fig. 2I); last peraeopod more slender than others, merus with long spine continuous with its distal margin (Fig. 2J). Exopodite of pleopod bears four long setae and one short seta (Fig. 2H).

Distribution and habitat: Taken from Berkeley Yacht Harbor and Bay Farm Island on San Francisco Bay, Calif., and Drake's Lagoon, Marin County, Calif., where they are parasitic on *Hemigrapsus oregonensis*.

Type locality: Berkeley Yacht Harbor, Berkeley, Calif.

Types: The following specimens have been deposited in the United States National Museum: (1) Holotype, 1 adult female, U.S.N.M. no. 99177; (2) allotype, 1 adult male, U.S.N.M. no. 99178; (3) paratypes, 6 females, U.S.N.M. no. 99179.

Discussion: 372 crabs were examined from which 85 female entoniscids were obtained. These apparently included all stages of development. The frequency of infection is shown in the accompanying table.

	Host	Uninfected	Infected	Total	Percent infected	Locality
August 16	♂	50	4	54	7.4	Berkeley Yacht
1955	♀	8	0	8	0	Harbor
August 23	♂	61	12	73	16.4	Berkeley Yacht
1955	♀	3	1	4	25.0	Harbor
August 31	♂	50	5	55	9.1	Berkeley Yacht
1955	♀	8	1	9	11.1	Harbor
September 6	♂	22	6	28	21.4	Drake's Lagoon
1955	♀	17	2	19	10.5	
November 3	♂	12	12	24	50.0	Berkeley Yacht
1955	♀	1	16	17	94.1	Harbor
December 8	♂	41	12	53	22.6	Bay Farm Island
1955	♀	10	8	18	44.1	
TOTALS	♂	236	51	287	17.7	
	♀	57	28	85	32.9	
	♂ and ♀	293	79	372	21.2	

Simultaneous infection of a single host by more than one parasite occurred often. Where four were found in one host, they were all of the "asticot" stage. In cases where two parasites infected a single host, they were both mature and often gravid. Of the six male entoniscids examined, all were found on the females, either on the pleural lamellae, in the dorsal groove of the thorax, or on the abdomen in the mid-ventral line. In no cases were females accompanied by more than one male. Cryptoniscan larvae occurred frequently on females of all stages.

Unlike such cases as the infection of *Pinnotheres*

		P. maenadis	P. kossmanni	P. flavidus	P. conformis
Female	Ventral processes	Both processes directed backward	Anterior directed forwards, the posterior backward	Anterior vertical to thorax, posterior directed backward	Anterior vertical to thorax, posterior directed backward
Male	Cephalon	Distinct from thorax	Distinct from thorax	Fused with 1st thoracic segment	Fused with 1st thoracic segment
	Antenna	Present	?	Absent	Absent
	Abdominal hooks	In segments I–IV	In segments I–IV	In segments I–II	In segments I–IV
Epicaridium	Dactylus of peraeopod VI	Setose	?	Not setose	Setose

pisum by the entoniscid *Pinnotherion vermiforme* Giard and Bonnier as reported by Atkins (1933), where the thinness of the host's carapace reveals the presence of the parasite, the new species cannot be detected by external signs. The infected hosts appear perfectly normal and the presence of a parasite can only be determined by dissection.

The adult parasite is usually found on its side in the visceral cavity of the host. The body is V-shaped, head and thorax pointing anteriorly forming one arm, and the abdomen the other. The hepatic tissues of the host surround the head and abdomen of the parasite while the junction of thorax and abdomen lies under the alimentary canal.

Of the five species of *Portunion* previously described, *P. moniezii* Giard and *P. salvatoris* Kossman are poorly defined. However, *P. conformis*, the new species, has short, straight, ventral ovarian processes which distinguishes it from *P. salvatoris*. The greatly developed first pair of oöstegites of the new species distinguishes it from *P. moniezii*. It differs from the three remaining species as shown in the table above.

The species *P. flavidus* is commonly found infecting *Pachygrapsus crassipes* in Japan. This crab is a prominent member of the American west coast intertidal fauna and one might expect to find *P. flavidus* here. However, examination of 22 specimens of *P. crassipes* has failed to disclose any entoniscids.

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Experiment is the interpreter of nature. Experiments never deceive. It is our judgment which sometimes deceives itself because it expects results which experiment refuses. We must consult experiment, varying the circumstances, until we have deduced general rules, for experiment alone can furnish reliable rules.—Leonardo da Vinci.

ZOOLOGY.—*Cossura pygodactylata, a new annelid from San Francisco Bay (Polychaeta: Cirratulidae).*

Meredith L. Jones, University of California, Berkeley. (Communicated by Fenner A. Chace, Jr.)

In the course of sampling the benthic fauna off Point Richmond, San Francisco Bay, Calif. (Jones, 1954), numerous specimens of a polychaete worm of the family Cirratulidae were found. At the outset they were tentatively identified as *Cossura longocirrata* Webster and Benedict, but subsequent examination revealed characters differing sufficiently from the original description to justify setting up a new species for these worms.

Webster and Benedict (1887) erected the genus *Cossura* for the single species *C. longocirrata* from Eastport, Maine. Of their specimens only one was complete, the remainder apparently being anterior portions. Eliason (1920) found specimens which he tentatively identified as *C. longocirrata* in the Øresund, Denmark. He noted minor differences in the shape of the prostomium and the dimensions of the unpaired cirrus. In the following year, Thulin (1921) confirmed Eliason's identification and gave a detailed description of the species, based on well-preserved specimens from the Øresund. Mrs. E. Wesenburg-Lund (personal communication) has identified *C. longocirrata* in collections from the North Atlantic and from the coast of Chile.

Cossura has been reported from the Pacific coast of North America several times. Hartman (1952) identified *C. longocirrata* in collections from the Los Angeles–Long Beach area, and Reish and Winter (1954) recorded the same species from Alamitos Bay, California. Hartman (1954) in a checklist of the annelids of San Francisco Bay, listed "*Cossura* nr. *longicirrata*" and credited the author (M. J.) with its collection. In the preliminary results of her study of the benthos of the San Pedro Basin, Hartman (1955) reported specimens of *Cossura* sp. and has recently described this as a new species, *Cossura candida* (Hartman, 1955a). It should be noted that in the description of *C. candida,* Hartman has included the "*Cossura* nr. *longicirrata* (sic) . . ." of her San Francisco Bay checklist in the synonymy and distribution record of *C. candida*. Actually "*C.* nr. *longicirrata*" is the species to be described here and *C. candida* is not known to occur in San Francisco Bay.

Family Cirratulidae

Genus **Cossura** Webster and Benedict, 1887

Cossura pygodactylata, n. sp.

Fig. 1, A–F

Cossura longocirrata Jones, 1954, pp. 36, 37, 48, 83, et al.

Cossura nr. *longicirrata* Hartman, 1954, pp. 11, 15.

Cossura nr. *longicirrata* (sic) Hartman, 1955a, pp. 44 and 45 (in synonymy and distribution record of *Cossura candida*).

The specimens under consideration were collected from mud off Point Richmond, San Francisco Bay, Calif., at depths of 3, 5, and 30 feet below mean lower low water, and were most numerous at the lowest depth. Approximately 100 specimens were obtained; of these, 15 were entire, the remainder having fragmented when preserved with 10 percent formalin. Several observations of living, intact animals were also made.

Preserved, whole, mature specimens of *Cossura pygodactylata* are 6 to 7 mm in length and about 0.3 mm wide at the 14th (widest) setiger. The number of segments varies from 43 to 56.

Contrary to the observations of Eliason (1920) and Thulin (1921) on *C. longocirrata, C. pygodactylata* appears to secrete no well-defined tube. The living animal secretes mucus along the body, to which material (fecal pellets, debris) may adhere, giving the impression of a very loosely constructed tube.

The body is composed of three general regions. The anterior region extends to the 17th–19th setiger and the segmental length is 80–100 micra; the setae occur in bundles at the anterior edge of each segment. The midregion extends back to about 12–20 segments from the pygidium and segmental length is 280–340 micra; the setae are centrally located on each segment. The posterior region consists of 12–20 segments and the segmental length is 100–120 micra; the setae are centrally placed on each segment. Characteristically, fragmentation occurs just posterior to the beginning of the midregion.

There are no defined parapodia. The setae appear to arise from depressed areas on the body surface, and the bulging of the body surface anterior and posterior to these areas may give the impression of parapodia, with pre- and postsetal lobes (Figs. 1b, 1d, 1e). A ring of thickened tissue surrounds each area of setal insertion (Fig. 1c, TR).

Setae are all simple and vary from capillary to narrowly limbate. They are inserted in two vertical series; the anterior series are composed of coarser setae which are directed from perpendicular to the body axis to slightly posterior of perpendicular; the posterior series consist of slightly finer setae which are swept posteriorly.

The prostomium is conical and devoid of appendages (Fig. 1a), and no sense organs such as eyespots or Thulin's (1921, p. 4) "knopfenförmiges Organ" (button-shaped organ) have been observed. Near its base the prostomium bears a transverse furrow (Fig. 1a, PF), which, as both Eliason and Thulin have observed in *C. longocirrata*, gives a misleading impression that the basal portion is an achaetous segment. In both cleared whole mounts and frontal sections it is seen that the longitudinal muscle bundles are inserted at this point. It seems probable that the furrow is produced as these muscles contract at fixation. The peristomial segment has neither setae nor appendages. The next segment, the 1st setiger, bears a bundle of about six setae on either side. These are nearly perpendicular to the body axis, and their tips are slightly curved posteriorly. The 2d setiger bears a single dorsal median cirrus at its posterior border.

The cirrus remains attached throughout preservation and subsequent washing, but the tip is easily broken off. In one case, a preserved fragmented specimen of 21 segments (3 mm) possessed a cirrus 14 mm in length. Near its point of attachment the cirrus is constricted slightly; it then enlarges to its maximum diameter at the level of the 9th setiger and tapers gradually to its free end. In preserved specimens the cirrus shows a central core of muscle fibers running throughout its length, and the surface epithelium is circularly wrinkled as if it were capable of extreme extension when living. In life the cirrus trails close to the dorsal surface of the body.

The 2d to 6th setigers carry approximately 12 setae on either side (Fig. 1b), and all setae, to the 6th setiger, appear to arise with no indication of noto- and neurosetal bundles. The dorsal setae of these anterior setigers project laterally (most of them are in the anterior series), while the more ventral ones tend to be inclined posteriorly (the posterior series). Further along the body, the dorsal setae become recurved and the ventral setae become more recurved until they are almost parallel to the body surface (Fig. 1c). At about the 7th to 8th setiger, it is possible to differentiate noto- and neurosetal bundles and the number of setae increases to 16–18 per side (Fig. 1d). This number and disposition continue through the remainder of the anterior region to about the 17th to 19th setiger.

The midregion is characterized by longer segments and, in the case of ovigerous females, by the presence of many large eggs. The setae in this region arise in the middle of each segment and are slightly recurved. There are from 4 to 6 notosetae and a like number of neurosetae in this region (Fig. 1e).

In the posterior region the number of setae is gradually reduced from 4–6 in each bundle to 2 notosetae and 2 neurosetae on each side in the segments just preceding the pygidium. In the posterior region, the setae are directed more and more anteriorly as the anal segment is approached. In preserved material, the segments of the ovigerous and following region take on a moniliform appearence, which has not been observed in living material.

The eggs are oval and up to 140 micra long by 100 micra wide. A single segment may contain as many as forty eggs. All specimens large enough to be considered mature and which had not fragmented anterior to the ovigerous region, contained eggs. Unequivocal males have not been observed.

The pygidium or anal segment (Fig. 1f) is cleft in the dorso-ventral plane to form two lateral lobes (AL). It has three long cirri (PC) up to 0.7 mm in length (approximately as long as the last 10 segments). Two of these are inserted dorsolaterally on the outer surface of the anal lobes; the 3rd is inserted ventrally, where the lobes join. Along the margin of each anal lobe are 6–10 fingerlike processes approximately 0.1 mm long (PP). No mention of these is made by either Webster and Benedict (1887) or Thulin (1921) in their descriptions of *C. longocirrata*, or by Hartman (1955a) in her description

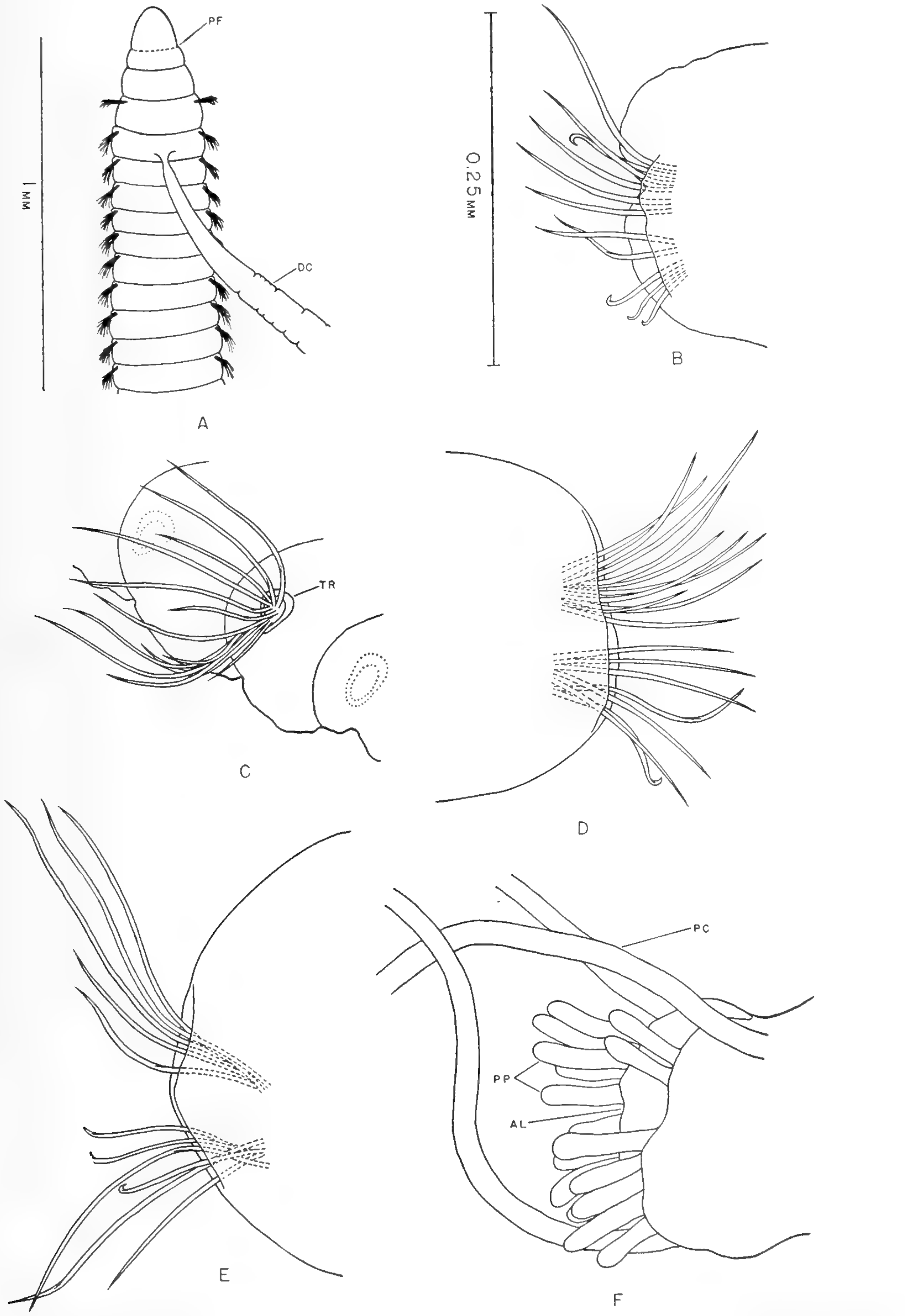

Fig. 1.—*Cossura pygodactylata*, n. sp.: *a*, Dorsal view of the anterior end of the animal; *b*, 5th right setiger in anterior view (setae appear bent or hooked in the figures to indicate their curving posteriorly); *c*, 5th right setiger in dorsolateral view, dotted areas show the position of the setal bundles of the 4th and 6th setigers; *d*, 9th left setiger in anterior view; *e*, 25th right setiger in anterior view; *f*, lateral view of the pygidium. Figures 1c, 1d, 1e, and 1f are to the same scale as 1b. (Abbreviations are as follows; AL—anal lobe; DC—dorsal cirrus; PC—pygidial cirrus; PF—prostomial furrow; PP—pygidial processes; and TR—thickened ring of tissue.)

of *C. candida.* These processes are the most obvious character separating the new species from the other species of *Cossura,* and the new specific name is based on their presence. In living animals it has been observed that these pygidial processes are not retractile.

Unfortunately, only 2 specimens were observed with the proboscis everted. The proboscis apparently has 4–8 finger-shaped processes directed anteriorly, and they appear to be similar to those shown by Thulin (1921, Fig. 2) for *C. longocirrata.*

A table comparing the described species of *Cossura* is presented. It is based on the work of Webster and Benedict (1887), Eliason (1920), Thulin (1921), Hartman (1955a), and the present description.

	C. longocirrata	*C. pygodactylata*	*C. candida*
Insertion of cirrus	2d setiger	2d setiger	3d setiger
Pygidial processes	Absent	6–10 on each anal lobe	Absent
Length	6–12 mm	6–7 mm	7–10 mm
Width	0.35–0.8 mm	0.3 mm	0.5–0.7 mm
Number of segments	50–70	43–56	50–75
Sense organs on prostomium	Present	Absent	Nuchal organs present at sides of prostomium.[1]
Number of setae per segment	8–18	8–18	12–16
Character of tube	Thin, rather long, membranous	None	Present on some.[1]
Depth where found	6–120 feet	3–30 feet	36–2640 feet
Distribution	Eastport, Maine; Øresund, Denmark; North Atlantic; coast of Chile.	San Francisco Bay, Calif.	Southern California.

[1] According to personal communication from Dr. Olga Hartman.

The holotype of *Cossura pygodactylata* (U.S.N.M. no. 27609) and the paratypes (U.S.N.M. no. 27610) have been deposited with the U. S. National Museum.

The author is indebted to Dr. Cadet Hand, of the Department of Zoology, University of California, Berkeley, to Dr. Olga Hartman, of the Allan Hancock Foundation, University of Southern California, and to Mrs. Elise Wesenburg-Lund, of the Zoological Museum, Copenhagen, Denmark, for their kind advice and criticism.

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MAMMALOGY.—*Two new long-tailed pocket mice* (Perognathus formosus) *from Arizona*. E. Lendell Cockrum, University of Arizona. (Communicated by Charles O. Handley, Jr.)

In the summer of 1953 I spent some time in Washington, D. C., studying the mammals from Arizona in the collections of the United States National Museum (including the Biological Surveys collection). Long-tailed pocket mice occur, in Arizona, only in the Arizona "strip," that is, the area north and west of the Colorado River. Attempts to determine the subspecific status of the specimens in the Biological Surveys collection revealed the presence of two heretofore unnamed subspecies. The following descriptions were, in part, prepared at that time.

In December 1953 I visited the Museum of Vertebrate Zoology, at the University of California, Berkeley, California. In this collection are a number of long-tailed pocket mice from Arizona. Discussion with Dr. Seth B. Benson revealed that, on the basis of the specimens in that collection, he had recognized the presence of the two unnamed subspecies. Dr. Benson has kindly given me permission to publish the descriptions, incorporating the data available from the specimens in his care.

Grateful acknowledgement is made to the National Science Foundation for a research grant (G-333, Investigations of the Mammals of Arizona) for financial assistance; to Drs. Remington Kellogg, David Johnson, and Henry Setzer, of the U. S. National Museum; to Dr. John W. Aldrich and Miss Viola Schantz, of the U. S. Fish and Wildlife Service; and to Drs. Alden Miller and Seth Benson, of the Museum of Zoology at Berkeley for permission to examine the material in the collections under their care as well as for their personal kindnesses.

Perognathus formosus domisaxensis,[1] n. subsp.

Type.—Adult female, skin and skull, U.S.N.M. no. 249006, Biological Surveys collection; from Houserock Valley, 15 miles west of [the Navajo] bridge, Coconino County, Ariz., collected August 6, 1929, by Vernon Bailey, original number 10758.

Distribution.—Insofar as is now known, this subspecies occurs in Arizona west of the Colorado River, north of the Kaibab Plateau, south of the Paria Plateau, and east of the Kanab Plateau.

Diagnostic characters and comparisons.—A small-sized race of *Perognathus formosus*. Similar to *P. f. formosus* in general color but much smaller in size (see measurements). The occipitonasal length, the frontonasal length, the length of the bullae, and the basilar length are all less than in *P. f. formosus* or *P. f. mohavensis*. The auditory bullae are least inflated in *P. f. domisaxensis*, but the inflation of the brain case is, proportionally, about as in *P. f. formosus*.

Color.—Basal portions of hair near Gray (Gull Gray)[2]; subterminal band close to Light Buff; terminal portion of hairs tipped with dusky. The color of subterminal portion dominates the color of the dorsal surface.

Measurements.—Type: Total length, 185; tail vertebrae, 111; hind foot, 24; ear, 11. Two topotypes, 1 male and 1 female, respectively, 184, 175; 105, 100; 23, 23; 11, 11. *Skull* (type, followed by measurements of 1 male and 1 female topotype): Occipitonasal length, 25.3 (00.0, 24.9); frontonasal length, 16.9 (00.0, 16.8); mastoidal breadth, 13.6 (13.6, 13.5); length of bulla, 8.7 (8.6, 8.2); interorbital constriction, 6.6 (6.4, 6.5); alveolar length upper tooth row, 3.8 (3.6, 3.7); length of interparietal, 3.7 (3.4, 3.4); width of interparietal, 6.4 (6.1, 6.0); basilar length, 18.1 (17.9, 17.5).

Remarks.—Two of the three specimens from the type locality show considerable rosaceous staining. This strain is evident on the usually white hairs of the venter as well as on the dorsal surface. As a result these appear to be much lighter and brighter.

Specimens examined.—Total, 32, distributed as follows: 6 mi. se. of Fredonia, 1, BS; Houserock Valley, 15 mi. w. of Bridge, 3 (BS); Soap Creek, 15 mi. sw. Lees Ferry, 1 (BS); 2 mi. w. of Lees Ferry (BS); 3,250 ft., 11 (MVZ); 6 mi. w. of Grand Canyon Bridge, Marble Canyon, 3,800 ft., 13 (MVZ).

[1] From *domus*, house, and *saxum*, rock, as this subspecies is known from Houserock Valley.

[2] Capitalized color terms after Ridgway, *Color standards and color nomenclature*, 1912.

Perognathus formosus melanocaudus, n. subsp.

Type.—Adult female, skin and skull, U.S.N.M. no. 262918, Biological Surveys collection; from the lower end of Toroweap Valley (Rim of Grand Canyon), Mohave County, Ariz.; collected July 30, 1937, by Luther C. Goldman, original number 341.

Distribution.—In so far as is now known, this subspecies is restricted to the region of the type locality.

Diagnostic characters and comparisons.—A dark-colored race of *Perognathus formosus* (similar to *P. f. formosus* in general size (see measurements) but auditory bullae and brain case more inflated and interorbital region more constricted; distinctly darker in general dorsal coloration including dorsal part of tail. These same conditions are evident when comparisons are made with *P. f. mohavensis* and *P. f. domisaxensis.*

Color.—Basal portions of hairs near Gray (Dark Dull Gray), Gray (Gull Gray) in *P. formosus formosus* and *P. f. domisaxensis*; subterminal band close to Pinkish Buff is quite narrow; terminal portion of hairs tipped with black. The basal and terminal colors dominate the color of the dorsal surface.

Measurements.—Type: Total length, 190; tail vertebrae, 111; hind foot, 25. Two adult female topotypes, as follows: 193, 188; 104, 108; 24, 24. *Skull* (type and two adult female topotypes) Occipitonasal length, 26.7 (26.5, 26.2); frontonasal length, 18.3 (18.1, 17.7); mastoidal breadth, 14.4 (13.9, 14.4); length of bulla, 9.0 (8.9, 8.8); interorbital constriction, 6.4 (6.3, 6.7); alveolar length upper cheek teeth, 3.8 (3.9, 3.8); length of interparietal, 3.7 (3.9, 3.8); width of interparietal, 6.0 (6.1, 6.3); basilar length, 18.2 (18.5, 17.8).

Remarks.—The series of animals in the Biological Survey collection from the Toroweap Valley all show signs of molting. Further, most of the animals were young when taken. However, the young are much darker than those of similar age and pelage condition from all other localities represented.

Specimens from four miles north of Wolf Hole and 12 miles north of Wolf Hole, here referred to *P. f. formosus*, are intergrades between *P. f. melanocaudus* and *P. f. formosus*. This is demonstrated by the intermediate nature of the inflation of the auditory bullae, inflation of the braincase, interorbital width, and pelage color.

Specimens examined.—Total, 52, as follows: Lower end of Toroweap Valley, 16, BS; Lower end of Toroweap Valley, 4200 ft., 36, MVZ.

Comparative material—Perognathus formosus formosus: UTAH: St. George, 17 (BS). ARIZONA: 4 mi. n. of Wolfe Hole, 1 (BS); 6 mi. n. of Wolfe Hole, 4,900 ft., 4 (MVZ); 10 mi. n. of Wolf Hole, 3,800 ft., 10 (MVZ); 12 mi. n. of Wolf Hole, 3,500 ft., on road to St. George, Utah, 17 (BS). *Perogmathus formosus mohavensis:* ARIZONA: Near mouth Beaverdam Creek, 1,500 ft., just above Little field, 1 (BS); Grand Wash, 1,800 ft., 8 mi. s. of Pakoon Spring, 1 (BS). CALIFORNIA: Oro Grande, 37 (BS).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1397TH MEETING, OCTOBER 8, 1954

WILLIAM SHOCKLEY, of the Bell Telephone Laboratories, spoke on *Transistor physics*.

Transistor physics is the modern name for that branch of solid-state physics that treats semiconductors. The particular material discussed was germanium; its four valence electrons cause it to crystallize in the same structure as diamond. The perfect lattice of pure germanium is analogous to a vacuum; various defects act like free particles in a vacuum. The six known imperfections that contribute to the semiconductor behavior are:

(1) An excess electron.

(2) A "hole," or missing electron.

(3) Deathnium, which may be an atom of copper or nickel, or simply a structure defect. Deathnium is a generic name for centers which catalyze hole-electron pair generation and recombinations.

(4) A donor atom, which acts like a bound or anchored "hole."

(5) An acceptor atom, which is a bound negative charge, creating a freely moving "hole."

(6) A trap, which is a bound charge in a low dielectric constant crystal, and therefore tends to attract and hold free charges.

The apparent motion of a hole in an applied electric field is produced by the motion of an electron that fills the hole, and leaves a new one elsewhere. Surprisingly, the mobility of holes is almost as great as the mobility of electrons.

Semiconductors exhibit photoconductivity. Incoming photons release valence electrons, making the crystal conducting until the electrons recombine with holes. The density of deathnium recombination centers in such that this induced conductivity decays with a half-life in the range of 1 microsecond to 1 millisecond.

If an impurity having 5 valence electrons is present, it donates a free electron, and the donor atom becomes positively charged but held in position in the lattice. The donor atom is therefore a bound hole. Since the conductivity is due to free electrons, or negative charges, such impure germanium is called n-type. Conversely, an impurity such as Gallium, with three valence electrons, in an acceptor. The gallium atom becomes a bound negative charge and contributes a free hole, making p-type germanium.

In the case of a relatively low dielectric constant crystal such as silicon, the bound negative acceptor atom acts as a trap for holes. Under photon bombardment hole-electron pairs are created, and the holes are trapped, leaving free electrons for conductivity. With the photon source removed, this conductivity persists until the holes escape the traps and recombine with the electrons at deathnium centers. The time constant of this conductivity decay ranges from several seconds to a minute.

The melt-grown process for making P-N junctions was described. The internal potential field that maintains equilibrium was explained graphically. Application of an external field to increase to very small current or large current respectively, yielding a rectifier action. Illumination of the n-type region generates hole-electron pairs; the holes slide down the potential hill to the p-type region, making this more positive. Such a system acts like a battery, and in fact has been made as a solar battery with a conversion efficiency of greater than 5 percent.

This junction discussion was extended to the case of the n-p-n "sandwich" transistor. The potential curve in this case resembles a dam, and illustrates vividly how gain is obtained. In the water analog, raising the reservoir bottom slightly yields a large increase in the water-wheel power available. Such n-p-n transistors can operate say as audio oscillators, at the fantastically low power input of one microwatt. This is approximately the average power expended by a common dog flea jumping up 50 cm, once every 10 seconds! (*Secretary's abstract.*)

1398th meeting, October 22, 1954

The Society was addressed by S. A. Schaaf, of the University of California, on the subject *Aerodynamics at very high altitudes.*

At sufficiently high altitudes, the air is a rarefied gas. For aerodynamic purposes, a gas is definitely rarefied when the mean free path of its molecules is greater than 1 percent of some significant parameter of the flow field, such as the boundary layer thickness, the shock wave thickness, or the missile size. Under such conditions, aerodynamics becomes a problem in molecular dynamics. The design of a supersonic wind tunnel operating at a pressure of 10^{-4} atmospheres was described, and the experimental techniques and results discussed. Such a low air density makes Schlieren photos impossible, and so a new technique was used to make the flow pattern visible. Air or nitrogen ions are introduced upstream; a variable intensity afterglow develops in the flow and provides a self-luminous pattern.

Simple theory indicates that the maximum temperature reached by the nose of a missile should be the adiabatic molecule stopping temperature, the temperature corresponding to the impact velocities of the molecules. It was observed, however, that for sufficiently thin air, higher temperatures were reached. This molecular impact heating makes possible an interesting new probe. The probe is a very fine wire, much less than a mean free path in diameter, so that it cannot affect the flow. The impact heating increases the resistance of the wire. This is the converse of the cooling of a hot wire used in ordinary wind tunnels. Such a wire was used to probe the internal structure of a shock wave.

Navier-Stokes theory says that a shock wave should be three or four mean free paths thick. The behavior is different for monatomic and diatomic gases. Diatomic gases possess rotational degrees of freedom, that may or may not come into equilibrium with the translational kinetic energy during the time the molecules are in the shock wave. If the equilibrium is slow in being established, a gas behaves as though it is monatomic. Expansion of a monatomic gas is friction-less; if the rotational states get into equilibrium, there is a frictional effect which is quantitatively introduced by a bulk viscosity constant. Experiments up to speeds of Mach 4 show shock waves that fit almost too well with the Navier-Stokes theory including bulk viscosity. It is concluded that this theory is adequate, and that rotational equilibrium is established quickly, in air. (*Secretary's abstract.*)

1399TH MEETING, NOVEMBER 5, 1954

The Society was addressed by S. F. SINGER, of the University of Maryland, on the topic *The age of meteorites.*

One hundred and fifty years ago, it was not generally believed that meteorites existed. It was in 1803 that a proof was presented to the French Academy that meteorites are of extra-terrestrial origin.

Meteorites are of two types, with some mixed samples, METAL meteorites consist primarily of iron, with up to 20 percent of nickel. STONE meteorites are primarily silicates, and appear to be the slag that collected on the surface when the large mass of molten material solidified—the mass that later broke up into meteorites. About one ton per day is the earth's total accretion rate. Most meteorites are small, but there is a 60 ton metal one in South Africa.

Meteorites are probably parts of asteroids, or small planets. The first evidence of this comes from their low impact velocities, characteristic of nearly circular orbits around the sun. On the other hand, meteors have very high velocities, approximating solar escape velocity, so are probably parts of comets. Indeed, meteor showers often coincide with comet approaches. Conversely, if meteorites were from outside the solar system, their impact speeds would probably burn them up in the earth's atmosphere.

Cutting, polishing, and etching meteorites reveals beautiful crystalline structure patterns, known as Widmanstaetten figures. These patterns can be reproduced in the laboratory by slow cooling of an iron-nickel melt; the patterns thus produced, however, show smaller crystals. It is concluded that meteorites were once liquid, and cooled very slowly under high pressure. Such conditions would be found in the interiors of small planets, of say 500 miles diameter. The structure of iron meteorites also shows definite evidence of shock wave passage, suggesting the break-up of such a planet. The silicate meteorites would then be pieces of the slag that became the crust of the planet.

Attempts have been made to date the solidification of meteorites by measuring the concentrations of U-238 and helium. U-238 has a decay half-life of 4½ billion years; a typical meteoritic concentration in a 1-gram sample is 10^{-8} grams of uranium, and 10^{-6} cc of helium, referred to normal temperature and pressure. This method, with its attendant delicate helium determination, was developed by Paneth. As to the possibility that most of the helium had leaked out, Paneth eliminated this by heating meteorites to 1,000°, and finding that although helium leaked badly from stone, only 5 percent was driven out from iron meteorites.

One thoroughly tested meteorite had an apparent age of 8 billion years by this method, about twice the age of the universe! And a correction for assumed helium leakage would INCREASE this figure! A suggestion made some years ago that cosmic ray bombardment had produced the apparent excess helium had been discarded, because the estimated yield was too low. This thought was revived by Singer in view of the modern knowledge of pi-mesons, etc. Both primary photons and secondary mesons knock alpha particles out of the iron nucleus, thereby producing helium. Theoretical calculations yield a curve for helium yield vs. depth from the surface, with a broad peak some 2–15 cm in. Even more useful is the prediction of one atom of He-3 for every two of He-4 produced, an isotope ratio over a million times larger than in the earth's atmosphere. The "8-billion year" meteorite has 31 per cent of its helium in the He-3 form, hence practically all its helium is of cosmic-ray origin, and the age data are meaningless. Meteorites exhibiting a lower percentage of He-3 can be evaluated by subtracting the 2-to-1 correction, and dating by the remaining radiogenic helium.

On the other hand, if we assume that the average cosmic ray intensity seen by a meteorite in its flight has been sensibly constant, we can consider the meteorite as an integrating cosmic ray exposure meter and compute the duration of its exposure. Unfortunately, the corrected radiogenic age estimate runs around 100 million years for a number of specimens but their apparent exposure time has been 300 million years, hence a new paradox has replaced the old one.

A new hypothesis has been put forward. It states that the radiogenic helium leaks out badly, because the Uranium is concentrated on grain boundaries, and the cosmic helium does not leak out. This is compatible with Paneth's experiment, for his helium leakage test was on a specimen that later was found to contain only cosmic helium, judging from the 31 per cent He-3 content. A crucial test would be to find a specimen having about half cosmic and half radiogenic helium, and heat it. If the hypothesis is correct, the He-3 to He-4 ratio should increase.

It now appears feasible to measure the radiogenic Pb-206 and ordinary Pb-204 contents, and date by this means. This should yield the time of solidification, whereas the cosmic helium measurements should yield the time of break-up. (*Secretary's abstract.*)

1400TH MEETING, NOVEMBER 19, 1954

LESLIE S. G. KOVASZNAY, of Johns Hopkins University, spoke on *Image processing by electro-optical techniques.*

A picture can be regarded as the representation in the plane of a function of two independent variables. A transformation of the independent variables corresponds to a distortion. Operators on the function correspond to a process. By the application of electro-optical scanning techniques to a picture the elements are converted into electrical quantities and can be subjected to various operator functions. The speaker's work in this field was not induced by any considerations of television but rather by a desire to understand more about the mechanism of vision. The corresponding study of the mechanism of hearing has been greatly aided by the application of electronic circuits which suppress certain frequencies or make other distortions of the original sound. In the visual case electro-optical scanning was chosen because it is much more flexible than photography. A still more sophisticated approach would be to make use of a computer, which could then perform any desired set of operations on the elements of a picture.

The system devised by Mr. Kovasznay has been brought to experimental realization under his direction at the National Bureau of Standards. One requirement called homogeneity limits the operator functions which may be used. A second requirement called isotropy prevents the television-type of scanning from being used. To overcome this difficulty a special system of saw-tooth waves of slightly different frequencies is used in scanning. The result is that a given point is scanned first along a line making a 45° angle with the frame, then along a line at right angles to the first, then along the first line in the opposite sense and finally along the second line in the opposite sense.

Electric circuits produce first and second derivatives of the function represented by the picture. The difference between the function and its second derivative is a deblurring operator which can be used to sharpen the contrast in photographs. Examples were shown where this has been accomplished, including an X-ray photograph of the heart. Outline drawings can be produced from photographs by using the first derivative alone. The derivative is rectified and applied to a trigger circuit to obtain lines to constant intensity.

The system can also be used in the study of operators and filters in 2-dimensional arrangements. A considerable number of possible applications were outlined. (*Secretary's abstract.*)

1401ST MEETING, DECEMBER 3, 1954

FRANÇOIS N. FRENKIEL, of the Johns Hopkins University Applied Physics Laboratory, addressed the Society on *Atmospheric pollution.* The five basic factors are:

(1) Production of pollutants.
(2) Emission.
(3) Transfer by atmosphere.
(4) Chemical changes en route.
(5) Deposition from atmosphere.

The paper discussed some details of the third factor: the fluid dynamics and meteorology of pollution. The complicated fluid motion of the atmosphere requires so many iterative applications of complicated equations that more artistic means are needed, partly science and partly intuition or art. Electronic computers, however, allow a brute force attack.

Atmospheric pollution can be responsible for much suffering. One week of London smog in 1952 increased the weekly death rate from 1,000 to 2,500, mostly in circulatory and respiratory diseases. The recent Los Angeles and Pasadena smog fortunately had no such result, but might at another time.

The pattern of smoke from chimneys can be averaged over a long time to obtain its mean concentration distribution and is generally elliptical. Each smog puff from each chimney moves with the wind and disperses. Eventually an equilibrium condition is reached at some distance from the sources.

The wind at Los Angeles reverses direction between 5:30 a.m., and 9:30 a.m., and thereafter shifts gradually with a fairly consistent pattern. Considerable numerical integration of wind velocity data yields the effects produced by an assumed distribution of sources. The Los Angeles area is a half bowl, bounded by mountains. The sea breeze blows into the open side of the bowl. A temperature inversion stops upward diffusion and currents, thereby putting an effective lid on the bowl, trapping and concentrating pollutants.

Computations have been made, using what wind velocity and smog diffusion data were available, and assuming various sources, such as a point source at Long Beach or automobiles in Los Angeles. The resulting concentration contours were shown, and agreed roughly with observed smog conditions. The effect of oxidization of hydrocarbons by solar radiation was added, and the resulting distribution also shown.

The rough agreement of these computations with reality indicate that a calculation with much more data would be valid and useful. Such computations can be made in a reasonable time by using electronic computing machines. Fast computation should be useful for predicting an approach to the danger level, and indicate which sources should be shut down until conditions change. Computation should also be useful in planning the development of a region, as to which parts are safest for industrial zoning, for example. (*Secretary's abstract.*)

1402D MEETING, DECEMBER 17, 1954

JOHN P. HAGAN, of the Naval Research Laboratory, spoke on *Radio sources and the structure of the galaxy.*

The material presented was based on studies of the radio spectrum of the heavens carried out at the Naval Research Laboratory with the 50-foot "Radio-telescope." Such studies depend largely upon the known properties of the hydrogen atom in radiation and absorption. Radio reception has supplemented ordinary telescopic observation, as for example in the neighborhood of Cassiopiea, where Mt. Wilson found diffuse luminous clouds of hydrogen after their existence had been detected by radio waves.

As is well known, our galaxy is pervaded with hydrogen atoms in various degrees of dispersal, varying from one atom per cc in the more diffuse parts of the galaxy arms to 100 atoms per cc in the hydrogen clouds and to very much higher figures in the stars themselves. The neutral hydrogen atom in this diffuse state absorbs and emits a radiation of about 21 cm wavelength (1,420.405 Mc). Both emission and absorption, of course, show appropriate doppler shifts with respect to an observer on earth. Studies were also made of the continuous spectrum at 21, 9.4, and 3.15 cm.

In addition to the line radiation there is a continuous background radiation, often called "white noise" (essentially independent of frequency, for not too wide bands), and also a number of "objects" that are much brighter than the diffuse hydrogen and that are at a temperature of tens of thousands of degrees. These sources seem to lie with few exceptions on the galactic equator. The diffuse hydrogen of the cold clouds has an effective temperature of about 100° K.

By analysing the radio spectrum in the neighborhood of the radio line as a function of both frequency and direction (i.e., Right Ascension and Declination), it is possible to win much information on the distribution of the hydrogen in the absorbing clouds that lie between a discrete radio source and the observer. In the case of Cassiopeia, absorption lines are seen corresponding to at least three clouds: one of which lies in the second arm of our galaxy and the other two in the first arm. The radio source itself lies at least in the second arm and probably beyond it. By using this technique the galaxy can be mapped in terms of such measurement, showing the hydrogen clouds and their relative velocities. Such mapping shows that the hydrogen is not loosely and unrelatedly distributed in the arms of the galaxy, but has many denser "cells" of 5–6 parsecs in diameter. The center of the galaxy, 8,000 parsecs away, displays a complicated absorption spectrum which was exhibited and discussed.

Further increases in resolving power depend upon larger diameter radio-mirrors, and it is hoped that when and if such mirrors are built it will prove possible to extend this type of spectrum analysis to lines from other elements, notably deuterium. (*Secretary's abstract.*)

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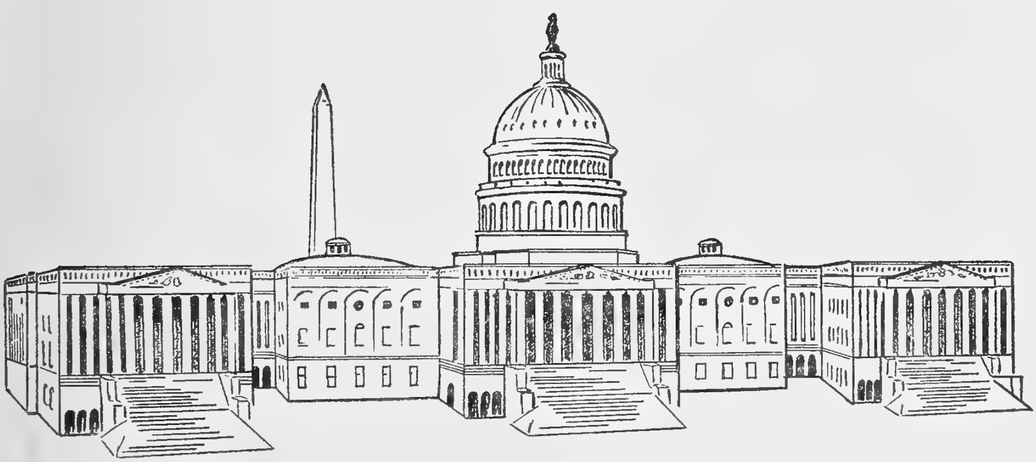

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CHEMICAL ENGINEERING.—*Joule-Thomson coefficients for Freon-12.*[1] Richard A. Schmidtke. (Communicated by C. H. Page.)

The increasing demand in recent years for mechanical refrigeration because of its application to domestic refrigerators, air conditioning, and food and industrial processing has led to the development of new refrigerants. In order to make proper engineering use of these new compounds an accurate knowledge of their thermodynamic behavior is necessary. The purpose of the present investigation of the Joule-Thomson effect in Freon-12 is to add to the experimental data regarding its thermodynamic behavior.

Freon-12 (dichlorodifluoromethane) was selected for study because of its importance in engineering application. Buffington, Gilkey, and their coworkers (*1*, *2*, *3*, *4*, *5*, *6*) have prepared tables of thermodynamic properties for Freon-12 by the use of pressure-volume-temperature data together with specific heat determinations. The Joule-Thomson coefficients reported here are useful in the superheated region for verification of the previously published properties and as additional data relating to the behavior of Freon-12.

The experimental work was done in the Thermodynamics Laboratory of the Mechanical Engineering Department, Illinois Institute of Technology. The range of the data is: pressure, 15 psia to 50 psia; temperature, 100°F. to 300°F.

The Joule-Thomson experiment has been discussed in the literature many times since 1852, when Joule and Thomson (*7*) first reported their work. Although the thermodynamic theory is well known, the basis for the experimental work will be given. The definition of the Joule-Thomson coefficient, μ, is

$$\mu = (\partial t/\partial p)_h \tag{1}$$

where the subscript h refers to partial differentiation at constant enthalpy. The particular experimental method employed, called the radial flow porous plug method, has been used by other investigators such as Budenholzer and his coworkers (*8*, *9*, *10*, *11*, *12*). It is based on the assumption that

$$\mu \approx (\Delta T/\Delta p)_h \tag{2}$$

is sufficiently accurate provided the finite increments are kept small enough. The requirement that the enthalpy remain constant is best achieved by a steady flow process. If the First Law of Thermodynamics is applied to the steady flow process of a unit mass of substance between cross sections 1 and 2 along the flow path, the following equation results:

$$\begin{aligned} &Z_1/J + V_1^2/2gJ + Q_{12} \\ &\quad = Z_2/J + h_{12} + V_2^2/ZgJ + W_{12}/J \end{aligned} \tag{3}$$

Now a process which occurs with no change of elevation, no change of velocity, no external work, and no heat exchange with the surroundings would be one of constant enthalpy. The experimental apparatus was designed to meet these conditions and to permit measurement of the pressure and temperature increments as well as the pressure and temperature level of the process.

The general arrangement of the apparatus is shown schematically in Fig. 1. The compressor is a 4-cylinder reciprocating machine of about 2.7 cubic feet per minute capacity. The volume chambers served to damp out pressure fluctuations. The heating coils were each of ¼-inch diameter copper tubing about 7 feet long immersed in a

[1] Received March 13, 1956.

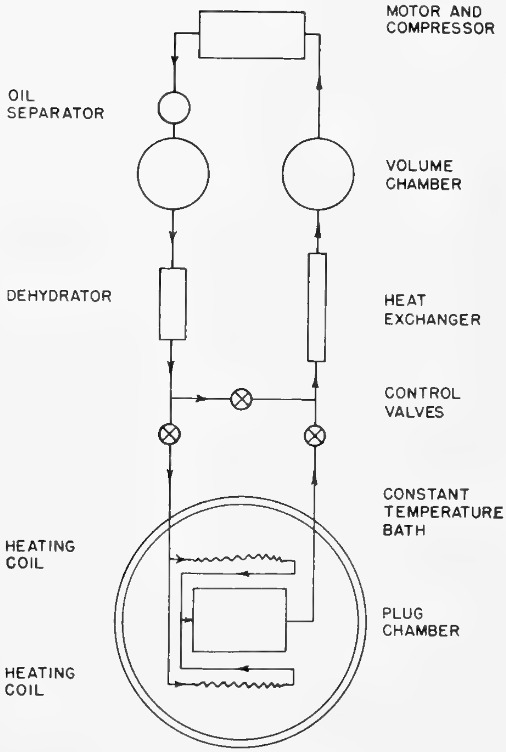

FIG. 1.—General layout

corn oil, controlled temperature bath to bring the gas to the proper temperature. The heat exchanger, a small water-cooled shell-and-tube type, is used for protecting the compressor from too high operating temperature. The valves shown are for flow control and for controlling the pressure drops in the plug chamber.

The plug chamber shown in cross section in Fig. 2 is the most important part of the apparatus as all the measurements are made there. A steel chamber with highly polished inner surfaces and aluminum foil radiation shields at E, F, and I prevent radiant heat exchange. The porous plug through which the gas flows is a modified microporous porcelain filter candle such as used for biological filtering. This thimble shaped plug is 1 inch in diameter and has an effective flow length of 3 inches. In order to satisfy the conditions stated in connection with equation 3, the chamber was placed horizontally to have constant elevation, the large flow area assures very small velocities, and no external work is done from one side of the plug to the other. The heat exchange is kept very small by the controlled bath (held to 0.1°F), the radiation shielding, and asbestos insulation within the plug chamber.

The pressure drop was measured by a mercury-in-steel manometer, which was read electrically and calibrated so that the pressure difference (measured at points C and D of plug chamber) could be determined to 0.05 psi. At the usual pressure drop of 17.9 psi used in the experiments, this amounted to an uncertainty of 0.3 percent. The copper-constantan three junction thermopile used to measure the temperature drop was calibrated at the ice point, steam point, and sodium-bromide transition point. This permitted the determination of the temperature drop to 0.01°F, which at the worst experimental case of a 1° drop amounts to 1 percent. The upstream pressure and temperature were measured to establish the state of conditions. The pressure was

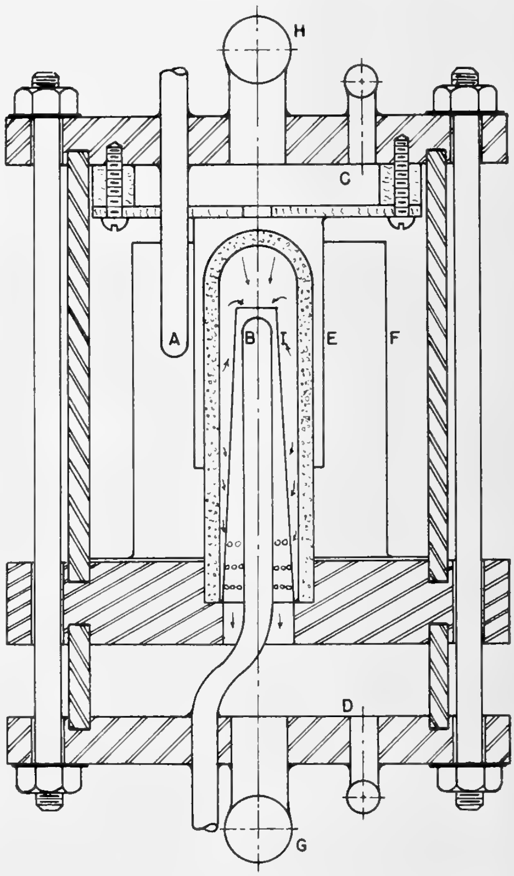

FIG. 2.—Plug chamber

Table 1.—Joule-Thomson Coefficients for Freon-12

Temperature (°F)	Joule-Thomson Coefficient, μ (F/psi)			
	p 15 psia	p 25 psia	p 35 psia	p 50 psia
100	0.144	0.194	0.213	0.229
120	0.125	0.173	0.193	0.211
140	0.112	0.158	0.181	0.198
160	0.100	0.146	0.169	0.188
180	0.092	0.138	0.162	0.183
200	0.088	0.133	0.157	0.177
220	0.086	0.128	0.152	0.173
240	0.084	0.124	0.147	0.170
260	0.082	0.120	0.143	0.168
280	0.080	0.117	0.139	0.164
300	0.077	0.112	0.135	0.160

Table 2.—Specific Volume of Freon-12 at 15 Psia

Temperature (°F)	Specific Volume (ft^3/lb) Author	Specific Volume (ft^3/lb) Buffington and Gilkey
100	3.266	3.266
120	3.387	3.388
140	3.507	3.510
160	3.627	3.632
180	3.745	3.755
200	3.866	3.877
220	3.985	3.998
240	4.106	4.120
260	4.225	
280	4.344	
300	4.464	

measured, depending upon its magnitude, with either a 0–60 psi or a 0–300 psi Bourdon tube gage. These gages were of excellent quality and were carefully calibrated against a dead-weight gage tester. The pressure could be determined to 0.1 psi, which at the worst conditions of 15 psia, amounts to 0.7 percent. The upstream temperature was measured with a carefully calibrated (ice, steam, sodium-bromide points) copper-constantan thermocouple. Therefore the upstream temperature was determined to 0.01°F, which at 100°F results in an uncertainty of 0.01 percent. Emf measurements were made with a Leeds and Northrop type K-2 potentiometer, Eppley Standard cell, and a Leeds and Northrop type E galvanometer.

The calculated uncertainty in the values of μ is 0.0006 F/psi, or less than 1 percent. However, owing to the slow drifts in the pressure and temperature levels reported by most other investigators of Joule-Thomson coefficients—see, for example, Roebuck (*13*, *14*)—and also the possibility of heat leakage, it is estimated that the over-all accuracy of the values of μ is about 4 percent.

The results are shown graphically in Fig. 3, which was plotted from the original data. Fig. 4 was obtained by cross-plotting from the smoothed curves of Fig. 3.

To check the values of μ found in this work, the specific volume and the compressibility factor were computed and compared with the directly measured quantities of Buffington and Gilkey (*6*). The specific volume was determined from the equation

$$v/T = v_0/T_0 + \int_{T_0}^{T} (\mu C_p/T^2)\, dT, \qquad (4)$$

where v_0 and T_0 represent at an arbitrary state on the isobar of integration. The isobar was chosen at 15 psia and the reference temperature at 100°F. The isobaric heat capacity was compiled from the equation of Buffington and Fleisher (*4*) and the tables of Buffington and Gilkey (*6*) give $v_0 = 3.266$ ft^3/lb. Table 2 shows the comparison of computed and directly measured values of specific volume.

The compressibility factor is defined by the equation

$$C = pv/R_gT \qquad (5)$$

Table 3.—Compressibility Factors for Freon-12 at 15 Psia

Temperature (°F)	Compressibility Factor Author	Compressibility Factor Buffington and Gilkey
100	0.987	0.987
120	0.988	0.989
140	0.989	0.990
160	0.990	0.991
180	0.991	0.993
200	0.991	0.994
220	0.992	0.995
240	0.992	0.996
260	0.993	
280	0.993	
300	0.994	

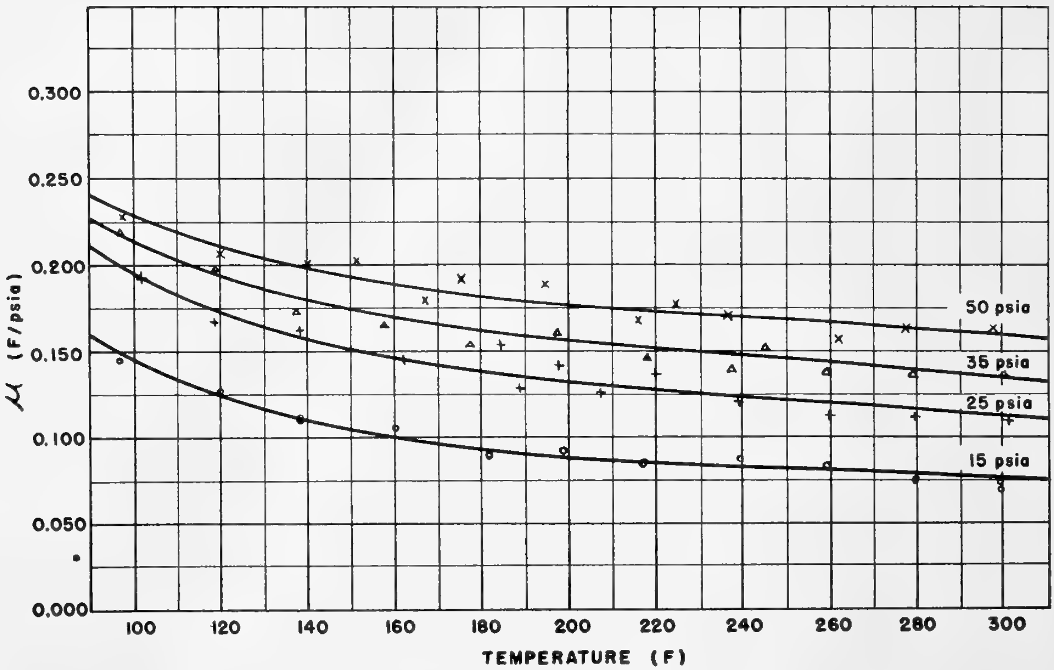

FIG. 3.—Joule-Thomson coefficient vs. temperature

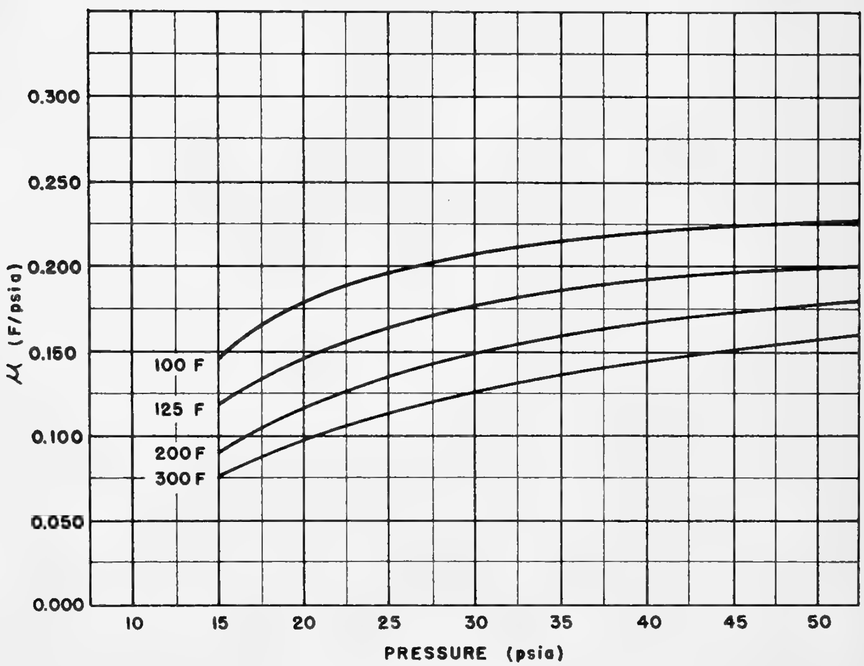

FIG. 4.—Joule-Thomson coefficient vs. pressure

It is related to the Joule-Thomson coefficient in the following:

$$C = C_0 + \int_{T_0}^{T} [p\mu C_p/R_g T^2]\, dT, \quad (6)$$

where C_0 and T_0 represent the compressibility factor and temperature at an arbitrary base state on the isobar of integration. The comparative results are given in Table 3.

ACKNOWLEDGMENT

The author wishes to express his gratitude to Dr. R. G. Owens and Dr. R. A. Budenholzer for their aid and encouragement in this work.

NOMENCLATURE

Symbol	Definition	Units
C	Compressibility factor	
C_p	Isobaric heat capacity	Btu/lb F
g	Acceleration of gravity	ft/sec^2
h	Enthalpy	Btu/lb
J	Mechanical equivalent of heat	ft lb/Btu
p	Pressure	lb/ft^2 or psi
R_g	Gas constant	ft lb/lb R
T	Temperature	R
V	Velocity	ft/sec
v	Specific volume	ft^3/lb
W	Work	ft lb/lb
Z	Elevation	ft
μ	Joule-Thomson coefficient	F ft^2/lb or F/psi
Δ	Finite difference	

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The progress of science is as orderly and determinate as the movement of the planets, the solar systems, and the celestial firmaments. It is regulated by laws as exact and irresistible as those of astronomy, optics, and chemistry. S. Brown (1843).

ENTOMOLOGY.—*Three new Neotropical flea beetles.* DORIS H. BLAKE, Arlington, Va.

Three Neotropical flea beetles of similar color pattern and representing three different genera are herewith described. All belong to obscure and little-known genera and had not been definitely placed in the U. S. National Museum collection. Two of them were with *Diabrotica pulchella* (Jacq. DuVal), a drawing of which is included (Fig. 3). Jacquelin DuVal originally described this as a *Phyllobrotica* (it is still listed as such in Blackwelder's Checklist), possibly because its color pattern resembled that of the well-known European beetle *Phyllobrotica quadrimaculata* (Linnaeus).

Pseudogona subcostata, n. sp.
Fig. 4

About 6 mm in length, elongate oval, shining, very finely and obsoletely punctate, pale yellow, with the head and breast black, and on the elytra a wide basal and a preapical black band, the basal band having two elongate yellow spots near the suture. Antennae pale with joints 7 and 8 deeper brown and joints 9 to 11 paler yellow.

Head entirely dark, the interocular space one-half width of head, eyes prominent and large, occiput rounded, polished, and with a few fine punctures and two larger punctures on each side near the eye connected by a faint groove; frontal tubercles well marked, interantennal area narrowly produced into a carina extending down to labrum. Antennae not half the length of the beetle, third joint a little shorter than fourth, and fourth a little shorter than fifth, remainder subequal and gradually becoming a very little shorter. The basal six joints yellow, 7 and 8 brown, 9 to 11 paler yellow. Prothorax entirely pale, minutely punctate, about one-third wider than long, smoothly convex, without depressions, with a rounded margin, the frontal angles not wide as in *Disonycha*, or obliquely cut as in *Systena*, but small; the basal angles with a small tooth. Scutellum small and entirely dark. Elytra broader in apical half, not very convex, without depressions, shining, and with numerous fine costae, not extending the entire length and between these, rows of fine confused punctures; pale yellow with a piceous black wide basal band not extending to the middle of the elytra or to the margins, and having on each elytron an elongate pale spot near the scutellum, a piceous band also behind the middle, the apex pale. Body beneath pale except the black breast, legs pale. Anterior coxal cavities closed, posterior femora enlarged, tibiae on hind feet spurred, claws appendiculate. Length 6.4 mm; width 3 mm.

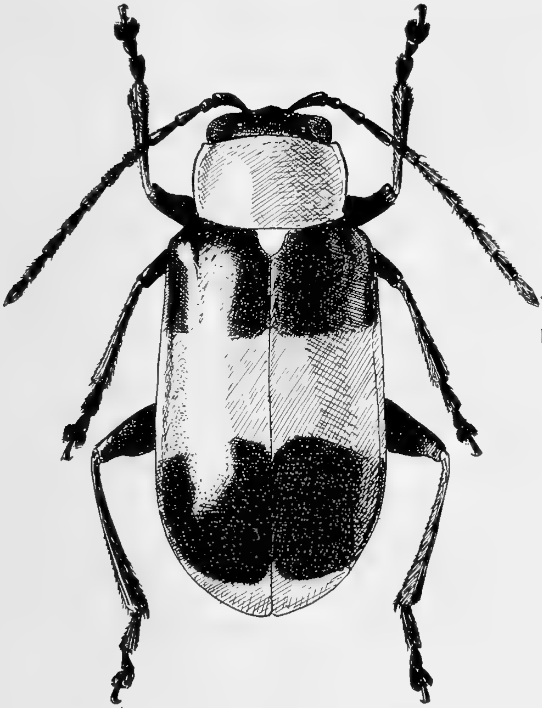
Type, female, U.S.N.M. no. 63136, collected by Schild and Burgdorf at Tucurrique, Costa Rica.

Remarks.—H. S. Barber has labeled this "Not a *Diabrotica* [which it strikingly resembles and with which it was placed] but a female Halticid, ?*Pseudogona panamensis* var. Jac." Jacoby's description of *P. panamensis*, however, differs in that there are three dark elytral fasciae instead of two, as well as different punctation. In *P. militaris* Jacoby from Panama, the basal joints of the antennae are all black and the elytra have a shallow transverse depression below the base and are opaque and not shiny. In Jacoby's description of *P. pallida* (also from Tucurrique, Costa Rica, the type locality of the present species) the color pattern is quite different, and the tibiae and tarsi are more or less black. In none of the species is there any mention of the faint elytral costation so apparent in the present species.

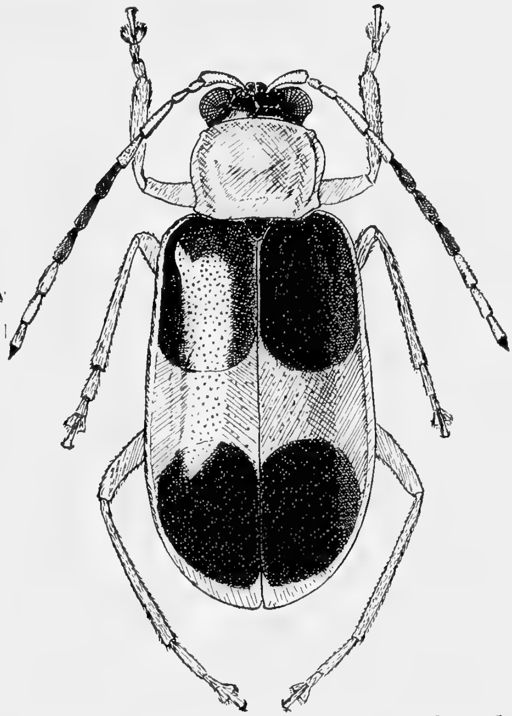
It is curious that although these species are all listed in the Zoological Record, Heikertinger in the Junk Catalogue omits four species of *Pseudogona*, and Blackwelder in his Checklist omits two species of this same genus. Jacoby described all six species that have comprised the genus up to the present, namely: *P. panamensis, chiriquensis, argentinensis, discoidalis, militaris,* and *pallida*. He characterized the genus as being similar to *Systena* but with differently shaped antennae and with the thorax having no groove. He stated that it differs from *Oxygona* in having a narrower, subquadrate thorax.

Nephrica macrops, n. sp.
Fig. 2

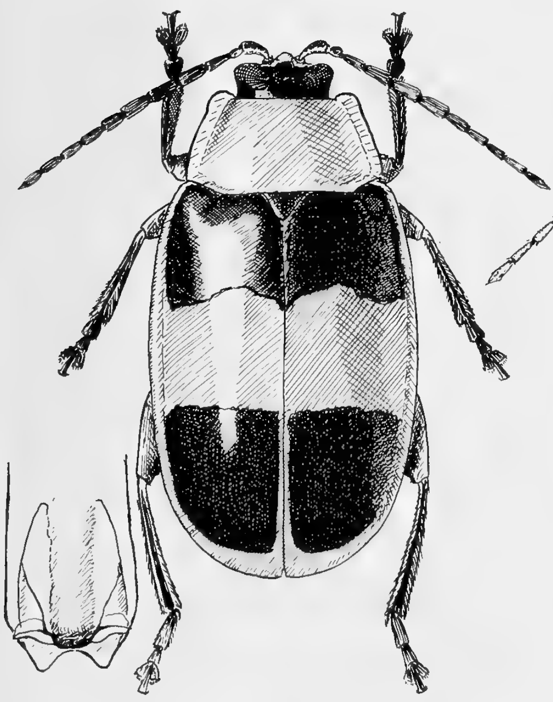
About 6 mm in length, ovate, moderately shiny, pale yellow with the upper half of head and mouthparts, the antennae, tibiae and tarsi dark, the elytra pale with a broad basal band and another below the middle not quite extending



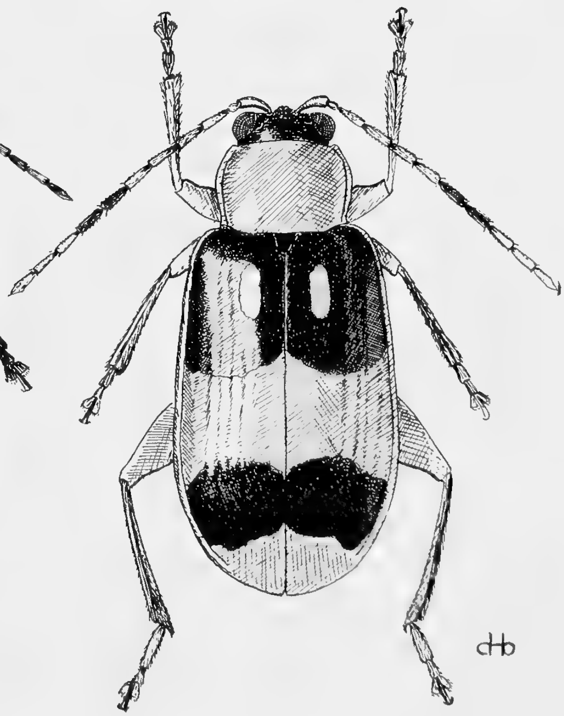
1. Pseudodisonycha turquinensis



3. Diabrotica pulchella Jacq.DuVal [Cuba]



2. Nephrica macrops



4. Pseudogona subcostata

FIGS. 1-4.—Neotropical flea beetles

to the apex, these bands dark with a metallic blue lustre. Eyes elongate and emarginate.

Head with large elongate eyes, somewhat emarginate on the inner side but not so markedly as in *N. inornata* Jacoby, and on the vertex separated by one-third the width of the head; on either side near the eye a large puncture or fovea, and from this a line of fine punctures extending down to the clearly marked frontal tubercles, the upper part of the head otherwise polished and piceous in color; carina produced and extending down the front, the lower front pale with the mouthparts brownish. Antennae not half the length of the beetle, deep brown except the two basal joints which are paler, third joint not as long as fourth, joints 4, 5, and 6 broad, the following joints becoming gradually thinner. Prothorax twice as wide as long with wide explanate margin and broadly rounded anterior angles, not very convex, shining, impunctate, pale yellow. Scutellum dark. Elytra broad, with wide explanate margin, shining, impunctate, pale yellow with a wide dark basal band and an equally wide band below the middle not reaching the apex, these bands having a dark blue metallic lustre, the margin being always pale. Body beneath entirely pale, the femora pale reddish brown, tibiae and tarsi deepening to piceous; the hind tibiae grooved, the anterior and middle tibiae with a sharp ridge in the middle of a shallow channel. Hind tibiae with a spur. Claws appendiculate. Length 6.2 mm; width 3.2 mm.

Type, male, U.S.N.M. no. 63137, collected "in banana trash from Panama."

Remarks.—Jacoby's description of *N. boliviana* agrees with this except that in his beetle the undersurface is entirely dark and the elytral markings are metallic green. This is the second species of the genus to be described from north of South America, the other, *N. inornata* Jacoby, also from Panama, being entirely pale with kidney shaped eyes.

Pseudodisonycha turquinensis, n. sp.

Fig. 1

About 6 mm in length, oblong oval, shining, nearly impunctate, pale yellow, the head, antennae, legs, except the basal half of femora, black, a deep blue wide transverse band at base of elytra and another equally wide below the middle, not reaching the apex.

Head with interocular space more than half its width, a large fovea on each side of vertex near eye with a few finer punctures about it; frontal tubercles bulging; a somewhat produced carina between antennal sockets extending down the short lower front; head entirely dark except for the pale labrum and the pale neck beneath the mouthparts. Antennae black, stout, third joint shorter than fourth, which is longest, remainder subequal and a little shorter than fourth. Prothorax not twice as broad as long with rounded sides and narrow margin; a small tooth at apical and basal angles; disk moderately convex with a slight median basal depression; entirely pale yellow. Scutellum pale yellow. Elytra with prominent humeri and deep intrahumeral sulcus, shining, very finely and not densely punctate; a wide deep blue band at base and also one below the middle, the latter not reaching the apex. Body beneath pale with the basal half of all femora pale, shining, a few pale hairs on the abdomen, coxal cavities open. Hind femora not as much thickened as in *Oedionychus*; a spur on hind tibiae; claws appendiculate. Length 6.4 mm; width 3 mm.

Type, female, U.S.N.M. no. 63138, collected by S. C. Bruner and C. H. Ballou on Pico Turquino, altitude 4,000–5,000 feet, Oriente Province, Cuba, July 20, 1922.

Remarks.—Because the markings resemble so much those of *Diabrotica pulchella* (Jacq. Du Val), this beetle was long concealed in the collection with that species. It is difficult to place in a genus. The hind femora while not greatly enlarged nevertheless are those of an alticid. The tibiae with the ridge on the upper side and the spur at the end, and the head with the fovea near the eye so characteristic of *Disonycha*, place it near that genus. The thorax, however, is not so broad as in *Disonycha* and does not have the wide anterior angles. There is unfortunately no male, and I have doubtfully assigned it to the genus *Pseudodisonycha* Blake.

ENTOMOLOGY.—*Two new species of* Rhyopsocus (*Psocoptera*) *from the U. S. A., with notes on the bionomics of one household species.* KATHRYN M. SOMMERMAN, Arctic Health Research Center, Public Health Service, Anchorage, Alaska. (Communicated by A. B. Gurney.)

The genus *Rhyopsocus* is currently placed in the family Psoquillidae according to Pearman's classification, 1936, or in Trogiidae following the classification of Roesler, 1944. If we assume that *Rhyopsocus*, *Deipnopsocus*, and *Rhyopsocopsis* are subgeneric categories in the genus *Rhyopsocus*, only one species of this genus is known to occur in the United States, *R.* (*Deipnopsocus*) *texanus* (Banks 1930) described from Brownsville, Tex. A second species, *R. eclipticus* Hagen, 1876, questionably from this country, was collected on Kerguelen Island in October 1874. The following comment is quoted from the original description: "The only specimen noticed during the stay of the Transit Party at Kerguelen was captured October 17, in-doors, and was mounted in balsam on a slide. Shortly before its capture some instrument boxes, brought from Washington and containing a quantity of packing straw, had been unpacked in the same room; a circumstance rendering the habitat of the insect very doubtful at the time. J. H. K." Hagen states that the antennae of this specimen were broken, one having eight basal segments and the other twelve, while an apical section of fourteen segments lay near by on the slide. It seems quite probable that the apical part was broken off the 8-segmented base instead of the 12-segmented one as he assumed.

The characteristics possessed by the species of this genus are: head short and oblique, labial palps 2-segmented, antennae 22-segmented, peg like sense organ on inner side of second segment of maxillary palp, Fig. 1, lacinia bifid, Fig. 2, ocelli usually completely developed in macropterous forms; wings variable in length, forewings rounded apically and possessing stout setae on veins and margin, usually a closed discal cell bounded by R and M and their derivatives (cell sometimes absent, especially in brachypterous forms), Cu usually shorter than Cu_2, in hind wing M not branched; tarsi 3-segmented, claws without preapical tooth, Fig. 3; paraprocts each with a mesad anal spine.

Two species of this genus came to my attention while collecting in the Southeastern States, one of which was taken indoors in small numbers in my house at Orlando, Fla. The latter was living year-round on the bedroom walls, the only walls covered with a water-base paint, in association with a species of the *Liposcelis bostrychophilus* complex and *L. entomophilus* (Enderlein, 1907). This species is of no apparent economic importance but because a study of some of the household psocids was being made at that time, preliminary observations were made on this one too. Unfortunately it was necessary to move before a detailed study of the bionomics could be made so the information is incomplete.

I am indebted to Mr. J. V. Pearman for comparisons and comments regarding these two species and *Rhyopsocopsis peregrinus* Pearman, 1929, and *Deipnopsocus disparilis* Pearman, 1931. Dr. P. J. Darlington examined the types of *eclipticus* and *texanus* and supplied information in answer to my questions. On learning that this paper was in preparation, Dr. A. B. Gurney kindly contributed for study the specimen he had collected in Texas. To each I extend my sincere thanks.

I have not seen specimens of the other species in this genus, and so my comments are based on the original descriptions and on observations made by others. These two new species apparently most closely resemble *R. eclipticus*, but the sex of the type of the latter is not known to me. Brachypterous individuals of these two new species are usually smaller than the macropterous forms and lighter in color. If such is generally true of the species in this genus, then these two species are smaller than *eclipticus*, the brachypterous form of which is larger than the macropterous forms of these two new species. Regardless of the sex of the type of *D. spheciophilus* Enderlein, 1903, a Peruvian species, available information indicates that it differs from these two in several ways, the most noticeable being: color pattern, absence of setae along the margin of the anal lobe, and presence of rows of scales along the wing margin. Although there is some question concerning the presence of scales on the wings of *texanus* it is likely that the presence of the white hair on the head and legs of this species distinguishes it from these two.

Rhyopsocus bentonae, n. sp.

Figs. 1–12

Length of alcoholic specimens 1.15 to 1.6 mm including wings. Head and thorax of macropterous forms dark brown, antennae, legs and dorsal parts of terminalia light brown, abdomen pale yellow. Corresponding parts of brachypterous forms light golden brown to buff, with abdomen likewise pale yellow. Wing membrane almost hyaline, with a slight fumose tinge. There is considerable variation in wing venation, some veins having extra branches which may anastomose, but in general venation is as shown in Fig. 8.

Dorsal, posterolateral margin of male terminalia with two stout, curved, bluntly pointed and sparsely setose prongs; ventral surface of terminalia with a broad, thin, tail-fin-like flap (hypandrium?) which is a bit asymmetrical, Figs. 6, 11, 12.

Dorsal, anterior margin of female terminalia medianly expanded to form a quadrangular plate bearing a non-pigmented spot; anterior lateral limits of terminalia densely pigmented, much darker than lateral and apical margins of egg-guide; anterior margin of faintly pigmented subgenital plate convex, Figs. 4, 9, 10.

Holotype, macropterous male, Orlando, Fla., October 1953, ex culture, K. M. Sommerman. **Allotype,** same data. These are deposited in my collection. **Paratypes,** four specimens, a macropterous and brachypterous male and female, all same data as above, deposited in each of the collections of the following institutions or individuals: USNM, INHS, MCZ, P. J. Chapman, E. L. Mockford, and J. V. Pearman, and ten of each of the four kinds of individuals in my collection. The following additional distribution records are available, all from Florida: Daytona Beach, Nov. 2, 1941, ex dry palm leaves, A. H. Sommerman, ♂, ♀; Englewood, May 22, 1952, ex Flame vine, A. H. S. ♂; same, but March 13, 1953, ♂, 3 ♀; Orlando, Oct. 1953, ex cultures (original specimens from bedroom walls), many specimens, both sexes, nymphs of all instars, eggs on cotton; same, but July 7, 1954, 6♂, 2♀, 4N; Orlando, Feb. 15, 1954, ex bedroom walls, K. M. S. ♂, 5♀, 4N.

I take pleasure in naming this species after Jimmie Benton, who kindly furnished the materials for construction of the rearing racks. Her active interest in the rearing project concerning the household species was, indeed, stimulating and encouraging.

Rhyopsocus phillipsae, n. sp.

Figs. 13–17

Length of alcoholic specimens 1.1 to 1.5 mm including wings. Overall color similar to *bentonae.* Wings of macropterous forms, Fig. 13, with a more sharply defined, angulated anal lobe, much like that of *peregrinus.*

Dorsal, posterolateral margin of male terminalia with two thin, broad, rounded lobes; ventral surface of terminalia with exposed, median hooklike projection on anterior margin, Figs. 16, 17.

Dorsal, anterior margin of female terminalia medianly with slight expansion cephalad, or if pronounced, more rounded than *bentonae*; anterior lateral limits of terminalia faintly pigmented, much lighter than lateral and apical margins of egg-guide; anterior margin of lightly pigmented subgenital plate concave, Figs. 14, 15.

Holotype, brachypterous male, Valdosta, Ga., State College Campus, Apr. 23, 1955, ex bamboo sheaths, Sommerman and Phillips. **Allotype,** macropterous, same data. These are deposited in my collection. **Paratypes,** a brachypterous male and female, same data, deposited in USNM, brachypterous female, same data but ex ground cover, deposited in my collection. The following additional distribution records are available: Myakka S. Pk., Fla., June 7, 1952, ex Spanish moss, K. M. Sommerman, 3♂, ♀; Hayesville, N. C., Aug. 25, 1954, ex Boxwood, W. E. Snow, 2♂, 2N; same, but Oct. 26, 4♂, 10♀, 5N; 90 miles west of Orange, Tex., Oct. 8, 1951, beating trees, A. B. Gurney, ♂.

It is a privilege to name this species after Grace R. Phillips, who helped collect the type material and who has contributed other interesting specimens and records to my collection.

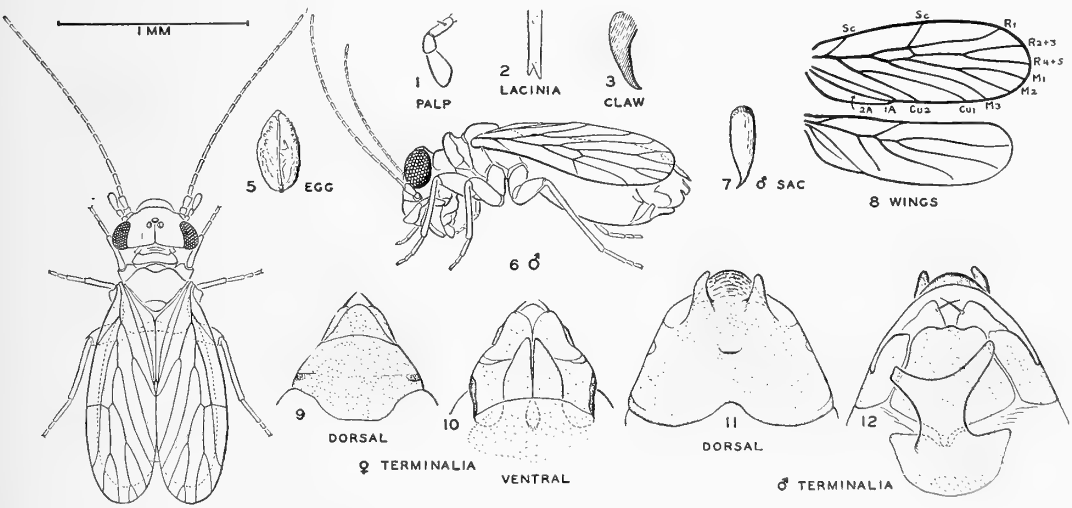
BIONOMIC NOTES

The following preliminary notes on the bionomics of *R. bentonae* were obtained from specimens reared under somewhat unnatural conditions. This rearing technique was used with good results for *R. bentonae* and these other household species: *Psoquilla marginepunctata* Hagen, 1865, *Psocatropos lachlani* Ribaga, 1899, *Ectopsocus* sp., and several species of *Liposcelis*. Some difficulty was encountered with the first instars of *P. lachlani*. The equipment consisted of small glass tubes 30 mm long by 9 mm in diameter, which had been cut from dental tubes. These were placed in half-inch wire mesh (hardware cloth) racks with screen bottoms, which were stacked in a quadrangular aquarium containing a little water below the racks. The aquarium was covered by a plastic tray with rounded corners which allowed an interchange of air and moisture, and the whole was kept at uncontrolled room temperature which fluctuated daily during September to mid-October when these preliminary observations on development were made, the extremes being 71° and 85°F.

The food was composed of the following ingredients (the recipe furnished enough medium to coat the ends of 200–300 corks): One teaspoon of dry solids, consisting of equal parts by volume of dried yeast, dehydrated mashed potato, starch and dehydrated skim milk, was added to one teaspoon of water and mixed well. Some of this mixture was smeared on the small end of each cork. The corks were put in a covered pan on a hot plate and heated until the medium was a pale brown. They were then stored in jars in the refrigerator.

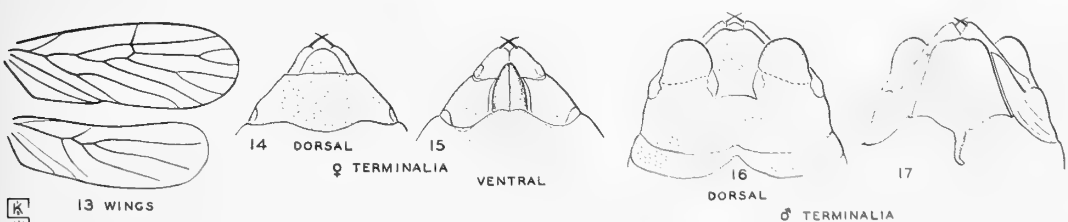
A cork containing the food was inserted in one end of a rearing tube, the psocids introduced and a thin cotton plug put in the other end. The tubes were then placed in the rearing racks. The medium softened in the moist atmosphere and the psocids ate it as well as the mold that grew on it. Eventually some tubes became infested with mites and the psocids retreated to the cotton plugs. Consequently food consumption was reduced and often either the psocids or the mites injured the psocid eggs. If a dead psocid were left in a vial containing more than one psocid, it was eaten by the others.

R. bentonae was an extremely active species,



FIGS. 1-12 *RHYOPSOCUS BENTONAE*, N. SP.

FIGS. 4-8 AND 13 TO SCALE, FIGS. 9-12 AND 14-17 ENLARGED TO SCALE, ALL SETAE OMITTED



FIGS. 13-17 *RHYOPSOCUS PHILLIPSAE*, N. SP.

often darting rapidly and making unexpected starts and stops. The courtship approaches were usually made by the male while rapidly vibrating his wings, which were held in a vertical position. If the female were in a receptive mood she would sometimes flit her wings in a vertical position for a fraction of a second, several times before mating. Occasionally the two psocids approached each other and rubbed palps but such antics were kept to a minimum or dispensed with entirely. Then the male approached the female head-on with his wings held vertically, quickly turned around and backed under the female as she raised her body to allow him to slip under her from the front. He curled the tip of his abdomen up and behind hers and when the genitalia were joined the male sidestepped 180° with the ventral side of the body twisted on the longitudinal axis at about 40° so that usually some of his tarsi were not on the substrate. Copulation lasted an hour on the average (eight timed matings varying from 41 to 73 minutes), and during this time there were prolonged rhythmic contractions of the abdomen of the male. Apparently a considerable amount of fluid was forced into the female abdomen because the dorsal prongs of the male terminalia and the ventral tail-fin-like flap eventually took a viselike grip on the female terminalia as her abdomen became considerably swollen. Toward the end of the copulation period the female sometimes walked around dragging the male behind. Almost immediately after separation the male deposited on the substrate a transparent, slightly curved (upward) carrot-shaped sac, which was drawn to a fine tip at the posterior end. The sac usually contained only a small amount of a transparent fluid at the anterior end. To my knowledge this is the first recording of the deposition of a copulatory sac by the male psocids after mating. Apparently it is not uncommon, in one group of psocids at least, because I have observed the same procedure immediately after each mating of *Psocquilla marginepunctata* and *Psocatropos lachlani*. Often the males turned around and ate part or all of the sac, or sometimes the females ate it. The approximate measurements of the sacs were 0.39 by 0.09 mm; these measurements were made through the glass tubes. Fig. 7 was sketched from memory according to averaged measurements. Apparently the psocids have preferences as the female sometimes resisted the approaches of the male and butted him with her antennae, and usually by the next day the antennae of the male were broken off to stubs if he were still alive. Occasionally on the following day the male was dead and partly consumed, but these "fights-to-the-finish" were not observed. However, one such resistant female was placed with another male and mating occurred shortly thereafter.

Mating occurred more than once. Two pairs were observed mating again 31 days after the first time. In one instance a male and female of *bentonae* were kept isolated from each other, but in the company of a *P. marginepunctata* individual of the opposite sex. Both sexes of *marginepunctata* made courting advances upon the opposite sexes of *bentonae* but their efforts were ignored. The two sexes of *bentonae* were put in the same tube for a short time on the 5th, 7th, 11th, and 20th days and each time mating occurred and a sac was deposited by the male. Limited data suggest that fertilized eggs may be deposited for a period of about two weeks at the most, after mating.

Information regarding length of the preoviposition period is lacking, but 9 pairs ranging in adult age from 3 to 6 days mated immediately when paired off. Seven of the 9 females deposited eggs the following day while the other two did not oviposit until 7 days later.

The eggs were deposited singly with little or no pre- or post-ceremonial activity. They were bare, not covered with excrement or silk, and there seemed to be a tendency to place them in depressions. They were most often laid on the cotton plug or on the food, but only rarely on the surface of the glass tubes. If mating had not occurred a reduced number of non-fertile eggs was deposited but they turned yellow and shriveled. The egg totals were recorded for 9 females from mid-October to late December when the temperatures fluctuated between 60° and 80° F. The average number laid was 74, with a maximum of 101. Under the more favorable conditions 5–7 eggs were laid each day, which suggests that perhaps as many as 400 eggs could be deposited by one female under optimum conditions.

The eggs, Fig. 5, are somewhat boat-shaped with a wrinkled chorion which has a distinct center ridge dorsally with an indication of two lateral ridges at the anterior end, each bearing four or more little tubercles. About four days after oviposition the eggs darkened. As they approached maturity the eyes and also the egg burster, which was stretched across the front of the head could be seen through the shell. At hatching the nymph was ventral side up, with the head at the anterior end of the egg. Hatching occurred 8–10 days after oviposition. Air was swallowed at both eclosion and molting, a practice common among psocids.

The following information on development was obtained from group rearings since the eggs laid each day were allowed to hatch in the vial where oviposition occurred. Only the parents and, later, the newly emerged adults were transferred to a fresh vial each day; consequently the young from each daily "brood" grew up together. Although molts and instars could be recorded, one had to assume that the molting sequence was always the same as development progressed, but such is probably not the case. Most of the eggs hatched without any trouble and it was only after the continued absence of a male that non-fertile eggs were deposited.

The various observations on the nymphal stadia were based on a minimum of 17 and a maximum of 78 individuals. The average duration of the nymphal stage was 19.5 days, the first stadium being 2–5 days, usually 3. The duration of each of the second, third, fourth and fifth stadia ranged from 2–3 days and the sixth stadium was a little longer, 3–5 days, with an average of 4.

Based on observations from early October to January of nine mated pairs, the duration of the adult stage averaged 64 days for the females and 69 for the males with maximum periods of 86 and 89 days respectively. The sex ratio was 1:1. If males were present oviposition continued until a few days before death of the female, assuming that the few females under observation died of natural causes.

SUMMARY

Two new species of *Rhyopsocus* are described, and salient features illustrated for both *R. bentonae* and *phillipsae*. A rearing technique for household species is explained and notes on the bionomics of *bentonae* are given as determined from individuals reared under these somewhat unnatural conditions. Courting and mating are described, and the deposition on the substrate of an almost empty transparent sac by the male immediately after mating is noted. The life cycle is completed in a little more than a month, the duration of the egg stage being about 9 days and the nymphal period 20 days. The females laid an average of 74 eggs and adult life lasted approximately two months.

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Even if we resolve all matter into one kind, that kind will need explaining, and so on for ever and ever deeper and deeper into the pit at whose bottom truth lies, without ever reaching it, for the pit is bottomless.—O. Heaviside.

MALACOLOGY.—*Mollusca dredged by the* Orca *off the Santa Barbara Islands, California, in 1951*. S. STILLMAN BERRY, Redlands, Calif. (Communicated by Harald A. Rehder.)

Through the kindness of Dr. Carl L. Hubbs, of the Scripps Institution of Oceanography, there was recently placed in my hands a collection of mollusks taken by himself, J. W. Sefton, and others, working from Mr. Sefton's research vessel, the *Orca*, off the Santa Barbara Islands, Calif., in the summer of 1951. Mollusca were not the items principally sought by this expedition, and since the collections were obtained in one of the more important areas in the Californian province where few precise studies in this field have been made it is most fortunate that in the press of the other important pursuits so many of them were eventually salvaged. By reason of our inadequate knowledge of the area the resulting list gains a significance quite out of proportion to the size of the collection. It is of further interest in that it includes a number of infrequently reported or little-known species, several of which constitute important extensions of range. In the first part of the paper each station from which mollusks have been submitted is cited in turn, and an annotated list of the species obtained is appended. These include dredge hauls from seven stations having recorded depths from 11 to 58 fathoms. The richest of these was H51-254, in 46 to 58 fathoms, north of Anacapa Island, whence no less than 59 species are here recorded. The second part of the report covers the formal descriptions of the three species obtained which are recognized as new.

The author is happy to express his appreciation of the kindness of both Mr. Sefton and Dr. Hubbs in supplying the material studied. The assistance of Ellis Rich, of the College of Medical Evangelists, Loma Linda, Calif., who made the photographs used in the accompanying illustrations, is likewise gratefully acknowledged.

ANNOTATED LIST

Stations H51 240 and 241 (pipe-dredge), 11 to 20 fathoms, lat. 34°01′45″ to 34°02′20–35″ N., long. 119°41′40″ to 119°42′07–22″ W., off Pelican Bay, Santa Cruz Island, June 29, 1951.

Lima hemphilli Hertlein and Strong: 3 adolescents.

Cardium (*Trachycardium*) *quadragenarium* Conrad: 1 juvenile.

Calliostoma gloriosum Dall: 4 adolescents.

Callicstoma supragranosum Carpenter: 1.

Pteropurpura carpenteri (Dall): 1 adult, 2 juveniles. It appears not impossible that the oldest name for this species is *Murex macropteron* Deshayes (1839:360; 1841:pl. 38; 1843:606). This was originally described without citation of locality. Its subsequent history has been a checkered one. Poirier (1883:93) attributed it to Japan, but I have found no confirmation of an Oriental habitat in the writings of any recent worker in that field. Dall (1889:201) thus identified two specimens dredged off Cape Hatteras, N. C. This western Atlantic species has since been separately recognized as *M.* (*P.*) *bequaerti* Clench and Farfante (1945:40). Unhappily I have only once seen the original figure of *M. macropteron*, and the holotype has never been refigured unless, perchance, it be the shell figured under this name by Reeve (1845: Murex pl. 27, sp. 123) and Sowerby (1880: Murex pl. 11, fig. 111). These figures, both drawn by Sowerby, are so nearly alike as almost certainly to have been made from the same shell, that in Reeve being by all odds the better executed and more detailed. That these are excellent representations of the Californian shell subsequently named *carpenteri* by Dall is at once apparent when shell and drawing are placed side by side. Should they then have been correctly affiliated by the iconographers with Deshayes' species, there would seem little doubt where that century-old enigma will finally come to rest. As I intend dealing with this situation much more fully in a forthcoming contribution, no further elaboration of the case history seems necessary here.

Station H51-243 (pipe dredge), **43 to 45 fathoms, lat. 34°02′37″ N., long. 119°41′, 35 to 05″ W,. northeast of Pelican Bay, Santa Cruz Island; mud bottom; June 29, 1951.**

Nucula (*Nucula*) *tenuis* (Montagu): 23, nearly all mature.

Nucula (*Acila*) *castrensis* Hinds: 114 of various ages, and 2 valves.

Nuculana taphria (Dall): 1 valve.

Nemocardium centifilosum (Carpenter): 5 immature.

Compsomyax subdiaphana (Carpenter): 3½.

Tellina (*Moerella*) *carpenteri* Dall: 1.

Dentalium neohexagonum Pilsbry and Sharp: 2.

Turritella orthosymmetra Berry: 1 (plus a fragment).

Bittium sp. (nov. ?): 1. This can be referred to no described species known to me, but in so difficult a genus as *Bittium* a new species should be distinct indeed to justify its foundation upon a single specimen.

Crepidula adunca (Sowerby): 1 bleached shell.

Megasurcula carpenteriana (Gabb): 1 juvenile. Probably referable to the form *tryoniana* (Gabb).

Turbonilla (*Mormula*) *regina* Dall and Bartsch: 2. These can presently be identified in no other way, although the larger has three brown bands on the body whorl not specified in the original description or in Bartsch's key.

Acteocina intermedia Willett: 2. This and *eximia* (Baird) seem not too happy in *Acteocina*. I fail to see why either of them ever need be confused in any way with *A. culcitella* (Gould).

Station H51-251 (pipe dredge), **162–150 feet (26–27 fathoms), lat. 34°00′38″ to 20″ N., long. 119°30′35–13″ W., Anacapa Passage; gravel bottom, with some stones; July 2, 1951. Vegetation: *Callophyllis, Drouetia, Reticulobotrys, Lithothamnia,* predominant.**

Pecten (*Pecten*) *diegensis* Dall: 2 not quite mature. Both carried *Capulus*, q.v. infra.

Oldroydia percrassa (Dall): 1 juvenile.

Dendrochiton (?) sp.: 1 juvenile.

Capulus californicus Dall: 3 immature. Two of these *in situ* on *Pecten diegensis*, the third loose in jar.

Trivia (*Pusula*) *ritteri* Raymond: 1. Surface of shell somewhat altered by preservative used.

Bursa californica (Hinds): 3. Very small for the species, but of mature aspect.

Odostomia (*Evalea*) *santarosana* Dall and Bartsch: 1. The specimen seems best referable to this little-known species. The color, however, is much paler than would be inferred from its original description as "light olive."

Station H51-252 (pipe dredge), **174–190 feet (29–31.5 fathoms), lat. 34°00′10″ N., long. 119°27′35–05″ W., Anacapa Passage; gravel bottom, with stones; July 2, 1951. Vegetation: *Drouetia, Reticulobotrys, Lithothamnia,* etc.**

Terebratulina unguicula (Carpenter): 11. The specimens were taken adhering to a small piece of coral. Not a mollusk, but included for the sake of the record.

Chlamys hastatus (Sowerby): 1.

Diplodonta cf. *subquadrata* Carpenter: 2 adolescents. Californian shells are more acutely beaked and possess a much more strongly developed dentition than any of the west Mexican mainland specimens examined by me. The question of their identity might well be reinvestigated by someone having access to more complete series than I have seen.

Semele aff. *incongrua* Sowerby: 1, probably immature.

Acmaea funiculata Carpenter: 1 juvenile shell, remarkable in that a sharply ribbed initial stage is abruptly succeeded by a stage in which the ribs become in large degree obsolescent. For a finely detailed discussion of this still somewhat enigmatic species see Hanna and Smith, 1931:21.

Astraea (*Pachypoma*) *inaequalis rutila* (C. B. Adams): 2. The specimens are small for the species. I am unable to detect any material difference between this form and *A. i. montereyensis* Oldroyd. Carpenter's suggestion that *rutila* belongs under *A. undosa* (Wood) I believe to be erroneous.

Calliostoma annulatum (Martyn): 2 juveniles. Those who reject Martyn's names can save this one by quoting it as of Humphrey (1786:101).

Vermicularia fewkesii (Yates): 1.

Trivia (*Pusula*) *ritteri* Raymond: 1. A perfect example of this lovely chaste species.

Nassarius insculptus (Carpenter): 1.

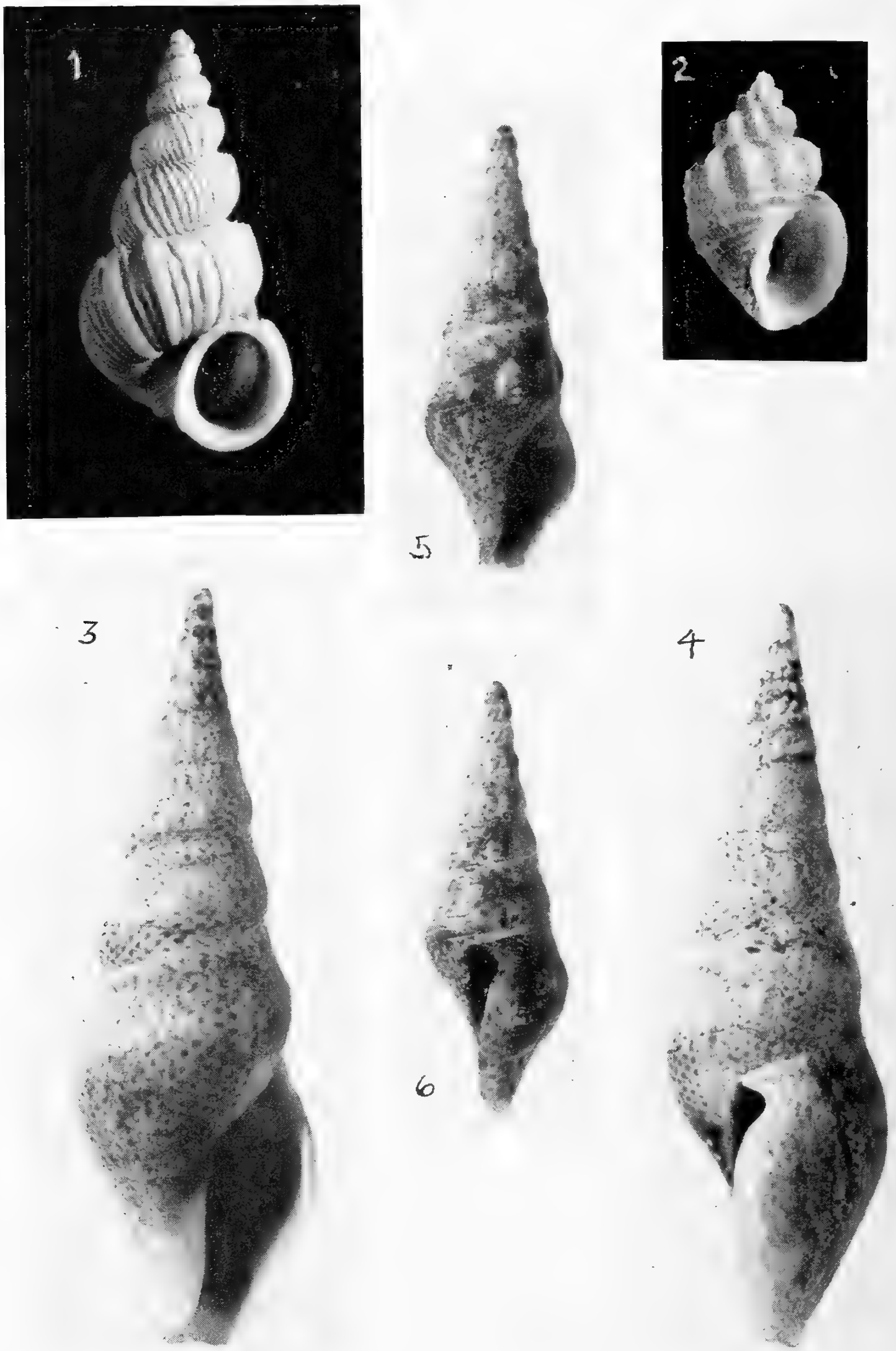
Fusinus sp.: 1 adolescent.

Pseudomelatoma sticta, n.sp.: 1 adult; 1 immature. Described in the concluding portion of this paper (p. 156).

Conus californicus Hinds: 7 immature.

Station H51-254, 46–58 fathoms, lat. 34°03′05″ to 45″ N., long. 119°26′02″ to 25′28″ W., ca. 2½ miles N. of W. end of Anacapa Island; July 2, 1951.

This was the richest in Mollusca of any haul



FIGS. 1–6.—1, *Epitonium* cf. *lowei* (Dall), mature shell taken in 46–58 fathoms, north of west end of Anacapa Island, Calif., × 2.6; 2, *Admete seftoni*, n.sp., holotype, taken in 46–58 fathoms, north of west end of Anacapa Island, Calif., × 4.25; 3, *Pseudomelatoma sticta*, n.sp., ventral aspect of holotype, taken in 26–27 fathoms, Anacapa Passage, Calif., × 3.5; 4, *P. sticta*, n.sp., lateral aspect of holotype, same scale; 5, *P. sticta*, n.sp., ventral aspect of the immature paratype, × 3.5; 6, *P. sticta*, n.sp., lateral aspect of same specimen; same scale.

made, both as to species and as to number of individuals.

Nucula (Acila) castrensis Hinds: 105½.

Nuculana hamata (Carpenter): 1½.

Modiolus pallidulus (Dall): 1.

Cardita (Cyclocardia) longini Baily: 13½. For this name and the reasons impelling rejection of two prior names for the species see Baily, 1945.

Pseudochama granti Strong: 1 juvenile valve. The specimen shows the larval shell with exceptional distinctness.

Nemocardium centifilosum (Carpenter): 14 juveniles and adolescents.

Tellina (Moerella) carpenteri Dall: 6.

Spisula cf. *planulata* (Conrad): 1 right valve.

Hiatella arctica (Linné): 2 juveniles.

Cuspidaria (Cardiomya) californica Dall: 1.

Leptochiton oldroydi (Dall): 1. A distinctive species, although one of the smallest of west American chitons.

Puncturella cooperi Carpenter: 1. This example clearly displays the curious punctations which characterize the shells of a number of species in this genus.

Margarites (Lirularia) acuticostatus (Carpenter): 2 shells.

Margarites (Lirularia) pedroanus (Arnold): 3. The Californian species of *Lirularia* are exceedingly difficult of satisfactory disposition. The determinations here suggested are believed to be about as close as is possible in the absence of a thoroughgoing revision.

Solariella peramabilis (Carpenter): 4, plus 3 empty shells.

Cidarina cidaris (Carpenter): 1 half-grown shell.

Calliostoma annulatum (Martyn): 1 juvenile bleached shell.

Calliostoma turbinum Dall: 1.

Liotia farallonensis A. G. Smith: 1. This rare species has hitherto been known only from the vicinity of the Farallon Islands (see Smith, 1952:385). A fine mature example now provides an important extension of range.

Homalopoma sp.: 1. A thoroughly puzzling specimen, the closer determination of which is postponed pending the aquisition of additional material.

Turritella cooperi Carpenter: 10 shells, representing a form in which the spiral keels are quite strongly developed.

Turritella orthosymmetra Berry: 6 shells. These are badly bleached but are apparently referable here.

Bittium sp. indet.: 7 (plus 15 shells). This is a form rather close to *B. subplanatum* but with flatter whorls and more regular tuberculation. It is possibly undescribed, but for the time being I refrain from adding another name to this genus of many and difficult species.

Bittium sp. indet.: 1 bleached shell. Similar to the preceding but much more sparsely and coarsely tuberculate.

Bittium cf. *rugatum* Carpenter: 5 bleached shells.

Seila montereyensis Bartsch: 1. Altitude of shell exclusive of missing apex, 14.2 mm.

Epitonium (Nitidiscala) indianorum (Carpenter): 1.

Epitonium (Asperiscala) cf. *lowei* Dall (Fig. 1): 1. This superb example is remarkable for its very numerous and crowded, strongly reflexed, coronate costae, a few of which become much thickened and with their exaggerated reflexed portions also much wider than the ordinary costae, thus taking on the character of true varices and to this extent casting doubt on current interpretations of simple repetitive costae as varices. The costae number 30–31 on each of the last two whorls and 28–29 on whorls higher up the spire. The inadequately known *E. lowei* is stated to have 26–27 costae, none of which is described as varically thickened, but the recorded specimens are much smaller with an altitude of only 7 mm. (see Dall, 1906:44; 1921:214, pl. 6, fig. 11), and I am unable to find any really trenchant characters whereby they might be distinguished from the apical whorls of this shell. The *Orca* specimen measures: altitude 21.6; maximum diameter 10.6; altitude of aperture 6.4 mm.; extreme apex decollated.

Balcis (Balcis) micans (Carpenter): 1.

Balcis (Vitreolina) titubans, n.sp.: 1. Described in the concluding section of this paper (p. 154).

Calyptraea contorta (Carpenter): 1 juvenile shell.

Crepidula cf. *onyx* Sowerby: 1 bleached shell. An example of a small narrow form such as one sometimes sees on a *Turritella* or *Olivella* shell.

Natica (?) sp. indet.: 3 small shells. These have much the aspect of *Cryptonatica*, but as there is at least one species in the area with a tight umbilical callus of this type, yet having a horny operculum, they must for the time being be left unplaced.

Polinices (Euspira) draconis Dall: 1.

Trivia (Pusula) ritteri Raymond: 1 immature.

Neosimnia catalinensis (Berry): 1. A perfect although not quite typical adult example of this rarely taken species.

Ocenebra clathrata (Dall): 5 shells.

Ocenebra (?) sp.: 1 shell.

Boreotrophon triangulatus (Carpenter): 1 shell.

Boreotrophon aff. *bentleyi* Dall: 2 (plus 1 shell). These seem quite similar to *B. bentleyi* and may represent a form of it, but the shell is smaller, more compact, and obscurely spirally striate.

Mitrella tuberosa (Carpenter): 5 shells.

Amphissa reticulata Dall: 2 shells.

Amphissa undata Carpenter: 198 (plus 70 shells). By far the most abundant species in the haul.

Nassarius aff. *perpinguis* (Hinds): 1 shell. A puzzling shell, similar in general aspect to *N. perpinguis*, but much higher and with a different and peculiar sculpture, especially on the spire. More material will be needed for its satisfactory disposition.

Nassarius insculptus (Carpenter): 2 (plus 6 shells).

Olivella baetica Carpenter: 1 bleached shell.

Mitra (Atrimitra) idae Melville: 1 shell. A hermit-crab shell of fair size.

Admete cf. *gracilior* Carpenter: 2. These represent a form close to typical *gracilior*, differing chiefly in the more acute shoulder tuberculation and in the possession of but 8 axial ribs on the body whorl. It may eventually prove nameable as a further-evolved living race of the earlier species.

Admete, n.sp.?: 2. These appear quite close to a fossil form which the author has in MS.

Admete seftoni, n.sp.: 2. Described in the concluding section of this report (p. 155).

Elaeocyma empyrosia (Dall): 4 (plus 1 doubtful bleached shell).

Antiplanes perversus (Gabb): 5. These are of medium size only.

Antiplanes (Rectiplanes) sp.: 2. Surface corrosion is here too great to permit certain determination without additional material.

Lioglyphostoma crystallina (Gabb): 1 (plus 3 shells): Although there are obvious discrepancies with Dall's figure (1921:214, pl. 6, fig. 4), there is reasonable agreement with the original description of Gabb. Relative age may conceivably explain the differences.

Mangelia (Kurtzia) roperi Dall: 1 shell.

Turbonilla (Pyrgolampros) sp. indet.: 1. A long slender species which can not at present be affiliated with any of the described forms.

Turbonilla (Mormula) regina Dall and Bartsch: 5. Of various ages and sizes, several showing spiral bands on the body whorl. Altitude of largest shell, 21.0 mm.

Acteocina intermedia Willett: 1 (plus 7 shells).

"Retusa" harpa (Dall): 1.

Cylichna diegensis Dall: 2.

Station H51-260 (pipe dredge), **86–94 feet** (ca. **14–16 fathoms**), **west of Ford Point, Santa Rosa Island. Vegetation: abundant red and brown algae; July, 4, 1951.**

Glycimeris corteziana Dall: 1.

Cardita (Cyclocardia) longini Baily: $13\frac{1}{2}$.

Chama pellucida Conrad: 1 damaged immature.

Dentalium sp.: 1.

Calliostoma splendens Carpenter: 3.

Bittium attenuatum Carpenter: 1.

Balcis (Vitreolina) thersites (Carpenter): 1 immature.

Ocenebra clathrata (Dall): 1.

Ocenebra (?) cf. *munda* Carpenter: 1 imperfect shell.

Mitrella carinata (Hinds): 98. Small for the species, but nearly all mature.

Nassarius cooperi (Forbes): 4 shells.

Conus californicus Hinds: 7, mostly immature.

DESCRIPTIONS OF NEW SPECIES

Balcis (Vitreolina) titubans, n. sp.

Figs. 7, 8

Shell of fair size for a Californian member of the genus, solid, smooth, polished, basally robust, with an acute, rapidly tapering, doubly flexed spire; apex moderately tipped dorsad, with the body of the shell strongly diverted to the right. Whorls 10 to 11, the first translucent, the second less so, and those succeeding opaque milky white, very slightly swollen above the tightly appressed and barely indented suture; last whorl rounding smoothly into the full and moderately produced base. Sculpture wanting except for the distinct varical grooves, which, beginning dorsally on the sixth whorl, descend the shell in narrowly stepped obliquely protractive alignment, each groove producing an angular downward dip in the suture as it leaves it, the series terminating just back of the lip; final whorl without a varix and without a sutural indentation. Aperture a trifle over one-quarter the altitude of the shell, narrowly pyriform, its posterior angle acute, rounded and slightly produced in front; parietal wall barely convex, forming a widely obtuse angle where it adjoins the nearly straight, narrow, and somewhat oblique columella, the whole covered by a moderately thick, sharply bounded callus which is slightly expanded in front and appressed against the base of the shell; output lip entire, gently sinuate below the suture, thence rather weakly produced peripherally; from the periphery the lip rounds smoothly back and inward to its narrow expansion into the columellar thickening.

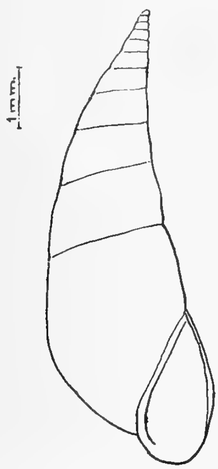


FIG. 7.—*Balcis* (*Vitreolina*) *titubans*, n. sp., camera-lucida outline of holotype; much enlarged.

Measurements (of holotype): Altitude 7.4; maximum diameter (est.) 2.7; altitude of aperture (to suture) 1.87; diameter of aperture (edge of columellar lip to outer lip) 0.9 mm.

Holotype: Berry Collection no. 23624.

Type locality: 46–58 fathoms, ca. 2½ miles north of Anacapa Island, Calif.; one example, *Orca*, July 2, 1951.

Commentary: The distortion of symmetry in *B. titubans* is one of the most extreme seen in any of our species. It is much laiger than the more or less similar *B. grippi* (Bartsch) of the same region, and it is both more robust and more eccentric in form than either that species or the more northern and likewise similar *B. columbiana* (Bartsch).

The specific name is the present participle of the Latin *titubo*, I stagger.

Admete seftoni, n. sp.

Figs. 2, 9

Shell small, robust, with 5 to 5¼ whorls; spire short, acutely conic, with sunken channeled sutures; nuclear whorls rounded, more or less corroded in examples studied, but apparently smooth, subcarinate above, and at the beginning partially immersed; subsequent whorls strongly convex, slopingly subtabulate above, with 8 to 9 strong, moderately retractive, axial ribs, and with a strong spiral cord on the angle as well as another below it a little more than halfway to the suture; between these two primary spirals a third cord shortly arises, followed sometimes on the penultimate whorl by a fourth more slender cord below these and a fifth above the shoulder cord; body whorl more narrowly and less distinctly tabulate than the preceding whorls, bearing about 9 axial ribs, the last of which back of the aperture is somewhat obsolescent, and the above-mentioned 4 or 5 spiral cords, the most emphatic of these being the strong cord on the periphery separated by quite a wide space from a similar cord farther down the whorl, while below on the base are 4 lesser spirals of diminishing strength, the subperipheral and two posterior basal threads penetrating the aperture parietally; entire surface including the cords delicately spirally striate and more crudely axially threaded; axial ribs subtuberculate where crossed by the spiral cords, the nodules being best developed on the earlier whorls Aperture ovate, rounded posteriorly, more pointed, though very obtusely so, in front; outer lip thin, smooth within, although the external cords shine through to give somewhat the effect of a liration; lip margin ascending a little from the suture, then roundly descending into the very short, widely open canal; inner lip covered by a wash of callus which is thin, well expanded, and closely applied parie-

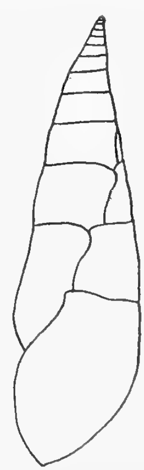


FIG. 8.—*Balcis* (*Vitreolina*) *titubans*, n. sp., camera-lucida outline of holotype as seen from right side; same scale as Fig. 7.

tally, but heavier and lip-like at the columella where it becomes appressed over the very narrow and impermeable umbilical chink; columella sloping very slightly inward and furnished with two fairly strong oblique plications.

Measurements (of holotype): Altitude 9.4; maximum diameter 5.8; altitude of aperture 5.4; maximum diameter of aperture (edge of columellar flare to margin of outer lip) 3.5 mm.

Holotype: Berry Collection no. 23679. *Paratype:* Berry Collection no. 23629.

Type locality: 46–58 fathoms, ca. 2½ miles North of Anacapa Island, Calif.; 2 examples, Orca, July 2, 1951.

Commentary: This very attractive little species is closely similar to no described form known to me. Its large body whorl, low-conic spire, deep suture, and strong axial plication afford a combination of characters which sets it well apart. In general form it somewhat resembles the considerably larger Alaskan species which currently passes for *A. couthouyi* (Jay), but it differs sharply in nearly every detail.

The species is dedicated to Joseph W. Sefton, of San Diego, master of the *Orca.*

Pseudomelatoma sticta, n. sp.

Figs. 3–6

Shell of moderate size, elongate-fusiform, with tall, sharply conic spire; whorls 9+, slightly constricted in front of the suture, the anteriorly thrust periphery smoothly convex; suture sharply defined; first nepionic whorl and a quarter smooth, mammillate; succeeding whorl rather abruptly showing about 6 fairly sharp spiral grooves and about 10 strong protractive axial ribs which do not cross the fasciole; although remaining strong for yet another whorl or so, all this sculpture gradually tends thereafter to obsolescence except at the periphery where the ribs persist as low rounded knobs, the number of which to a whorl remains about the same until the body whorl is reached, when the entire later portion becomes practically smooth; spiral grooving particularly strong on the base of adolescent shells, but even in this region represented only by traces on such a fully mature shell as the holotype. Aperture elongate-pyriform, about 38 percent of the height of the shell, widest posteriorly, its posterior angle acute; outer lip moderately thick, sharp-edged, unarmored, produced anteriorly into the short, open, very slightly recurved canal; inner lip and columella smooth, weakly sigmoid, covered by a rather thick callus the outer boundary of which is a rather sharp groove in the adolescent shell and a low ridge in the adult. Anal notch distinct, shallow, subjoining the suture; fasciole rather wide, marked principally by the inbowed lines of growth. Color generally a light golden brown, everywhere speckled with small, rounded, discrete, dark brown spots, in some areas showing a tendency to a certain regularity of arrangement; the holotype also shows a large, conspicuous, blackish brown spot over and immediately in front of the inner lip and there is considerable dark staining or a suggestion of banding in the outer wall of the chamber.

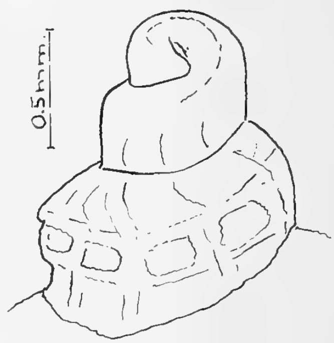


FIG. 9.—*Admete seftoni*, n. sp., camera-lucida sketch of apex of paratype; greatly enlarged.

Measurements: Holotype—altitude 29.5; maximum diameter 9.2; altitude of aperture 11.2; diameter of aperture 4.4 mm. Paratype—altitude 17.3; maximum diameter 6.5; altitude of aperture 7.3, diameter of aperture 2.8 mm.

Holotype: Berry Collection no. 23785. *Paratype:* Berry Collection no. 23584.

Type locality: 26–27 fathoms, Anacapa Passage, Calif.; 2 specimens, *Orca*, July 2, 1951.

Commentary: Even amid the graceful family of the turrids this is a trimly elegant species, characterized by the down-sagging (or anteriorly thrust) noded convexity of the whorls comprising the spire, by the eventual obsolescence of the originally sharp axial and spiral sculpture, and by the neatly speckled color pattern. These features separate it from all other members of the genus *Pseudomelatoma*, with which its present affiliation can be only tentative in the absence of any knowledge of the animal and particularly of its radula. The shells of both holotype and paratype were almost completely covered by a heavy whitish bloom, apparently limy and perhaps algal, which proved exceedingly difficult of even incomplete removal.

The specific name is the Latin *stictus*, dotted, and has reference to the speckled color pattern of the shell.

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LOW-TEMPERATURE ALIGNMENT OF RADIOACTIVE NUCLEI PROVIDES DATA ON NUCLEAR DISINTEGRATION

Low-temperature research at the National Bureau of Standards has succeeded in aligning the nuclei of three radioactive elements—cerium-139, cerium-141, and neodymium-147. These results were achieved by cooling samples of the three materials to within a few thousandths of a degree of absolute zero. At such temperatures the effects of thermal agitation become so small that atomic nuclei can line up in a given direction within the crystal lattice. A corresponding directional effect can then be observed in the emitted radiation.

The nuclear alignment experiments[1] were carried out by Drs. E. Ambler and R. P. Hudson, of the Bureau staff, in cooperation with Dr. G. M. Temmer, of the Carnegie Institution of Washington. Initial phases of the work were sponsored by the Office of Naval Research.

Low-temperature alignment of nuclei promises to provide a new tool for studying the processes of nuclear disintegration. The nucleus may be regarded as a magnetic top spinning about an axis. If this spinning magnet is radioactive, the orientation of the spin axis will determine the directions in which the nucleus emits radiation. Normally, when nuclei are randomly oriented, a radioactive specimen emits gamma rays with equal intensity in all directions. However, when the nuclei are aligned, the intensity of gamma radiation varies with angle of emission. By measuring the degree of this directional effect, valuable information can be obtained concerning the decay scheme of the nuclei, and an insight can be gained into the mechanisms controlling such processes. For example, the magnetic moment of the nucleus can be determined as well as the changes in angular momentum accompanying the emission.

In the Bureau's experiments, radioactive nuclei were incorporated into certain inorganic crystals formed by the elements studied, which were then cooled to temperatures as low as 0.003°K. Nuclear alignment was observed by measuring the angular distribution of the intensity of the gamma radiation emitted by the crystals.

Inasmuch as the crystals used were paramagnetic, the necessary low temperatures could be conveniently produced by the method of adia-

[1] For further details, see *Alignment of cerium-141 and neodymium-147 nuclei*, by E. Ambler, R. P. Hudson, and G. M. Temmer, Phys. Rev. **97:** 1212. 1955; and *Alignment of three odd-A rare earth nuclei*, by the same authors, ibid. **101:** 1096. 1956.

batic demagnetization. In this method a paramagnetic crystal is first magnetized by a powerful magnet. The resultant heat of magnetization produced in the crystal is removed from the system. Then when the magnetic field is turned off, the reverse effect occurs, and the temperature of the crystal falls to a very low value. The specimen soon begins to reheat, of course, but if due care has been taken to reduce heat leaks, the rate of heating is sufficiently slow to allow enough time for measurements.

In the Bureau's experiments a magnetic field of about 23,000 oersteds was used. A radioactive crystal containing the element under study was mounted on a thermally insulating support within a glass tube containing a small amount of "exchange gas" (helium at low pressure). The exchange gas provided thermal contact between the crystal and a surrounding bath of liquid helium boiling at about 1°K under reduced pressure. The liquid helium bath was protected against heat influxes by a Dewar vessel, which was in turn surrounded by liquid nitrogen.

When the magnet was switched on, the heat of magnetization was conducted from the crystal through the exchange gas to the liquid helium. This kept the temperature of the crystal from rising. The crystal was then isolated thermally by pumping the exchange gas away. Thus, when the magnet was turned off, the temperature of the crystal fell appreciably.

To observe nuclear alignment, the apparatus was then quickly moved into position between two scintillation counters, and the intensity of gamma radiation was measured along two different directions. As the crystal warmed up, a gradual decrease in the degree of alignment was observed. Finally, when the temperature reached 1°K, the nuclei were again found to be randomly oriented. This process was repeated a number of times in order to provide sufficient data to reduce the effects of random variation. From the data, basic information was obtained on the nucleus and its radioactive decay.

During each run the temperature of the crystal was monitored. This was done by measuring its magnetic susceptibility, which had previously been determined as a function of temperature by other investigators.[2]

The physical processes which give rise to nuclear alignment may be described as follows. Interaction with the electric fields within the crystal causes the electronic magnetic moment of certain atoms to line up either parallel or antiparallel to a certain crystallographic direction. Then at very low temperatures, where thermal agitation is much less, the coupling between the atomic magnetic moment and the nuclear magnetic moment is strong enough to allow the nuclei also to be pulled into alignment. This coupling cannot begin to overcome the forces due to thermal motion, however, until the temperature falls well below 1°K.

The anisotropic angular distribution of gamma rays from the aligned nuclei can be explained by considering angular momenta. Since the angular momenta of the parent and daughter nuclei as well as that carried away by the gamma ray are fixed by nature, it follows from the principle of conservation of angular momentum and from radiation theory that definite restrictions are placed upon the pattern of gamma-ray emission. The phenomenon is analogous to the radiation from a radio antenna, where anisotropic emission patterns are also observed. This close relationship between gamma radiation and angular momentum makes it possible to utilize gamma-ray intensity data as a basis for deductions concerning the angular momentum of the parent nucleus and the changes occurring during radioactive decay.

Work in this general field is continuing at the Bureau. Attention is now being directed to low-temperature methods of polarizing, rather than aligning, nuclei. Stable nuclei can be employed in experiments of this kind, and a larger number of different nuclei can be studied. The Bureau hopes to obtain additional data of value both to cryogenics and nuclear physics.

[2] Daniels, J. M., and Robinson, F. N. H. Phil. Mag. **44:** 630, 1953.

The man who makes no mistakes does not usually make anything.

—Edward J. Phelps

ZOOLOGY.—*A new fairy shrimp from western United States, with notes on other North American species.*

Ralph W. Dexter, Kent State University, Kent, Ohio. (Communicated by Fenner A. Chace, Jr.).

Recent studies on the fairy shrimps (Crustacea; Anostraca) of North America have brought to light some new and interesting records worthy of publication. One new species collected from Nevada, Washington, and California is described. The known geographic range of nine species is extended considerably by the acquisition of some new locality records. Additional records of two species of fairy shrimps living in the same pond are given and the seasonal occurrences of *Eubranchipus serratus* and *E. vernalis* in certain ponds studied in east central Illinois during the spring seasons of 1951–1955 inclusive are outlined in detail. This report continues the studies published in an earlier paper (Dexter, 1953).

Specimens of Anostraca collected by Robert S. Bray which are mentioned in this paper were sent to the writer by Dr. Folke Linder of Sweden. Specimens sent from the U. S. National Museum were obtained through the courtesy of Dr. Fenner A. Chace, Jr., curator of the Division of Marine Invertebrates. To these men and to the others named below who contributed specimens for this work my heartiest thanks are given.

Family Branchinectidae

Branchinecta mackini, n. sp.

Male (Figs. 1–4): Total body length, including cercopods, 16–25 mm. First antennae 4.5 mm. Second antennae 8.0 mm, consisting of two articles of equal length. Proximal article contains at its base a spur 0.4 mm long with minute spinules on it. Near the lower end of the same article are 3 or 4 inconspicuous spines well spaced along the lower medial surface. The distal article is gently curved, somewhat flattened, and the end is not recurved. There is no antennal appendage and no frontal appendage. Eye stalk 0.8 mm in total length. Penes 1.0 mm in length with a process 0.2 mm long and two swollen, spinous areas near the tip. There are seven postgenital segments. Cercopods are 2.0 mm in total length, gradually taper to a sharp point, and are fringed with setae 0.2–0.4 mm long. Swimming appendages are 2.5–4.0 mm long, with one proepipodite and one epipodite.

Female (Figs. 5, 6): Total length, including cercopods, 16–25 mm. First antennae 3.2 mm. Second antennae 1.3 mm in length, swollen with a short, sharp point at the end. Eye stalk 0.8 mm in total length. Ovisac 6.5 mm in total length; 1.3 mm in greatest diameter. There are seven postgenital segments. Cercopods and thoracic swimming appendages are like the male.

This species resembles most closely *Branchinecta shantzi* Mackin, 1952. However, *B. mackini* has a pointed spur at the base of the second antennae of the male instead of a rounded knob, the spines along the medial margin are not concentrated and are not on a swollen prominence, and the tips of the male antennae are not recurved as they are in *B. shantzi.*

Specimens were collected by Dr. Ira La Rivers from a playa pond 15 miles north of Reno in Washoe County, Nev., on February 16 and June 9, 1940 (eight males and two females, seven males and one female, respectively), and again from a playa pond south-southeast of East McNett Place, Fish Lake Valley in Esmeralda County, Nev., on March 26, 1951. Seven males and 14 females were collected at that time from which the holotype and allotype have been selected. Dr. R. H. Whittaker and his student C. W. Fairbanks collected many specimens from a large shallow pond some 40–50 hectares in area at Alkali Lake, Grand Coulee, Wash., on May 15, 1949. Dr. Arthur S. Lockley collected some from Bicycle Dry Lake near Barstow, Calif., in November 1955.

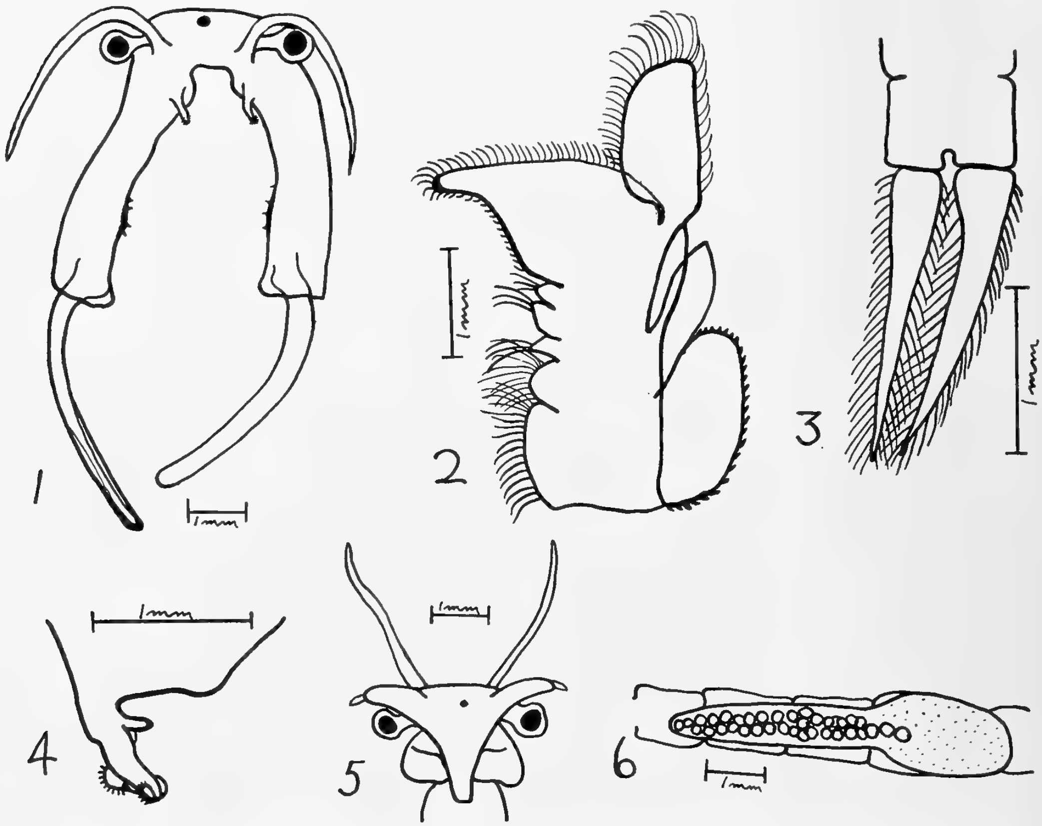
This new species has been named for Dr. J. G. Mackin, who first called its attention to the writer and who has made the most thorough study and revision of the genus Branchinecta in North America. The male holotype and the female allotype have been deposited in the U. S. National Museum (nos. 99216 and 99217). Paratypes have been divided among that institution (no. 99218), Dr. J. G. Mackin, Dr. Ira La Rivers, Dr. N. T. Mattox, Dr. R. H. Whittaker, and the writer.

NEW RECORDS OF GEOGRAPHICAL DISTRIBUTION OF ANOSTRACA

Since the publication of my previous paper outlining the known geographical distribution of certain species of fairy shrimps in North America, some new field records have come to hand which extend the known range of nine species and give additional locality data on some uncommon species.

The distribution of *Polyartemiella hazeni* (Murdock) has usually been given in the literature in very general terms as "the coastal plains of Alaska and Yukon Territory." Few specific records on those plains have ever been published. For that reason two which have come to hand recently are given here. Dr. N. T. Mattox sent some specimens of this species that had been collected by Roy Robinson near the Meade River at Point Barrow, Alaska, on August 15, 1952. Lawrence C. Bliss collected for the writer about 50 specimens of this species from depressed polygons on the coastal plain of Alaska at lat. 70° 25″N., long. 150° 40″W., on August 6, 1953. This locality is about 18 miles south of the Arctic Ocean and about one-quarter of a mile east of the Colville River. The polygons, formed by ice action, were about 2–4 feet deep, for the most part, and had an average diameter of 10–20 feet. Specimens were collected from six of them, and many of the animals observed were in copulation at the time. The polygons do not dry out as do temporary ponds in the temperate belt, but they do freeze to the bottom. Thus, the eggs of fairy shrimps are just as effectively removed from free water, a condition which usually seems to be necessary before they will hatch in any quantity. The name of this species was misspelled as *P. hanseni* by Daday, in 1910, and copied by most North American writers ever since. The correct spelling is *P. hazeni*.

Recently, specimens of another arctic species seldom collected have come to hand. Ten specimens of *Artemiopsis stefanssoni* Johansen were



FIGS. 1–6.—*Branchinecta mackini*, n.sp.: 1, Head of male; 2, swimming appendage of male; 3, cercopods of male; 4, penis; 5, head of female; 6, egg sac.

collected from a lake 3 miles north of Mound Bay Weather Station, Prince Patrick Island, in Northwest Territory, Canada.

Thamnocephalus platyurus Packard is now known from Utah, Nebraska, and Missouri. Specimens of the former two were sent from the U. S. National Museum. Two males and four females were collected from an impoundment of fresh-water at Monument Valley, Utah, by Marvin Walter on August 10, 1952. A single female specimen was collected by Dr. H. W. Manter from the western part of Nebraska. Date and locality were not recorded. Also, from the National Museum were sent specimens which are the second State record from Nevada, the first having been published in my previous paper. Two females were collected from near Dry Lake, 6 miles west of Boulder City, on October 29, 1952, by Mrs. V. B. Vehling. One specimen measured 28 mm in total length. Dr. Ira La Rivers sent another lot of two females collected from the same region. One of his students, E. A. Carl, found them at "Dry Lake, 4 miles south of the railroad pass between Las Vegas and Boulder City, Clark County, on September 17, 1953." The first records from Missouri were sent by Dr. Peter W. Frank, of the University of Missouri. He and one of his students, Robert W. Kelly, collected *T. platyurus* in July 1954 and from June to September 1955. They were collected from more than 15 temporary pools on the north bank of the Missouri River flood plain between Jefferson City and Booneville, and they were much more abundant during the latter year.

Eubranchipus vernalis (Verrill) has been found in Delaware, Maryland, and Virginia for the first time. R. S. Bray collected this species in Newcastle County, Del., on December 29, 1940. He also found it in a barnyard at Yellow Springs, Md., on December 14, 1940, and in Loudoun County, Va., on March 2, 1942. The occurrence of this species from Kentucky, inadvertently omitted from my earlier report, seems to rest solely upon an early record (1874) from near Covington. Additional records have recently come to the attention of the writer. Dr. Gerald A. Cole, of the University of Kentucky, collected *E. vernalis* between 1950 and 1954 from seven temporary pools and one permanent pond, which has dry margins annually, in various parts of Jefferson County. For the most part these pools were formed by flood waters of the Ohio River. In 1955 the water level was so high that these pools were washed over by the flood waters of the river, which carried away any pond fauna that had developed by early spring.

Eubranchipus neglectus Garman was described from Kentucky. The U. S. National Museum has eight specimens of *E. neglectus* collected from a clay pit near New Philadelphia, Ohio, by Dr. Victor Sterki. No date was recorded. Identification was made by Dr. E. P. Creaser and Dr. Folke Linder. This record extends the known range to eastern Ohio.

Eubranchipus serratus Forbes is now reported from Virginia and Maryland for the first time, and the second record from Indiana and Montana are listed. R. S. Bray collected this species on December 15, 1940, at Daday's Pond in Loudoun County, Va. A second lot was collected on April 5, 1941, from a cornfield pond near Seneca, Md. Dr. R. B. Brunson obtained the second record of this species from Montana with specimens he collected from Union Creek on April 17, 1951, and from a pond near Kicking Horse Reservoir on April 23, 1951. Identifications were made by Dr. N. T. Mattox, who sent the records to the writer. The first record from Indiana was recently published (Dexter, 1953). The second one from this State was made by Dr. Clarence Goodnight, who found this species in a gravel pit near West Lafayette in April 1953. Although most of the specimens received from him were mature, they were smaller than usual in size, averaging only 12 mm in total length. Dr. Mattox noted that the specimens from Montana were also smaller than average. It has been the experience of the writer to find that fairy shrimps vary greatly in size, not only in different geographic localities and during different years, but also in the same general locality at the same time.

Eubranchipus holmani (Ryder) has been collected in Maryland for the first time by R. S. Bray. Two males and two females were found at Martinsburg on April 16, 1940. A single male was taken from a barnyard pond at Yellow Springs on December 14, the same year, and two males and four females were collected in the Sunday Swamps at Bear Island on March 22, 28, and May 14, 1941. In my previous paper I overlooked an old published record of this species from Pennsylvania and from Minnesota. These States should now be added to the list.

Artemia salina (Linnaeus) is usually found in saline lakes and evaporating basins. Only rarely is it found in temporary pools. However, Ernest J. Roscoe collected specimens from a temporary pool northwest of Granite Mountain in Tooele County, Utah, on October 6, 1953. Recently this species was reported from Saskatchewan for the first time (Moore, J. E. 1952). It was found in abundance in Little Manitou, a saline lake.

Branchinecta shantzi Mackin is now reported for the first time from Nevada. Dr. Ira La Rivers collected 10 females and 8 males from railroad playa northwest of White Mountain in Washoe County on May 16, 1940.

Branchinecta coloradensis Packard, formerly known quite generally as *B. lindahli* until the genus was revised by Mackin (1952), is now known from Washington, California, and Utah. Dr. R. M. Bond obtained a large number of specimens, not quite mature, from a pool on the east side of the Columbia River, 2½ miles northeast of Vantage Bridge in Washington, on March 26, 1937. Dr. Ira La Rivers collected *B. coloradensis* on July 23, 1953, at upper Convict Creek basin in Mono Co., Calif., some 35 miles north of Bishop. Abundant specimens were found in several temporary meadow pools, formed from melting snow. The water temperature at the time of collecting, however, was 24°C. These pools are on the eastern slope drainage near the crest of the southern Sierras at an elevation of 10,300 feet. By August 13 all but the largest one had dried out. Records of this species collected by Dr. La Rivers and T. J. Trelease from Marble Butte in Nevada published in my previous paper did not include the dates. The dates of collecting were March 31 and April 23, 1949. The first Utah collection of *B. coloradensis* was made by Nyvin Marchette on April 19, 1954, from a temporary pond in Government Creek Valley, Tooele County. These were sent to me through the courtesy of Ernest J. Roscoe. Dr. Elizabeth McClintock obtained the second record of this species from Arizona by collecting specimens from temporary pools in red sandstone rocks in Toroweap Valley of Mohave County about 1 mile from the rim of the Grand Canyon, on May 6, 1952.

Two errors that have appeared in recent literature concerning *Branchinecta lindahli* should be corrected. First, W. G. Moore (1950) published a record of *B. coloradensis* from Texas that should have been designated as *B. lindahli* through an error on the part of the writer. Specimens sent by Dr. Moore were identified before the revision of the genus by Mackin (1952), and a misinterpretation led to an incorrect diagnosis. Secondly, in Mackin's revision (ibid.) of Branchinecta, the species *B. lindahli* Daday, 1910, is cited as a synonym of *B. lindahli* Packard 1883, whereas it should be listed in the "non" group. It is unfortunate that so much confusion has developed in the published literature on this genus in North America to continually plague students of the group since the genus was first found here.

Streptocephalus texanus Packard is now reported from Montana and Missouri. It was collected for the first time in Montana by H. E. Nelson, who found specimens at Glasgow in May 1952. This represents the most northerly locality from which the species has been recorded to date. This record, and the one of *S. seali* from Montana mentioned below, were brought to my attention by Dr. Mattox, who had received specimens for study from Dr. R. B. Brunson. Dr. Peter Frank and his student Robert Kelly have collected *S. texanus* from temporary pools along the north bank of the Missouri River near Booneville, Mo., in recent years. Specimens without field data were examined by the writer.

Streptocephalus seali Ryder is now recorded from North Carolina, Maryland, Missouri, Montana, and California for the first time. The U. S. National Museum contains specimens of *S. seali* collected by S. F. Hildebrand on June 3, 1926, from Thomas Pond No. 3 at Beaufort, N. C. R. S. Bray collected specimens from Bear Island, Md., on November 16, 21, and 28, and December 5, 1937, and again on August 6 and September 2, 1938. Dr. James Kezer, formerly at the University of Missouri, sent numerous mature specimens, 28–30 mm in length, which he collected in the fall of 1952 from a mud hole not far from the Missouri River near Booneville, Mo. They were still living in the pool on November 10. The water was clouded with mud and as a consequence the fairy shrimps were colorless. This relationship has been observed by the writer for several species of Anostraca. Late in October 1953 and in the latter part of March 1954, Dr. Kezer again found *S. seali* in the same mud hole. Dr. Peter Frank and Robert Kelly subsequently found the same species in many ponds of various types in the area. Dr. N. T. Mattox sent a record of *S. seali* collected from Glasgow, Mont., in May 1952 by H. E. Nelson. In the collections of the U. S. National Museum there are specimens of this species collected in September 1930 from a pond in the Sierra Nevada at an elevation of about 9,000 feet. The locality was in Tuolumne County, Calif., and the collector was R. Innis Bromley. Dr. Mattox has sent a record of *S. seali* collected by Dr. R. E. Smith from Eldorado County, Calif., on July 11, 1936. Dr. Douglas M. Whitaker has collected this species from the same county. On September 4, 1952, he found many specimens in a temporary pool filled from melted snow at an elevation of 6,600 feet in the Sierra Nevada of Eldorado County. The pond is located approximately half a mile east of Fallen Leaf Lake and about 4 miles south of the southeastern end of Lake Tahoe. Usually this pond dries out late in summer or early in fall, but heavy snows of the preceding winter caused it to persist through the season of 1952. Four male specimens ranged in size from 30 to 36 mm, with an average of 34 mm. In my previous paper I overlooked an early published record of this species from the State of New York, which should now be added to the list of known State records.

ADDITIONAL RECORDS OF COLLECTING TWO SPECIES OF ANOSTRACA TOGETHER

More records of finding two species of fairy shrimps in the same pond have come to hand. The 12 specimens of *Eubranchipus vernalis* and the single one of *E. holmani* collected at Yellow Springs, Md., as mentioned earlier in this paper, were found together. The specimens of *Streptocephalus seali* and *S. texanus* mentioned earlier from Glasgow, Mont., were together in the same vial and had a common label so that presumably they were found together. Likewise, specimens of these same two species reported above from Booneville, Mo., have been collected together. The writer collected *Eubranchipus vernalis* and *Chirocephalopsis bundyi* together in another locality of northeastern Ohio. They were found in a button-bush swamp pond near Mogadore in Portage County on April 27, 1952. The following year this pond did not fill with water, but in 1954 enough water accumulated to hatch out a few of each species. In the spring of 1955 there was an abundance of both species living together. The ratio, as determined by a count of 251 males, was 1 *E. vernalis*:1.5 *C. bundyi*. In a collection of fairy shrimps made by Walter Hintz near Pokagon State Park some 5 miles from Angola, Ind., there were 23 males of *E. vernalis* and 8 males of *C. bundyi*. They were found together on April 16, 1954, in a pasture pond. On March 17, 1952, a single specimen of *E. serratus*, 26 mm in length, was collected by the writer with 11 specimens of *E. vernalis* in a pool on the flood plain of the Salt Fork River near Homer, Ill. *E. vernalis* is the only species previously collected in this pond and in two others nearby, but all other ponds sampled in this section of Illinois have contained *E. serratus* as the common species (Dexter, 1953). Lawrence C. Bliss collected *Branchinecta shantzi* and *Chirocephalopsis bundyi* together from a small morainal pond at an elevation of 9,900 feet in the Medicine Bow Mountains of Wyoming on June 23, 1955. These species were found separately in three other ponds in this area (two with the former and one with the latter). Dr. Peter Frank and his associates have collected *S. seali* and *Thamnocephalus platyurus* together in pools near Booneville, Mo. Dr. A. S. Lockley at the Los Angeles State College collected *T. platyurus* along with specimens that proved to be the new species *Branchinecta mackini* described in this paper. They were taken from Bicycle Dry Lake, near Barstow, Calif., in November 1955.

FAIRY-SHRIMP POPULATIONS STUDIED IN ILLINOIS, 1951–1955

After my previous report on observations of fairy-shrimp populations in east-central Illinois was published, this field study was limited to six of the ponds which had been studied earlier. One new station was added in 1953. Table 1 gives a résumé of observations made in the third week of March for the years 1951–55, inclusive. No visits were made in 1954, but residents in the area reported a very dry spring during which time the temporary pools contained no water. It can be assumed that fairy shrimps did not hatch in these stations during 1954 for lack of water. The following year conditions for fairy shrimps were only slightly better.

In addition to the five temporary pools and one permanent pond (no. 8, near Urbana) sampled in 1951, Miss Sarah A. Joyner found three ponds 6 miles northeast of Urbana which were inhabited that spring by fairy shrimps. One was a permanent woodland pond in Trelease Woods, another was a permanent grassland pond, and the third a temporary pool, the latter two situated in nearby Trelease Grassland. The two permanent ponds have a dry margin during the summer season, which is always found in such bodies of water which contain fairy shrimps. Samples of fairy shrimps were collected by Miss Joyner in all three during the spring of 1951. She collected mature specimens of *Eubranchipus serratus*, identified by the writer, on March 8, 1951, from the permanent grassland pond.

In 1951 the collections were made on March 21 from five selected stations chosen from those formerly studied. Specimens were obtained from under a cover of ice. Two days later another collection was made after the ponds had thawed. The populations sampled that year were small. However, during the next two years they increased in number each year for the most part. Those records showing a wide range of sizes undoubtedly represent more than one hatching brood as the result of rising water levels with each new rain. The collections of 1952 were taken from under a skim of ice which coated most of the ponds. That year, one pool on the flood plain of the Salt Fork River near Homer yielded one specimen of *E. serratus* as well as its usual population of *E. vernalis*.

In spite of the fact that pond no. 8 near Urbana was bulldozed to a depth of 11 feet during the summer of 1951, fairy shrimps hatched in abundance the following spring. Apparently many eggs were left still exposed at the surface although great quantities of eggs must have been buried deeply by the earth-moving operations. By the next year, however, game fish had been introduced into this pond, and fairy shrimps were not found there again.

The season of 1953 was a favorable one for fairy shrimps. A new pond adjacent to the one at Oakwood was sampled for the first time. In the spring of 1954 water was not known to collect in any of the temporary pools under observation because of a severe drought in the area. (The same situation was reported by Dr. James Kezer for the region of Columbia, Mo. Ralph W. Stark found a similar situation in Boone County, Ind., until March 19, when rain broke the drought. On March 28 a heavy rainstorm there filled the pools bringing out a hatch of *E. vernalis*. In Portage County, Ohio, the writer was not able to collect fairy shrimps in some of the stations under observation until the middle of April, when rain filled many of the depressions for the first time that year. Studies on fairy shrimps in Ohio will be reported in a separate paper.)

In 1955 dry conditions still prevailed in Illinois. One pool (no. 2 near Oakwood) had 4 inches of water when examined, but no metanauplii were found in the plankton sample taken. Pond 7 near Urbana, however, had sufficient water to bring out a good-sized population of *E. serratus*.

In 1951 the sex ratio of *E. serratus* determined by a sample of 204 individuals was 1 male:1.2 females. The following year a reverse ratio of 1 male:0.6 female was found in a sample of 162 individuals. Dexter and Kuehnle (1951) found males of *E. vernalis* to predominate (1:0.8) in two of the counties in Ohio sampled, while females predominated in two other counties (1:1.5). Coopey (1950) found the sex ratio of *E. oregonus* to change markedly during the season as the males died off at a much greater rate. W. G. Moore (1955), on the other hand, found a balanced ratio of approximately 1:1 throughout the season in populations of *Streptocephalus seali* he studied in Louisiana.

SUMMARY AND CONCLUSIONS

1. *Branchinecta mackini*, n.sp., is described from specimens collected in Nevada, Washington, and California.

2. The known geographic range of the following species is extended by recent collections: *Thamnocephalus platyurus*, *Eubranchipus vernalis*, *E. neglectus*, *E. serratus*, *E. holmani*, *Branchi-*

Table 1.—Collecting Records of Anostraca in East-central Illinois

Location of ponds	Pond No.	1951	1952	1953	1955
Near Oakwood-Field ditch	1	S, 9–30.5	C, 13–23	A, 2–20	Dry
Near Oakwood-Field ditch	2	—	—	N, 13–22	0, nearly dry
Near Homer-Flood plain pool	2	S*, 9–24.5	R, 26; S*, 22–27	N*, 4.5–9.5	Dry
Near Homer-Flood plain pool	3	0	0	0	Dry
Near Urbana-Pasture pool	7	S, 5–16.5	C, 9–29.5	N, 9–21	N, 8.5–12
Near Urbana-Pasture pool	8	N, 16–30	A, 17–27	0 (fish intro.)	—
Near Urbana-Pasture pool	9	S, 4.5–23	Destroyed	—	—

Relative abundance is indicated as follows: A—abundant; C—common; N—numerous; S—scarce; R—rare; *—*Eubranchipus vernalis*. All other records are for *E. serratus*. Beside the symbol for abundance is given the range in size expressed in millimeters on date of collection.

necta shantzi, *B. coloradensis*, *Streptocephalus texanus*, *S. seali*.

3. New localities with notes on habitats are given for *Polyartemiella hazeni*, *Artemiopsis stefanssoni*, *Artemia salina*.

4. New records are cited for finding the following species living together in the same pond: *Eubranchipus vernalis* with *E. holmani*; *Streptocephalus seali* with *S. texanus*; *E. vernalis* with *Chirocephalopsis bundyi*; *E. vernalis* with *E. serratus*; *Branchinecta shantzi* with *C. bundyi*; *S. seali* with *Thamnocephalus platyurus*; *T. platyurus* with *B. mackini*.

5. Fairy-shrimp populations studied in seven pools in east-central Illinois during March 1951–55 are reviewed. Two species were collected: *E. serratus* which was common in most cases and *E. vernalis* which was uncommon and found in a single pool. Insufficient rainfall in the spring of 1954 prevented a hatch that season, and in the following spring only one pool had enough water to support a population. The years 1952 and 1953 were favorable ones for the fairy shrimps. Sex ratio of *E. serratus* was 1 male:1.2 females in 1951 and 1 male:0.6 female in 1952.

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NOTES AND NEWS

A SONIC TECHNIQUE FOR TESTING LEATHER

A nondestructive method for testing leather, based on the transmission of sound waves, has recently been developed by the National Bureau of Standards. The chief instrument employed is a pulse propagation meter which measures and records the speed of a generated sound pulse through the leather. As a result, the specimen under test is left unharmed, in contrast to the tearing or other destructive effects of existing test procedures.

The experiments[1] carried out at the Bureau have shown that the velocity of sound transmission in leather varies substantially with changes in chemical and physical structure and, particularly, in fiber orientation. Velocity measurements, accordingly, are indicative of modifications of the fibrous order produced by strain, aging, and impregnating material. The study that supports these conclusions was sponsored by the Office of the Quartermaster General, Department of the Army, and was conducted by Joseph R. Kanagy and Myron Robinson, of the NBS staff.

In recent years the use of sonic techniques to determine certain mechanical properties of high polymers has become widespread. Such methods have employed frequencies ranging from less than 1 cps up to several megacycles. The use of a single frequency throughout a series of tests readily permits mathematical analysis of the data and determination of the physical constants characteristic of the viscoelastic behavior of the material. Besides furnishing a means for securing fundamental information, sonic methods have been successfully utilized in nondestructive testing. These applications relate mainly to the location of flaws in a variety of manufactured products.

The investigations of the NBS leather laboratory are part of a larger program of fundamental and applied research on natural and synthetic polymers—rubber, plastics, textiles, leathers, and papers. This program seeks not only to improve present basic knowledge of high polymers but also to make possible their more effective utilization in commercial products. The present study of the potentialities of sound-transmission measurements is expected to provide the basis for im-

[1] For further technical details see *Studies on leather by means of a sonic technique*, by J. R. KANAGY and M. ROBINSON, Journ. Amer. Leather Chem. Assoc. (in press).

proved methods of testing finished products like military footwear as well as the unworked hide.

The Bureau's sonic experiments were based on the relationship between sound velocity and the elasticity of the medium as given by Young's modulus. If a sound wave is propagated along a medium whose transverse dimensions are small compared to the wavelengths utilized, then the following well-known relation holds:

$$E = v^2\rho \tag{1}$$

where v is the velocity of sound, ρ is the density of the medium, and E is Young's modulus, the latter being defined as the force per unit cross-section area required to produce unit elastic strain. However, if the material produces appreciable acoustic attenuation, as shown by a notable decrease in the amplitude of the sound wave as it travels through the medium, the single relation given above no longer suffices for an accurate determination of the modulus. An additional factor based on a viscosity coefficient must then be applied to the right-hand side of the equation.

In the current investigation, estimates of sound attenuation in leather were obtained by observing on an oscilloscope the decreasing amplitude of a particular section of a 3,000-cps wave train as the transmitter and receiver crystals of the propagation meter were separated. On the basis of these rough measurements, the attenuation for shoe-upper leather was estimated at 0.1 to 0.2 nepers per cm. For purposes of comparison, the attenuation constants were also obtained, under the same conditions of frequency and temperature, for other polymeric materials, with these results:

polyethylene	0.012 nepers per cm
nylon (undrawn filament)	0.003
neoprene GN at 6 percent strain	0.51

It may be seen that the acoustic attenuation in leather lies midway between that of materials with highly crystalline fibers and that of rubber-like materials.

In developing leather test methods, attenuation and frequency are of secondary importance since only relative velocity measurements are required to establish the deviation of a sample from its control. The data of this investigation were therefore studied in terms of the more directly measurable quantity, velocity. Now, the defining equation,

$$E = \frac{\text{stress}}{\text{strain}} = \frac{\text{load}}{\text{elongation}},$$

makes clear the direct relation holding between E and the resistance to elongation. In the light of this relation, equation (1) may be interpreted as saying that the speed of sound through a medium such as leather is greatest in the direction that offers the greatest resistance to elongation—that is, along the individual fibers.

In experiments with leather from cattlehide, the speed of propagation of sound varied with the lateral dimension of the specimen, increasing with width up to a certain maximum dependent on the wavelength of the sound. In cattlehide the fibers are oriented at random; consequently, there is no sound path directly along the specimen. That the speed of sound through a material like leather is related to fiber orientation was shown with vegetable-tanned sharkskin. In sharkskin the fibers occur naturally in a highly oriented basket-weave pattern, the two fiber axes being mutually perpendicular in the plane of the hide. Specimens were cut so that sound could be transmitted either in the direction of a fiber axis or at a 45° angle with the axes. The specimens cut at an angle of 45° with the fiber axes should have sound paths roughly comparable with those existing in cattlehide, and a similar velocity-width relation would be expected. On the other hand, specimens with one set of fibers oriented in the direction of sound propagation should show no velocity decrease when width is decreased, since there is a sound path that goes directly through the specimen. For both types of specimen, experiment conformed to expectation. The 45° cuts showed the same sort of velocity-width relation as did leather, and in parallel cuts the velocity was independent of the width within experimental error. The velocity of parallel propagation was also observed to be greater than the maximum velocity in the oblique direction.

Additional evidence that sound propagation follows fiber orientation was obtained from experiments with kangaroo tail tendons. These tendons are composed of collagen fibers highly oriented along a single direction. The speed of propagation through the tendons was approximately 2,000 meters per second, or about three times greater than the speed in cattlehide.

Another study showed that the speed of sound through leather increases with period of aging at

100°C until it reaches a maximum. Therefore, an indication of the quality of a sample of leather may be obtained by comparing the speed of sound through the sample with the maximum speed in a control specimen that has been subjected to aging.

It is thus possible, without harming the specimen, to detect changes in fiber orientation caused by strain, aging, and filling by comparing sound-velocity measurements. Moreover, there is good correlation between sonic measurements and the results of tensile and breaking elongation tests. The effects of tannage, grease, and moisture can also be demonstrated. Finally, for an inhomogeneous material such as leather, the sonic technique has the distinct advantage of providing a means of following the effects of aging, chemical treatments, and the like on a single specimen.

ARCTIC MARINE INVERTEBRATES STUDIED

Abundant and often fantastic are the animals of the shallow Arctic sea bottom. All are invertebrates—worms, sea anemones, and a host of others—many of which spend their lives buried in the bottom mud. They are described in a report recently published by the Smithsonian Institution by Prof. G. E. MacGinitie on his collections while principal investigator at the Navy's Arctic Research Laboratory at Point Barrow, Alaska.

Some of the creatures and their curious ways of life, as related in the report, follow.

A delicately peach-colored sea anemone, a bottom-dwelling animal remotely related to the coral polyps, which displayed what Professor MacGinitie calls an "amazing phenomenon." "When it was subjected to unfavorable conditions, such as overcrowding in a pan or jar of sea water," he says, "it cast out through the mouth a translucent white inner lining, with translucent, stubby tentacles. This offspring was somewhat suggestive of a pickled onion. If conditions remained adverse more offspring were cast off, each one becoming smaller than its predecessor." In other words, when in trouble the animal spits out babies—presumably an emergency measure for preservation of the species. Apparently the same thing happens in the sea. Partly grown specimens of these offspring dredged from the bottom at first were mistaken for a new species. Some quite colorful types of these animals were found—one purplish-red, one lavender, one lemon-yellow, and one with translucent, peach-colored tentacles.

Among the more abundant animals found on the shallow bottom were nemerteans, or ribbon-worms, notable for their ability to stretch the body to twice or more its normal length. Two specimens of one species that washed ashore had, as a means of self preservation, Professor MacGinitie says, "literally tied themselves in knots, curled up into balls, and then secreted bags of mucous around themselves."

Very abundant mud-dwelling animals off the Arctic coast are the echiuroids, otherwise known as "spoonworms," or "sausage-worms." They burrow very deeply in the mud and are seldom seen unless washed ashore in storms. One species was bright green in color and about 3 inches long; these worms, Professor MacGinitie found, were eaten raw by Eskimos.

Among the most abundant animals in the sea are the small, transparent *Sagitta*, or arrow-worms. Thousands were obtained in tows for plankton. One species, about half an inch long, apparently is among the kangaroos of the invertebrate world. "Two specimens," the report says, "were carrying young in a marsupium (pouch) formed by folding the posterior lateral fins together. In the laboratory some of the young about 3 millimeters long began escaping from this marsupium."

An extremely important part of the bottom fauna at Point Barrow, Professor MacGinitie found, were the bryozoans. They are colonial animals, somewhat like corals but of a higher order, which cover stones with growths that sometimes look like patches of moss, sometimes like weavings of delicate lace. Hardly a stone was found which did not have at least one "moss patch." Sometimes the entire surface would be covered. These miniature moss forests provide refuge for numerous other minute animals. Some of the lacelike colonies are quite beautiful. Some form peach-colored, some deep red, and some yellow lacework.

Marine annelid worms, or polychaetes, comprise an important group in the Point Darrow fauna. Among them was one species, of the type known as syllids—a flesh-colored worm with brownish-red eyes which emitted a bluish-white light. It lived ordinarily hidden among the bryozoan growth on stones, but its luminescence betrayed it.

Numerically the most abundant animals are amphipods, members of the sand-flea family, which form an important food source for fishes and seals. Great numbers live on the underside of ice cakes from which the bearded seal can sweep them with its whiskers. If seals can live on them, why not men? "It would seem," says Professor MacGinitie, "that they should form a source of food for military personnel forced to abandon ship or make a forced landing. *Apherusa glacialis* (the species found in such numbers on the bottoms of ice cakes) could be gathered with nets from the swarms that dart away when an ice cake is disturbed." This species is circumpolar in distribution.

E. C. Crittenden

Dr. Eugene Casson Crittenden, 75, internationally known scientist and expert on standards of physical measurement, died of cancer on Wednesday, March 28, 1956, at Garfield Hospital, Washington, D. C., after an illness of several months. He had retired as associate director of the National Bureau of Standards in December 1950 but had continued to serve the Bureau as a consultant to the director up to the time of his illness.

Dr. Crittenden is perhaps best known for his achievements in the development and adoption of electrical and photometric standards. As vice president of the International Commission on Illumination, from 1939 to 1948, and president of its U. S. National Committee from 1928 to 1935, he played a major role in the establishment of modern photometric units, standards, and methods of measurement which culminated in the international adoption of the "candela" in 1948. As the United States representative on the International Committee on Weights and Measures from 1946 to 1954, its vice chairman from 1950 to 1954, and as chief of the Bureau's Electrical Division for many years, he was a leading scientific figure in replacing the obsolescent international system of electrical units by the so-called absolute electrical units. These new units provide a basis for all electrical measurements now made in this country and throughout the world; they were given legal substance by Public Law 617 passed by the 81st Congress.

Crittenden was born at Oswayo, Pa., on December 19, 1880. He attended Cornell University and received his B.A. degree in 1905. He remained there as an instructor and graduate student until he came to the National Bureau of Standards as an assistant physicist in July 1909. He was first assigned to the Photometric Laboratory, where he subsequently made so many important contributions. He was named chief of the Bureau's Electrical Division in 1921 and continued in this position until 1946. Under his leadership, the program of the Division expanded substantially, keeping pace with the rapid developments in radio and electronics. Major organizational units of the Bureau came from nuclei assembled under his leadership. These include the former Ordnance Development Division, now the Diamond Ordnance Fuze Laboratories of the Department of the Army, and the Bureau's Central Radio Propagation Laboratories at Boulder, Colo.

In 1933 Dr. Crittenden was made assistant director of the Bureau and placed in charge of the over-all research and testing activities of the organization. In 1946 the title was changed to associate director, and he assumed the responsibilities of this office on a full-time basis and continued in this role until his retirement. He was awarded the Department of Commerce Gold Medal for Exceptional Service in 1949, the first year in which these awards were established. In 1946 he was honored with the Gold Medal of the Illuminating Engineering Society for "meritorious achievement conspicuously furthering the profession, art, or knowledge of illuminating engineering." Also in 1946 the Case Institute of Technology awarded him an honorary D.Sc. as "a devoted servant of the public, exponent of precise measurement, and international authority on the standards of science and industry."

He was extremely active in many scientific and professional organizations. He served on the Standards Council of the American Standards Association from 1925 to 1948 and as its chairman from 1945 to 1948. He was president of the Illuminating Engineering Society in 1925; president of the U. S. National Committee of the International Electrochemical Commission from 1939 to 1946; president of the Optical Society of America, 1932 to 1933; associate editor of the *Review of Scientific Instruments*, 1934 to 1936; and chairman of the Interdepartmental Screw Thread Committee in 1952. He also participated in the work of the American Society for Testing Materials, the American Institute of Electrical Engineers, the American Institute of Physics, the National Research Council, the International Organization for Standardization, and the International Committee on Legal Metrology. Locally, he was president of the Philosophical Society of Washington in 1922, of the Washington Academy of Sciences in 1940, and of the Cosmos Club in 1946.

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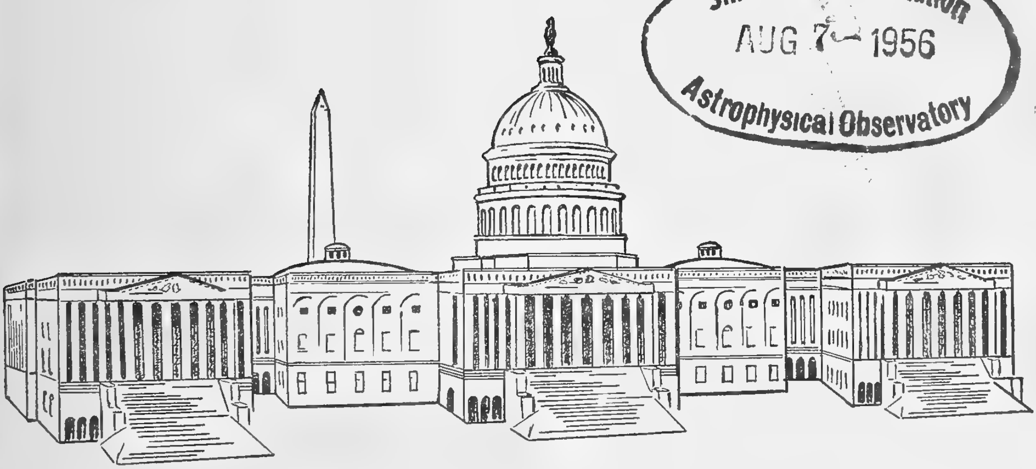

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GENERAL SCIENCE.—*Man and science*[1].

RAYMOND J. SEEGER, National Science Foundation.

(Received May 7, 1956)

One of the great issues today is the relation of man to science. I have deliberately used the phrase man and science, rather than science and man, to suggest that man himself is the key to the problem. I shall stress only the scientific aspect of this relationship today although I am quite sensitive to the human significance.

One phase of the issue may be stated thus: Is science inherently individualistic? If so, personal freedom is a primary requisite for each scientist. Or, is science essentially social? Then government planning is a fundamental necessity for all science.

The present emphasis all over the world seems to be on the social importance of science, arising probably from the prominent place it occupies in the economic structure of modern society (cf. the medieval social interest in astrology and alchemy). First of all, man is searching intensively for all kinds of materials and for cheap sources of energy, owing partly to catastrophic World War II losses, partly to normal population growth, and partly to an ever increasing demand for commodities. Secondly, the dramatic use of atomic energy within six years after its identification has encouraged a belief that the usual time lag between discovery and application can be greatly decreased by a sufficient expenditure of simultaneous efforts. (A more recent, but less well-known example from solid-state science is the invention of the transistor.) It is conceivable that the mastery of nature through science will make possible the mastery of the world. The uppermost question, therefore, in everyone's mind is this: if science is to rule the world, who is to rule science? Accordingly, we find governments generally sensitive to the basic research studies of technology. Sometimes, indeed, there is a deliberate attempt to make basic research captive, often indirectly through the support of education. For example, in recent years more than 60 per cent of education in Great Britain has been supported by the national government; in Germany about 90 per cent of all research at educational institutions has government funds for its source; in Russia technological development is being exploited in an all-out effort. Even in the United States it is estimated that the Federal Government supports about 70 per cent of the research performed at educational institutions. Hence it is not surprising to find President J. D. Millet, of the University of Miami, chairman of the Commission on Financing Higher Education of the Association of American Universities, saying, "Many of America's greatest universities are on the verge of becoming purely scientific, if not technological institutions." In any case the spectrum of the distribution of national funds for the support of science is anxiously watched as an index to technological progress.

Let us, therefore, consider in more detail the question: is science essentially social? Some years ago Julian Huxley concluded his book *Science and social needs* with the statement: "Science is not the disembodied sort of activity that some would make out, engaged in the abstract task of pursuing universal truth, but a social function, inti-

[1] Vice-Presidential Address for Section L, "History and Philosophy of Science, 1956 Atlanta Meeting of the AAAS. Based upon talks given at Purdue University, the Virginia Theological Seminary, Industrial College of the Armed Forces, and the State Department Foreign Service Institute.

mately linked with human history and human destiny." In the same spirit Hyman Levy in *The universe of science* has emphasized that science creates social needs, whereas Lancelot Hogben has boasted continually that science fulfills social needs. The Union of Soviet Socialist Republics notes in the Soviet encyclopedia that "The ultimate aim of all science is the satisfying of the needs of society." The Soviet Union itself is a good example of this thesis.

In the official Marxist doctrine of 1930 we are informed that science is identical with technology; that science advances practical needs; that science, therefore, must be organized for practical needs; and that central direction is necessarily part of economic planning. A dramatic illustration of this doctrine in practice was the recent development of biological science in the Soviet Union. In 1948 Lysenko expressed opposition to genetics because of its hereditary emphasis in contrast to the envoronmental factor, proper for Soviet thought. He was opposed also to Darwinian theories with their emphasis upon individual species combatting one another in contrast to the Lamarckian influence of environment. Within two years Michurin of Russia announced that through Lysenko's methods actual changes had been effected in plants, such as the transformations of wheat into rye, of elm into hazelwood, of pine into fir, et al. Two years later an announcement foretold animal changes soon to come (to date, the speaker has no knowledge of the fulfillment of this prophecy).

In practice the Soviet doctrine resulted early in a nationalization of science quite contrary to the international character that has been generally accepted in western culture. For example, in 1935 Soviet scientists were not permitted to publish in scientific journals outside Russia; later the Soviet journals themselves were published only in the Russian language; still later, references were confined mostly to Russian literature. To say the least, history may become greatly distorted through such a procedure. (The new look of the USSR is quite encouraging for an international outlook in the area of scientific publication (e. g., permission for external publication, and English abstracts of internal journals).)

If we would see ourselves as others see us, we might well read the somewhat prejudiced book of S. F. Mason, *Main currents of scientific thought* (1953). He argues that in the nineteenth century the main current of Soviet thought was essentially of a theoretical nature (cf. Lobachewsky's non-Euclidean geometry, Mendeléef's periodic table, Pavlov's conditioned reflexes), whereas in the United States it had more of a technological character (e.g., anaesthetics, the telephone, the airplane, et al., culminating in the twentieth century production of the atomic bomb). Perhaps, we should look critically in our own historical mirror. We see Benjamin Franklin promoting in 1773 the founding of the American Philosophical Society "For Promoting Useful Knowledge." In 1836 Joseph Henry, before his appointment as first Secretary of the Smithsonian Institution, said, "Though many excel in the application of science to practical arts of life, few devote themselves to the continued labor and patient discovery and development of new truths." With respect to Thomas Edison, Henry Ford remarked, "Today we think of scientific discoveries in connection with their possible or future application to the needs of man." In his *Science, the endless frontier* Vannevar Bush warned in 1945, "Our national preeminence in the fields of applied research and development should not blind us to the truth that with respect to pure research—the discovery of fundamental new knowledge and basic scientific principles—America has occupied a second place." Thus, we see from the beginning of American history to modern times a utilitarian tradition.

Nowadays there appears to be a world-wide phenomenon of such technological emphasis. On the one hand, those countries without industries are urgently striving to encourage industrial research; while, on the other hand, those countries with well-developed industries are busily engaged in fostering military research. In Great Britain, for example, during the period 1936–37 to 1950–51 the government support of basic research in the universities increased only sixfold, while government expenditures increased 8 times in agricultural research, 9 times in medical research, 10 times in industrial research, and 67 times in military research and development.

In all this social emphasis upon science, to be sure, there always lurks the potential danger of undesirable control. Physicists are ever mindful of the meeting of the British Association for the Advancement of Science in 1847 at which James Joule's experimental conclusion of the conservation of energy would have been dismissed ex cathedra by the chairman, had it not been for the alert and sensitive intervention of a young man by the name of William Thomson, later Lord Kelvin. A tragic series of events took place in Germany partly because of Hermann von Helmholtz's failure to recognize the theoretical work of Robert Mayer on the mechanical equivalent of heat in 1842, even though he admitted its value at the Innsbruck meeting in 1869. We are all aware of the German decision not to develop atomic energy during World War II. An "expert" here once informed a class that supersonic flight of aircraft would never be a possibility—at the very time that the Germans had privately completed their basic aerodynamic research for the V-2. I myself still recall certain individuals who advised against sponsoring basic research on the long-range application of interferometry to jets because of a supposed urgency of a short-range duration. Then, too, I recollect the scoffing attitude of some persons who questioned certain theoretical work in favor of practical improvements amounting, say, to an increased efficiency of a tenth of one per cent. It turned out later, however, that the theoretical ideas became embodied in the air-burst principle used in the bombing of Hiroshima and Nagasaki with its untold percentage increase in effectiveness. Men of affairs unfortunately are not alone in being adept in making wrong choices. In his outstanding work on *Hydrodynamics* (6th edition) the scholar Horace Lamb mentions the basic Rankine-Hugoniot law of shock waves only casually (in a footnote), viz, "No evidence has yet been adduced in support of this law." Yet since that year of 1933 shock waves have assumed a major role of practical importance and of theoretical significance. It is evident that the high stakes involved in wrong choices make the management problem of judging social significance a matter of utmost importance. Even though control of science by scientists is not without serious problems and handicaps, there would appear to be an even greater danger if the development of science should be controlled by nonscientists—for motives other than scientific progress.

What is more, there is always also a limiting manpower problem in any social endeavor. Some time ago a representative of a foreign oil company pointed out from an analysis he had made, that research output has apparently doubled every seven years in recent times. He estimates that just one more effective doubling is possible owing to the limitation of sufficiently intelligent persons available for guiding basic research in a balanced economy. Regardless of the correctness of the prophecy, evidently the availability of scientific personnel at any particular place and time does impose an upper limit so that efficient utilization of people may be of primary significance. In our own country we note the rapid depleting of scientific personnel in colleges and universities owing to the increasing competition among industries for technical talent at the very time when schools are beginning to bulge. It may well be that in this process we are all robbing the academic goose who lays the intellectual eggs. France long ago pointed to a more likely road to scientific achievement in the establishment of the École Polytechnique with its utilization of research-minded individuals as teachers.

Is science, perhaps, inherently individualistic? There is no doubt that much scientific growth has psychological and sociological roots in more or less practical requirements. It must always be borne in mind, however, that intellectual curiosity per se also is often a primary incentive. The element of wonder and astonishment is always a pertinent motivating factor. Newton himself, when asked about his own discoveries, stated that he had made them "by always thinking aside about them." In more recent times, X-rays were discovered as a serendipity biological by-product of a physics investigation. In the scientific laboratory, as well as in kindergarten, the intellectual activity must be fun. Perhaps, here is a clue to the scientific productivity of young people—their attitude toward real problems, rather than the condition of their environment. Strangely enough, Einstein as a young man made his brilliant discoveries about special relativity, the Brownian movements, and the photoelectric effect not in a university, not even in a laboratory, but in a government patent office. Not only must we bear in mind socially that scientists are people, but individually that each scientist is a person—a person that sees visions and later dreams dreams. He is not so much a doer—or even a knower—he is truly a seer. Poincaré once noted, "It is not science that is useful because its discoveries make technical progress possible but technical progress is useful because it enables mankind by relieving it of material cares to give more time to science and to art."

Science, indeed, is fundamentally not so much a common-sense residue from the past, but rather a challenge to the common sense of the present. Perhaps, a familiar illustration may be useful. Here is a trailer with a candle in the center. When the candle is lighted, will the rays of light reach the front end or the back end of the trailer first? It is obvious that both will take place at the same time. I forgot to mention, however, that the trailer is moving (unknown and unknowable to the occupants)—or is it the earth that is moving? To persons on the outside it is equally obvious that light will reach the back end of the trailer before light arrives at the forward end, which appears to be moving away from the initial position. In other words, to these observers, the events are not simultaneous. The only knowledge used in making these two contrary deductions is the experimental fact that the velocity of light is the same for all observers regardless of their own state of motion. Thus the common-sense concept of simultaneity, which seems generally intelligible and self-evident to us, is challenged by science. It should be emphasized, however, that the real contribution of Einstein in this instance was to call attention not to the doubtful conclusions relative to different observers, but rather to the certainty resulting from that which is invariant with respect to all observers.

Another challenge to common sense is seen in the very nature of energy. Here we find that by exercising discipline with regard to logical consistency we arrive again at greater freedom of thought. Let us take another familiar example, say, a space ship having two radio emitters inside, one at each end. The first station emits a radio beam consisting of electromagnetic radiation. It is known that such waves have momentum given by E/c, where E is the energy of the radiation and c its velocity. The action on this emitted radiation is associated with a reaction on the space ship, which obtains an opposite momentum given by Mv, where M is the mass of the space ship and v its resultant velocity. During the time t that the radiation travels the distance l from the first station to the second one, where it is received, the ship will have moved a distance x, given by vt. There is no apparent reason why the two radio stations cannot then be interchanged (in principle), and the whole process repeated over and over again. In this event the space ship would move on indefinitely in the same direction—a violation, of course, of the conservation of energy. In what respect, then, have we been theoretically inconsistent? We have not associated any mass with the radiation. Accordingly, in interchanging the stations we have failed to preserve the location of the center of mass of the whole system. In other words, Mx must equal ml, where m is the mass of the emitted radiation. From these few relations we find readily that the unknown mass m of the radiation is equal to E/c^2. In this simple way we have obtained an expression for the mass equivalent of radiation energy; and so we are compelled to think of atomic (mass) energy, in addition to mechanical energy, electrical energy, thermal energy, et al.

Perhaps, the greatest danger, however, that exists for the individual scientist who hopes to be free to see such visions, is the polluted atmosphere of materialism. To many people science has become socially just a magic phrase for nature like "open sesame," which will reveal money for many things close to the heart's desire. As a graduate student, I heard a college preacher remind the students upon the occasion of a great monetary gift for buildings that universities consist not of things, but, in the main, of ideas. How sad it is to see inside many large edifices with magnificient equipment the obvious imprint "No men—at work." A more dangerous personal influence is the subtle, often subconscious lure of higher salaries, extra privileges, more power, which might even be called professional patronage in the vulgar sense. We are ever reminded that "man does not live by bread alone," that

The world is too much with us, late and soon,
Getting and spending, we lay waste our powers,
Little we see in Nature that is ours.

Einstein remarked in his introduction to the 1931 reprint of Newton's *Optics*, "Fortunate Newton, happy childhood of science, he who has time and tranquillity can by reading this book, live again the wonderful advantages which the great Newton experienced in his young day." Time and tranquillity, rather than material benefits, these are the prerequisites for the individual scientist who wishes to understand the world about us!

Thus I find myself concluding that science is inherently individualistic in its origin, but essentially social in its development. Basically, it is man made and hence anthropomorphic. Let us consider, therefore, what science is.

Science, I should say, is strictly the result of the use of the scientific method and the scientific method is simply the instrument used by the scientist. The answer to the question, what is science, is given basically in terms of the scientist. A related question, of course, which we shall not be discussing today, is this one, "Who is man?"

In science we begin existentially with sense impressions, which change with our own impressionistic outlooks and which in their totality constitute observed facts. To many non-scientists science is nothing more than a collection of such observed facts—or at most combined with some inductive inferences, as in the early positivism of August Comte. It was recognized later, however, that a scientist just doesn't collect facts at random in the tradition of Francis Bacon. Who, for example, would note all the motional aspects of fluttering leaves in order to ascertain the general laws of motion? On the contrary, one carefully selects facts together with their relations, which constitute the later positivism of Ernst Mach. It has become evident that the more popular or general a language the more even simple interpretations of facts require some kind of semantics, or operational rules, as advocated by modern logical positivists. For example, what do we mean scientifically by the length of a body? No more than the answer we get in making a measurement, either thoughtfully or experimentally, in a certain prescribed manner regardless of any preconceived categories of knowledge! We note that in each case it is the scientist who collects, the scientist who selects, the scientist who operates.

Any person having objects of different sizes, shapes and colors will attempt to separate out those that are alike and, if possible, to relate those that are different into a single pattern. So, too, the scientist looks for related factors amid his collection of observed facts. In this respect, he may be guided by the cogency of logical consistency, or by the urgency of simplicity for economic or some other purposeful convenience. For example, it is well known that a descriptive characteristic of a material is its specific gravity, that is, the weight of a given sample relative to the weight of an equal volume of water. It is equally true, however, that the square of the specific gravity is also uniquely characteristic—not to mention the cube, etc. We prefer to utilize specific gravity because of the simplicity of its form. Here again it is the scientist who chooses the relations.

To the traveler who has gone along various roads and who has seen many places, it is always refreshing to go up on a mountain top from which he can see at a glance the whole surrounding region with its network of roads. So, too, the scientist is not content with the observed facts, or even with the related factors. He looks for an overall view, what the Greeks called a theory (from the same root word as theater); such a theory is necessarily factitious in that it is inspired in the scientist by compelling beauty or by ingrained truth (based on analogies with common sense), or merely by the heuristic value of pragmatism. Not everyone could or would or should be an Einstein, a Bohr, et all. Max Born concludes his "Natural Philosophy of Cause and Chance" with the remark "Faith, imagination, intuition are decisive factors in the progress of science as in any other activity." The scientist is truly a maker, or to use the Greek word, a poet. In a strict sense the scientist strives to achieve a poetical view; his formal relations are freely creative, as Poincaré has emphasized. Hence the scientist himself plays a major role in the development of theory. He can never be completely eliminated. The studied attempt to eliminate the subject for greater objectivity finally becomes only increasingly more subjective.

Every scientist has a question in mind as he looks out upon the world about him. The observed facts are its answers. From them he obtains related factors. From both he makes a factitious theory, which enables him to see farther and wider so that new questions arise in his mind as he again looks out upon the world about him. The new answers are in the form of additional observed facts. The cycle will be continually repeated, although its completeness will ever depend upon the controllability of the material. For example, observed facts may be difficult to isolate as in self-involving social phenomena; or a factitious theory may be difficult to achieve as in the omnipresent observational earth sciences. In any case the cycle represents a single instrument in the hands of an instrument maker.

In the use of the scientific method, however, there are two necesary conditions. The first one is conformity to nature, which is based upon the assumption of the uniformity of nature. In other words, at all times predicted conclusions must check with observed data.

The second condition is acceptability by society, which is based upon the assumption of human comprehensibility of nature. Einstein once said that to him the most incomprehensible feature of nature is its comprehensibility. The scientist's understanding, his reasons for accepting certain general principles, depends on his own personality as well as the social class, the political group, the religious faith, et al., to which he adheres. In a strict sense such factors are included in the sociology of science. In the celebrated case of Galileo, we note, the Roman Catholic Church opposed philosophically the favored position of the sun. (One wonders what influence this social problem may have had later in the eighteenth century, which saw science in a dormant state both for the Catholic Italy of Galileo and for the Protestant Germany of Kepler, which was undoubtedly influenced by the antirational attitude of Luther.) In our own day we found Nazi leaders, with the physicist Johannes Stark as their spokesman, voicing similar opposition to the lack of favored observers from the relativistic point of view. They were opposed also to the concept of materialistic clocks for time determination, which seemed irreconcilable with their own idealistic position. On the other hand, in the USSR also there has been official opposition to the relativity theory, but in this instance because of a supposedly idealistic view of material mass as energy. (Can it be altogether accidental that the use of atomic energy was first developed in English-speaking countries?) The social acceptability of science is intrinsically involved in the philosophy of science, again impressing us with the fact that in all science there is indelibly imprinted something of the scientist himself.

As we look about us, we are aware of phenomena, appearances that play like Plato's shadows in his underground den. It is upon the foundation of the totality of these sense impressions, of course, that one constructs the world of science. Here, however, is always an element of surprise—the theories are never merely descriptive of what is known; in addition, they are predictive of what is unknown—probably due to the fact that a thing itself is always greater than any experiential impressions and, even more so, than any symbolic expressions of it. That there is a world of nature beyond sense impressions gains credence as a philosophy of nature extrascientific (metaphysical) in character. Thus we find Max Planck insisting upon the existence of three worlds: the world of sense impressions, the world of science, and the real world, as he calls it. He says "Physical science demands that we admit the existence of a real world independent from us"—actually, an assumption. As far as I can see, the data of sense impressions form a contact surface of phenomena, in which I am existentially involved, between two possible worlds, the world of nature and the world of science. What relationship, if any, exists between these two worlds? Is nature possibly non-existent? Is science, perhaps, purely fictional? Is science merely the imperfect reflection, or imperfect image of nature made in the rational image of man? Are these two worlds possibly identical? Is science a re-construction of the world of nature? There are various views as to how the world of science may be related to the world of nature. P. Duhem urged "To the extent that physical theory makes progress, it becomes more and more similar to a natural classification which is its ideal end." Einsten stated, "Our experience up to date justifies us in feeling sure that in Nature is actualized the ideal of mathematical simplicity." A. A. Michelson once suggested that "What can surpass in beauty the wonderful adaptation of Nature's means to her ends, and the never-failing rule of law and order which governs even the most apparently irregular and complicated of her manifestations? These laws it is the object of the scientific investigator to discover and apply. In such successful investigation consists at once his keenest delight as well as his highest reward." We are reminded here of Keat's creed that "Truth is beauty." P. Bridgman, however, cautions us that "The known laws of nature are simple if we consider only a limited range of facts." Hence we must always be aware of limitations of scientific data, which are necessarily incomplete and imperfectly described by man. We must be conscious also that the world of science, in turn, is necessarily incomplete as a description even of the sense impressions, not to mention as a description of their matrix; at best it represents only an incomplete and imperfect theoretical outlook. Uniqueness, of course, is always wanting. It would seem unlikely, therefore, that a one-to-one correspondence would exist at any time between the world of nature, involving the sense-data plane, and the world of science, involving the same plane. One would hardly be justified, I believe, in any extrapolation like that of P. Jordan in his *Science and the course of history*, viz., "The discovery of new laws of atomic physics has shown the old materialistic view to be untenable even in the field of physics." The necessary conditions of conformity to nature and of acceptability by man, moreover, may be related to the philosophy of nature as a guiding faith. To me the cumulative and integrative development of scientific theories, leading to more inclusive description and ever surprising prediction, points more and more to a probable world of nature, which may be susceptible of metaphysical interpretations, such as the theological premise "In the beginning God"! We should never dogmatically exclude Einstein's "Faith in the possibility that the regulations valid for the world of existence are rational."

Unfortunately there is a widening gap between any philosophy of science approached from the standpoint of science, and any philosophy of nature, approached from the standpoint of philosophy per se. Yet there can be no sharp line of demarcation; for the scientist himself is the link. As man looks at the environment about him from the different points of view of physical, biological, psychological, and sociological sciences, it is always he himself who is viewing. Invariably, from any viewpoint he ponders three questions: what is true? what is real? what is value? The attempt to obtain answers to these questions in any discipline may properly be called the philosophy of that discipline. To seek common answers to these common questions is general philosophy. The attitude may be that of an agnostic, or of a skeptic, or of a man of faith. No compelling evidence will be agreed upon by all viewers. Because of inevitable incompleteness the same set of observed facts may be seen in different ways—as a cube may be visualized on a flat surface, or as a limited outlook of white clouds in a blue sky may be interpreted as white caps on a blue sea. As far as I can see, there is no way of demonstrating just what is precisely true and just what is precisely false; for there are no general criteria for truth. The choice for each of us may be determined by unconditional imperatives like loyalty to a human cause, like love to a human partner, like obedience to a divine Will, et al., or merely by unconditional recognition of other people as individual persons. What must be admitted by all is that civilization is the product not of the pessimism of agnostics and of skeptics, but of the optimism of men of faith. Enthusiastic men have varied as to what they have believed, but they have all believed either in some thing, or in some one, or in Some One. Some have believed that answers to the three questions can be obtained from one's environment (materialism); others, from men (humanism); still others, from God (theism). Unfortunately, while a man considers leisurely how to make up his mind, he may already be virtually making up his life. Three practical decisions are open to every man. He may refuse to consider the matter and thereby fix his ignorance; or he may purge his beliefs and thus leave a vacuum for chance filling in; or he may clarify all aspects and then make an intelligent (from the Latin words inter legere meaning to choose among) choice. We note that detachment is itself a choice.

What then shall we do about the original question, is science inherently individualistic, or essentially social? Dr. Conant, I believe, gives us a clue when he says "Science should be relevant to man." In other words, as men, we can not have science for the sake of science any more than we can have art for the sake of art. We must have science and art for the sake of man—man individually or socially. Science is both an *end* for man and a *means* for society. The best results will be obtained, of course, if their interrelations are understood. Freedom for the individual, I would urge, should be listed first. Man is truly a social being; but first of all, a man is actually a man.

When I think of man and science, I find a parable in the apotheosis of Faust, as set forth in that poetical, philosophical autobiography of Goethe. The theme there seems to be that he who strives, strays, yet in that straying finds his salvation. At the beginning Faust flouts science. He tries vainly to make man master of his environment. Mephistopheles taunts Faust with his demand for everything, his satisfaction with nothing. He wagers that Faust will one day demand nothing, but will be satisfied with whatever chance throws his way. In the last scene we watch expectantly the 100-year old Faust looking upon the sand dunes along a shore marked with engineering feats of dykes and canals—a political enterprise in which people strive daily to make buttresses against the ever-surging sea. Faust muses on future generations living and laboring in this wholesome danger. He mutters, "Verweile doch, du bist so schön" (Stay, thou art so fair)—almost the very words of the original wager. Yet even here Faust is maintaining his enthusiasm for a difficult, but endless life:

> The noble spirit now is free
> And saved from evil scheming!
> Whoever aspires unweariedly
> Is not beyond redeeming.

ETHNOLOGY.—*Stone "Medicine Wheels"—memorials to Blackfoot war chiefs.*

Hugh A. Dempsey, Calgary, Alberta. (Communicated by John C. Ewers.)

Two stone "medicine wheels," which are still in existence on the Blood Indian Reserve in southern Alberta, Canada, offer excellent examples that the line between archeological and ethnological work is sometimes a fine one. For these two "medicine wheels"—and a third recently inundated by backwaters of St. Mary Dam—are not ancient markers whose significance is lost in antiquity. Rather, they have been constructed within this century, and a summer's field work has revealed the date and ownership of the rings, the reason for their existence, and has enabled interviews to be made with individuals who actually participated in or witnessed their creation.

The Blackfoot "medicine wheel" consists of a circle of stones, or "tipi ring," with concentric lines of stones of varying lengths extending away from it in the four cardinal directions. This pattern is similar to those described by Kehoe's informants (1954, pp. 133–34), although it differs from his Lowry, Mont., site which has ten such lines.

The tipi ring itself is common in Blackfoot country and has been used within the past two decades by at least two tribes of this nation (Blood and North Peigan) where the owner wished to follow early customs.

The tipi rings were aptly described in 1955 by One Gun, an elderly North Blackfoot informant: "The circles of stones were normally used to hold down the edges of the lodges. The old tipis were made of buffalo skins and were much heavier than the canvas ones. They could not be blown away as easily, so stones were able to hold them in place. But when we started to use canvas, we had to use pegs or our tipis would be blown over. Stones were also used between the pegs."

Although many of these tipi rings have been destroyed in cultivated areas, some are still known to exist on the North Blackfoot Reserve in Canada, the Blackfoot Reservation in Montana, and on the Blood Reserve, where the writer has observed well over two dozen in casual traveling.

The Blackfoot term for the "medicine wheel" is *atsot-akeeh' tuksin*. The literal translation is: "from all sides" (*atsot*), "a small marker of stones" (*akeeh'*), "for posterity" (*tuksin*). It will be noted that the word merely designates the radiating lines and makes no reference to the tipi ring itself. This conforms with Blackfoot tradition that the lines were merely appendages to existing tipi rings, rather than the whole marker being constructed at one time.

According to informants, "medicine wheels" were used to mark the residence or grave of a warrior chief. There were apparently three such allied uses: for a tipi in which a warrior chief died and was buried; one in which he had been residing at the time of his death but which was not his burial place; and one which was used during his lifetime but not related to his death. Each may be a variation, or they may reveal a change in the use of these markers over the years.

The earliest reference to a Blackfoot "medicine wheel" known to informants is credited to Bull Back Fat, a Blood chief who died in 1842. But, according to Jack Low Horn, a reliable Blood informant who supplied this data, the marker did not originate with this chief but "was started in the days when our people used dogs instead of horses." The informant told the following story:

"The use of this sign saved the life of the first Bull Back Fat.[1] The Bloods had been on a raiding party to the south and were returning home. In each camp, Bull Back Fat used these signs around his lodge. A party of enemy Crows discovered one of these camps and saw his marks. They had never seen them before and wondered what they meant, so they began to follow the trail of the Bloods. They found two deserted camps and arrived at the third shortly after the Bloods had left. Bull Back Fat and his wife were a few miles from this camp when they discovered that a colt

[1] There were at least five Blood chiefs named Bull Back Fat during the period 1830–1900 and each is remembered by some characteristic—i.e., the first Bull Back Fat, the short Bull Back Fat, the Bull Back Fat who was buried by women, etc.

had been left behind, so they returned to find it. When they came to a point overlooking the camp, the Crows saw the pair and waved to them. Escape was impossible, so Bull Black Fat rode down to meet them. Speaking in sign language, the Crows asked about the meaning of the stones. Bull Back Fat explained that these were used by a great warrior chief who was leading the party of Bloods; but he did not tell them that he was the chief. They became anxious to visit this man and Bull Back Fat agreed to lead them there under a pact of peace, but asked that his people have time to be prepared. He left the Crows and found the new camp where his lodge was placed in readiness for the visitors. When the party arrived, they were shown to Bull Back Fat's tipi. When they entered, they were surprised to meet the same man whom they had seen earlier. It was then they learned who he was and realized they had missed the opportunity of killing a great chief. . . ."

According to the informant, other tribes soon learned the meaning of the "medicine wheel" and it served a practical purpose, for the enemy was always hesitant about pursuing a camp which was led by a noted warrior. "Anyone passing one of these markers would know that a great warrior chief had camped there," he commented.

If this at one period was the common Blackfoot use of the "medicine wheel," it evidently underwent a change in the late nomadic period, for most modern informants consider these to be solely memorials or death markers. One Gun stated that "when a chief died, he was left in his tipi. After it had fallen down and rotted, anyone travelling past would know that a chief died there because of the radiating lines." Alternately, Rides at the Door, a Blood informant, said that "any stranger passing such a place would recognize that a chief

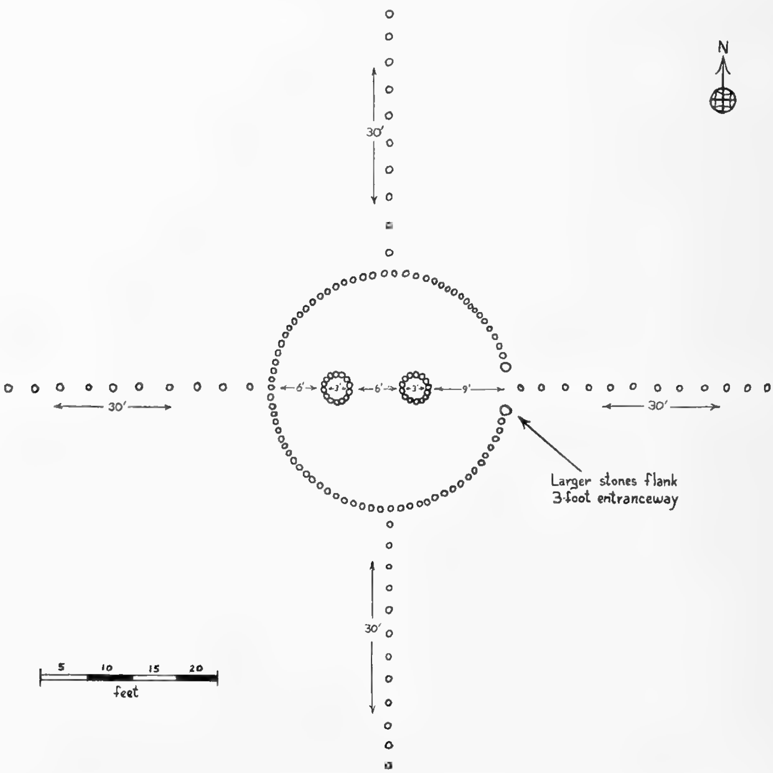

Fig. 1.—The "medicine wheel" of Steel, a noted Blood warrior, is located on the Blood Indian Reserve, southern Alberta, about 3 miles north of Spring Coulee. It is 27 feet in diameter at the circle with four 30-foot radiating lines. There were 77 stones used in the circle portion, and 14 each in the 3-foot fireplaces. This "medicine wheel" was constructed in April 1940, following the death of Steel.

Fig. 2.—The Eagle Child "medicine wheel," looking northeast.

had died there, but the body would not be left there."

It is possible that these two distinct lines of thought are the result of Blackfoot mortuary customs. At times, particularly during plagues or when moving camp, a dead person was left in his sewn-up lodge. On other occasions, he was buried in the trees or on a scaffolding on a high hill. This variation possibly affected the use of the "medicine wheel," with the radiating lines being left at the death lodge if it was used, or at the tipi ring if the chief was buried elsewhere.

The Bloods and North Blackfoot know of several "medicine wheels" which were erected for warrior chiefs. Some of these markers are still in existence, but most have been destroyed by the inroads of civilization. One Gun knew of two wheels which he claimed were intact on the North Blackfoot Reserve, east of Calgary. He said that "at Blackfoot Crossing there is one for Little Medicine Pipe, a Blackfoot who died in the smallpox epidemic of 1869–70, and on Arrowwood Creek is one for Bad Head, a Blood chief." Another informant said that Many Spotted Horses, a noted Blood war chief who died in 1884, had a "medicine wheel" on the Blood Reserve near Whoop-Up. A search revealed only this chief's tipi ring, but the stones of his "medicine wheel," which were at an inaccessible point on Weasel Fat's Bottom, had reportedly been scattered. Local Indians had replaced the stones as much as possible, but it was felt that this interference limited the usefulness of this wheel for comparative study.

However, two existing "medicine wheels" belonging to other Blood warriors were closely examined, and data was obtained on a third ring which in 1950 was submerged by the backwaters of an irrigation dam project.

The two inspected were the "medicine wheels" of Steel (*Ski-mátsis*, literally Fire Steel) and Eagle Child (*Péta-poka*), while the third belonged to Red Crow (*Mékai-sto*). All these wheels were constructed during the present century and are likely the only ones made by the Blood tribe during that period. A similar "medicine wheel" has been credited to Running Wolf, a Blood chief who died in 1921, but conflicting stories tend to dispute the authenticity of the claim.

Of the three markers, Red Crow's is the earliest. It was made immediately following his death on August 28, 1900. Red Crow was head chief of the tribe from 1870 until his death and was one of the most influential men in the nation. An elderly informant, Mrs. Bruised Head, who was present at the event, provided the following description of the making of his "medicine wheel":

"I was staying at Red Crow's tipi at the time. He went across the river to round up his horses and, when he didn't return, his wife, Long Time Singer, went to look for him. She found him laying on the gravel at the edge of the river. I saw her crying and we knew what had happened. We all went across with the Red Crow's wagon and brought his body over. Both religious denominations were at the funeral, together with many white people. When it was finished, we started to move camp. But before we left, we placed the markers on the four sides of his tipi ring. Red Crow had used pegs on his tipi, but also had stones between them. When the lodge was removed, the circle of stones was incomplete, so we took rocks from other tipi rings and completed it. Then we placed the four radiating lines. There was no ceremony; several of us in the family did it because it was the custom as far back as the days when we used dogs; they were just the marks of a warrior chief.

"After this, we left the camp site. That night, Bull Horn, a minor chief, camped in the next bottom. He had not heard about Red Crow's death. Next morning he went to the camp site and when he saw the marks around Red Crow's tipi ring he began crying, for he knew that Red Crow was dead."

The second example is the Eagle Child wheel which was constructed in 1931 after this man's death. It is located about 150 feet west of his house on the Blood Reserve, and 1½ miles south-west of St. Paul's Anglican School. The tipi ring portion is 12 feet in diameter and contains 54 field stones ranging from four to 12 inches in diameter. There are no hearth stones. When examined in the summer of 1955, the north and south lines contained six stones, the east line seven stones and the west line four stones. All extended in lines four to six feet in length and, by the spaces, would appear to have been disturbed by cattle or horses.

According to available information, Eagle Child had lived in his house, but moved to his tipi shortly before his death in 1931. The radiating lines were set in place by Francis Eagle Child following his father's death.

The most interesting "medicine wheel," from all aspects, is the memorial to Steel, a great Blood warrior. It is of the most classic design and the fact that it was constructed in 1940, probably makes it the most recent and last such stone marker.

Born in about 1850, Steel was an outstanding fighter against the Crow and Assiniboin and, although he never gained official chieftain status, he was held in this regard by his people. For his exploits, he became the owner of a 30-buffalo tipi and was permitted to have two fireplaces. Because these two points are reflected in his "medicine wheel" they should be briefly explained.

The average Blackfoot tipi contained 12 to 14 skins (Ewers, 1955, p. 131), but warriors who performed certain brave deeds were permitted to have tipis made of 30 buffalo skins. Because of its size and weight, such a lodge was said by informants to have been divided in half for moving, and was carried on two travois. Therefore, besides fulfilling the warrior requirements, the owner of such a tipi had to be fairly wealthy in horses. Some Bloods who owned these tipis were Seen From Afar, brothers Hind Bull and Fish Child, Packs His Tail, and Holy Sleeps. Naturally, a 30 buffalo tipi was far larger at the base than the average tipis, and this size is immediately evident when inspecting certain tipi rings or "medicine wheels."

If a Blackfoot owner of a 30 buffalo tipi carried his bravery and heroism to an even greater degree, he might become one of the select few to possess twin fireplaces. To gain this envied prize, a warrior had to perform some outstanding *coup* of a double nature. For example, an early Blood chief, Big White Child, knocked two enemy from the same horse—one from each side. Steel, according to an informant, gained twin fireplaces when he killed two Crow Indians in a singularly brave action.

The fireplace nearest the doorway was apparently used for everyday purposes, while the one to the west was reserved for burning incense associated with a medicine pipe held by twin fireplace owners.

Informants knew of only five Bloods who had possessed both 30 buffalo tipis and twin fireplaces. These were the first Bull Back Fat, Tail Feathers Coming Over the Hill, Big White Child, Many Spotted Horses, and Steel. Even Seen From Afar, remembered by the Bloods as their greatest chief, had not performed the "dual" exploits necessary to gain this honor.

Therefore, Steel's final memorial—a 30 buffalo tipi ring, with twin fireplaces, and flanked with four radiating lines—would appear to be the greatest tribute that could be paid a Blackfoot warrior chief.

In his later life, Steel was a progressive Indian who lived in a log cabin, built corrals, and owned cattle and horses. Early in 1940, shortly before his death, he pitched his large canvas tipi (of 30 buffalo size) a short distance south of his home, in preparation for a meeting of the Horn Society—a secret organization which guides the religious life of the reserve. Although he used pegs, he also obtained stones to hold the canvas in place. Following the meeting, Steel showed his son, Bob, how to lay out the four directional lines.

Steel died at Standoff on April 7, 1940, and was buried on a hill near the Belly Buttes. His son, assisted by his sister, Mrs. Laurie Plume, then completed the "medicine wheel" in accordance with his father's last wishes.

"The lines signify that he was a brave man, a leader who had been to war," stated his daughter. "It was Steel's wish to have this done as a proper tribute to a warrior chief." She added that, if he had not been entitled to it, the elders of the tribe would have quickly ordered the stones removed, as they were jealous of undeserved honors.

The Steel "medicine wheel" is located on the Laurie Plume farm, three miles north of Spring Coulee and about three-quarters of a mile from St. Mary River.

The tipi ring portion is 27 feet in diameter (compared to Eagle Child's 12-foot ring) and contains 77 field stones. There is a three-foot entrance to the east which is flanked by two larger stones. The concentric lines are all 30 feet in length, with the stones evenly spaced. The north and west lines contain 10 stones while the south and east lines contain 12 each.

The double fireplaces are both three feet in diameter and each contains 14 stones. The everyday fireplace is nine feet from the east entrance, while the ceremonial fireplace is six feet in either direction from the west edge of the ring and from the other fireplace.

There is no doubt that this "medicine wheel" was carefully prepared and, when it was visited in 1955, it was overgrown with grass but was reverently treasured by Mr. and Mrs. Plume. Because the tall grass could not be cleared away, it was impossible to properly photograph the entire ring.

Evidence that Steel did not vary the general size of the circle, fireplaces or entrance, was obtained when two informants stated that the first twin fireplace tipi ring constructed by Steel was still in existence in the Standoff area. By checking winter counts, the date of this ring was set at 1885.

When found after considerable searching, this tipi ring was seen to be almost identical with the "medicine wheel," with the exception that it did not have the radiating lines. It had the same diameter, the entranceway was the same size, and there was only slight variation in the size of one fireplace. The only major difference was that the fireplaces appeared to be closer to the east entrance by some 3 feet. There was no doubt that this ring was older than the "medicine wheel" as all stones were deeply imbedded in the soil, some being level with the surface.

There was one point about "medicine wheels" upon which all informants were in unanimous agreement: the radiating lines had no religious or symbolical significance. The number "four" is a sacred one among the Blackfoot and often occurs in religious ceremonies and traditional tales. But all agreed that no such symbolism applied here or, if it ever had, all knowledge of it is forgotten. The reply of informant Rides at the Door is typical: "There is no symbolical meaning to the four lines; they just denote his status as a warrior chief."

Upon existing evidence, it would appear that the use of Blackfoot "medicine wheels" are relatively recent. Informants knew of only two such markers which they could not immediately identify. One was near Red Crow's wheel and was thought to have been much older, while the other was on Sun Dial Hill (Kehoe, 1954, p. 134) and is recorded only through the Geological Survey of 1882-83-84. However, the title, *Onoka-katzi* used by surveyor G. M. Dawson to describe the site, likely means "Elk Shirt" (*Ponoka-sokaxsin*), which was believed by informants to have been the name of a mid-nineteenth century chief of the North Blackfoot.

Because it has been possible only to study "medicine wheels" located on the Blood Reserve and interview informants from the Blackfoot nation, no attempt has been made to carry this study beyond the region of the stated territory. "Medicine wheels," of a type, have been mentioned at Lowry, Mont., by Kehoe, and in the Big Horn Mountains east of Lovell, Wyo., by Mulloy, (1954, pp. 54–55), but further research would be necessary to ascertain if there is any relationship between these, and the relatively recent markers of the Blackfoot. Also field work among the Crow, Assiniboin, Gros Ventre, or other Northern Plains Indians might determine if this custom was familiar to tribes other than the Blackfoot.

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LARGE TERMITE COLLECTION GOES TO SMITHSONIAN

A collection of 230,000 specimens of termites, including 1,286 distinct species of the approximately 2,000 known in the world, has been presented to the Smithsonian Institution by the U. S. Department of Agriculture Forest Insect Research.

Probably the second most valuable of its kind in the world, this collection represents the work of more than 46 years during which Dr. Thomas E. Snyder, retired Department of Agriculture entomologist, has collected termites in the Western Hemisphere and has also obtained many Old World species by exchange and gift. Included in the collection are 943 type specimens. When Dr. Snyder started his collection in 1915 there were only 12 identified species of termites in the Smithsonian collections.

Termites are found over most of the world except the Arctic and Antarctic, Dr. Snyder explains, and probably many kinds still remain unknown. Only those that do damage to human structures have been intensively studied, and extermination of these is now a multimillion-dollar business in the United States. There is always the danger, he says, that some foreign species may invade the country at any time, and therefore means of immediate identification, such as is provided by the Smithsonian collection, may prove invaluable.

Although termites are customarily referred to as "white ants," Dr. Snyder says, there is little, if any, relationship between ants and termites. These two kinds of insects have developed only roughly similar body forms and ways of life by quite independent routes. Termites, he explains, are more nearly related to the roaches, which were among the earliest forms to appear on earth approximately 250,000,000 years ago. The termites, as indicated in fossil deposits, made their first appearance not much more than 50,000,000 years ago and represent a long road from the primitive roaches. They have been termed "social cockroaches." The first ants did not make their appearance until about 30,000,000 years ago. They took on the environment and habits of the termites and, being more advanced organisms, soon drove the older creatures to a wholly subterranean habitat. The ant is much better equipped as a predatory animal.

BOTANY.—*New Umbilicariaceae from the Western Hemisphere, with a key to genera.*

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The taxonomic portion of this paper is the second concerning the Arctic lichen flora (*6*) and follows the systematic classification first proposed by Scholander (*8*) for the Umbilicariaceae, later revised by Llano (*5*) with the addition of a new genus. Scholander's system, based primarily upon the structure of the apothecia, allows a natural phylogenetic arrangement of species into four well defined genera. A secondary distinction, the presence or absence of a pustulate thallus, serves to distinguish *Lasallia* from *Agyrophora*, as indicated in the following key:

Apothecial disk plane, the whole surface smooth and with a continuous proper margin.
  Thallus pustulate.............. *Lasallia* Mérat
  Thallus not pustulate......... *Agyrophora* Nyl.
Apothecial disk plane or convex, surface with a central button and/or fissures, or furrows.
  Apothecial disk plane with sterile central button, or fissure, and/or secondary fissures *Omphalodiscus* Schol.
  Apothecial disk convex, furrowed, with or without a margin.
    Furrows of concentric gyri contained within a continuous proper margin. *Umbilicaria* Hoffm.
    Furrows of radial gyri without any margin. *Actinogyra* Schol.

1. **Agyrophora scholanderii** Llano, sp. nov.

Thallus parvus, 1-2 cm in diam., crassus, monopolyphyllus, marginibus tenuibus infrequentibus laceratis, umbonis eminente, leniter pruinosus in rugis rotundis, supra laevis, mollis, papillis minutissimis, leniter reticulatus-venosus, marginibus integris aut subperforatis, marginibus bruneis obscuris vel atris, subtus niger ebeninus, verrucosus, irregulariter rhizinis longis, rotundis vel planis, irregulariter ramosis, attenuatis, superficies scabra; apothecia pauca vel numerosa, adnata, atra 0.5–1 mm in diam., leiodiscis, marginibus irregularibus, persistentibus; asci 40–45 x 17–24 μ, octospori; paraphyses simplices, apicibus, incrassatis obscurioribus et usque 1.5–2.5 μ inflatis; sporae hyalinae, ellipsoideae, 11–14 x 5–7.7 μ.

Alaska: lat. 69° N., long. 145° W., Shubelik Mountains, on rocks about 1,300 m alt., near Lake Peters, July–August 1948, P. F. Scholander. Holotype (in author's herbarium). Mount McKinley National Park, on a large erratic in thinly wooded muskeg off road from McKinley Park Station, about 700 m alt., September 1952, G. A. Llano. Washington State: Mason County, summit of Mount Ellinor about 2,000 m alt., July 29, 1912, A. S. Foster no. 2120, ex herb. G. K. Merrill, Farlow Herbarium. The taxon is named in honor of Dr. Peter F. Scholander, professor of zoophysiology, Oslo University, Norway, who, through his studies and field collections, has contributed greatly to our understanding of the lichen family Umbilicariaceae.

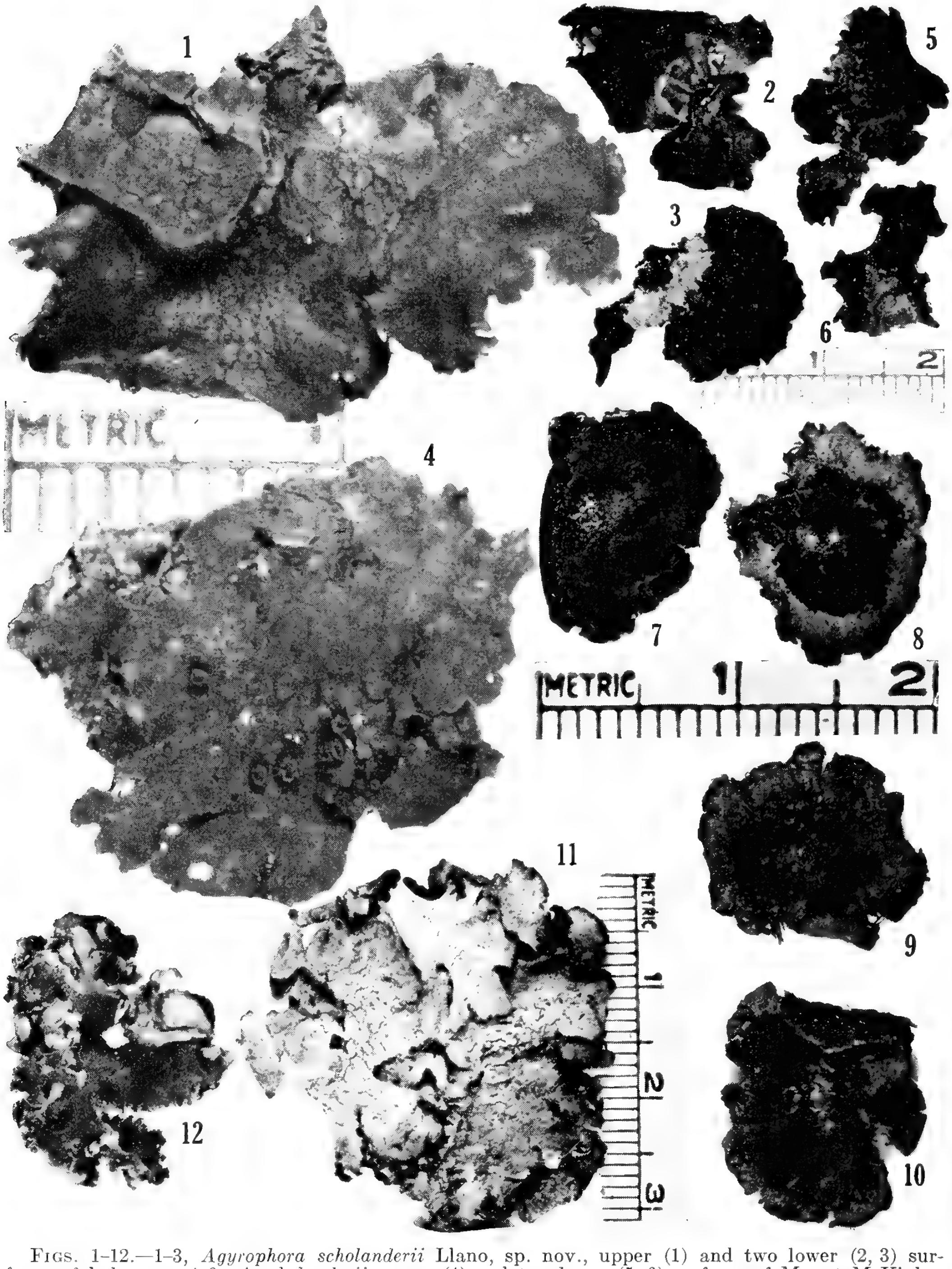
The range of *A. scholanderii* suggests that it is, with *U. angulata* Tuck., a species of the western mountains of North America. However, the former appears to be a plant of the higher interior mountains and of a more arctic distribution; while the latter is typically oceanic and occurs on the Pacific coast from southern California north to the Kenai Peninsula and west to Adak Island. These species, which overlap in the Olympic Mountains in Washington, are the only two Umbilicariaceae endemic to North America.

2. **Umbilicaria aprina** Nyl., in Syn. Lich. 2: 12. 1863. var. **halei** Llano, var. nov.

Thallus minor magnitudine, 1.3 cm in diam., rhizinis minus manifestis vel absentibus.

Canada: N.W.T., Baffin Island, head of Clyde Fiord, on exposed gneiss boulders, August 26, 1950, M. E. Hale, Jr., no. 450. Holotype (in author's herbarium).

Hale's no. 450 (*3*), was tentatively referred to *U. aprina* Nyl. (*7*), an Abyssinian species later reported from the Ruwenzori Mountains by Frey (*2*). Hasselrot's report (*4*) gave one Norwegian and two Swedish localities, the first recorded occurrences of the species outside of Africa. Comparison of the Scandinavian material with the holotype (Nyl. no. 31742) reveals that Hasselrot's specimens are less densely hirsute then the holotype. Nevertheless, the over all morphological characteristics, especially the conforming shape and color of the rhizinae, substantiates Hasselrot's decision. Hale's specimens are homogeneous and differ in the following details from the African and European material:



FIGS. 1–12.—1–3, *Agyrophora scholanderii* Llano, sp. nov., upper (1) and two lower (2, 3) surfaces of holotype; 4–6, *A. sholanderii*, upper (4) and two lower (5, 6) surfaces of Mount McKinley sample; 7–10, *Umbilicaria aprina* Nyl., var. *halei* Llano, var. nov., upper (7) and three lower (8–10) surfaces of holotype; 11, 12, *Ophalodiscus decussatus* (Vill.) Schol. var. *tortuosus* Llano, var. nov., upper (11) and lower (12) surfaces of holotype. (Photo by R. K. Stockard).

They are dimunitive, spherical, and slate to gray black; one-third to three-fourths of the inner lower surface is covered by a circular, sooty, rarely mottled patch terminating in black flecks, and contrast sharply with the fuscous, pruina-tinged outer lower rim. Rhizinae are sparse to absent, and are confined to the fuscous zone. Otherwise, they are typical. Strap-shaped, bifurcate rhizinae extend outward, mainly from the thallus periphery, as tongue-like extensions. Lacking more definitive or fertile material, the original determination for Hale's no. 450 is maintained. However, the singular features cited justify a variety designation. The name honors the collector, Dr. Mason Hale, Jr., for the first record of *U. aprina* Nyl., from the Arctic and New World.

3. **Omphalodiscus decussatus** (Vill.) Schol., in Nyt Mag. Naturvid. 75: 23. 1934. var. **tortuosus** Llano, var. nov.

Thallus 2–5 cm in diam., irregularis, rigidus, mono-polyphyllus, densus, umbo obscurus, crasse verrucosus, superficies superior subverrucosa vel laevis, rugi absentes vel molles, marginibus laciniatis; subtus laevis, ater, raro bruneus, raro lacunis. Apothecia non visa.

ANTARCTICA: MacRobertson Land, A.N.A.R.E. Base Mawson (lat. 67° 36′ 21″ S., long. 62° 52′ 48″ E.). "Uncommon and occurring as a large patch covering an area 100 x 200 yards on a northwest facing slope." Leg. R. O. Summers, January 1955.

Through the courtesy of the director of the Antarctic Division, Department of External Affairs, Melbourne, Australia, exsiccatae material was obtained of four Antarctic Umbilicariaceae. The collections made by two members of the 1954–1955 A.N.A.R. Expedition, David P. Sweetensen and Dr. R. O. Summers, included the following species: *Omphalodiscus spongiosus* (Dodge & Baker) Llano, *O. decussatus* (Vill.) Schol., and *O. decussatus* (Vill.) Schol. var. *cerebriformis* (Dodge & Baker) (*1*) Llano, and a homogeneous number of *O. decussatus* var. *tortuosus* Llano.

The writer gratefully acknowledges the assistance of Mrs. Kenneth R. Whiting with the Latin diagnosis; and of Dr. E. H. Walker, of the Smithsonian Institution, whose valuable criticisms in the preparation of this paper are much appreciated. M/Sgt. J. L. Pearce, NCOIC, and M/Sgt. R. K. Stockard, special photographer, Maxwell Air Force Base, Alabama, provided the illustrations.

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I often say that if you can measure that of which you speak, and can express it by a number, you know something of your subject; but if you cannot measure it, your knowledge is meagre and unsatisfactory.—LORD KELVIN.

ENTOMOLOGY.—*Redescriptions of four species of neotropical* Culicoides *of the* debilipalpis *group (Diptera: Heleidae).* WILLIS W. WIRTH[1] and FRANKLIN S. BLANTON.[2] (Communicated by Alan Stone.)

In the course of our taxonomic study of the Panama *Culicoides* of the very difficult *debilipalpis* group, we have restudied type material of several non-Panamanian species for purposes of comparison. We feel that the study of certain characters which were not utilized when these species were described a number of years ago is essential for recognition of species in this group. We therefore take this opportunity to offer redescriptions and figures of four of these species.

We are deeply grateful to Paul Freeman and the trustees of the British Museum (Natural History) for the opportunity to study type material (see discussion under *germanus*) of *dasyophrus* Macfie and *germanus* Macfie from British Guiana. To Irving Fox of the University of Puerto Rico we are equally appreciative of his kindness in lending us the holotypes of *trilineatus* Fox and *hoffmani* Fox from the West Indies.

There are several terms the exact definitions of which are essential to the descriptions. Wing length is measured from the basal arculus to the wing tip; we use the Tillyard modification of the Comstock-Needham terminology of wing veins, thus the two discal forks emit the branches M_1 and M_2 on the anterior fork and M_{3+4} and Cu_1 on the posterior fork. The antennal ratio is the value obtained by dividing the combined lengths of the last five segments by the combined lengths of the preceding eight. The measurement of the length of the spermatheca includes the sclerotized portion of the duct. Our measurements are of single specimens unless followed by values in parentheses in which case the values are "mean (minimum-maximum, n = number of measurements).'

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Culicoides dasyophrus Macfie

Fig. 1

Culicoides dasyophrus Macfie, 1940, Ent. Monthly Mag. **76:** 27 (male, female; British Guiana); Ortiz, 1952, Acta Cient. Venezolana **3:** 126 (Amazonas Terr., Venezuela; female redescribed; fig. antenna, spermatheca).

Characters of female.—Length of wing 0.74 (0.69–0.76, n = 4) mm.

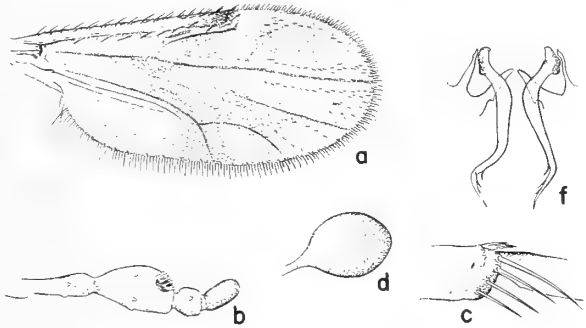
Head: Eyes narrowly separated above, with long interfacetal hairs. Antenna with flagellar segments in proportion of 15:10:10:10:10:10:10:10:15:18:19:20:33, antennal ratio 1.23; distal sensory tufts present on segments III, VII-X. Palpal segments in proportion of 5:14:14:6:7, third segment swollen, 1.65 times as long as greatest breadth, with a broad, shallow, sensory pit. Mandible with 14 teeth.

Thorax: Mesonotum dark brown with a pair of large, elongated submedian yellowish spots and a pair of obscure, dark-brown vittae laterad of these; scutellum brown in middle, paler on sides. Legs dark brown, fore and mid femur with subapical, all tibiae with subbasal and hind tibia with apical, narrow pale rings; hind tibial comb with 4 spines, the one next to the spur longest.

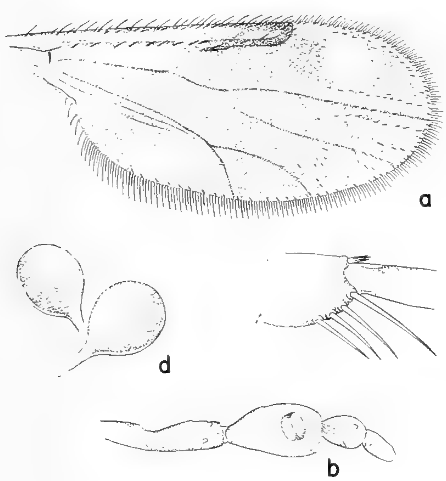
Wing: Pattern as figured, pale spots rather small and not very distinct; poststigmatic pale spots in cell R_5 more or less fused, the posterior one located slightly proximad of the anterior one; distal pale spot in cell R_5 small, only one small pale spot in distal part of anal cell and one pale spot in distal part of cell M_2; indistinct pale spot in front of mediocubital fork; macrotrichia sparse on distal third of wing; costa extending to 0.61 of distance to wing tip. Halter whitish.

Abdomen: Dark brown, cerci yellowish; spermatheca one, pyriform, measuring 0.044 by 0.033 mm, the duct narrow and sclerotized for a considerable distance.

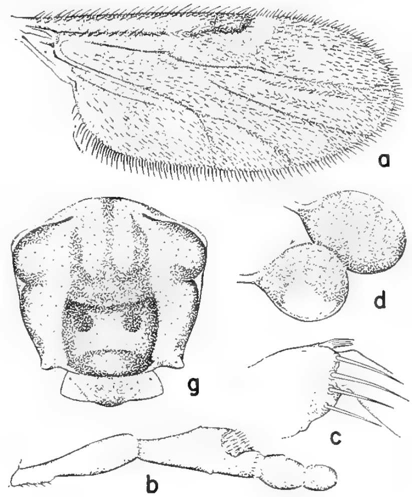
Male genitalia.—Ninth sternum without caudomedian excavation, the posterior membrane not spiculate; ninth tergum long and tapering, the apicolateral processes short and blunt. Basistyle with ventral root foot-shaped, the caudal heel not long, dorsal root longer and slender; dististyle



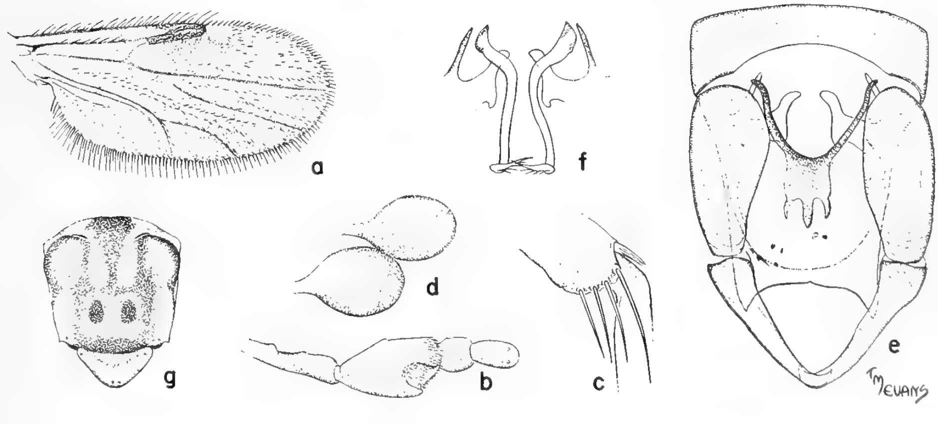
1. DASYOPHRUS



2. GERMANUS



3. TRILINEATUS



4. HOFFMANI

FIGS. 1–4.—1, *Culicoides dasyophrus* (paratype from New River, British Guiana); 2, *Culicoides germanus* (presumed type, New River, British Guiana); 3, *Culicoides trilineatus* (from St. Croix, Virgin Islands); 4, *Culicoides hoffmani* (Puerto Rico; ♂ from Carolina, ♀ from Guyanilla). (*a*, female wing; *b*, female palpus; *c*, apex of hind tibia showing spur and comb of tibial spines, female; *d*, female spermathecae; *e*, male genitalia, parameres omitted; *f*, male parameres; *g*, thoracic color pattern, female. Drawings by Thomas M. Evans.)

nearly straight, with slender apex. Aedeagus very short and broad, basal arch more than half as high as total length of aedeagus, the transverse anteromesal sclerotized membrane rounded, apex with a short blunt inner sclerotized point enclosed by a short, bluntly conical, hyaline lobe. Parameres each with knobbed base, slender, sinuate stem without apparent ventral lobe and slender, tapering tip with 4 or 5 subapical, lateral barbs.

Distribution.—British Guiana, Venezuela.

Specimens examined.—As follows:

BRITISH GUIANA: New River, 750 feet, March 20, 1938, C. A. Hudson, 1 male, 7 females (paratypes of *dasyophrus*).

VENEZUELA: Amazonas Territory, 1951, P. Anduze, 7 females.

Discussion.—The redescription and illustration of the paratypes from British Guiana are made possible by the generous cooperation of Paul Freeman and the trustees of the British Museum (Natural History), who kindly lent us the material for study. We are also indebted to I. Ortiz for the gift of Venezuela specimens from the same collection upon which he reported in 1952. We are thus able to confirm Ortiz's determination of this species by direct comparison with type material. Barbosa's record (1947, An. Soc. Biol. Pernambuco *7:* 14) and figure of the male genitalia of *dasyophrus* from Panama, however, are erroneous, and specimens from Barro Colorado Island in the U. S. National Museum labeled *dasyophrus* by Barbosa are actually *castillae* Fox.

The long distal five antennal segments, the presence of sensoria on segments III, VII–X, the short, broad, third palpal segment, the prominent mesonotal pattern, the obscure wing pattern with only one distal spot each in anal cell and cell M_2, and the pale apex of the hind tibia will serve to characterize *dasyophrus*.

Culicoides germanus Macfie

Fig. 2

Culicoides germanus Macfie, 1940, Ent. Monthly Mag. **76:** 27 (female; British Guiana).

Characters of female.—Length of wing 0.79 mm. The head was not dissected from the body and can be seen only in side view. Eye apparently hairy above, bare on lower portion. Antenna with flagellar segments in proportion of 18:15; 15:19:19:19:19:19:19:19:20:19:41, antennal ratio 0.80, distal sensory tufts present on segments III, VII-X. Palpal segments in proportion of 6:18:20:6:7, third segment distinctly swollen, about twice as long as greatest breadth, with a broad, shallow sensory pit. Mandible in wrong position to count teeth. Mesonotum dark brown, without apparent pattern (but may be due to being a slide mount); scutellum, postscutellum, and pleuron uniformly dark brown. Legs dark brown, femora entirely dark, tibiae with subbasal pale rings, hind tibia with apex broadly pale, comb with four spines, the second from the spur longest.

Wing with pattern as figured, second radial cell rather long and narrow, costa extending to 0.60 of distance to wing tip. The three pale spots in cell R_5 arranged in a triangle, the two poststigmatic pale spots in cell R_5 small and well separated, the posterior one located far proximad of the anterior one, distal spot in cell R_5 rounded except on distal side. Two pale spots in cell M_1, only one pale spot each in apices of anal cell and cell M_2, no pale spot present anterior to mediocubital fork but an indistinct pale spot present behind base of medial fork. Macrotrichia sparse, in rows, in apices of cells, R_5, M_1, and M_2, Halter pressed against thorax, not visible in profile, its color undetermined.

Abdomen dark brown, cerci pale; spermathecae two, slightly unequal, collapsed and impossible to measure, apparently pyriform, with the ducts sclerotized a considerable distance.

Specimens examined.—Macfie (1940, Ent. Monthly Mag. **76:** 27–28) described this species and *debilipalpis* var. *glabrior* each from a single female from New River, British Guiana, collected in February and March 1938 by C. A. Hudson. In response to our inquiry regarding the types of *germanus* and *glabrior* Paul Freeman of the British Museum (Natural History) stated that the only material of these species which he could find in the Macfie collection in the Museum was one slide on which were mounted two females, without locality data, but bearing only the label in Macfie's handwriting, "*Culicoides*/ *debilipalpis* Lz. / v. *glabrior* / ♀ (large specimen) / *C. germanus* / ♀". After careful study we can only conclude that these specimens are in fact the types of *glabrior* and *germanus*, and the smaller specimen is here redescribed as the presumed type of *germanus*. The larger specimen will be redescribed elsewhere as the presumed type of *glabrior*. To our knowledge *germanus* is still known only from the type specimen.

Discussion.—*Culicoides germanus* is very closely related to *debilipalpis* Lutz and *hoffmani* Fox but can be distinguished by the very hairy eyes, the presence of sensoria on the seventh antennal segment, the entirely dark femora, and the greater separation of the two proximal pale spots in cell R_5.

The description and figures given under the name of *germanus* by Wirth (1955, Proc. Ent. Soc. Washington **57:** 111) from Guatemala specimens are based on misidentifications of *gabaldoni* Ortiz. *Culicoides insinuatus* Ortiz and Leon, 1955, from Ecuador is very similar to *germanus*, with similar wing pattern and femora without subapical pale rings, but *insinuatus* differs in having a very deep sensory pit with a small pore on the third palpal segment.

Culicoides trilineatus Fox

Fig. 3

Culicoides trilineatus Fox, 1946, Ann. Ent. Soc. Amer. **39:** 250 (female; St. Thomas, Virgin Islands; biting man; fig. mesonotum, wing); Fox, 1949, Bull. Brooklyn Ent. Soc. **44:** 30 (male, female; Puerto Rico; reared, tree hole; fig. palpus, spermathecae, male aedeagus, parameres).

Characters of female.—Length of wing 0.97 (0.92–1.02, n = 7) mm.

Head: Eyes broadly separated, bare. Antenna with flagellar segments in proportion of 19:15:15:17:17:15:15:15:17:18:19:20:33, antennal ratio 0.86 (0.82–0.94, n = 3); distal sensory tufts present on segments III, sometimes on V, always on VI-X. Palpal segments in proportion of 13:24:30:10:12, third segment slightly swollen toward extreme tip, 2.6 (2.3–3.0, n = 7) times as long as greatest breadth, with a shallow, small, sensory pit. Mandible with 18 (17–18, n = 7) teeth.

Thorax: Mesonotum grayish brown, with a prominent dark-brown pattern consisting of three longitudinal lines connected posteriorly by a transverse line just in front of prescutellar depression, the two lateral lines continued caudad along sides of this depression and extending from humeral pits to sides of scutellum; lateral margins dark brown with mesal extensions anteriorly to humeral pits and posteriorly along mesonotal suture. Scutellum dark brown, ends slightly paler; postscutellum and pleuron dark brown. Legs brown, fore and mid knees dark, with narrow pale rings on each side of joint, hind tibia with pale band at base and apex; hind tibial comb with 4 (n = 7) spines, the second from the spur longest.

Wing: Pattern as figured, a double poststigmatic pale spot in cell R_5, the posterior portion extending slightly proximad of the anterior part; distal pale spot in cell R_5 small, transverse; proximal spot in cell M_1 very small, one small pale spot in apex of anal cell, no pale spot in front of mediocubital fork but a pale line connecting pale spot behind medial fork to a distinct subapical, second spot in distal portion of cell M_2. Macrotrichia very long and abundant, extending to base of wing in anal and medial cells; costa extending to 0.57 of distance to wing tip. Halter brownish, the flat end paler.

Abdomen: Dark brown; spermathecae two, pyriform, subequal, measuring 0.056 by 0.039 mm, the bases of the ducts sclerotized a short distance.

Distribution.—St. Thomas (type locality); Puerto Rico, Barbados, St. Croix.

Specimens examined.—60 females from:

Barbados: 1, no. 861, A. J. Jennings.

Virgin Islands: St. Croix—3, Diamond School, September 1938; 1, Fountain, valley of jungle and stream 1 mile from seacoast, May 1935; 15, Salt River, September 1938; 11, Tagus Pond, May 1936; all collected by H. A. Beatty. St. Thomas—Red Hook, September 11, 1937, biting in the afternoon (holotype of *trilineatus* lent from Univ. Puerto Rico collection through the courtesy of Irving Fox).

Discussion.—This species is obviously closely related to *debilipalpis* Lutz but can be readily separated by its prominent mesonotal pattern, its hairier wings, with reduced pale spot at base of cell M_1, no pale spot before mediocubital fork, the third palpal segment shaped differently, and the greater number of proximal antennal segments with sensoria.

Culicoides hoffmani Fox

Fig. 4

Culicoides hoffmani Fox, 1946, Ann. Ent. Soc. Amer. **39:** 251 (female; Cumuto Village, Trinidad; biting; fig. mesonotum, wing); Fox, 1949, Bull. Brooklyn Ent. Soc. **44:** 29 (male, female; Puerto Rico; reared, tree hole; fig. palpus, spermathecae, male aedeagus, parameres).

Characters of female.—Length of wing 0.76 (0.73–0.86, n = 9) mm.

Head: Eyes separated, the line of separation broad above but narrowed below, eye with short interfacetal hairs. Antenna with flagellar segments in proportion of 14:11:13:15:15:14:14:15:14:14:15:15:25, antennal ratio 0.79 (0.75–0.84, n = 3); distal sensory tufts present on segments III, VIII-X. Palpal segments in proportion of 6:11:19:6:7, third segment very short and swollen, 1.6 (1.5–1.7, n = 9) times as long as greatest breadth, with a moderately large and deep sensory pit. Mandible with 14 (13–15, n = 5) teeth.

Thorax: Mesonotum pruinose brown with pattern as figured, consisting essentially of a sublateral pair of darker brown patches, widest at midlength; scutellum, postscutellum and pleuron dark brown. Legs dark brown; fore and mid femora with subapical, all tibiae with subbasal and hind tibia with apical, narrow pale rings; hind tibial comb with 4 (n = 9) spines, the one nearest the spur longest.

Wing: Pattern as figured; two slightly separated, poststigmatic pale spots in cell R_5, the posterior one lying only slightly proximad of the anterior one; distal pale spot in cell R_5 moderately large, rounded; two pale spots in cell M_1; one pale spot each in apices of cells M_2, M_4 and anal cell, the one in anal cell failing by its own diameter to meet wing margin; a pale spot lying in front of mediocubital fork and another pale spot lying behind medial fork; macrotrichia sparse on distal third of wing, none in anal cell, cell M_4 or base of cell M_2; costa extending to 0.59 (0.57 – 0.62, n = 9) of distance to wing tip. Second radial cell well developed. Halter brown, the flat end of knob whitish.

Abdomen: blackish, cerci pale; spermathecae two, pyriform, slightly unequal, measuring 0.048 by 0.034 and 0.043 by 0.031 mm.

Male genitalia.—Ninth sternum with very broad and shallow caudomedian excavation, the posterior membrane bare; ninth tergum long with large, triangular, apicolateral processes. Basistyle with ventral root large and foot-shaped, dorsal root slender; dististyle slender and nearly straight with hooked apex. Aedeagus with basal arch rounded caudad, extending to slightly more than half of total length, basal arms slender and curved; distal apex broadly expanded with three pointed lobes of subequal lengths. Parameres each with knobbed base, stem abruptly bent near base, very slender, mid-portion sinuate, no trace of ventral lobe, apex pointed with lateral fringe of fine hairs.

Distribution.—Trinidad, Puerto Rico.

Specimens examined.—As follows:

TRINIDAD: Cumuto Village, June 11, 1941, biting, 1 female (holotype from University of Puerto Rico collection). Cumaca, June 16, 1954, Aitken and Downs, biting man, 2 females. Macqueripe, October 20, 1955, T. Aitken, light trap, 1 female. Melajo Forest, Sangre Grande, October 19, 1955, T. Aitken, biting man, 1 female. Port of Spain, June 1953, U. S. Army, 25 Med. Det., light trap, 2 males, 3 females. St. Pats, Arima, December 31, 1954. W. G. Downs, 1 female; December 10, 1954, T. Aitken, 4 females.

PUERTO RICO: Carolina, September 20, 1949, I. Fox, reared from tree hole, 3 males. Guyanilla, March 1949, I. Fox, reared from tree hole, 2 females. Mamayes, November 5, 1948, I. Fox, treehole, 1 male, 1 female.

VIRGIN ISLANDS: St. Croix, August 1935, H. A. Beatty, 6 females.

Discussion.—*Culicoides debilipalpis* Lutz, which is also common in Trinidad and the Antilles, can be distinguished by its slightly larger size (wing 0.80 mm long), longer, more slender palpus, the third segment 2.2 times as long as broad, with a small, deep pit, the second segment subequal in length to the third; wing hairier, macrotrichia extending in two lines to base of cell M_2 and numerous in anal cell, and the two post-stigmatic spots in cell R_5 more closely approximated and the posterior one located more distinctly proximad of the anterior one.

Culicoides equatoriensis Barbosa from Ecuador resembles *hoffmani* in wing markings, in restriction of the macrotrichia to the distal half of the wing, and in the possession of a broad shallow palpal pit but, according to the original description, differs in having the third palpal segment slightly longer, the eyes bare and contiguous, and subapical pale rings on all three pairs of femora.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1403D MEETING, JANUARY 14, 1955

The retiring president's address on *Solar influences on cosmic-ray variation* was delivered by SCOTT E. FORBUSH.

For almost 22 years, or two full sunspot cycles, the Carnegie Institution has carried on a program of continuous measurement and recording of total cosmic-ray ionization on a world-wide basis and the accumulated results of this program and their extensive statistical analysis was presented.

The instruments used are ponderously shielded but delicate and highly sensitive, high-pressure ionization chambers, of 20 liters volume and filled with argon at 50 atmospheres. The measuring device is a Lindemann electrometer, photographically recorded, and so connected that most of the ionization current is balanced out against the current produced in a subsidiary chamber by a constant uranium source. These instruments have been installed in, among other places, Cheltenham, Md.; Godhavn, Greenland; Teoloyucan, Mexico; Christ Church, New Zealand; and Huancayo, Peru. This wide geographic distribution serves to cover as many geomagnetic latitudes as possible. An extensive series of slides illustrating the changes in ionization current and its correlation geographically and with solar phenomena was presented.

There seem to be at least four types of variation detected in the ionization currents: (1) Sudden, rare, but quite large, increases, associated probably with low energy heavy particles from the sun; (2) world-wide decreases associated with magnetic storms; (3) a quasiperiodic variation of 27-day period—the period of rotation of the sun—that lasts only for a few periods and disappears, like the sun-spots themselves; and (4) an 11-year variation correlated with the sunspot numbers. The four variations are all clearly associated with solar phenomena, and the conclusion reached is that the sun is responsible, directly or indirectly, for them all.

CHESTER H. PAGE, National Bureau of Standards, contributed an informal communication on a widely known puzzle: the so-called "Odd Ball Problem." "Given 13 coins, or other objects, either identical *or* with just one of them either light *or* heavy, how decide with only three weighings on a balance, which one, if any, is bad and in which sense?"

It will be noted that each weighing provides one of three possible answers: Pan A heavy, balanced, Pan A light. What is needed is a weighing schedule showing which coins go in which pans at each weighing. To get it, assign the number 1 to "Pan A heavy," 0 to a "balance," and -1 to "Pan A light." We also assign each coin a number, including zero: the zeroth coin is 000, the first coin is 001, etc. on the base of enumeration 3, with the added proviso that we use the digits 1, 0 and -1. Thus the second coin is (3–1), or numerically $01\bar{1}$, the third 010, the fifth $1\bar{1}\bar{1}$, etc. These numbers are now to be written in a column, omitting zero and 13, and the column of first digits is the required weighing schedule, with 1 meaning the coin goes in Pan A, $\bar{1}$ in pan B, 0 in neither. To get four coins in each pan, however, evidently the signs of four coins have to be changed, in such fashion that each column shall contain as many plus 1's as minus 1's. This change can be made in any of seven ways, and when carried out, the three columns of digits give the three weighing schedules. The result of each then gives a number, and the three weighings together give the three digit number of the coin that is heavy, or if it comes out negative, light. If all weighings balance, 000, all coins are good.

To weigh 13 coins the fulcrum of the balance must be shifted so that the arms are in the ratio 5:4, and the thirteenth coin put always in the short arm with four others. The same schedule applies as before, and the behaviour of the balance gives the answer, in the same numerical code. (*Secretary's abstract.*)

1404TH MEETING, JANUARY 28, 1955

MARK KAC of Cornell University, spoke on *The emergence of statistical thought.*

There have been two approaches to statistical methods in the past: as a necessary evil on the one hand and as a logical and scientific necessity on the other. The discovery of the Mendelian laws represent one of the rare successes of the first approach; in the other branches of the exact sciences a hypothesized model acts as a guide to the data to be taken.

A series of horrible examples will show the dangers of applying statistical methods without due care. Consider the mania for "objective tests." Suppose a man answers 60 out of 100 yes-or-no questions correctly. Is the result meaningful? A monkey and a coin have a 34-percent chance of doing as well. Consider the apparent cycles in the population of rabbits, or lemmings or other animals. A plot shows that the average time between peaks of population is $3\frac{1}{3}$ years, with a 20-percent reliability. But a plot of acknowledgedly random numbers also shows a figure of 3.1 years with a 20-percent reliability. (One trouble here is admittedly psychological and semantic: the work random connotes to the statistically untrained a phenomenon of no observable regularity.) The work of Udne Yule showed that the use of a moving average on the "business cycle" curve introduces spurious periodic behavior, just as a band pass filter does to a noise spectrum.

Intuition is not a safe guide. For example, in the heads-or-tails game, if one throw is made every second, and the game is played for a year, it is not "incredible" that one player was behind all but $13\frac{1}{2}$ hours, but merely a 5 percent chance. The chance of being behind all but 32 minutes is one percent. Again, a false estimate of the effects of a particular procedure may be disastrous, as is the "optional stopping" used in the ESP experiments at Duke. Dropping out "those who cease to do well" may change the probabilities, not by a few percent, but by a factor of four or five.

The logical difficulties inherent in Quantum Mechanics were, and are, of no mean order. For a most uncomfortably long time logic showed that the theory was untenable, but its agreement with experiment was unshakable. The Ehrenfest model of 2R balls in two boxes, properly handled, resolves the Poincare paradox and others, by showing that although the probability of recurrence of the initial configuration after an infinite time is unity, the probable time taken to achieve this recurrence is in fact so nearly infinite that the recurrence is practically impossible. Mathematically, if $P(s)$ is the probability that after s steps we return to the initial configuration with all the balls in one box, then $\sum_2^\infty P(s) = 1$, but $\sum_2^\infty sP(s) = 2^{2R}$.

Finally, can the statistical approach be of use in pure mathematics? A consideration of the Descartes "Rule of Signs" for determining the number of positive roots of an equation of nth degree shows that it can. Statistically the number of positive roots should be about $(1/\pi)$ log n., a smaller quantity in general than the number of sign changes. Multiplying the entire polynomial by $(1 + t + t^2 + \cdots + t^n)$ reduces the sign changes to $\sqrt{n}$ which is much nearer the expected value. "We ask a little less, we get a little more."

"To use statistics best, immerse the problem at hand in an ensemble of statistical data and deal with it rigorously." Three great discoveries of basic importance to science are Logic by the Greeks, the Experimental Method by Post-Renaissance Western Europe, and Statistical Thought by the Twentiety Century. (*Secretary's abstract.*)

1405th meeting, february 11, 1955

The 1405th meeting of the Society was called to order at 8:15 p.m., by the Recording Secretary in the absence of all officers senior to him in authority. It was reported by the Chairman of the Communications Committee that the Speaker was snowed in somewhere along Route 1.

After announcement of the next speaker, there was a call for informal communications, and the Society took a recess for 15 minutes to await a larger audience.

The Society reconvened at 8:30, Mr. Tuckerman spoke briefly on Hexaflexagons, and Mr. Montroll gave a short talk on *Cayley trees* and their applications (when generalized to include closed figures) to governmental and other executive organizations.

Methods for the calculation of the number of trees of a given type, for selection of the type of tree (i.e., organizations best suited to a given job) and for their applications were all indicated. For example, a group doing operations analysis should have many cross-connections, a dictatorship is a "classic" branching tree, a system of checks and balances is a triangle.

Further discussion of "Tuckerman trees" by their author, a reference to a system of shorthand for use in organic chemistry by the Recording Secretary, and a note on Quaternions from the floor ended proceedings.

1406th meeting, february 25, 1955

Robert G. Breckenridge, of the National Bureau of Standards, spoke on *Gray tin.* There are many substances that exist in two or more allotropic forms (familiar examples are carbon, sulfur, and phosphorus), but tin seems to be the most puzzling and romantic of them all. All gray tin, of which a specimen was shown, quite possibly originates from one original crystallization, a seed from which seems to be needed to initiate the spontaneous change from the ordinary metal that may occur at temperatures below 13.2° C. Gray tin is the so-called alpha phase of tin, with a cubic lattice, of the diamond type, lattice constant 6.4912 A, and density of 5.763. The ordinary metal, the beta phase, stable above 13.2° C, has a density of 7.281. Gray tin is a semiconductor, a gray amorphous powder of very little strength, and bearing no resemblance to the white metallic phase. It is no wonder that the term tin disease, or tin plague, has been applied to the transformation.

The conditions for transformation are not well understood. Temperatures below 13.2° are necessary but not sufficient. After much fruitless work, it was necessary to procure a seed crystal from Cornell, which laboratory had obtained theirs from the Dutch worker Ernest Cohen, who had had some from an 1868 chance crystallization of a shipment in St. Petersburg Harbor. The retransition back to metallic tin takes place easily above the transition temperature, but is apparently not complete until the metal is actually melted. Some specimens have evidently retained their seeding power for many decades. The low-temperature transition is accelerated by Al and Mg ions, among others, but is inhibited by Bi, and to some extent by Pb. Contact with electrolytes has no influence on the transformation at the National Bureau of Standards, but is frequently reported to have some elsewhere! Germanium is contradictorily reported sometimes as favoring the change, sometimes as of no effect. Work using gray and white tin as electrodes in the electrochemical cell lead to anomalous results. Instead of the ½ millivolt at zero degrees predicted from specific heat measurement, falling to zero linearly as the temperatures rises to the transition point, the EMF is approximately constant at 10 millivolts (for divalent ions in solution) falling abruptly to zero at the transition point. This result has thus far remained unpublished, being not understood. Independent measurements of the heat capacity, however, yield a normal value.

Measurements of energy change based on a first order reaction equation yield a ΔE of 180 calories in the white to gray direction, but 2,300 calories in the reverse. Particle size appears to have an important effect here. On successively transforming and retransforming many times, the gray form reduces to a micro-fine powder, on which consistent values, less than 2,300, but still much higher than 180 calories are obtained.

Determined effects to produce gray tin in a form suitable for electrical measurements finally succeeded, using a technique of depositing an electroplated film on a suitable substrate, transforming the film to the alpha modification and then removing the substrate. Another technique, transforming thin single crystals was also successful. Measurements of the Hall effect and of conductivity with these specimens show an abnormally high mobility: about 28,000 while the best Ge is only 3,000–4,000. The material shows photoconductivity well into the infra red. The Hall coefficient is a function of the magnetic field, unlike Ge and other well-behaved materials, and the $T^{3/2}$ power law does not hold. Other workers have found it to be obeyed. This difficult material is indeed a semi-conductor, but all its properties are very unusual and lie in a range where they are most difficult to measure and where the usual approximations and assumptions do not hold. (*Secretary's abstract.*)

1407th meeting, March 11, 1955

James D. Hardy, of the Naval Air Development Center, Johnsville, Pa., spoke on *Pain and tissue damage*. Concerning the phenomenon of pain as a whole there is little agreement among either philosophers or laity. There are moral aspects, psychological aspects, physical aspects and sociological aspects. In order to isolate an objective element of the problem, the studies presented were strictly limited to the sensation or the "experience" of pain. Some authorities state that even this cannot be done and that meaningful results can be obtained only by treating pain "holistically."

The technique employs a projection light as a source of heat, with a shutter to regulate the time of exposure, shining onto the blackened skin of the subject. The intensity of the light is increased during three second exposures until the threshold of pain is reached: this threshold being judged by the subject. It turns out that this technique is quite a satisfactory one: all subjects of all ages and both sexes responding to the same threshold with only a 4 percent standard deviation. "Everybody is equally sensitive to pain" is the conclusion for this limited type of stimulus. Even though limited, it is a conclusion quite contrary to the usual doctor's belief. However, the ordinary physician is not measuring a pain threshold, but observing a human being as a whole in a far more complex situation

"Are two pains worse than one?" Plotting log of the exposed area against intensity of stimulus it is found that the threshold of feeling falls as the area increases, but the threshold of pain does not. Pain does not exhibit "area summation." That is a unique phenomenon in sensory psychology. The threshold can be raised by 10 to 50% by reading, hypnosis, distractions like loud bell-ringing, but nothing lowers it.

Extensive data show that pain occurs when the skin temperature reaches 45° C through a wide range of initial conditions. The input required to produce pain is greater when the skin is cold initially, but the criterion for pain remains 45°. Other materials beside the cooperative human subject were employed as well, among them a paraplegic case, bats' tails, guinea pigs' skin, and non-English-speaking Eskimos. The data were satisfactorily consistent.

There are three different sensations here: cold, warmth, and pain, but only one set of nerve endings. This is a morphological puzzle for which there seems to be no current explanation.

Data taken by Henriquez and Morris were quoted to show that tissue damage was dependent upon the product of time and temperature. In contrast, Dr. Hary's results show that pain is an indication of the rate of damage. It is well known there is no one-to-one relation between pain and integrated tissue damage, as is shown by severely wounded cases during the last war.

The scale of pain, measured in "dols" was explained. There seem to be subjectively 22 perceptible steps from initiation to saturation of the sensation. Two parts are called a dol, and there are thus 11 dols in the scale. The dols go up with the skin temperature.

When there has been previous tissue damage, even though fairly mild, as in a case of sunburn, the threshold for pain may be lowered quite markedly, even down to 35°. In the normal skin the rate of tissue repair can keep pace with the damage up to 45°, but if there is previous unrepaired damage, as in the sunburn, then the repair mechanisms are overloaded and pain results. 45° is the temperature at which human proteins are inactivated. Some animals, e.g., birds, have higher body temperatures, and it would be interesting to determine if their threshold is higher too.

A wide-ranging discussion elicited some further points of interest. For example, cold blooded animals suffer irreversible changes at 35° or less, it takes approximately 100,000 calories per mol to inactivate a protein, a sustained pain of neurologic origin is not shut off by cutting the nerves to the part in which the pain is felt. Laboratory pain is different from pain in the sickroom and caution should be used in applying the results of this study, but in general pain and rate of tissue damage are strongly correlated. (*Secretary's abstract.*)

1408TH MEETING, MARCH 25, 1955

This meeting of the Society was the occasion of the twenty-fourth Joseph Henry Lecture on *Tritium in nature*, by WILLARD F. LIBBY, of the U. S. Atomic Energy Commission. The lecture has been published in this JOURNAL **45:** 301–314. 1955.

NOTES AND NEWS

THE SCIENCE TEACHER REPLACEMENT PROJECT

On March 15 and 16, 1956, the Joint Board for Science Education of the Washington Academy of Sciences and the D. C. Council of Engineering and Architectural Societies sponsored an unusual teacher replacement program in the junior and senior high schools in the Greater Washington area to free teachers to attend meetings of the National Science Teachers Association in Washington and to visit local laboratories. On these days scientists and engineers took over classes in the schools so that students, scientists, and teachers would learn something of one another's interests and problems. In all, 100 schools and 320 teachers from the District of Columbia, Prince Georges and Montgomery Counties in Maryland, and Arlington and Fairfax Counties and Alexandria and Falls Church in Virginia took an active part; and 1,350 scientists volunteered to serve as substitute teachers and many more expressed a willingness to serve if needed.

The plans for this program were initiated by the Joint Board early in October, when the superintendents of various schools in this area were contacted to establish their willingness to participate in such a program. The schools cooperated directly by supplying the names of teachers desiring replacements along with their subjects and class schedules. The detailed plans for the recruiting of scientists and engineers were carried out primarily by a liaison committee composed of scientists in the Washington area. These plans started with a meeting on December 19, at which chairmen were chosen for the various scientific fields such as biology, chemistry, physics, and general science. It was the task of each of these chairmen to choose representatives in each of the universities, and in government and industrial laboratories in his particular field, who would be responsible for enlisting individual scientists and engineers in his laboratory to serve as teacher replacements. The directors of these organizations and laboratories and the presidents of various technical societies were also approached for their cooperation in this project. Many technical societies appointed individual members who were active in publicity and enlisting scientists and engineers from their respective societies.

The office of the science supervisor of the D. C. Public Schools at Woodrow Wilson High School served as headquarters for the liaison committee during this period. One full-time secretary and another part-time secretary were provided for this office by Science Service. These secretaries did large amounts of the typing, answered the telephones, and participated in all phases of the work. After February 1, scientists, school supervisors, and teachers converged on the office of the science supervisor to help with the assignment task. The actual assignment task was one of primarily matching scientist cards with teacher cards so that the indicated times at which scientists were available fitted with the subjects and periods of the teacher's classes. Insofar as possible attempts were made to place scientists in or nearby their indicated schools of preference. Throughout all these proceedings the advice of the science supervisor with regard to schools, teachers, and related subjects was freely drawn upon.

When once the assignments were completed, large amounts of correspondence became necessary. This was handled by secretaries and teachers in the office of the science supervisor, outside laboratories, schools, the Joint Board, and elsewhere. Because of the large number of applications by scientists it was possible to make teaching assignments to only 730. Many thank-you letters therefore had to be written and were late in arriving because of the large task of completing the assignments. The liaison committee knows that many very able scientists and engineers were not utilized, for there was not sufficient time to place the best qualified person in each teaching assignment.

After all the initial assignments were made and the associated correspondence taken care of, the primary concern became one of supplying replacements for scientists who later found they could not take part. About a hundred cards of unassigned scientists were catalogued with respect to possible teaching areas, and each of these groups of cards was placed in the hands of the area chairmen of the Secondary Schools Contact Committee of the Joint Board for Science Education. These scientists had been asked previously by letter to remain in a standby status. If for some reason a scientist or engineer could not meet his scheduled class, the school contact committeeman reported his particular need to his area chairman, who supplied an immediate replacement. Many last-minute assignments, substitutions, and changes were also made by telephone in the office of the science supervisor.

From the reports received to date, the effort contributed by the scientists and engineers in this Special Substitute Teacher Program was both interesting and worthwhile. One scientist, who was forewarned of a possible discipline problem, found quite unexpected and spontaneous interest in his lecture. Another found that his second scheduled class of some 30 students was, at the principal's request, extended to include the complete school of 600 students. Still other scientists have taken the time to summarize their experiences and impressions. One of these indicated that it was possible to interest only certain students, and he concluded his remarks with the observation that superior students are the ones who should receive more attention. Since the advent of these lectures, there have been reports of students asking their teachers and principals about more advanced courses in science. The suggestion has been made by several that these lectures be repeated as an annual project. A survey at one of the scientific institutions indicated that all the scientists who participated in this project would be glad to do so again on the same basis. Other cities have also expressed an interest in this project and are making inquiries about it. Any real measure of success must, however, await future evaluation. It is hoped that those who participated and others who offered their services which were not utilized will again be generous in helping science education when called upon in the future.

ZINC OXIDE-EUGENOL DENTAL FILLINGS

Deep dental cavities have long been treated with a mixture of zinc oxide and eugenol. This white, puttylike material relieves toothache and acts against bacteria in a tooth cavity. However, quality control of such fillings has been largely a matter of experience gathered in practice over the years. Little has been known about the actual reaction taking place between the zinc oxide and eugenol—whether it is, for example, a true chemical reaction or a physical process like hydration. Since scientists did not know the precise nature of the reaction, it has been difficult to predict, much less accurately control, such things as setting time, hardness, and strength of the hardened product.

The National Bureau of Standards' dental research laboratory therefore began an investigation of zinc oxide and eugenol mixtures. The study, sponsored by the armed services' dental corps and the American Dental Association, has shown that a chelate compound is formed by these materials.[1] The compound produced, zinc eugenolate, absorbs any unreacted materials to form a hardened mass of remarkable stability. The investigations were made by Maj. H. I. Copeland, Air Force guest worker at the Bureau, Dr. G. M. Brauer and W. T. Sweeney of the Bureau staff, and Dr. A. F. Forziati, research associate, American Dental Association.

Chelate compounds are cyclic compounds formed by a coordination process, in this case with a zinc atom. Most chelates are remarkably stable. In the case of zinc oxide and eugenol, long, thin crystals are formed. The crystals act as a matrix for the set mass and absorb any unreacted material. The reaction is thus both a chemical and a physical process.

The Bureau made use of several modern techniques in its study of zinc eugenolate. Chemical procedures coupled with X-ray diffraction measurements were employed. The infrared absorption spectra of zinc eugenolate were compared to those of another chelate compound, zinc quinolate, since information with respect to the latter's structure was available from recent studies elsewhere.[2] For further comparison, guaiacol and the zinc oxide-guaiacol reaction product were employed. Elementary analysis and molecular weight determinations established the empirical formula of zinc eugenolate as being $(C_{10}H_{11}O_2)_2Zn$.

With the information that a chelate compound is formed by zinc oxide and eugenol, it is possible to predict other materials that will form like compounds for dental use. The Bureau has produced similar chelate compounds for study using guaiacol and methyl guaiacol as chelating agents. Such agents must have a replaceable hydrogen and a near-by donor group. Mixtures of zinc oxide and liquids such as phenol or veratrole cannot harden (form chelate compounds) because they do not have the required molecular structure.

Having described the reaction, the Bureau plans to compile further data on various chelate compounds and their ingredients so that the mixtures used in dental fillings may be directly controlled. Present studies in this area include determinations of the required amount of surface activity of the zinc oxide employed, optimum amount of water, mixing temperatures, and kind and amount of fillers.

CONSTANT-TEMPERATURE OVEN FOR QUARTZ CRYSTAL OSCILLATOR

The National Bureau of Standards has developed a simple, compact oven that stabilizes the temperature of a quartz crystal for precise oscillator frequency control. This oven utilizes the heat of fusion of an extremely pure organic compound—*p*-dibromobenzene—to hold the oven temperature within 0.01° of 87.31°C. Power requirements are low: 10 watts for normal operation and 20 watts during the brief warmup period. The instrument was developed for the Army Signal Corps by R. Alvarez and C. P. Saylor of the Bureau's pure substances laboratory.

Quartz crystals are widely used as frequency standards, as filters in receiver circuits, and as

[1] For further technical details, see *Setting reaction of zinc oxide and eugenol*, by H. I. Copeland, G. M. Brauer, W. T. Sweeney, and A. F. Forziati. Journ. Res. NBS **55**: 133. 1955.

[2] Merrit, L. Journ. Anal. Chem. **25**: 718. 1953.

frequency stabilizing elements in oscillator circuits. Since a temperature change in a crystal will produce a change in its frequency, common practice has been to control the temperature of the crystal in precise frequency applications. Such close temperature control is usually achieved only by relatively large and complex systems. The Bureau's special-purpose oven eliminates the need for much of the complex and bulky equipment ordinarily used.

Although the Bureau's instrument was designed specifically as a quartz crystal oscillator oven, it can be applied wherever a simple, compact thermostat for close temperature control is required. It can, for example, provide a constant temperature for a reference thermojunction for extended temperature measurement and control. The oven uses *p*-dibromobenzene in its particular application, but other substances with different melting points provide other operating temperatures. Phenoxybenzene, for instance has been employed in maintaining quartz crystals at a constant temperature of 26.88°C. where the ambient temperature is low.

When a substance is partially molten, its latent heat of fusion provides thermal ballasting; that is, a heat loss causes crystallization of the material with evolution of the latent heat of fusion. A heat gain, on the other hand, results in absorption of heat as the solid phase melts. The melting temperature at the solid-liquid interface remains unchanged, provided that the material is pure and that the pressure is constant. A substance used for temperature control in this way must possess (1) a melting temperature within the desired operating limits, (2) extreme chemical stability when in contact with the oven components, (3) a high heat of fusion, and (4) a high velocity of crystallization. *p*-Dibromobenzene meets these requirements.

The oven is contained in a cylinder 3⅓₂ inches high and 2¹¹⁄₃₂ inches in diameter, mounted on an octal base. Inside the oven is a vacuum-tight container into which a quantity of paradibromobenzene has been sealed. During operation of the oven, the material is about half liquid and half solid, and completely fills the container. At the top of the container is a metal bellows that is linked to a spring-loaded miniature switch. The volume changes occurring during phase transformations are transmitted to the bellows, which turns a heater on or off to keep the chemical partially molten. Spring-loading the switch provides a pressure relief system in case a greater proportion of liquid is formed during the warmup period than would be present at the normal operating point. A second heater provides rapid warmup. It is controlled by a bimetallic element that cuts off the power when the substance is about 7° below the melting point. A copper vane system distributes the heat rapidly throughout the container and reduces any temperature gradients that might exist if solid and liquid become separated during operation. The crystal and its holder fit into a well within the container.

Temperature stability data on the instrument were obtained by fastening a calibrated thermistor to a dummy crystal inside the crystal holder. The total temperature variation during a six-day period of continuous operation did not exceed 0.007°C.

NEW CHIEF OF NBS METALLURGY DIVISION

Dr. James I. Hoffman has been selected to head the Bureau of Standard's Metallurgy Division. He succeeds Dr. John G. Thompson, who recently retired.

An outstanding analytical chemist who developed one of the first methods for purifying uranium, Dr. Hoffman had been serving as assistant chief of the Bureau's Chemistry Division and Chief of the Surface Chemistry Section. The Department of Commerce recently honored his work by awarding him the Gold Medal for Exceptional Service. In his new capacity he will direct the Bureau's diversified program in metallurgical research and development. Author of numerous publications in his field, he is well known for his work on the chemistry of the rarer elements and the chemical analysis of iron, steel, refractories, and various minerals, such as phosphate rock, bauxite, and fluorspar. He has taught analytical and physical chemistry at George Washington University, American University, the Department of Agriculture, and in graduate courses given at the National Bureau of Standards.

In 1946 Dr. Hoffman was awarded the Hillebrand Prize for significant contributions to chemical science. His specific achievements were listed as the determination of the atomic weights of aluminum and gallium, the construction of a pilot plant for the production of alumina from clay, and the development of an ether extraction process for the purification of uranium oxide. The purification of uranium oxide by this method removed the greater part of the difficulties encountered by the Manhattan District in securing pure materials for the production of uranium metal. The process perfected by Dr. Hoffman for obtaining alumina from clay was the result of an effort to utilize domestic sources of alumina at a time when submarine warfare was seriously interfering with shipments of bauxite to this country.

ROCKEFELLER PUBLIC SERVICE AWARD TO DR. FANO

Dr. Ugo Fano, chief of the Nuclear Physics Section of the National Bureau of Standards, has been granted a Rockefeller Public Service Award, which will allow him to complete a book on quantum physics for nonphysicists. Dr. Fano is internationally known for his theoretical work in various branches of physics and in related sciences. An authority on the penetration and diffusion of radiation through matter, his theories are widely used in connection with nuclear reactor shielding problems. An important part of his work at NBS is consultation with experimental scientists on the theoretical aspects of their work.

In this work Dr. Fano has shown a unique ability to explain the fundamental concepts of classical and modern physics in terms and analogies that scientists working in other fields such as biology and medicine can readily understand. Since the number of scientists who have need for this type of information is steadily increasing, Dr. Fano's book would be an important contribution to the literature.

The award will also give Dr. Fano the opportunity to accept an invitation to spend the 1956 academic year teaching at the University of Rome. He has been invited to lecture on subjects of his own choice, working in line with the University's program for developing peaceful applications of atomic energy.

Born in Torino, Italy, in 1912, he received his D.S. degree from the University of Torino in 1934. After his graduation he worked in Rome under the direction of Prof. Enrico Fermi, serving as an instructor. During this period he held also a fellowship at the University of Leipzig, under Prof. Werner Heisenberg. He came to the United States in 1939, serving first as a research associate at the Washington Biophysical Institute. From 1940 to 1946 he worked with Dr. Millislav Demerec in genetics and radiobiology at the Carnegie Insitution of Washington, joining the NBS staff in the latter year.

A RAPID QUANTITATIVE ANALYSIS OF COLLAGEN

A method for measuring the amino-acid content of collagen in a relatively short time and using simple apparatus has been developed by the National Bureau of Standards leather laboratory.[1] The procedure, an application of 2-dimensional paper chromatography, was worked out by James M. Cassel by modifying and adapting a recently published qualitative method.[2] The quantitative technique can be applied not only to collagen, the parent substance of leather, but also to the derivatives and degradation products of collagen. In contrast to other methods currently employed, it enables the analyst to follow with a high degree of detail the reactions and changes in which collagen may be involved. It is therefore expected to provide a useful tool in understanding the structure of collagen and the properties of leather.

Improvements in technique during the past few decades have made chromatography one of the more important methods available to the analytical chemist. The partition chromatographic process brings about separation of components in a mixture by distributing the solutes between two liquid phases, one of which is mobile and the other essentially fixed by sorption to a support, i.e., to a column of silica gel or to a sheet of cellulose paper. In one form of the method, a small quantity of unknown mixture is applied to one end of a strip of paper and that end placed in an appropriate irrigating solution. The solution rises by capillary action and carries the mixture with it. Mainly because of differences in solubility, however, the various components move up the support medium at different rates. After a period of time, the components are spread out into a series of separate patches.

The use of paper as the chromatographic adsorbent has broadened the range of application of the method and, at the same time, has made

[1] For further technical details see *A paper chromatographic analysis for collagen and collagen derivatives*, by James M. Cassel, Journ. Amer. Leather Chemists' Assoc. (in press).

[2] *Two-dimensional paper chromatographic system with high resolving power for amino acids*, by R. Redfield, Biochim. et Biophys. Acta **10:** 344. 1953. The first description of paper chromatographic methods for the analysis of protein hydrolysates was given in 1944 by Consden, Gordon, and Martin.

it accessible to even the most modestly equipped laboratories. The use of paper also facilitates two-dimensional chromatography. If a drop of unknown mixture is applied to a corner of a paper square and solution is passed through the paper parallel to one of the edges, the unknown will spread out into a line of patches along one edge of the square. Often, however, the separation is not complete, some of the patches being still made up of several components. If now another solvent is passed through the paper perpendicularly to the line of patches, each of the latter may be split up into several patches, the final result being a 2-dimensional pattern of patches on the paper.

The Bureau's method produces separation of all eighteen of the amino acids of collagen, with the exception that lysine and hydroxylysine are separated as a single entity, as are also leucine and isoleucine. The procedure is simple and requires for accurate analysis as little as 150 micrograms of protein per chromatogram. If certain precautions are observed, very good reproducibility of data is obtained.

The first step in the procedure is to apply, by micropipette, a small spot of the solution to be analyzed to the corner of a sheet of Whatman No. 1 paper, 37 cm square. The sheet is then stapled in the form of a cylinder and placed spot downward in a glass cylinder, 6 inches in diameter and 12 inches high, containing the solvent mixture. A crystallizing dish is inverted and sealed to the top of the chamber with electrical tape to serve as a tight sealing lid.

The paper is irrigated in the first direction with a mixture of methyl alcohol, water, and pyridine. After this, it is removed, dried, restapled, and then irrigated in the second direction with tertiary butanol, water, and diethylamine. Once again the sheet is dried, and the last traces of diethylamine are removed by hanging the sheet in a steam hood at 75°C. for approximately seven minutes. An alcohol solution of the coloring agent ninhydrin is sprayed on the sheet, and the color is developed under carefully chosen conditions of temperature and humidity.

At this point the chromatographic separation of the amino acid components, with the exceptions noted, is complete, each component appearing as an irregular, colored patch on the paper. Each of the spots is now cut out and then cut into small strips. The strips, in turn, are placed in test tubes and washed out with fixed quantities of aqueous n-propanol. Optical densities are then read with a spectrophotometer set at 570 mμ for all components except proline and hydroxyproline, which are read at 350 mμ. Finally, the amount of each amino acid present is determined by comparing the optical densities with calibration curves obtained from standard solutions run in the same manner.

Amino acid values for collagen as determined by this technique agree well with those reported in the literature. If four to eight chromatograms are run per sample, quantitative information concerning all the amino acids in either collagen, a collagen derivative, or a collagen degradation product can be obtained in only four or five days. If conditions are maintained constant throughout the procedure, standards need not be run simultaneously with the unknowns and hence an important saving in labor and time is achieved.

The development of a rapid quantitative analysis for collagen is part of a larger program of research which the Bureau is conducting on the physical constants and structure of leather. Basic information on leather and collagen, the principal constituent of cattle hide, is needed to assure continued advancement in methods of tanning and leather manufacture. Related investigations now in progress deal with the pore structure of the leather matrix, specific heats of collagen and leather, and the effects of high pressure. The Bureau's method for analyzing collagen is being applied to a study of the reaction of collagen with nitrous acid. It is also planned to use the new technique to obtain information about the layerwise distribution of amino acids in hides and the effect on the distribution produced by various types of degradation processes.

BISON BASIN FOSSILS

An isolated Wyoming valley has yielded a considerable collection of fossil remains of archaic mammals of about 60 million years ago, animals only remotely related to those living today. The fossils from this locality, known as the Bison Basin, first discovered by a Geological Survey party four years ago, have just been described by Dr. C. Lewis Gazin, curator of vertebrate paleontology at the Smithsonian Institution, who had a major part in collecting them.

The creatures lived during the Tiffanian epoch, next to the last subdivision of Paleocene geologic time—a period that lasted approximately 20 million years but which was just the start of the

"Age of Mammals." The Paleocene was the time when mammals were coming up as the dominant animals on earth and the importance of the dinosaurs had just passed. The warm-blooded creatures were becoming markedly diversified, filling many of the habitats left by the disappearance of the host of reptilian forms which previously ruled the earth.

Notable in the collection are remains of plesiadapids. These were small, probably tree-climbing animals belonging to the primate order, but only remotely related to the living New or Old World monkeys. They were most like lemurs, and are classified in the same superfamily, but the living lemurs may not have been derived from the plesiadapids but from some closely related contemporary.

Plesiadapids were not only North American in distribution but are known also from the Paleocene of France, from beds about the same age as our North American Tiffanian time. The Bison Basin beds in Wyoming produced at least four species and two genera of these creatures, represented by teeth and jaws. Among them is one of the most primitive known of the family, a rather minute creature known as *Pronothodectes*. In the Bison Basin beds this represents a survival of the group recognized as the precursor of true *Plesiadapis*. Present also is one of the most advanced of the plesiadapid family, not in the same beds but stratigraphically higher than the level which produced the most primitive. They just happened to have died in the same general locality, Dr. Gazin says, but at different times.

Among other creatures represented are condylarths—archaic, subungulate mammals that paleontologists now generally believe gave rise to the modern hoofed or ungulate animals. The condylarths themselves, however, were not truly hoofed but had toes with structures intermediate between claws and hoofs. They show evidence that the claws at this stage were beginning to spread out or flatten. Some of the condylarths were very small; the largest of those in the Bison Basin, however, was *Phenacodus*, an animal over 4 feet long and about 2 feet high. It may have looked rather like a carnivore, but its teeth demonstrated that it was an herbivorous type. At that time the condylarths and the creodonts, the latter including the forerunners of the true carnivores, were not so greatly different in structure.

The Bison Basin collection also contains fossil remains of several kinds of creodonts, including the miacids that later gave rise to the more modern carnivores, and such creatures as claenodonts, animals that probably had somewhat the appearance of small bears but were definitely not ancestral to them.

A pupil began to learn geometry with Euclid and asked, when he had learnt one proposition, "What advantage shall I get by learning these things?" And Euclid called the slave and said, "Give him sixpence, since he must needs gain by what he learns."—Sir T. L. HEATH, *A History of Greek Mathematics.*

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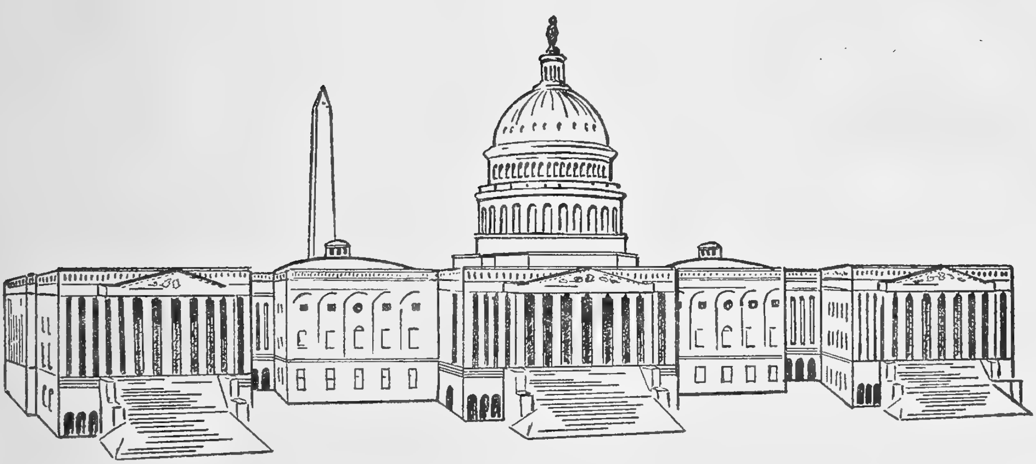

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PHYSICS.—*Atomicity and patterns.*[1] Sir GEORGE P. THOMSON, Cambridge University, England. (Communicated by C. H. Page.)

(Received May 3, 1956)

Joseph Henry was a man of very versatile mind, as the wide range of his work shows. He lived, moreover, in an age in which science was far less compartmentalized than it is now, and I hope that you will not think it out of place if I speak to you to-day on a subject which covers a wide range, a subject on which indeed I have no new discovery to tell you, except to try to emphasize a point of view which is perhaps somewhat neglected. In the realm of nature there is one characteristic which appears again and again, but which does not seem to have been given in general a name. I mean the existence of large numbers of individuals of a particular kind, nearly or quite indistingiushable from one another. This characteristic ranges through the whole scale of the material world, from electrons to galaxies; each exists in countless numbers. But what makes the effect, in my opinion, more remarkable, is that it is not limited to dead matter. On the contrary, the most striking manifestations of it are in biology. The individuals of a species, whether from bacteria or human beings, are an obvious (but not the only) example. The same principle pervades the whole of biology. It is the principle of cellular structure, and it also applies to many of the organs of individual creatures. The hairs on a dog's back, the leaves on a beech tree, are alike, examples of the love of production in large numbers which pervades nature. Henry Ford may have supposed that he was initiating something new when he gave us mass production in its most characteristic form, but he was merely a humble imitator of nature, and though his cars were possibly more similar than the proverbial peas, they could not rival for a moment the identity of atoms or molecules. Nature is the grand mass producer; for individuality you must turn to the works of men: to art.

It will be a convenience, I think, to introduce the word *atomicity* in a new sense, to mean a group of individuals which closely resemble one another. Thus the scales of all the herrings in the sea, or the collection of the galaxies, may alike be described as atomicities.

It was in physics that the name "atom" was first applied, or rather in the natural philosophy of the Greeks and Romans. Starting from an almost legendary Leucippus, the idea was developed by Democrates and Epicurus, but far the best statement of it is by the Roman Lucretius, whose work survived the Middle Ages in a single copy more, I suspect, because of its poetic beauty than for its very great scientific merit. Lucretius was a poet; I believe he took most of the ideas from his Greek predecessors, but they are very remarkable ideas. Not merely is the general statement of atoms as constituents of matter introduced and amplified, but one can find traces of the most up-to-date discoveries of physics—no doubt this is partly a case of the reader finding what he has himself brought, but it may possibly be a little more. Lucretius anticipates Prout's hypothesis that atomic weights are integral multiples of a unit. He does so from an argument which does not hold water, but at least he makes the statement. He has, it is true, no idea of molecules, but he anticipates in an astonishing fashion one of the great advances of the quantum theory—the idea of indeterminacy. His atoms fall through empty space; for him

[1] The 25th Joseph Henry Lecture of the Philosophical Society of Washington, delivered before the Society on April 20, 1956.

there is an absolute vertical; he has no idea of universal gravitation; but although his philosophy is, on the whole, deterministic, he introduces the "clinamen," an arbitrary motion designed to upset the regularity of the downward motion, and be the cause of the collisions which he rightly regards as the fundamental condition for happenings. Except for these, he says, nature would create nothing. He realizes that the arbitrary nature of these assumed motions prevents a complete causal sequence.

"Lest cause should follow cause in endless sequence," he says, and ends the passage[2]: "Hence is this power torn from fate, I say, by which we walk as will points out the way." It is all strangely reminiscent of Heisenberg and the uncertainty principle!

In modern physics, of course, the ideas have been carried further, and what are still called "atoms" are no longer impossible to divide, but are made of electrons and nuclei. The electrons are identical, not merely in practice but in principle, and have no individuality. The same is true of the particles that make up the nucleus, protons and neutrons. It is difficult to know quite what position to assign to the mesons—the π mesons appear to be the particles responsible for the forces between nucleons (neutrons or protons), but they also by spontaneous decay pass to μ mesons, and these in turn to electrons. It is perhaps possible to regard them as in a kind of sense excited electrons, and some of the very heavy mesons recently discovered are apparently excited protons or neutrons. The meaning of these mesons is still very obscure, but at least they exist as a series with discrete masses and do not, I think, differ fundamentally in respect of atomic status from electrons or protons. It is somewhat different with quanta. Here indeed you have an atomicity, but with a continuous variation in a single property, what one may describe as a partial atomicity. Although quanta of the same frequency are identical, those of a different frequency are not. Yet this difference is, in a sense, artificial, since it is modified by the Doppler effect, while the Doppler effect does not alter the number of quanta in a given region.

Chemistry, which is in a sense the physics of the parts of atoms outside the nucleus, is in principle understood. Chemical combinations can be explained in terms of wave mechanics, and of the properties of equations whose nature is fundamentally determined by the number of electrons that take part. A single atom, apart from the nucleus, is a pattern of electrons round the nucleus. This business of patterns is, I think, very fundamental. The charge and mass of the electrons, and those of the nucleus do indeed come into the calculations, but the most important thing is the *number* of electrons. The atom is essentially a pattern of integers. It seems likely that the nucleus may be very much the same. It is true that in these two cases we have to consider different substances, electrons in the case of the outer part of the atom, protons and neutrons in the case of the nucleus. But the stress on integers is the same in both. It reminds one of the famous saying: "God made the whole numbers and men made the rest." The same thing occurs when one passes to chemistry. A chemical compound is a special pattern of electrons, a pattern which can in fact be plotted out by the methods of X-ray diffraction. Again patterns of integers, electrons, and individual nuclei form the molecule. Bind the molecules into a crystal, and you get a pattern on a larger scale but with the same integral properties. It is pure speculation, I admit, but I cannot help feeling that the constituent substances that we still have to use—electrons, protons, neutrons, and perhaps mesons, will in the long run themselves turn out to be patterns—patterns of what? It will not be necessary to answer, for where all the substances are the same you do not need a name. They would, so to speak, be patterns of the first order, nuclei and the electrons around them will be patterns of the second order, molecules of the third, crystals of the fourth, and so on, and the world of inanimate nature will become reduced to a series of patterns more or less perfect (since atoms may be ionized and crystals have defects, while gases and liquids lack the highest kind of order), but all patterns and all concerned with integers. It is strange to recall—I do not venture to say that it is significant—that this idea goes back to the time of Pythagoras. He stressed the importance of integers. His discovery of

[2] Lucretius, *De rerum naturae.* II, line 257.

numerical relations between the lengths of a string that produced musical intervals is possibly the oldest recorded experiment in pure physics, and I cannot help a feeling of satisfaction that it should be so closely in tune with the modern ideas of quantum numbers and Eigenwerte. The Pythagoreans not merely regarded numbers as in some sense divine, but paid particular attention to the types of patterns which can be made by integers, e.g., triangular numbers.

Let us turn from the very small to the very large.

Though stars resemble one another considerably, and especially in mass, they are by no means identical, and there are at least two kinds of galaxies, with again minor variations; but there is a kind of order-of-magnitude agreement. A galaxy contains an order of 10^{11} solar masses, and different galaxies probably do not vary by more than one or two powers of 10. It is, I think, of interest to consider how these and other imperfect atomicities, as one may call them, in fact arise, to see if one can trace any common factor. Unfortunately the creation of stars and galaxies is still not fully explained. It is generally supposed to be due to an instability occurring in a continuous amount of gravitating mass if this is large enough, as was suggested by Jeans. But I am told that Jeans's original theory is unsatisfactory in certain points and has not been fully replaced. But at least one can see that a distribution into discrete objects will be more stable in certain circumstances than a uniform distribution, and it is reasonable to suppose that this has something to do with the origin of these objects. There is another class of imperfect and partial atomicity of which much more is known. I refer to eddies. If a liquid is streaming in a pipe with every particle moving along the axis at more than a certain speed, depending upon the size of pipe and rate of flow, turbulence sets in, as Reynolds showed many years ago. This turbulence consists essentially of sets of eddies. The eddies resemble quanta rather than electrons in that there is a continuous distribution in size. The smallest eddies are near the wall, and they increase in size as they go outwards. This turbulent action is now pretty well understood, and has been closely studied in connection with the boundary layer that forms on the wings of aeroplanes and on the hulls of ships. In this case the simple undifferentiated motion is unstable and breaks down into a more complicated atomicity.

If we turn to biology we find at once the cell as an atomic unit. There are many kinds of cells and their size may vary greatly up to the giant nerve cells of the squid which are about ½ mm diameter and 20 cm long. Ordinary cells are of order 20 μ. But the cells of one kind are of roughly comparable size. Physiology is not far enough advanced to say for certain what determines the size of a cell; it must be some question of balance between surface tension, electrical forces and diffusion. However the size is arrived at, it is possible to have not merely unicellular organisms all roughly alike, but to have a part of an organism made up of a vast number of closely similar cells. Cells have the power of reproduction, and after they have divided grow to their original size, or roughly so. In some way the particular size characteristic of a particular cell represents a stable value which is rapidly reached, but never greatly exceeded. In some way too the undifferentiated material out of which the organism grows is organized most suitably into units of a certain size. The conditions of stability in this case as in those of turbulence are, of course, quite different from those of static stability. There is no question of searching for the position of minimum energy. In both cases energy is available from outside, and as in the case of some electrical systems the tendency may be toward a state of maximum energy subject to certain constraints.

If one takes an extended view of atomicity it affects one's view of the so-called *cosmological principle*. This principle in its most complete form asserts that the universe when suitably smoothed out looks the same from all places and at all times. In a less complete form variation with time is allowed but not with space. This principle has been very widely used, but there are substantial objections to it as ordinarily stated. In the first place it apparently not merely throws out the baby with the bath water, but throws out the baby (or babies) and retains the water, and the babies are big, nothing less than galaxies! The striking thing about the night sky is precisely its nonuniformity, the light comes from a discrete set of points which are of varying brightness, and are not distributed at random but grouped round the Milky Way, which itself is a unique feature. Clearly an observer on another star would see a substantially different pattern. Limiting observation to a single galaxy the principle is certainly quite untrue; the smoothing must proceed much further. It is supposed to hold as between galaxies, but even here the distribution is irregular as many galaxies form part of clusters, others do not. It is only on the very largest scale that the principle is not demonstrably false. On that very large scale it states that the distribution of matter and of the velocities this possesses are independent of the observer. But even here there is a restriction. At any place there is a privileged or "fundamental" observer, roughly speaking an observer at rest with regard to the average of the galaxies. We are, in fact, in such a position, for observations in different directions in space—as far as they are possible in view of the absorption due to clouds in our own galaxy—show galaxies roughly uniformly distributed and with apparent velocities which do not on balance vary with direction. Clearly an observer moving past the earth with a velocity say a quarter that of light would not see this isotropy because of the well-known relativistic effects on angles and velocities. Indeed such effects would exist even on a nonrelativistic view of aberration and Doppler effect.

The need to choose these privileged observers detracts rather from the principle, for some of the regularity observed is manufactured by the choice. However it appears that observers near the center of galaxies could be representatives of a set which would not be so arbitrary—some theorists specify them. Taking this set of observers it is postulated that each would see a distribution of galaxies with density and velocity each a function of distance only, and these two functions would be the same for all fundamental observers. There is here a point which seems to me to present some difficulty. The principle is concerned with a smoothed out distribution for it is usually assumed that the fundamental observers form a continuous set, yet all that can be observed at the distances at which alone the principle applies is the *discrete* set of galaxies. To apply the theory one has to consider as important just that aspect which the theory neglects.

I venture to suggest that what is useful in the principle is best expressed in terms of atomicity. What it really says is that there are a very large number of approximately similar galaxies and that their distribution in space is that of the molecules of a uniformly expanding gas, with the addition that if there is an edge we are not near it. This is all that the observations justify. The recent work at Cambridge (England) on the so-called radio stars allows observations deeper into space even than the 200-inch telescope. So far this work does not support the idea that galaxies are uniformly distributed in space. Assuming, as one must from the principle of cosmogony, that the proportion of radio stars to galaxies is constant, more radio stars imply an increased density of galaxies, and this is what Ryle[3] and his workers find at great distance.

It is well known[4] that there are some connections between cosmic and electronic data which appear in the form of nondimensional ratios leading to the same very large number about 4×10^{39}. Thus:

(1) $\dfrac{e^2}{\gamma m_p m_e}$ = ratio of electric to gravitational force of electron and proton = 2.28×10^{39}

(2) $\dfrac{cT}{\left(\dfrac{2e^2}{m_e c^2}\right)}$ = ratio of characteristic size of expanding universe to diameter of electron = 6.6×10^{39} or ratio of age of universe to time for light to cross electron.

(3) $\dfrac{\rho_0 c^3 T^3}{m_p}$ = number of protons in a volume characteristic of the universe = $[5.6 \times 10^{39}]^2$

(4) $\gamma \rho_0 T^2 \div 1$ which after reduction implies that the gravitational P.E. of a particle in the field of the universe is about equal to its rest mass.

Here ρ_0 is the mean density of matter in space; ρ_0 is taken as 10^{-27}: which may easily be wrong by two powers of 10. T is the reciprocal of Hubble's constant, with a

[3] Proc. Roy. Soc., A, **230**: 448. 1955.

[4] Cf. Bondi, *Cosmology*. Cambridge University Press.

probable value of about 4×10^9 years. The other constants are accurately known (c velocity of light, e charge of electron, m_e mass of electron, m_p mass of proton, γ universal constant of gravitation). In any case one would not expect such relations, if derived from some yet-to-be discovered fundamental theory, would be exact, factors of $\frac{1}{2}$, 2, 4π would be expected to occur.

But the agreement seems better than a coincidence and is one of the reasons for regarding atomicity as very fundamental in the universe, since atomic constants are related to cosmic ones. Dirac has suggested that these large numbers are not really constant but increasing steadily with time, and (2) can be regarded as the age of the Universe in natural units, but if so e, γ, m_e, or m_p must change with time. Eddington on the other hand regarded them as fixed by geometrical considerations and found for the number of elementary particles in the universe $N = \frac{3}{2} \times 136 \times 2^{256} \div 2.4 \times 10^{79}$.

Some modern theories of cosmogony, those of Bondi and Gold, and of Hoyle, require matter to be continuously created in the form of neutrons or hydrogen atoms, thus again implying a connection between the atomicity of the very small and cosmogony.

I understand from my biological friends that there is a tendency to reinstate the species as an important biological conception, but in any case there is no doubt that animals and plants of one general kind constitute an atomicity in our sense of the term. Even if there is a continuous gradation, as appears occasionally to happen in species that are widely distributed over the earth, so that individuals at the two ends of the range are markedly different, it yet remains true that there are a vast number of individuals which for practical purposes are indistinguishable and that is all that we need. How far can this be explained? To some extent the existence of species or, indeed, larger groups, is a consequence of the stability of the germ mechanism. Mutations indeed occur and abnormal individuals are born, although rarely. Among the normal individuals there is a gradation in all qualities, and rearrangement of genes can bring about changes within this range, of which some will be favored by natural selection and others discouraged. But the general effect is one of stability. Most of the creatures born to a particular pair are closely alike, and this process continued for generations produces a fairly homogeneous population. If large mutations were the rule and not the exception this would not occur, but since most mutations are harmful, a creature which had too many would not long survive. Atomicity here is the consequence of a stability of organization which itself is a prerequisite for the continued existence of creatures of that general kind.

In all these cases it is perhaps fair to see atomicities as arising where there are large amounts of energy available, gravitational in the case of the galaxies, kinetic in the case of turbulence, and chemical or electrochemical in the case of living matter. In such cases there seems to be a tendency to divide into units and this apparently makes for stability.

I ought perhaps to deal with one possible objection, that some of these atomicities may be due to the observer. We can only have a limited number of names, and we apply them somewhat arbitrarily to classes which may have no sharp edge. I think this may be true to a slight extent, but in the cases I have collected at least, and in many others, there is a real physical effect; that is, there are a great many individuals greatly alike in any particular quantity, and then a large gap before one comes to any more.

In a sense the subject that I am discussing is one of the oldest in philosophy, in that it is linked with the idea of universals, that is of names for groups of things, and of course the controversy between those who held that the groups had a real existence (the realists), and those who held they were only names (the nominalists), raged throughout the whole Middle Ages. I am in no sense a philosopher, and I dare not go further into this aspect of the subject. I do not think, though, that what I have presented to you can be explained as merely a matter of words. It seems to me that atomicity is as real and as prevalent in nature as it is in the modern factory, and for those who dislike what they refer to as "this machine-made age" it may be some consolation that it is, at least, foreshadowed by nature.

GEOPHYSICS.—*Radioactive pollution and civil defense.*[1] FRANÇOIS N. FRENKIEL, Applied Physics Laboratory, The Johns Hopkins University.

(Received May 31, 1956)

The present development of nuclear sciences points to continuously increasing possibilities of the use of nuclear technology in the civilized world. This new source of power may serve to further advance our civilization or to destroy it. We often describe the possible damages of a nuclear war. We should also keep in mind the dangers of radioactive pollution whether produced by wartime or by peacetime applications of nuclear reactions. Radioactive pollution control measures will be less costly if planned while the development of nuclear power is still in its infancy. As to civil defense plans against nuclear warfare, their effectiveness should be measured not by the number of possible casualties but by the number of people who can be rescued. Since any such plan must be based on the understanding and active support of the population, it is urgent to correct the widespread impression that no effective civil defense plan can exist. Many of the studies and control measures referring to radioactive pollution are similar to those which can be used in conventional atmospheric pollution problems. This similarity is important when one wishes to evaluate the costs of effective methods of protection from dangers of atmospheric contamination. In urban planning, for instance, many of the measures suggested with the desire of reducing atmospheric pollution from combustion and other chemical reactions will also be applicable as civil defense measures. We will therefore refer in what follows not only to radioactive pollution but also to some problems of conventional air pollution.

As far as human protection from air contamination is concerned it is necessary to limit the contacts of the population with the pollutants and restrict the irradiation doses (*1*). The safe limits will be based on "allowable threshold concentrations" for acute short-time exposure effects and on "allowable long-exposure concentrations." Consideration should also be given to the possible dangers of polluting the world atmosphere to such a degree that there may be an appreciable effect on the climate or health of the population.

In fixing the allowable concentrations one must take into account the fact that too stringent limitations will impose great costs and operating difficulties on many indispensable or useful activities of the population. On the other hand, insufficient restrictions may result in harmful effects on the health of the population and damage to property. Therefore, the costs and operational difficulties of these limitations should be measured by their beneficial effects.

At least four general classes of methods to limit contacts between the contamination and the population can be considered:

(a) reducing the amount of atmospheric pollutants,
(b) moving the contaminating sources away from the population,
(c) moving the population away from the contaminating sources,
(d) isolating the population from contact with the contaminants.

In industrial and urban pollution we are mainly concerned with the first two classes, which consist of a control over the sources of pollution. In civil defense studies we are primarily concerned with the last two classes involving the destination of the pollutants and the population behavior in avoiding dangerous contacts with them. In all cases it will be important to evaluate the costs and effects of various methods of pollution control and of civil defense strategies.

To make such an evaluation one can use mathematical models of atmospheric pollution, which include in their description: the pollution sources, the nature of the pollutants, their emission conditions, the chemical reactions and other changes to

[1] This work was supported by the Bureau of Ordnance, Department of the Navy, under Contract NOrd 7386. The paper was presented at the Joint Meeting of the American Geophysical Union and the American Meteorological Society in Washington, D. C., May 4, 1956.

which they are subjected, the pertinent meteorological conditions, the topographical situation of the area, etc. Using appropriate equations one can then determine mean concentration patterns of the pollution as a function of the hour of the day. The relative contributions of each of several pollution sources to the contamination at each point of the area can then be evaluated, as well as the effects of changes in the operation of the pollution sources on the expected pollution patterns.

In the case of radioactive pollutants one will be interested not only in the concentrations of atmospheric pollutants but also in the solid and liquid pollutants which have accumulated on the ground. The radiological hazards will be due to the added effects of the pollutants which come into contact with the population and those which radiate from some distance whether they are in the air or on the ground. One must, of course, take into account the differences between the radioactive decay times of various contaminants when determining the pollution pattern.

As an example of the results which can be obtained with a mathematical model of atmospheric pollution, we have used Los Angeles County for which extensive data on the meteorological conditions and the distribution of pollution sources are available. A large part of the County is located in a basin bordered on two sides by a mountain chain. Temperature inversions frequently act as a relatively impermeable lid under which the pollutants accumulate. Los Angeles County is therefore a good proving ground for atmospheric pollution studies. The pollution sources include: industry, motor-car exhausts, oil and gas heating, and refuse incinerators. The pollutants emitted by those sources include nitrogen dioxide and hydrocarbons which produce ozone as a result of a photochemical reaction (*2*). We have described elsewhere (*3*) how such a mathematical model can be used to determine:

(a) temporary emergency measures to be taken when atmospheric pollution threatens to reach the allowable concentration levels,
(b) efficacity of various plans to reduce the pollution in an urban area,
(c) effects of a new pollution source on the mean concentration patterns,
(d) pollution patterns for a city after future expansions,
(e) efficacity of various solutions in urban planning on predicted pollution levels.

These results were based on average meteorological conditions corresponding to a selected month of the year, and their variations as a function of the hour of the day. On each day of the month the meteorological conditions depart from this average. This departure results in a deviation from the pollution patterns for a particular day, from the results obtained by this analysis. One can, of course, use as a basis for the analysis the meteorological conditions for each particular day and as a result determine much more correctly the concentration patterns. Since the use of mathematical models of atmospheric pollution requires extensive numerical computations, such an analysis will be practical only if high-speed computing techniques are used.

A method of civil defense against radioactive pollution involving the use of high-speed computors was suggested some years ago (*4*). Similar methods show promise of success in problems of peacetime air pollution of urban areas and can be used not only to analyze data on atmospheric pollution and urban planning but also on an operational basis in the control of atmospheric pollution.

In an area to be protected from pollutants we place a net of instruments measuring the directions and the magnitudes of the mean wind velocities, the character of the turbulence and other meteorological information such as, for instance, the characteristics of the temperature inversion. If the expected degree of contamination is determined before dangerous concentrations are reached, then the operational expenses of many methods of pollution abatement as well as the investment in special control equipment could be greatly reduced. Evacuation into the atmosphere is indeed one of the best and most economical methods of disposing of pollutants. If we are able to determine the periods of time when such evacuation can be made without danger, then during those periods the use of the special equipment or special fuel will not be necessary. It is therefore important to determine the unfavorable conditions much more correctly than a human forecaster is able to do, since any action to reduce the emission of pollutants during the unfavorable time will be expensive. The meteorologist would alert the computing center whenever there seems to be a possibility of unfavorable meteorological conditions. The computing center would then take over the problem of continuously following the mean wind velocity pattern, the turbulence characteristics and the temperature inversion in the area. From these data the concentration of pollutants which may be reached over the area will be computed. At some chosen points of the area the concentration in contaminants will be measured and the results relayed to the computing center to improve the precision of the computation. The high-speed computation will determine what the expected concentration distributions will be if the operation of the sources of pollution continues without change. If, at any point in the protected area, the occurrence of a dangerous concentration is predicted, action would have to be taken to reduce the emission of pollutants. It will be possible to determine which individual sources contribute most to the dangerous concentrations, since the computation is done by adding the effects of the various sources. One will then find what the effects of shutting-down or reducing the production of pollutants at some of these individual sources will be on the predicted concentrations. As a result it may be sufficient to take such action at only some of the sources of pollution and limit the expense and inconvenience to a minimum.

The operational use of high-speed computing techniques is of particular interest in the protection from radioactive pollution. In this problem there is a difference between atmospheric pollution originating from a nuclear reactor, an experimental device exploding at a preassigned place and the burst of an enemy nuclear bomb. In the first two cases the location of the pollution sources and the general characteristics of pollutants are known. The problem is then somewhat similar to those considered in the study of conventional air pollution. In problems of civil defense the burst point of an enemy bomb is not well known in advance. An operational application of high-speed computing may therefore be of particular importance, since it makes possible rapid computations of several probable pollution patterns associated with various possible burst points. There is an essential difference between the most effective protection methods to be used after the explosion and those which should be used before the explosion.

After a nuclear explosion the dispersion of a nuclear cloud depends mainly on the meteorological conditions. If the information about the burst point, explosion characteristics and the nature of the radioactive pollutants is available to a computing center, then the probable pollution patterns can be predicted. Consideration may have to be given to evacuation versus use of shelters. The best protection methods may vary at each section of the area surrounding the burst point and may change at various times following the explosion. They will depend on the nature of the shelters and on the possible evacuation procedures and they will be influenced by the damage which the area has already suffered from blast and radiation effects. They will also depend on the indoctrination and susceptibility to panic of the population.

The problem of civil defense under threat of an immediate nuclear attack is quite different. Let us assume that enemy airplanes have been detected at some distance from, say, Washington, D. C. If the airplanes are detected several hours before they can reach Washington, then one cannot be certain that Washington is indeed the target and that the enemy is not planning to attack Baltimore, for instance. Even if the civil defense could suggest to the enemy where and how he should deliver his bomb, there is still a probability that he will not reach his target. Any civil defense measure must take into account the probability of having incorrect information about the enemy's target, the probability of an airplane being destroyed by the military defense, the possibility that such a destruction will result in a nuclear explosion, etc. If for instance the population were evacuated, under the assumption that the enemy will attack Washington, and then Baltimore should become the target, the population may find itself moving into an area contaminated by radioactivity. An operational study would thus involve not only following the motion and the dispersion of nuclear clouds, but also the prediction of probable burst points using the information about the activity of the enemy and the possibility of his interception by military defense.

Peacetime preparation of civil defense plans should take into account this difference between the pre-explosion and the post-explosion cases when comparing evacuation versus shelter protection. These plans should evaluate how proper protection methods of both kinds will affect future civil defense operations during wartime and consider if and how these operations may have to be coordinated with military defense activities. One should also distinguish between the pre-explosion defense plans made when a threat of nuclear attack is imminent and dispersal plans for the population made well before a war starts.

Some of the advance civil defense plans may also have a beneficial effect on industrial pollution control. To make possible a rapid evacuation as well as speedy relief of a city after bombardment, improved highways and city roads may be necessary. Civil defense may also wish to consider the effectiveness of a proper subway system which could serve for both shelter and evacuation. Consideration must also be given to dispersal plans in urban building to reduce the probability of large scale destruction. Each of these solutions will reduce atmospheric pollution as well as simplify traffic. In urban planning it may therefore be desirable to keep in mind the necessities of civil defense together with those of urban traffic and atmospheric pollution abatement. Some city planning ideas may be considered too expensive as merely insurance against nuclear attack effects; they may, however, become quite acceptable if atmospheric pollution and traffic problems should also be taken into account.

Most civil defense considerations refer to simultaneous attacks of several, say, eighty cities. Since such an attack may indeed be possible the civil defense problems are national in scope and any plans for individual cities will have to be interrelated. One may safely claim that civil defense plans made for each single city, however good they may be individually, will not add to the best national plan for a simultaneous defense of eighty cities. Nor can such a general plan be dissected into the most effective plans for single city attacks.

One should be cautious to avoid the tendency to decide for the enemy what his future strategy will be. It may be important to assume several possible actions of the enemy and try to determine those which are most probable. Strategic defense plans should not be based on a single plan for each enemy action but involve several possible methods of defense. The selection of the most appropriate will have to be made at wartime and may be influenced by the overall interest of the country. There may be serious danger that the assumption of a particular enemy strategy and the preparation of a single defense plan will limit the military defense strategy or force it to ignore civil defense requirements and expectations. It is also possible that a single and rigid civil defense plan will limit dangerously the general policies of a nation.

An essential part of any civil defense system will be a complete communication system. No system will operate to its full capacity unless the information needed to make appropriate decisions can be rapidly collected, evaluated, and used and the necessary instructions forwarded to the population. Various methods of collecting data on the point of burst, the nature of the explosion, the motions of the nuclear cloud, the meteorological conditions, the damages, the traffic possibilities, etc., will be required. These methods may include the use of helicopters for direct observation and measurements of radioactivity levels. In some cases the best civil defense strategy may require an initial evacuation followed by protection in shelters. In others it may appear desirable, but not always possible, to change the instructions to the population during the defensive operation according to sudden changes of the meteorological conditions.

If the operational use of high-speed computing techniques is to be applied, one must take the precaution of planning several interconnected computing centers, in order that the destruction of one or more of such centers not discontinue the civil defense operation. It would be incorrect to conclude that each large urban area should be provided with several computing centers. It may be possible to spread such centers over the whole country and plan proper communication facilities to make possible the use of any one of them to analyze the information from the attacked area. The use of these computing centers does not have to be limited to civil defense problems and could be extended to other purposes as well.

If there is no exaggeration in the publicly estimated numbers of casualties per nuclear bombardment, it should be expected that the number of those which could be rescued, with a properly used defense plan, is of a similarly large order of magnitude. An attack on numerous cities would then not only multiply the number of casualties but will also multiply the number of those which can be rescued. Let me repeat once more that as far as the protection of human lives is concerned, the importance of a civil defense plan should not be measured by the number of those which could be killed in a nuclear attack but by the number of those which can be saved.

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Whoever rejects faith in the reality of atoms and electrons, or the electromagnetic nature of light waves, or the identity of heat and motion, cannot be found guilty of a logical or empirical contradiction; but, he will find it difficult from his standpoint to advance physical knowledge.—Planck (1913).

MATHEMATICS.—*Generalization of a theorem of Konig.*[1] A. J. HOFFMAN, National Bureau of Standards.

(Received May 21, 1956)

Let R be a set with elements $p_1, \cdots, p_n$, $S = \{S_1, \cdots, S_m\}$ a family of subsets of R, and α a real number, $0 < \alpha < 1$. Denote the number of elements contained in a set T by $\overline{T}$, and the set of elements common to the sets T and U by $T \cap U$. In this note, we consider the question: does there exist a set $C \subseteq R$ such that

$$(1) \qquad |\overline{C \cap S_i} - \alpha\bar{S}_i| < 1, \qquad i = 1, \cdots, m?$$

Note that if $\alpha\bar{S}_i$ is an integer, then (1) requires $\overline{C \cap S_i} = \alpha\bar{S}_i$. If $\alpha\bar{S}_i$ is not an integer, (1) requires that $\overline{C \cap \bar{S}_i}$ be either of the two integers closest to $\alpha\bar{S}_i$. So our question concerns the existence of set C which has in common with each S_i a set of elements whose number is proportional to the number of elements in S_i, the proportionality factor being α.

Such a set C does not always exist; e.g., let $R = \{1, 2, 3\}$, $S_1 = \{1, 2\}$, $S_2 = \{2, 3\}$, $S_3 = \{3, 1\}$, $\alpha = \frac{1}{2}$. We prove below a simple sufficient condition for the existence of a solution of (1). As an application, we derive a well-known theorem of Konig [3]: Let R be a set with qk elements, and two families of subsets, $T = \{T_1, \cdots, T_q\}$ and $U = \{U_1, \cdots, U_q\}$. Assume further that $R = \mathbf{U}T_i = \mathbf{U}U_i$, $T_i \cap T_j = \phi$ (the empty set) if $i \neq j$, $U_i \cap U_j = \phi$ if $i \neq j$. (The foregoing conditions state that the family T is a "partition" of R, and so is the family U.) Finally, assume $\overline{T}_i = \overline{U}_i = k$, $i = 1, \cdots, q$. Then there exists a set $C \subseteq R$ such that $\bar{C} = q$, $\overline{C \cap T_i} = \overline{C \cap U_i} = 1$, $i = 1, \cdots q$. There are many proofs of Konig's theorem in the literature. A demonstration closely related to Konig's original proof, yet sharing the geometric spirit of the discussion offered below, may be easily deduced from the lemma contained in [2].

[1] This work was supported (in part) by the Office of Naval Research.

Our generalization of Konig's theorem requires consideration of the matrix A representing the incidence of elements of R with sets in S. Let $A = (a_{ij})$ be the incidence matrix defined

$$(2) \qquad \begin{aligned} a_{ij} &= 1 \text{ if } p_j \in S_i \\ &= 0 \text{ if } p_j \notin S_i \end{aligned}$$

for $i = 1, \cdots, m$, $j = 1, \cdots, n$.

We also require the following definition: a (rectangular) matrix is said to have the *unimodular property* if every square submatrix has determinant 0, 1, or -1.

Theorem. If the matrix A has the unimodular property, then, for any α, $0 < \alpha < 1$, there exists a solution to (1).

Proof: For x a real number, let $[x]$ denote the greatest integer not exceeding x. Consider now the set of points satisfying the linear equation and inequalities

$$(3) \qquad \sum_{j=1}^{n} a_{ij} y_j = \alpha\bar{S}_i,$$

for all $i = 1, \cdots, m$

such that $\alpha\bar{S}_i$ is an integer,

$$(4) \qquad [\alpha\bar{S}_i] \leqq \sum_{j=1}^{n} a_{ij} y_j = 1 + [\alpha\bar{S}_i],$$

for all $i = 1, \cdots, m$

such that $\alpha\bar{S}_i$ is not an integer,

$$(5) \qquad 0 \leqq y_j \leqq 1, \qquad j = 1, \cdots, n.$$

This system is consistent, for the point $\tilde{y} = (\alpha, \alpha, \cdots, \alpha)$ clearly satisfies (3), (4) and (5). Hence the set of solutions is a nonempty closed convex set K, which is, by (5), clearly bounded. Therefore, K admits vertices. Since A has the unimodular property, it follows [1] that every vertex has all of its coordinates integers. Let $\bar{y} = (\bar{y}_1, \cdots, \bar{y}_n)$ be any vertex. By (5), $\bar{y}_j = 0$ or 1. Let $C = \{p_j \mid \bar{y}_j = 1\}$. Then (3) and (4) imply (1).

A general theorem describing sufficient conditions for A to have the unimodular property is given in [*1*]. A special case worth mentioning occurs when the family S can be split into two subfamilies each of which has the property: if two subsets in the same family have a non-empty intersection, one is contained in the other. For example, a subfamily could be a partition of R. If each subfamily is a partition, if $\bar{S}_i = k$ $(i = 1, \cdots, m)$, and if we set $\alpha = 1/k$, then (1) becomes König's theorem.

Remark 1. The hypothesis that A have the unimodular property is not necesary for the existence of a solution to (1). Let $R = \{1, 2, 3, 4, 5, 6\}$, $S_1 = \{1, 2, 3\}$, $S_2 = \{3, 4, 5\}$, $S_3 = \{5, 6, 1\}$. Then the submatrix formed by the three rows of A and the first, third and fifth columns of A has determinant 2, so A does not have the unimodular property. On the other hand, for $0 < \alpha < 2/3$, $C = \{2, 4, 6\}$ satisfied (1), and for $2/3 \leq \alpha < 1$, $C = \{1, 3, 5\}$ satisfies (1).

Remark 2. Since we know that any bounded r-dimensional closed convex set admits at least $r + 1$ vertices, we can estimate a lower bound for the number of solutions of (1). Since α is properly between 0 and 1, a point of any sufficiently small sphere containing $\tilde{y}$ satisfies (5). Clearly, such a point also satisfies (4). If (and only if) v is any vector orthogonal to all rows i of (3), then $\tilde{y} + ev$, for e sufficiently small in absolute value, will satisfy (3) as well as (4) and (5). This remark tells us that the dimension of K is $n - d$, where d is the dimension of the space spanned by all rows i such that $\alpha\bar{S}_i$ is an integer. Hence, the number of solutions of (1) is at least $n - d + 1$.

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However certain the facts of any science, however just the ideas derived from these facts, we can only communicate false or imperfect impressions to others, if we want words by which these may be properly expressed.—A. L. LAVOISIER.

ENTOMOLOGY.—*Type specimens of mosquitoes in the United States National Museum: II, The genus* Aedes (*Diptera, Culicidae*).

Alan Stone, Entomology Research Branch, U. S. Department of Agriculture, and Kenneth L. Knight, Bureau of Medicine and Surgery, U. S. Department of the Navy.[1]

(Received May 8, 1956)

The first part of this series dealing with the genera *Armigeres*, *Psorophora*, and *Haemagogus* appeared in this Journal **45:** 282–289. 1955. The introductory remarks in that paper and especially those on early, possibly questionable, holotypes, apply equally well to this one. Following our treatment of nominal taxa requiring special attention we present a list of those in the collection based on unique specimens or for which holotypes were clearly designated.

We are particularly indebted to Dr. J. B. Schmitt and Dr. B. B. Pepper, of the Department of Entomology of Rutgers University, for giving to the U. S. National Museum most of the type material of mosquitoes from the New Jersey Agricultural Experiment Station, consisting of syntypes of five species described by Grossbeck and one species described by Coquillett.

Genus **Aedes** Meigen

Aedes aboriginis Dyar, Ins. Insc. Mens. **5:** 99. 1917.

A male, bearing the data, "Longmire Springs, Mt. Rainier National Park, Washington, 18. VI.17, H. G. Dyar," was selected as lectotype by Knight (1951, p. 96).

Culex aestivalis Dyar, Journ. New York Ent. Soc. **12:** 245. 1904.

This was based upon adult specimens referred to *Culex reptans* Meigen by Dyar (1904, p. 38) and a description of the larva. No type material was mentioned in either publication. The collection contains a male with terminalia mounted on a slide. The pinned specimen bears the labels: "2790 iss III.04 / H. G. Dyar Collector / See slide No. 22 / Aedes aestivalis Dyar ♂ type." The slide bears a red type label with no number and the labels: "22 C. repitans [sic] 279.0 Kaslo B.C. Dyar III.04 / Culex (Culicada) aestivalis Dyar Type ♂ genitalia, Dec. 14, 1904." We select this as lectotype of the species. There are many other specimens from Kaslo, British Columbia, but none of these is marked as type.

Aedes stimulans albertae Dyar, Ins. Insc. Mens. **8:** 115. 1920.

The three syntypes from Edmonton, Alberta, are in the collection, and we select as lectotype the male collected May 17, 1919, which bears Dyar's determination and type label. The terminalia of this specimen are mounted on slide no. 1226.

Gymnometopa albonotata Coquillett, Proc. Ent. Soc. Washington **7:** 183. 1906.

This was originally described from five male and three female syntypes collected by A. Busck in the San Francisco Mountains, Santo Domingo, West Indies, Type no. 8297, U. S. National Museum. We select as lectotype an undissected male bearing the labels: "141.3 / SFrncsco Mts. St. Domingo W.I. Sept. 05 / Aug. Busck Collector / Type No. 8297 USNM" and Coquillett's determination label. The associated pupal skin of this specimen is mounted on a slide.

Aedes aldrichi Dyar and Knab, Proc. U. S. Nat. Mus. **35:** 57. 1908.

The type locality of this species is Market Lake, Idaho, according to the original description and the U.S.N.M. type catalogue, and the description was based upon six females. The collection contains two females from Market Lake and four from Lewiston, Idaho, and it is probable that these are the original six on which the description was based and that Dyar did not notice when writing the data that they were not all from Market Lake. Dyar labeled one of the Lewiston specimens with a type label, but we prefer to select as lectotype one of the two from the published type locality.

[1] Studies upon which this paper is based were conducted under an exchange of funds from the Office of Naval Research (Biological Science Division) to the Smithsonian Institution. The opinions or assertions contained here are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.

Aedes alleni Turner, Ins. Insc. Mens. **12:** 84. 1924.

The two syntype males are in the collection, neither bearing any collection data, but each with an unnumbered red type label. One bears a number, 1885, which associates it with a terminalia slide labeled: "Aedes alleni Turner. Type. Mission, Tex. Jan. 30, 1924. 1885." We select this specimen as lectotype.

Aedes allotecnon Kumm, Komp, and Ruiz, Amer. Journ. Trop. Med. **20:** 417, 1940.

This name was originally proposed in a key to the adults of the *Aedes* of Costa Rica and is validated by the comparative characters given in the key. The formal description by Kumm and Komp (1941, p. 18) described the female as well as the larva and male but only three males with associated larval skins are designated as types. These syntypes are in the collection and we select as lectotype specimen no. 156.

Aedes altiusculus Dyar, Ins. Insc. Mens. **5:** 101. 1917.

This was described from an unstated number of specimens from "Indian Henry's," Mount Rainier National Park, Washington. The collection contains a female and a male each bearing the label "Type No. 21545 U.S.N.M." These are labeled Longmire Springs, Wash., June 24, 1917. Presumably they were collected as larvae on June 13 at "Indian Henry's" and they emerged June 24. We select the male as the lectotype. There are two other females, dated June 25, that are presumably of the original series.

Stegomyia amesii Ludlow, Journ. New York Ent. Soc. **11:** 139. 1903.

This species was described from Samar, Leyte, and Luzon in the Philippines. Only one of the original syntypes is in the collection, and this is the only one entered in the type catalogue. It is rather certain that the other syntypes are lost. This is a female bearing the type label and the label "Stegomyia amesii Ludl., Oras, Samar, P.I., June–Dec. Type C.S.L." Knight and Hull (1952, p. 158) call this a holotype, but since no holotype was mentioned originally we here designate it as lectotype.

Aedes angustivittatus Dyar and Knab, Journ. New York Ent. Soc. **15:** 9. 1907.

This was described from 25 specimens from three localities in Costa Rica and Bluefields, Nicaragua. There are 50 specimens in the collection bearing original data but only one, a female, bears the type label. Other labels on this specimen are: "Port Limon, C.R. / Fredk Knab Collector / Aedes angustivittatus Dyar and Knab Type." This we consider to be the holotype.

Culex annulifera Ludlow, Journ. New York Ent. Soc. **11:** 141. 1903.

The lectotype female selected by Knight and Hull (1951, p. 226) is in the collection.

Finlaya aranetana Banks, Philippine Journ. Sci. **1:** 1001. 1906.

The lectotype male selected by Knight and Marks (1952, p. 543) is in the collection.

Aedes argentescens Dyar and Knab, Proc. U. S. Nat. Mus. **35:** 55. 1908.

This species was described from six syntypes from Córdoba and Almoloya, Mexico. A male and a female, both from Córdoba, bear Museum type labels. It is impossible to determine which four of the remaining specimens bearing original data were intended to be syntypes. The male also bears the label "Aedes argentescens Dyar and Knab Type" and the rearing number 441.4. This specimen we select as lectotype. Unfortunately, there were 18 specimens originally under number 441.4, not all in the collection now, and it is impossible to determine which larval and pupal skins belong to this specimen.

Aedes argyrothorax Bonne-Wepster and Bonne, Ins. Insc. Mens. **7:** 179. 1920.

It was the intention of the authors of this species to deposit the type specimen in the Colonial Institute, Amsterdam, Holland, and an additional specimen, called a cotype, was deposited in the U. S. National Museum. No holotype was designated, nor has a lectotype since been selected. Knight and Marks (1952, p. 546) stated that the single "cotype" male in the U. S. National Museum was the holotype, but this is not the case. Dr. Bonne-Wepster informs us that the original specimens of all the new species described in the paper in which *argyrothorax* was described are in Amsterdam.

Aedes atlanticus Dyar and Knab, Journ. New York Ent. Soc. **14:** 198. 1906.

This is based upon a figure of the larva in the original publication and upon descriptions by

Smith and by Felt of what they took to be *Culex serratus* Theobald from the Atlantic coast of the United States. While several of the specimens in the collection may have been before Dyar and Knab, Smith, or Felt when they described this species, there is no certainty of this, and so we do not feel justified in selecting a lectotype from these specimens.

Culex atropalpus Coquillett, Can. Ent. **34:** 292. 1902.

This was described from 37 female and 3 male syntypes from Virginia, Maryland, Pennsylvania, and New Hampshire. The males and 31 of the females are now in the collection, none of them marked as type. We select as lectotype a female bearing the labels "Plummer's I., Md. 16.7.02 / H. S. Barber Collector."

Howardina aureostriata Grabham, Can. Ent. **38:** 171. 1906.

The original description of this species does not state the number of specimens but does state that they were collected at Newcastle, Jamaica, and that some came from bromeliads. In the collection there are seven specimens, each bearing the label "M Grabham Collector." Three have penciled "aureostriata" labels, one is dated April 1906, and one is labeled "Mavis Bank, in bromelias." It is quite possible that some or all of these are syntypes, but it would be difficult to prove. They should be considered if a neotype were desirable, but since the name is a homonym there is little need for type designation.

Culex aurifer Coquillett, Can. Ent. **35:** 255. 1903.

The three original female syntypes are in the collection, each bearing the label "Type No. 12022 U.S.N.M." We select as lectotype one of the two collected June 25, bearing Coquillett's determination label.

Aedes balteatus Dyar and Knab, Journ. New York Ent. Soc. **15:** 9. 1907.

Of the six original females, five now stand in the collection and one of these bears a type label. This we consider to be the holotype. It bears the labels "St. Domingo W.I. Aug. / Aug. Busck Collector / Type No. 10142 U.S.N.M. / Culex balteatus Coq. [sic]." The number 10152 in the original publication is a misprint.

Aedes (Ochlerotatus) bicristatus Thurman and Winkler, Proc. Ent. Soc. Washington **52:** 239. 1950.

According to the original description, "Type specimens have been deposited in the U. S. National Museum. Paratypes have been deposited. . . ." There are two specimens in the collection bearing determination labels with a red penciled border. These are presumably the "types." Of these two, a male and a female, we select as lectotype the male bearing the label "Lakeport, Lake Co. 10 March 1950. reared 39.5 ♂ Eric C. Winkler." The pupal skin and terminalia of this specimen are on two slides.

Culex borealis Ludlow, Can. Ent. **43:** 178. 1911.

This was described from an unstated number of specimens collected in Alaska in June, July, and August. There are five females of the syntype series in the collection, apparently all collected at Fort Gibbon, Alaska, in July. Each bears the label "Type No. 27809 U.S.N.M.," and they appear to be conspecific. We select as lectotype one labeled in Ludlow's handwriting "Culex borealis Ludl. Fort Gibbon Alaska July, C.S.L. Types." This specimen appears to have been correctly determined as a synonym of *communis* De Geer.

Culex bracteatus Coquillett, Proc. Ent. Soc. Washington **7:** 184. 1906.

The four original females are in the collection, only one bearing a type label. This, which also bears Coquillett's determination label, we consider to be the holotype.

Stegomyia busckii Coquillett, Can. Ent. **38:** 60. 1906.

The syntypes, two males and one female, are in the collection, each labeled "Type No. 9139 U.S.N.M." We select as lectotype the undissected male bearing Coquillett's determination label of, "Gymnometopa busckii Coq." It was collected in a cocoa plantation on Dominica, July 28, 1905, by August Busck.

Aedes cacothius Dyar, Ins. Insc. Mens. **11:** 44. 1923.

The six female syntypes are in the collection, all bearing the identical data as published. We designate one of these as lectotype.

Aedes callithotrys Dyar, Ins. Insc. Mens. **8:** 16. 1920.

Of the 816 specimens determined by Dyar as this species, he selected and labeled a male and a female as types. We select as lectotype the male, bearing the labels "1159 / White Horse, Y.T. VII.17.1919 / H. G. Dyar / Type No. 22616 U.S.N.M. / Aedes callithotrys Dyar ♂ Type." The terminalia are on slide no. 1159.

Aedes campestris Dyar and Knab, Journ. New York Ent. Soc. **15:** 213. 1907.

This was described from a number of syntypes from various localities in Saskatchewan and Utah. Fourteen of these are in the collection, one male and one female having been labeled as type. We select as lectotype the female which is indicated as type and bears the labels "19.VI.07 / Oxbow, Sask. / Fredk Knab Collector."

Aedes (*Ochlerotatus*) *camposanus* Dyar, Ins. Insc. Mens. **6:** 128. 1918.

This species was described from a male and a female from Guayaquil, Ecuador, designated as types, and 52 other specimens also from Guayaquil. We select as lectotype the male of the two "types."

Aedes centrotus Howard, Dyar, and Knab, Mosquitoes of North and Central America and the West Indies **4:** 747. 1917.

A female labeled "White River, Ont. 25.VI.07 / Fredk Knab Collector" was selected as lectotype by Knight (1951, p. 98).

Aedes (*Stegomyia*) *christianus* Dyar, Ins. Insc. Mens. **9:** 148. 1921.

The syntype series of this consisted of five males and three females in the U. S. National Museum and the private collections of C. W. Howard and C. S. Banks. The collection contains the two male and one female syntypes said to be deposited in the U. S. National Museum. We select as lectotype the male bearing the labels "Honam 3-4-20 / 1429 / Canton China / C. W. Howard / Type No. 24142 U.S.N.M. / Aedes christianus Dyar Type." The terminalia are on slide no. 1429.

Aedes stimulans classicus Dyar, Ins. Insc. Mens. **8:** 113. 1920.

The two male and one female syntypes are in the collection. Since this subspecies was based largely on characters of the male terminalia, we select as lectotype the whole male mounted on a slide.

Aedes condolescens Dyar and Knab, Journ. New York Ent. Soc. **15:** 11. 1907.

This was described from 24 specimens from five localities in the Bahamas. Nineteen of these are in the collection and one only bears a type label. This female is labeled "Nassau 6-24'03 Bahama Is. / T. H. Coffin Coll. #10 / Type No. 10248 U.S.N.M. / Aedes condolescens D & K. Type." We consider this to be the holotype.

Aedes cuneatus Dyar and Knab, Proc. U. S. Nat. Mus. **35:** 54. 1908.

Two specimens of the original 35 are labeled with U.S.N.M. type labels, a female and a male. The female also bears the label "Aedes cuneatus D. & K. Type" and the rearing number 422.19. We select this specimen as lectotype. It was collected at Córdoba, Veracruz, Mexico, January 20, 1908, pupated January 28, and emerged January 31. There are two larval skins and a pupal skin associated with this type specimen. The other syntypes are not labeled as such and cannot be distinguished from similarly unlabeled syntypes of *Aedes argentescens* Dyar and Knab.

Culex curriei Coquillett, Can. Ent. **33:** 259. 1901.

This was described from five females from North Dakota, Colorado, Idaho, and California. Of these, only two from Boise, Idaho, have been found, one of them bearing the label "Type No. 5798 U.S.N.M." and Coquillett's determination label. This we consider to be the holotype since it is the only specimen bearing the type number, it bears Coquillett's determination label, and Boise is the only locality that Coquillett entered in the Museum type catalogue. We do not feel that Dyar and Knab (1906, p. 202) were justified in selecting a North Dakota specimen as lectotype or that this selection is acceptable.

Aedes cyclocerculus Dyar, Ins. Insc. Mens. **8:** 23. 1920.

The lectotype male selected by Knight (1951, p. 93) is in the collection.

Aedes cyprius Ludlow, Ins. Insc. Mens. **7:** 160. 1920.

This was described from 22 females collected in Siberia. There are 9 specimens bearing type labels and 11 others that are probably of the original series. The locality of any one of the specimens labeled as type cannot be determined since only three of them bear any locality labels, and each one of these is marked both Selenga and Verkhne Udinsk with the dates July and August. We have selected one of the better specimens as the lectotype.

Grabhamia de Niedmannii Ludlow, Can. Ent. **36:** 234. 1904.

Although this was apparently described from several specimens, only one is in the collection. This bears a red type label (no number) and a label in Ludlow's handwriting reading "Grabhamia de niedemanni n. sp. Ludlow, Benicia Barracks, Cal. Type." We select this, a female, as lectotype. Four specimens in the British Museum sent to Theobald by Ludlow as this species are actually *Culiseta inornata* (Williston) rather than *Aedes squamiger* (Coquillett) of which *G. deniedmannii* is a synonym.

Aedes diantaeus Howard, Dyar, and Knab, Mosquitoes of North and Central America and the West Indies **4:** 768. 1917.

This was described from two males collected in May and June at Dublin, N. H., by August Busck. The June specimen, with terminalia on slide no. 484, we here select as lectotype.

Culex dupreei Coquillett, Can. Ent. **36:** 10. 1904.

This was based on a specimen of each sex collected by J. W. Dupree at Baton Rouge, La. These are in the collection, each bearing the label "Type No. 7340 U.S.N.M." The female, which bears Coquillett's determination label, is lost except for the abdomen and one wing. We select as lectotype the male, which is in good condition, with its terminalia mounted on a slide.

Aedes epactius Dyar and Knab, Proc. U. S. Nat. Mus. **35:** 53. 1908.

This was described from 10 syntypes in the collection from Mexico. One male and one female bear the red labels, "Type No. 11963 U.S.N.M." We select as lectotype the female, which also bears the labels "416.25 / Aedes epactius D. & K. Type." This was reared from a pupa collected at Córdoba, Veracruz, February 18, 1908, by Knab. The pupal skin of this specimen has not been found.

Aedes epinolus Dyar and Knab, Ins. Insc. Mens. **2:** 61. 1914.

This was described from 25 females from two localities in Peru. There are 24 of these in the collection, one labeled "type," the others "paratype." We select as lectotype the one labeled "type" from Ventanilla, Peru, February 4, 1914.

Aedes (Ochlerotatus) eucephalaeus Dyar, Ins. Insc. Mens. **6:** 127. 1918.

The original syntype series of this consisted of three males and two females collected by Bonne-Wepster in Paramaribo, Surinam, and labeled A, B, C. D, and L. These each bear the label "Type No. 21911 U.S.N.M." Adult A, larval and pupal skins B, and terminalia slide 971 from specimen D, are also labeled type by Dyar. We select as lectotype male specimen D with terminalia and associated larval and pupal skins on two slides.

Aedes euedes Howard, Dyar, and Knab, Mosquitoes of North and Central America and the West Indies **4:** 714. 1917.

The syntypes of this are a male and female from Ottawa and a male and female from Trenton, Ontario, Canada. We select as lectotype the male from Trenton, May 24, 1900, with terminalia mounted on slide no. 446.

Aedes euplocamus Dyar and Knab, Journ. New York Ent. Soc. **14:** 199. 1906.

This was described from larvae collected at Zent, near Port Limón, Costa Rica. No topotypic material determined as this species has been found in the collection. While it might be possible to identify certain larval and pupal skins in the collection from the type locality as being the species described by Dyar and Knab, no reared adults have been found associated with these skins, and it would not be possible to be certain what specimens were originally studied. For this reason we feel it best to consider that no syntype material is available for lectotype designation.

Aedes fisheri Dyar, Ins. Insc. Mens. **5:** 19. 1917.

Five of the six original female syntypes from Lake Tahoe, Calif., June 20, 1920, are in the collection and we select as lectotype the one bearing Dyar's determination label.

Culex fletcheri Coquillett, Proc. U. S. Nat. Mus. **25:** 84. 1902.

The two syntype females are in the collection, and we have selected as lectotype the specimen bearing Coquillett's determination label.

Stegomyia gardnerii Ludlow, Can. Ent. **37:** 99. 1905.

The lectotype male selected by Knight and Hull (1952, p. 172) is in the collection.

Aedes gonimus Dyar and Knab, Ins. Insc. Mens. **5:** 165. 1918.

The four syntype females are in the collection all bearing type labels. We select as lectotype the one with Dyar's determination label.

Aedes grahami Ludlow, Ins. Insc. Mens. **7:** 154. 1920.

This was described from a male and a female from Siberia. We select as lectotype the male collected at Mostovoi in July.

Grabhamia grisea Ludlow, Can. Ent. **39:** 130. 1907.

It is not clear from the original description of this how many specimens were involved, but possibly there was only one. There is one female in the collection bearing an unnumbered U.S.N.M. type label and a label in Ludlow's handwriting as follows: "Grabhamia grisea n. sp. Ludlow type Boise Bks, Ida. July." We consider this to be the holotype.

Aedes grossbecki Dyar and Knab, Journ. New York Ent. Soc. **14:** 201. 1906.

This was described in a key to larvae from specimens determined by Coquillett as *Culex squamiger* Coquillett, and by reference to a description by Smith and Grossbeck (1905, p. 13) of *Culex squamiger*. There is apparently no type material of this species.

Aedes habanicus Dyar and Knab, Journ. New York Ent. Soc. **14:** 198. 1906.

This was described from larvae collected at Havana, Cuba, October 28, 1903, by John R. Taylor. The only material in the collection bearing these data is a slide with the fragments of a larval skin along with fragments of two larval skins of the genus *Psorophora*, one of which contains a *Culex* larval skin. We select as lectotype these *Aedes* fragments, consisting of a siphon, anal segment, and abdomen.

Aedes hemisurus Dyar and Knab, Journ. New York Ent. Soc. **14:** 190, 199. 1905.

The authors of this name called it a new species in the center heading and a new name at the end of the brief statement concerning it. There is no description except for the characters given in the key and reference to Grabham's figure (1905, p. 405) of the larva of *Culex confirmatus* from Jamaica. Although there are adults in the collection determined as *hemisurus* these are not associated with larval skins, and there are no larvae from Jamaica in the collection; and so it is probable that there are no specimens that can be said to be of the type series.

Aedes cinereus hemiteleus Dyar, Ins. Insc. Mens. **12:** 179. 1924.

The five syntypes were said to be all females, but one of them is a male. The specimen in best condition is a female from Lake Center Camp, Plumas County, Calif., the type locality, June 1, and we select this as the lectotype.

Aedes triseriatus var. *hendersoni* Cockerell, Journ. Econ. Ent. **11:** 199. 1918.

This was described from two females, one of which is in the collection and bears the labels "Box Elder Cr. Wyo. Aug. 25, '17. Schwabe and Henderson / Janthinosoma n. sp. / Psorophora hendersoni Ckll TYPE / Aedes triseriatus Say." The first three labels are in Cockerell's handwriting and the fourth was written by Dyar. This is the specimen which Knight and Marks (1952, p. 572) called a holotype. We here select it as lectotype.

Aedes (*Finlaya*) *heteropus* Dyar, Ins. Insc. Mens. **9:** 152. 1921.

The original 20 specimens, all labeled "Type No. 24865 U.S.N.M." are in the collection. We select as lectotype a male dated July 1, with terminalia on slide no. 1542.

Aedes hexodontus Dyar, Ins. Insc. Mens. **4:** 83. 1916.

The female lectotype from Fallen Leaf, Lake Tahoe, Calif., selected by Knight (1951, p. 93) is in the collection.

Aedes terrens homoeopus Dyar, Ins. Insc. Mens. **10:** 92. 1922.

This was described from three males from Costa Rica and Mexico, all of which bear type labels. We select as lectotype the specimen collected at Alajuela, Costa Rica, October 1921.

Aedes hortator Dyar and Knab, Journ. New York Ent. Soc. **15:** 12. 1907.

We consider as holotype of this species the female of the two original specimens bearing the type label.

Howardina inaequalis Grabham, Can. Ent. **39:** 25. 1907.

This was described from an unstated number of adult specimens, presumably of both sexes, and larvae. There are eight specimens in the collection labeled "Kingston, Jam. M. Grabham Collector." It is not certain that all these can be considered as syntypes of *inaequalis*, but it is quite probable that most of them are. There are two males labeled *inaequalis*, one of the labels being on the pinned specimen itself, the other on the slide of the terminalia. We select as lectotype the specimen with the determination label on the pin.

Culex inconspicuus Grossbeck, Ent. News **15:** 333. 1904.

This was described from three males and one female reared from larvae collected on Garret Mountains, Paterson, N. J. The collection contains all these, one of each sex being labeled as type and the second male as cotype. We select as lectotype the male type collected October 5, with the terminalia still on the specimen.

Aedes increpitus Dyar, Ins. Insc. Mens. **4:** 87. 1916.

This was described from an unstated number of specimens of a species that was very common in the Yosemite Valley. There are a great many specimens from the Yosemite Valley under this name in the collection, but only one specimen, a male, bears the type number. One female is also marked type but was not given a red type label. We select as lectotype the male, bearing the following labels: "FB25 / Fallen Leaf, Lake Tahoe, Cal. June 3, 1916 / Type No. 20350 U.S.N.M. / H. G. Dyar Coll. / Aedes increpitus Dyar Type ♂."

Aedes indolescens Dyar and Knab, Journ. New York Ent. Soc. **15:** 11. 1907.

This was described from 30 specimens from Cayamas and Havana, Cuba, and Santo Domingo, West Indies. One female bears the type label and this we consider the holotype. The other labels on this specimen are: "Cayamas, Cuba 8.5 / E. A. Schwartz collector / in woods / Aedes indolescens D. & K. Type."

Aedes infirmatus Dyar and Knab, Journ. New York Ent. Soc. **14:** 190, 197. 1906.

This was described in a larval key from specimens collected by Dupree at Baton Rouge, La. There are no reared adult specimens bearing original data and only three slides of larval skins of Dupree material. One slide contains two skins and is labeled as from New Orleans, one contains one larval skin with no locality label, and one from Baton Rouge contains two larval skins and fragments of pupal skins. This last slide was apparently prepared from alcoholic material subsequent to description of the species. These are topotypic and might be syntypic, but we prefer to select no lectotype from this poor and uncertain material.

Aedes innuitus Dyar and Knab, Ins. Insc. Mens. **5:** 166. 1918.

The two male and two female syntypes are in the collection, and we select as lectotype the male bearing Dyar's determination label, with the terminalia mounted on slide no. 708.

Aedes intrudens Dyar, Ins. Insc. Mens. **7:** 23. 1919.

Dyar stated that he selected as types specimens from Karner, N. Y., in the New York State Collection and specimens from Ontario and Alberta [U. S. National Museum]. We select as lectotype the specimens bearing the labels "White River, Ont. 25.VI.07 / Fredk Knab collector / See slide No. 467 / Type No. 21823 U.S.N.M." The terminalia are on slide no. 467.

Aedes ioliota Dyar and Knab, Ins. Insc. Mens. **1:** 77. 1913.

The four original females of this species, from Trinidad, West Indies (F. W. Urich collector), are in the collection, one labeled as type with a determination label, the other three labeled as paratypes. The one labeled as type we consider to be the holotype.

Aedes (*Taeniorhynchus*) *jacobinae* Serafim and Davis, Ann. Ent. Soc. Amer. **26:** 14. 1933.

The original description of this species states that the male holotype and female allotype are to be deposited in the U. S. National Museum. The only specimens in the collection are a slide of the male terminalia bearing the labels "J. H. Sch. of Hyg. Protozoology Aedes jacobinae Davis Jacobina, Bahia, Brazil, Dec. 1931. J. Serafim / genitalia ♂ holotype," and a female, bearing the labels: "Jacobina, Bahia, Brazil Jan. 1932 / N. C. Davis Coll. / Slide *a* 29.III.49." This slide has not been found. The pin also holds the cleared female terminalia in glycerine. It is probable that only the terminalia of the holotype are in existence.

Culex knabi Coquillett, Proc. Ent. Soc. Washington **7:** 183. 1906.

This was described from seven syntype females. Six of these are in the collection but none bears a type label. We select as lectotype the specimen bearing the labels "No. 291*a* / See F. Knab's Entom. notes / Tehuantepec, Oax., Mex. / Culex knabi Coq." The pupal skin of this specimen is mounted on a slide.

Culex labeculosus Coquillett, Ent. News **16:** 116. 1905.

The eight syntypes are in the collection and we select as lectotype a male bearing the labels "Type No. 8314 U.S.N.M. / Slide 707 / Culex labeculosus Coq. / Ent. News xvi.116, 1905 6 ♀ 2 ♂ 8314." The terminalia are on slide no. 707.

Verrallina laternaria Coquillett, Proc. Ent. Soc. Washington **7:** 184. 1906.

Four of the five original males of this have been found. Only one of these bears a type label and this one, which is also labeled "Verrallina laternata" [sic], we consider to be the holotype.

Culex lativittatus Coquillett, Ent. News **17:** 109. 1906.

This was described from a large series of both sexes from Santa Clara and Alameda Counties, Calif. There are 37 specimens in the collection that are probably of the original series. No one of these bears a type label. We select as lectotype a female bearing the labels "Arden 19 July 03 / L. S. Jr. U. Lot 45 Sub. 1 / Ochlerotatus lativittatus Coq."

Aedes leuconotips Dyar, Ins. Insc. Mens. **8:** 24. 1920.

The male selected as lectotype by Knight (1951, p. 93) is in the collection.

Taeniorhynchus lineatopennis Ludlow, Can. Ent. **37:** 133. 1905.

Knight and Hull (1953, p. 468) selected as lectotype one of three females, each bearing the label "Type No. 27794 U.S.N.M." Only one of these specimens bears any other label, and this label reads "Taeniorhynchus lineatopennis Ludl. Camp Gregg, Angeles, Pampanga, P.I. Sept. Type C.S.L.," in Ludlow's handwriting. This is the specimen that was selected as lectotype. The label is obviously erroneous, since it was Camp Stotsenburg at Angeles. To accept this lectotype designation we must assume that Ludlow wrote the wrong locality for the camp rather than the wrong camp for the locality. There seems no way of proving that this specimen is not one of the two original syntypes so we feel that the lectotype designation can stand.

Aedes lithocoetor Dyar and Knab, Journ. New York Ent. Soc. **15:** 201. 1907.

The five syntypes of this species are in the collection, a male and a female being labeled as types. We select as lectotype the female, bearing the following labels "101.5 / Rio Chagres, Panama / Collected by August Busck / Type No. 10868 U.S.N.M. / Aedes lithocoetor D. & K. Type." No larval or pupal skin has been found for 101.5.

Aedes (*A.*) *margarsen* Dyar and Shannon, Ins. Insc. Mens. **13:** 80. 1925.

The male selected by Laffoon (1946, p. 237) as lectotype is in the collection.

Grabhamia mediolineata Ludlow, Can. Ent. **39:** 129. 1907.

This was apparently described from several female specimens. There are two in the collection that are apparently syntypes. One bears the labels "Type No. 10282 U.S.N.M. / mediolineata Ludlow." The second is labeled "Type No. —— U.S.N.M. / Grabhamia mediolineata n. sp.

Ludlow, Fort Lincoln, N. D." We select the second of these as lectotype since it has the locality label on it and it is somewhat the better specimen.

Stegomyia mediovittata Coquillett, Can. Ent. **38:** 60. 1906.

This was described from 34 specimens collected by August Busck in Santo Domingo, West Indies. The collection contains one male bearing the type label and many more than 33 specimens bearing original data. It is not possible to pick the original syntypes from these, but we accept the specimen marked as type as the holotype. This bears the labels "99.4 / St. Domingo W. I. Aug. / Aug. Busck Collector / Type No. 9138 U.S.N.M. / Gymnometopa mediovittata Coq." The larval and pupal skins are mounted on a slide.

Aedes melanimon Dyar, Ins. Insc. Mens. **12:** 126. 1924.

This was described from 15 females and 2 males, and all of them are in the collection. Five are labeled as types, including the 2 males, and the rest as paratypes. We select as lectotype one of the 2 males with terminalia mounted on slide no. 1955.

Aedes mercurator Dyar, Ins. Insc. Mens. **8:** 13. 1920.

This was described from 65 specimens collected at Dawson, Yukon Territory, July 1919. There are 84 specimens in the collection bearing the original data. One male and one female bear the type label and Dyar's determination label. We select as lectotype the male, with terminalia on slide no. 1165, collected July 15, 1919.

Aedes meridionalis Dyar and Knab, Journ. New York Ent. Soc. **14:** 195. 1906.

This was described in the larval stage from a specimen collected at Las Loras, near Puntarenas, Costa Rica, which had been determined by Coquillett as *Janthinosoma musica* Say. There are 22 topotypic adult specimens and several larval skins collected by Knab. One male bears the labels "No. 333*b* See F. Knab's Entom. notes / Las Loras nr. Puntarenas, C. R. / Aedes meridionalis D. & K. Type." Since the species was described from the larva, we select the larval skin associated with this adult as the lectotype. The pupal skin and the adult are part of the same individual, but left undescribed in the original publication. No specimen from the type locality bears any determination label by Coquillett.

Catatassomyia meronephada Dyar and Shannon, Ins. Insc. Mens. **13:** 71. 1925.

This was described from 16 females from Los Banos, Laguna, Luzón, Philippine Islands. Fifteen of these syntypes are in the collection and one in the British Museum. We select as lectotype a specimen collected May 12, 1921, bearing the additional label "Mt. Makiling 1500-2000 Ft."

Aedes metalepticus Dyar, Ins. Insc. Mens. **8:** 51. 1920.

There are seven specimens in the collection labeled "Type No. 22714, U.S.N.M." and apparently five specimens were returned to Italy. It is probable that Dyar intended the one male to be the type, although it is not clear from the original description. We select as lectotype this male, from Scais, July 19, 1901, bearing Dyar's label "Aedes metalepticus Dyar Type ♂," with the terminalia on slide no. 1236, also labeled "type."

Aedes metoecopus Dyar, Ins. Insc. Mens. **13:** 30. 1925.

The original description mentions no types, Dyar merely stating that both sexes were before him, and we know only that the specimens came from Ecuador. There are nine specimens from Ecuador in the collection, but only one of each sex bears a Museum type label (without number). We select as lectotype a male bearing the labels "2107 / 86 / Ecuador F. Campos R. / Aedes (Finlaya) metoecopus Dyar Type." The terminalia are on slide no. 2107.

Aedes (Skusea) miachaetessa Dyar and Shannon, Ins. Insc. Mens. **13:** 78. 1925.

The lectotype female selected by Knight and Hull (1953, p. 478) is in the collection.

Aedes stimulans mississippii Dyar, Ins. Insc. Mens. **8:** 113. 1920.

The two syntypes, male and female, are in the collection, and we select as lectotype the male, which bears Dyar's determination and type label in addition to the Museum type label. The terminalia are mounted on slide no. 1263.

Culex mitchellae Dyar, Journ. New York Ent. Soc. **13:** 74. 1905.

This was described from 61 specimens, one from Jacksonville, Fla., being selected as type [holotype]. Only one of the specimens bears the type label, and it also bears the labels " |3|7 & 8 / Miami, Fla. / H. G. Dyar Collector / Culex mitchellae Dyar Type 8402." The published type number is 8407, and the slide of larval and pupal skins bears the label "Culex mitchellae Dyar Type 8407 Culex sylvestris Theobald |3|7 & 8." The slide also contains a larval and pupal skin of *Aedes vexans* (Meigen). On going to the type catalogue we found that the number 8407 is assigned to *Mimagyrta pulchella* and that *Culex mitchellae* is listed under number 8402, with Jacksonville, Fla., as the locality. We conclude that 8402 is the correct type number, which was changed to 8407 in labeling the slide and in publication by error, and that the type locality is Jacksonville, since Miami is not even listed in the original publication as one of the localities for the species.

Aedes (*Heteronycha*) *muelleri* Dyar, Ins. Insc. Mens. **8:** 81. 1920.

The original description of this species states, "Types, No. 22826, U. S. Nat. Mus; male and female, Mexico City, Mexico (Juan Müller)." These two syntypes are in the collection with the male labeled as type, the female as paratype. We select as lectotype the male, with terminalia mounted on slide no. 1253.

Aedes mutatus Dyar, Ins. Insc. Mens. **7:** 24. 1919.

Dyar labeled one of the numerous males from Missoula as type and this we consider to be the holotype. It bears the labels "Missoula, Mont. July 6, 1917 / H. G. Dyar Coll. / Type No. 21918 U.S.N.M. / Slide 663 / Aedes mutatus Dyar Type." The slide is of the terminalia.

Stegomyia nigritia Ludlow, Can. Ent. **42:** 194. 1910.

This was described from two females collected at Cottabato, Mindanao, Philippine Islands, in December. There is a single female in the collection bearing the label "Stegomyia nigritia n. sp. Type P. I. Nov." Since no other specimen has been found that could be considered as the type, we select this specimen as lectotype in spite of the difference in date of collection.

Grabhamia nigromaculis Ludlow, George Washington Univ. Bull. **5** (4): 83. 1906.

This was described from an unstated number of specimens collected at Fort Keogh, Mont., and Fort Lincoln, N. D. The collection contains five syntypes labeled "Type No. 10147 U.S.N.M." Four were collected at Fort Keogh, September 1906, and the fifth at Fort Makenzie, Wyo., a place not mentioned in the original description. We select as lectotype the female from Fort Keogh bearing a determination label.

Aedes niphadopsis Dyar and Knab, Ins. Insc. Mens. **5:** 166. 1918.

The three syntype females are in the collection, and we select as lectotype the one bearing Dyar's determination label.

Aedes (*Finlaya*) *niveus nipponicus* LaCasse and Yamaguti, Mosquito Fauna of Japan and Korea, pt. **2:** 79. 1948.

The original description of this species designates no types but states that it was collected in a number of places on Kyushu and Honshu, Japan. A male and female in the collection are labeled as types, but since these were collected on August 29, 1949, more than a year after the species was published, they cannot be considered as types. The earliest adult labeled *nipponicus* was collected in May 1948, still too late for the March 1 publication. There is a single larval slide collected in September 1947, but it is not labeled *nipponicus* and may not have been seen by LaCasse or Yamaguti. It is probable that there is no true type material in existence.

Culex nivitarsis Coquillett, Proc. Ent. Soc. Washington **6:** 168. 1904.

This was said to have been described from a female and a male collected at Paterson, N. J., May 12, by J. B. Smith, and the specimens returned to the collector. The New Jersey collection contained these two specimens, each marked as type, but the female is dated May 17. Both were from Garret Mountain. These are now deposited in the U. S. National Museum collection, and we select the female as lectotype, since the male lacks the abdomen and all but one leg.

Aedes obturbator Dyar and Knab, Journ. New York Ent. Soc. **15:** 9. 1907.

This was described from 22 specimens from Tarpon Bay, Bahama Islands, only 12 of which are now under the name in the collection. Only one of these bears a type label, and this female we consider to be the holotype.

Danielsia pagei Ludlow, Psyche **18:** 128. 1911.

The lectotype female selected by Knight and Hull (1953, p. 463) is in the collection.

Aedes pagetonotum Dyar and Knab, Smithsonian Misc. Coll. **52:** 253. 1909.

A note in the collection reads, "Note re Aedes pagetonotum D. & K. Jan 28, 1925. Located 8 types. The 2 gone may have been sent to Dr. Hewitt by me not then known to be types. H. G. Dyar." The eight types are in the collection, seven of them bearing type labels. We select as lectotype the first specimen listed in the description, a male bearing the labels "15.5.00 / Ottawa / Through J. Fletcher / See slide No. 343 / Type No. 12057 U.S.N.M." The male terminalia are on slide no. 343.

Culex pallidohirta Grossbeck, Can. Ent. **37:** 359. 1905.

There are two syntype females of this in the collection, one labeled as cotype that has been in the collection for a considerable time, the other labeled female type and recently presented to the collection by Rutgers University. We select as lectotype this latter specimen, bearing the label "Orange Mts., N. J. V. 26."

Aedes palustris Dyar, Ins. Insc. Mens. **4:** 89. 1916.

This was described from an unstated number of syntypes in the collection. Several bearing the original data have been found and one male and one female bear type labels. We have selected as lectotype the male, bearing the labels "FKπ / Fallen Leaf, Lake Tahoe, Cal. June 6, 1916 / Type No. 20351 U.S.N.M. / H. G. Dyar Coll / Aedes palustris Dyar Type ♂."

Aedes palustris var. *pricei* Dyar, Ins. Insc. Mens. **5:** 16, 1917.

The number of original specimens of this variety was not stated, but inasmuch as there is only one in the collection bearing the type label "Type No. 21043 U.S.N.M." we consider this as the holotype. It is a female, also bearing the labels "Fallen Leaf, Lake Tahoe, Cal. June 9, 1916 / H. G. Dyar Coll / Aedes palustris var pricei Dyar. Type."

Reedomyia pampangensis Ludlow, Can. Ent. **37:** 94. 1905.

This was described from three specimens taken in September at Angeles, Pampanga, Luzón, Philippine Islands. No specimen bearing these data has been found in the collection, but there is one female bearing the labels "Type No. 27795 U.S.N.M. / Reedomyia pampangensis Ludl. Camp Wm. McKinley, Rizal, P.I. Oct. 25, Nov. 3, 05 Type." The last label is in Ludlow's handwriting. Knight and Hull (1953, p. 454) have accepted this as the holotype, but since it was collected after the publication of the name it does not seem possible to consider this as of the type series, and it is probable that there are no syntypes in existence.

Aedes panayensis Ludlow, Psyche **21:** 159. 1914.

The male lectotype selected by Laffoon (1946, p. 242) is in the collection.

Aedes (*Culicelsa*) *perichares* Dyar, Ins. Insc. Mens. **9:** 36. 1921.

This was described from nine males and five females from Ciruelas, Costa Rica. These syntypes are all in the collection, each bearing the label "Type No. 23972 U.S.N.M." We have selected as lectotype a female bearing the label "Aedes perichares Dyar Type."

Aedes pertinax Grabham, Can. Ent. **38:** 316. 1906.

This was described from an unstated number of specimens from Jamaica. There are three males and two females in the collection bearing the labels "Rec'd from Dr. Grabham 10 July 1906 / Kingston, Jam. IV.10.06 temp. pools." It is quite certain that these are syntypes, and we select as lectotype a male bearing Dyar's label "pertinax" and with the terminalia mounted on slide no. 206.

Aedes pionips Dyar, Ins. Insc. Mens. **7:** 19. 1919.

Dyar labeled a male and a female as types of this species, selected from 152 specimens. We select as lectotype the male bearing the labels "994 / B9 / White River, Ont. June 19, 1918 / H. G. Dyar coll. / Type No. 21922 U.S.N.M. / Aedes pionips Dyar Type." The terminalia are on slide no. 994.

Aedes pix Martini, Mosquitoes of Mexico: 55. 1935.

Two females were sent to the British Museum in 1950, and these were marked as cotypes by Mattingly (1955, p. 29). One of these was sent to the U. S. National Museum and was labeled as lectotype by John Lane. Through the kind offices of Mr. Mattingly, Dr. Weyer permitted this specimen to be deposited in the U. S. National Museum. Lane and Cerqueira, in Lane (1953, p. 652), state that the lectotype is in the British Museum, apparently forgetting that it had been deposited in Washington. The second specimen was in very poor condition and is probably lost.

Aedes plutocraticus Dyar and Knab. Journ. New York Ent. Soc. **15:** 11. 1907.

Fifty-eight of the original 63 specimens of this species are in the collection and a female bears the type label. We consider this to be the holotype. Its data are: "Nassau, Bahamas 6-21-03 T. H. Coffin Coll. #10."

Aedes podographicus Dyar and Knab. Proc. Biol. Soc. Washington **19:** 165. 1906.

Two specimens in the collection, a male and a female, bear type labels. We select as lectotype the female, bearing the labels "No. 325j. See F. Knab's Entom. Notes / Sonsonate, Salv. / Type No. 10015 U.S.N.M. / Aedes podographicus D. and K. Type." Number 325j applies to several specimens, no larval skins of which were saved.

Culex portoricensis Ludlow, Can. Ent. **37:** 386. 1905.

Syntypes of this stand under two Museum catalogue numbers in the collection, 10007 and 27804, the specimens apparently having been received and entered at two different times. We have selected as lectotype a male bearing the original data and the type no. 10007.

Culex pretans Grossbeck, Ent. News **15:** 332. 1904.

This was described from 15 females collected in four localities in New Jersey. There are 11 of these specimens in the collection, one labeled type and the others labeled cotype. The one labeled type was collected at Great Piece Meadow, N. J., May 12, and we select this as lectotype.

Aedes prolixus Dyar, Ins. Insc. Mens. **10:** 2. 1922.

"The three syntype males of this are in the collection and we select as lectotype the one from Anchorage, Alaska, with terminalia mounted on slide no. 1579.

Culex pullatus Coquillett, Proc. Ent. Soc. Washington **6:** 168. 1904.

The one female and ten males reared from larvae are all labeled "Type No. 8030 U.S.N.M." The female bears Coquillett's determination label, but we select as lectotype a male with terminalia mounted on slide no. 21. It is from Kaslo, British Columbia, and emerged June 12.

Aedes punctodes Dyar, Ins. Insc. Mens. **10:** 1. 1922.

The male lectotype selected by Knight (1951, p. 97) is in the collection, with the terminalia mounted on slide no. 1582.

Culex quadrivittatus Coquillett, Can. Ent. **34:** 293. 1902.

Seven of the original eight females are in the collection, and one of these bearing the type label and Coquillett's determination label we consider to be the holotype.

Aedes quaylei Dyar and Knab, Journ. New York Ent. Soc. **14:** 191. 1906.

This name was proposed for the salt-marsh form of *Culex curriei* Coquillett from the Pacific coast as treated by Quayle (1906, p. 4), and the only characters given are to be found in the key to the larvae. No specimens are labeled as types in the collection, and most of the specimens that might have been those seen by Dyar and Knab when they described *quaylei* are probably also the syntypes of *Culex lativittatus*. We do not feel that any specimens in the collection can be certainly identified as syntypes of *quaylei*.

Aedes (*Ecculex*) *rhecter* Dyar, Ins. Insc. Mens. **9:** 51. 1921.

This was described from one male and five female syntypes from Lomagundi and Lorenzo Marquez, Portuguese East Africa. The male bears the labels "Howard Coll. / Lomagundi Nov. '09 / Slide 709 / Type No. 23928 U.S.N.M. / Aedes rhecter Dyar Type," and we designate this as the lectotype. The terminalia are mounted on slide no. 709.

Aedes riparius Dyar and Knab, Journ. New York Ent. Soc. **15:** 213. 1907.

Only two of the original 68 specimens, a male and a female, are labeled as types. We select as lectotype the female, in excellent condition, collected June 21, 1907.

Stegomyia scutellaris var. *samarensis* Ludlow, Journ. New York Ent. Soc. **11:** 138. 1903.

This was described with no statement as to the number of specimens, time of collection, or locality other than Samar. The collection contains four females and two males, each bearing the label "Type No. 27790, U.S.N.M.," and one of these bears the additional label "Stegomyia samarensis Ludlow, Catabig, Samar, P.I., Type C.S.L." This is a female in fairly good condition, and we here designate it as lectotype.

Aedes sansoni Dyar and Knab, Can. Ent. **41:** 102. 1909.

This was described from five syntypes collected at Banff, Alberta. Dyar (1917, p. 114) selected specimen no. 10 as the type [lectotype].

Aedes septemstriatus Dyar and Knab, Journ. New York Ent. Soc. **15:** 10. 1907.

Two of the original three specimens are in the collection, and we consider the holotype to be a female bearing the following labels: "8 / Bluefields Nicar. / W. F. Thornton Collector / Type No. 10144 U.S.N.M. / Haemagogus septemstriatus D. & K. Type."

Taeniorhynchus sierrensis Ludlow, Can. Ent. **37:** 231. 1905.

There are 12 syntypes of this species in the collection, and we have selected as lectotype a female bearing the determination label in Ludlow's handwriting.

Culex siphonalis Grossbeck, Can. Ent. **36:** 332. 1904.

This was described from two females and five males reared from larvae collected at Livingston Park, N. J. All these specimens are in the collection, labeled "N Brunswick" with dates of V.9, V.10, and V.11. One female and one male are labeled as types and the rest as cotypes. We select as lectotype the female "type" collected May 10.

Culex squamiger Coquillett, Proc. U. S. Nat. Mus. **25:** 85. 1902.

The four female syntypes are in the collection, and we select as lectotype the one from Palo Alto (labeled "Stan U Cal.") and bearing Coquillett's determination label.

Culex sylvicola Grossbeck, Can. Ent. **38:** 129. 1906.

The original series on which this name was based consisted of 21 males and 20 females in the New Jersey Agricultural Experiment Station collection. A male and one female, each labeled type, and 24 "cotypes" are still in existence, and all but 13 of the "cotypes" are in the U. S. National Museum collection. We select as lectotype the female "type" labeled "Livingston Park, N. J. V.6."

Aedes tahoensis Dyar, Ins. Insc. Mens. **4:** 82. 1916.

This was described from an unstated number of specimens reared at Fallen Leaf, Lake Tahoe, Calif., the latter part of May and first of June 1916. The collection contains one undissected male labeled "FE14 / Fallen Leaf, Lake Tahoe, Cal., June 5, 1916 / Type No. 20352 U.S.N.M. / H. G. Dyar Coll. / Aedes Tahoensis Dyar Type ♂." There are a great many other specimens of the type series, but we select as lectotype the male mentioned above.

Aedes thibaulti Dyar and Knab, Proc. Ent. Soc. Washington **11:** 174. 1910.

This was described from a pair from Scott, Ark., both bearing a type label. The male bears the determination label, and the terminalia are on slide no. 524. The female is lost from the point except for one femur. We select the male as lectotype.

Aedes thorntoni Dyar and Knab, Journ. New York Ent. Soc. **15:** 10. 1907.

The seven original specimens are in the collection, and the female bearing the type number and Dyar's determination and type label we consider to be the holotype.

Aedes tormentor Dyar and Knab, Journ. New York Ent. Soc. **14:** 191. 1906.

This species was described in a key to the larvae from specimens collected in Baton Rouge, La., by Dupree. A female in the collection bears the labels "Baton Rouge, La. / J. H. Dupree #106 / Culex serratus Coq. / Aedes tormentor D. & K. "serratus" [Dyar's handwriting]. There are also the fragments of a larval skin on a slide, but the slide is not numbered and may not belong to this specimen. Since there is no determinable larval material from the original series, we feel that no lectotype can be selected.

Aedes traversus Dyar, Ins. Insc. Mens. **13:** 215. 1925.

The three original syntype females, all bearing identical original data, are in the collection. We have labeled the best of these as lectotype.

Culex trichurus Dyar, Journ. New York Ent. Soc. **12:** 170. 1904.

The original description of this is of the egg and four larval instars. A female collected in British Columbia flying over a pool containing larvae of this species produced eggs, which hibernated over winter and produced larvae the following spring. The only adult material was said to be the badly rubbed original female and a broken male reared in Massachusetts by Dimmock from a similar larva. Neither of these specimens has been found in the collection. There is one slide of fragments of three larval skins, two of them, at least, not last stage, that are probably of the original series, but these are so poor that there seems no point in selecting a lectotype from them.

Culex trivittatus Coquillett, Journ. New York Ent. Soc. **10:** 193. 1902.

This was described from two females collected at Chester, N. J. Only one of these appears to be in the collection, and this bears the type label and Coquillett's determination label. This we consider to be the holotype. There is one other specimen from Chester, but this has no type label and bears the label "Aldrich Collection," which throws some doubt on its being the other original specimen.

Aedes uncatus Grabham, Can. Ent. **39:** 25. 1907.

This was described from an unstated number of adults, presumably of both sexes, and larvae, from Jamaica. There are two females and five males in the collection labeled "Kingston Jam. / M. Grabham Collector." We select as lectotype a male which also bears the labels "See slide No. 210" and "uncatus," the latter in pencil, probably by Dyar. The terminalia are mounted on slide no. 210.

Aedes vinnipegensis Dyar, Ins. Insc. Mens. **7:** 34. 1919.

Thirty-six of the original 37 females are in the collection, but only one bears the type number. This, which we consider to be the holotype, bears the original data and Dyar's handwritten label "Aedes vinnipegensis Dyar Type."

Aedes whitmorei Dunn, Proc. Ent. Soc. Washington **20:** 128. 1918.

The 12 syntype females of this are in the collection, all in rather poor condition. We select as lectotype one bearing the label "Aedes whitmorei Dunn. Cotype."

The following taxa are in the collection based either on unique specimens or on clearly designated holotypes:

Aedes acrophilus Dyar, 1917
Aedes (A.) adustus Laffoon, 1946
Anisocheleomyia albitarsis Ludlow, 1905
Aedes aloponotum Dyar, 1917
Aedes (Finlaya) ananae Knight and Laffoon, 1946
Aedes (Stegomyia) arboricolus Knight and Rozeboom, 1946
Aedes (Howardina) argyrites Dyar and Nuñez Tovar, 1927
Aedes (Geoskusea) baisasi Knight and Hull, 1951
Aedes (Stegomyia) bambusicolus Knight and Rozeboom, 1946
Aedes (A.) bifoliatus King and Hoogstraal, 1947
Culex bimaculatus Coquillett, 1902
Aedes (Stegomyia) boharti Knight and Rozeboom, 1946
Aedes (Christophersiomyia) brayi Knight 1947
Aedes (A.) campylostylus Laffoon, 1946
Culex cantator Coquillett, 1903
Aedes cataphylla Dyar, 1916
Aedes (Finlaya) leucocelaenus clarki Galindo, Carpenter, and Trapido, 1953
Aedes colonarius Dyar, 1924
Aedes (Finlaya) croceus Knight and Laffoon, 1946
Aedes (Geoskusea) daggyi Stone and Bohart, 1944
Aedes (Skusea) dasyorrhus King and Hoogstraal, 1946
Aedes decticus Howard, Dyar, and Knab, 1917
Aedes (Finlaya) dobodurus King and Hoogstraal, 1946
Aedes (Finlaya) dorseyi Knight, 1946

Aedes (Stegomyia) downsi Bohart and Ingram, 1946
Aedes (A.) dux Dyar and Shannon, 1925
Aedes dysanor Dyar, 1921
Aedes (Ochlerotatus) edgari Stone and Rosen, 1952
Aedes (Finlaya) eucleptes Dyar, 1921
Aedes euochros Howard, Dyar, and Knab, 1917
Aedes (Mucidus) ferinus Knight, 1947
Aedes (A.) foliformis King and Hoogstraal, 1947
Aedes (Stegomyia) guamensis Farner and Bohart, 1944
Aedes (Stegomyia) gurneyi Stone and Bohart, 1944
Aedes (Stegomyia) hakanssoni Knight and Hurlbut, 1949
Aedes (A.) hamistylus Laffoon, 1946
Aedes (Finlaya) harperi Knight, 1948
Aedes (Ochlerotatus) hastatus Dyar, 1922
Aedes (Stegomyia) hensilli Farner, 1945
Aedes (Finlaya) hollandius King and Hoogstraal, 1946
Aedes (Stegomyia) hoogstraali Knight and Rozeboom, 1946
Verrallina insolita Coquillett, 1906
Aedes iridipennis Dyar, 1922
Aedes (A.) johnsoni Laffoon, 1946
Aedes (Finlaya) keefei King and Hoogstraal, 1946
Aedes klotsi Matheson, 1933
Aedes (Finlaya) knighti Stone and Bohart, 1944
Aedes labradorensis Dyar and Shannon, 1925
Aedes (Finlaya) lacteus Knight, 1946
Aedes (Stegomyia) laffooni Knight and Rozeboom, 1946
Aedes (Skusea) lamelliferus Bohart and Ingram, 1946
Aedes (Finlaya) laoagensis Knight, 1946
Aedes (A.) leilae King and Hoogstraal, 1947
Aedes (Finlaya) lewelleni Starkey and Webb, 1946
Aedes (Finlaya) leucopleurus Rozeboom, 1946
Aedes leucotaeniatus Komp, 1938
Aedes (Pseudoskusea) lunulatus King and Hoogstraal, 1946
Aedes (Finlaya) luzonensis Rozeboom, 1946
Aedes (A.) macrodixoa Dyar and Shannon, 1925
Aedes (Stegomyia) marshallensis Stone and Bohart, 1944
Aedes masamae Dyar, 1920
Aedes (Ochlerotatus) mathesoni Middlekauff, 1944
Aedes (Finlaya) medleri Knight and Laffoon, 1946
Aedes milleri Dyar, 1922
Aedes (A.) milnensis King and Hoogstraal, 1947
Aedes mimesis Dyar, 1917
Aedes (A.) multifolium King and Hoogstraal, 1947
Aedes (A.) neomacrodixoa King and Hoogstraal, 1947
Finlaya nigra Ludlow, 1905
Pseudoskusea nigrotarsis Ludlow, 1908
Aedes (Aedimorphus) oakleyi Stone, 1939
Aedes (Finlaya) okinawanus Bohart, 1946
Aedes oligopistus Dyar, 1918
Popea palawanensis Ludlow, 1914
Aedes (Ochlerotatus) fulvus pallens Ross, 1943
Taeniorhynchus palliatus Coquillett, 1906
Aedes (Stegomyia) pandani Stone, 1939
Aedes (Finlaya) paradissimilis Rozeboom, 1946
Aedes (A.) parasimilis King and Hoogstraal, 1947
Aedes (Stegomyia) paullusi Stone and Farner, 1947
Aedes pearyi Dyar and Shannon, 1925
Aedes (Stegomyia) pernotatus Farner and Bohart, 1944
Aedes platylepidus Knight and Hull, 1951
Aedes (Finlaya) plumiferus King and Hoogstraal, 1946
Aedes poliochros Dyar, 1919
Aedes polyagrus Dyar, 1918
Aedes prodotes Dyar, 1917
Aedes (Ochlerotatus) pseudodiantaeus Smith, 1952
Stegomyia punctifemore Ludlow, 1921
Aedes (A.) quadrispinatus King and Hoogstraal, 1947
Stegomyia quasinigritia Ludlow, 1911
Aedes (Stegomyia) quasiscutellaris Farner and Bohart, 1944
Aedes (A.) reesi King and Hoogstraal, 1947
Aedes (Stegomyia) riversi Bohart and Ingram, 1946
Aedes (Stegomyia) rotanus Bohart and Ingram, 1946
Aedes (Stegomyia) saipanensis Stone, 1945
Aedes (Finlaya) saperoi Knight, 1946
Aedes schizopinax Dyar, 1929
Aedes (Finlaya) scutellalbum Boshell-Manrique, 1939
Aedes (Stegomyia) scutoscriptus Bohart and Ingram, 1946
Aedes (A.) sentanius King and Hoogstraal, 1947
Aedes (Aedimorphus) senyavinensis Knight and Hurlbut, 1949
Aedes (Finlaya) sherki Knight, 1948
Aedes (A.) simplus King and Hoogstraal, 1947
Aedes (Finlaya) solomonis Stone and Bohart, 1944
Aedes (Finlaya) stonei Knight and Laffoon, 1946
Aedes (Finlaya) subalbitarsis King and Hoogstraal, 1946
Aedes (Levua) suvae Stone and Bohart, 1944
Aedes thaxteri Dyar and Knab, 1919
Aedes (Taeniorhynchus ?) thelcter Dyar, 1918
Aedes (A.) trispinatus King and Hoogstraal, 1947
Aedes (Finlaya) tsiliensis King and Hoogstraal, 1946
Aedes (Leptosomatomyia) variepictus King and Hoogstraal, 1946
Culex varipalpus Coquillett, 1902
Aedes ventrovittis Dyar, 1916
Aedes tortilis virginensis Dyar, 1922
Aedes zoösophus Dyar and Knab, 1918

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1409th meeting, april 8, 1955

J. R. Heller, of the National Institutes of Health, addressed the Society on *Some observations on cancer research and control.* Cancer control, from the standpoint of the Public Health Service is an entity that is susceptible to the same type of attack that has proved so successful in many other chronic diseases. The factors useful in this control may be summarized as follows:

1. Education, for both lay and professional people through all media.
2. Diagnosis, through the skillful application of all known methods.
3. Epidemiology: i.e., the study of its incidence, which shows very curious variation. For example, breast cancer is very low in Japanese women, stomach cancer very high in Japanese men, cervical cancer very low in Jewish women and two times higher in Negroes than in whites. Lung cancer six times higher in men than women, and particularly high in Austria, Scandinavia, and England.
4. Prevention, particularly through the removal of known carcinogens from the environment; e.g., beryllium, tar, sunlight.
5. Treatment: Surgery, radiation, and we hope ultimately chemical agents. (No one has been cured chemically yet, though some cancers respond favorably.)
6. Research in causes of cancers; and note the plural (there are probably as many kinds of cancer as there are other diseases, so we will have *cures*). Specific areas for research are: into carcinogenesis, into the nature and metabolism of cancers themselves, and into the "Host-parasite relationship." Illustrative of the latter is the fact that "an irascible old curmugeon hangs on a long time, while the gentle sweet person goes fast."

A series of colorful slides showing the changing and increasingly important cancer problem in the last forty years was shown. Cancer now ranks second in causes of death, and certain types, such as lung cancer, have shown phenomenal increases. This type has doubled in the past ten years and is 26 fold up over 40 years ago.

Dr. Heller also described in details the project in Shelby County, Tenn., where an attempt is being made to examine all women 20 years of age and older by a technique that is equivalent to a biopsy of the cervix. In the past two years, 165,000—about 85 percent of the population—have been done, a thousand were found to be suspicious, and half of these to have an unsuspected malignancy. The distribution of types of cancer with age showed that the intra-epithelial type in the 20-year-olds could be expected to change to the invasive type after an average time of 19 years. There seems therefore to be a type of cervical cancer that can stay safe for long enough for the woman to bear children. The method gives promise of completely eliminating cervical cancer as a cause of death, though it requires continual screening and control.

A short description of the facilities of the National Institutes of Health and their operation was given.

A discussion by McNish, Potter, Tuckerman, Henderson, and others followed. The problem of how to deal with cancer quackery produced the greatest interest. (*Secretary's abstract.*)

1410TH MEETING, APRIL 22, 1955

GEORG WEINBLUM, of The Institut für Schiffbau, Hamburg, spoke on *Problems in ship theory.* The art of the shipbuilder is a very old one, but is nevertheless replete with unsolved problems in nearly every phase, because not only are the conditions which a ship has to meet immensely variable, but also because the construction, the materials, and the methods of propulsion have all changed enormously in relatively recent times.

The discussion was deliberately simplified by considering a ship to be a rigid body; thus avoiding all problems of strength and elasticity. The properties that define a ship are:

1. Buoyancy—i.e. water support—three types may be noted:
   (a) archimedean or displacement
   (b) hydroplane using hydrodynamic forces
   (c) hydrofoil
2. Stability
3. Powering
   (a) Resistance
   (b) Propulsion
4. Seaworthiness:
   (a) Safety and seakindliness
5. Maneuverability
6. Freedom from vibration
7. We omit strength—a study in itself

Of these properties only powering was treated in detail. Powering, the relation between resistance and propulsion, is most complex. A slide (originally due to von Karman) plotting speed attained against specific power—that is horse power per ton of the vehicle in question—was presented showing practically all of man's vehicles: the pedestrian, the horse, submarine, ship, airplane, tank, truck, auto, hydroplane and hydroglider. The power required seems to go up never less fast than the cube of the speed, but may in some cases be much worse, and all vehicles tend to lie in a band of slope 3.

A series of technical slides showing the variations in "wave resistance" with hull form was shown: Wave resistance per ton of displacement plotted against Froude number (v^2/lg). It was pointed out that esthetics are a delusive guide: an "ugly" form sometimes proving to have a remarkably low wave resistance.

The frictional resistance problem has not been seriously attacked as yet. Desperate measures suggested are: Removing the boundary layer, or substituting air for it. Success would save two thirds of the power. River craft of small burden have in fact been constructed to float on air bubbles.

The only worth-while improvement in propulsion since the invention of the screw propeller has been the addition of the nozzle. Cavitation still sets limits to any propeller's effectiveness.

Maneuverability and seaworthiness are also complex problems. The latter may be divided into "safety" and "seakindliness," but a quantitative theoretical approach is all but impossible. (*Secretary's abstract.*)

1411TH MEETING, MAY 6, 1955

CONYERS HERRING, of the Bell Telephone Laboratories, spoke *On the surface energy of crystals and its relation to sintering.* Sintering is the process by which small particles of metal, or other substance, can be forced, at relatively modest pressures and at temperatures below the melting point, to coalesce into a mass indistinguishable from the bulk material. This process lowers the free energy by decreasing the total surface area. Quantitatively, the free energy, "gamma," of Ni, Cu, etc., is about 1,000 ergs per cm², and complete sintering of 10 micron particles reduces gamma by about 1 calorie per mol: quite a small amount as reaction energies go, but sufficient.

The processes by which the material moves in sintering are:

(1) Plastic flow, which is the principal process with glassy materials, and is motivated by surface tension.

(2) Evaporation and condensation, motivated by the difference in surface tensions of convex and concave surfaces, leading through the Gibbs-Thomson relation to a difference in vapor pressures. Smaller particles—more convex surfaces—evaporate faster, while atoms condense more easily on concave surfaces.

(3) Volume diffusion, the migration of atoms or interstitial vacancies, motivated as before by the curvature and pressure.

(4) Surface diffusion, migration in the surface itself.

A plane surface of maximum density of atoms is a surface of minimum gamma. If now we cut a new plane not quite parallel to this plane we will increase gamma by an amount which is proportional to the angle at which we cut. A polar plot of gamma against angle—the "gamma plot"—shows a cusp at zero angle, if the absolute temperature is zero degrees. As the temperature rises this cusp rounds off and becomes first merely a minimum and then washes out altogether. In principle there should be a cusp, at zero degrees absolute, for all rational Miller indices, not merely for small ones but the high numbered cusps wash out very soon, as the temperature rises. (Mathematically we have here an infinitely dense set of points, with an infinite number of discontinuities in slope!) A polar plot of these cusps leads to the question "What shape gives minimum gamma?" Planes drawn perpendicular to the radius vectors in the polar gamma plot define a solid which will have the shape required. The shapes that result are spherical for liquids; ellipsoidal or lenticular for liquid crystals, or tactoids; solids with cusps at all rational orientations for crystals at zero; a finite number of cusps at other temperatures for crystals; and combinations of smooth surfaces, curves, or angles for other substances. All these should be found in nature, and existence depends upon the number and location of the cusps in the gamma plot.

This is true, of course, only for really small crystals. Large crystals are too easily perturbed.

The same considerations also hold for small empty spaces in sintered crystals. The spaces (like particles) assume shapes determined by the gamma plot.

Turning to the kinetics of crystal growth and of thermal etching, the results can be predicted if we know the equilibrium shape. Any smooth boundary plane will have a lower free energy than a bumpy one, but any tangent plane that is not a minimum gamma surface will etch and become bumpy. Very slight differences in free energy are very important.

Experiments to measure the surface tension of multi-crystalline solids were described. On certain assumptions the rate of creep can be calculated from the self-diffusion constants and agreement is excellent. A striking result is that a single crystal wire showed enormously increased resistance to stretching, as compared to a polycrystalline one. (*Secretary's abstract.*)

1412TH MEETING, MAY 20, 1955

IMMANUEL ESTERMANN, of the Office of Naval Research, spoke on the *Interaction of molecular beams with surfaces.* 1956 will be the centenary of the kinetic theory of gases, first proposed by Clausius and others in 1856. It is a curious fact that the basic assumptions underlying it—elastic spheres, random motion, velocity in hundreds of meters per sec, etc.—were not given experimental proof for a most unusually long time. They were taken on faith for nearly fifty years. Dunoyer's invention of the molecular beam method was recognized by Stern as at last providing a tool to measure the individual velocity, mass, and elasticity separately and directly as well as the number of molecules.

The answer to the question "Does molecular reflection behave specularly, or does it obey the cosine law?" seems to be "Neither." For He atoms impinging on LiF at low angles of incidence, specular reflection is only 25 per cent, or less. The remainder is partly diffracted, and partly reflected according to the cosine law. The DeBroglie theory provided a new approach according to which the anomalous reflections of atoms and molecules might be understood, in terms of space lattices of atoms in the reflecting surfaces. Even a crystal surface is "partially rough" to an atomic beam. The molecular beam method went beyond Davisson and Germer's work and showed that *all* particles, not merely elementary ones, are characterized by a De Broglie wave length. Thus the interaction between surfaces and gases is not describable in general in terms of billiard balls, but in terms of waves and surface periodicities.

What happens to the velocity of the particle on reflection? Under the kinetic theory, it should be unchanged. Actually, the accommodation coefficient may vary all the way from zero to 1: (H on polished Pt: 0.3; CO_2 on Pt Black 0.98); in the latter case the particle takes up the temperature of the surface, in the former it remains unchanged.

We need to decide between two alternatives here: either all the particles are reflected with (say) a 75 percent accommodation coefficient, or some have unity and some zero in the proportion needed to give 75 percent. Helium on LiF turns out to have zero! Estermann and Bennett's work on K atoms at 305°, and on copper at 209°, 343°, and 401°C seems to show a coefficient of unity, and Maxwellian distribution after reflection. Future work on surfaces having intermediate values was promised. (*Secretary's abstract.*)

1413th meeting, june 3, 1955

William Shockley, of the Bell Telephone Laboratories and the WSEG, spoke on *The statistics of individual variation in productivity in research laboratories.* The talk reported the results of an Operations Research study of the productivity of scientists and its correlation with salary in various institutions. As criterion of productivity, the number of times a man's name appeared in Science Abstracts A over the past five years was taken. Nobel Prize winners, National Academy of Science members, and typical faculty members were compared. The Nobel winners published twice as much, and there is a strong correlation between quantity and quality.

By plotting the logarithm of the numbers of papers against the number of men who publish this number or less, the curve obtained is essentially a "normal" one, i.e., linear, except for the one or two very top men who are very productive. This plot is true for the NBS, Brookhaven, the Bell Laboratories (on the basis of patents taken out) and seems to be a general phenomenon.

A proposed law for productivity of the form $P_i = P_s \exp(-U_s\beta)$ would lead to such a plot. In this formula P_i is the individual productivity, P_s is the "situation" productivity, U_s the "mental barrier" to publication, and β is proportional to the reciprocal of the "mental temperature" of the individual, i.e. $1/kT_m$.

Why should the variation in rate be so large, when all are trained more or less alike? Rashevsky's idea was discussed: several ideas must inter-relate in the mind to produce an invention. The number of ideas the mind can hold at one time, therefore, is a very important parameter. "The seventh idea adds seven times the area."

Output versus actual pay was plotted for the NBS data. (Cautions to be observed are: References to faulty work, or to a compilation, are sometimes more frequent than to good ones; high pay people gravitate to administration with increasing age.) The cumulative publication figures for the four salary quartiles, plotted against age show the same linear plot, with an upturned tip. The first, highest, quartile publishes much more than the fourth, though some individuals in the fourth publish much more than some in the first. Many other criteria, of course, enter into the estimate of the value of a man to his organization.

It is of interest that the slope of the salary curve is only one fifth that of the productivity curve; that is 10 percent increase in salary is earned by 50 per cent increase in papers published.

In summary: the moral of the study is that one should always get a few men of high productivity, no matter what may be the cost. (*Secretary's abstract.*)

NOTES AND NEWS

PLASTIC SPRINGS

A practical procedure for mass-producing plastic springs has been developed by the National Bureau of Standards in work sponsored by the Army Ordnance Corps. Springs formed in this way[1] from glass fiber-reinforced resin have desirable mechanical properties for a wide range of applications. Until now plastic springs have been little used because suitable techniques for making springs of the types needed have been lacking.

Polymeric materials, such as plastics and rubbers, have a number of inherent advantages for use in springs for special purposes. For example, they are nonmagnetic and have low electrical and thermal conductivity. They can be molded directly to dimensions without the development of any considerable internal stress. Their high corrosion resistance should make them of value for applications in chemical plants and installations subject to acid fumes or to salt air. Other applications may benefit from the strength-to-weight ratios of plastics, which are often higher than those obtained with spring making metals. Also, the broad range of transparent and colored materials that can be used makes striking decorative effects possible.

The plastic springs are molded by drawing resin-soaked glass fibers through vinyl copolymer tubing and wrapping the loaded tubing in a helix around a mandrel. After curing in an air-circulating oven, the tubing is removed, leaving a solid plastic spring reinforced with glass fibers.

The most successful procedure uses vinyl chloride-vinyl acetate copolymer tubing having a ¼- or 3/16-inch inside diameter and a ⅛-inch wall thickness. Lengths of glass rovings are formed into a loose yarn, without twist, which is then doubled back to make a U-shaped bundle. This bundle is placed in a trough partly filled with liquid resin and is immersed until thoroughly soaked. A steel wire is threaded through the tubing, attached to the bend in the U-shaped bundle, and used to pull the bundle through the tubing. Considerable force is applied to the wire by means of a small windlass.

When the tubing is completely filled, the wire is disconnected and the ends of the tubing sealed with hose clamps. The tubing is wound on a mandrel, and the entire assembly is placed in an oven for curing under the conditions specified by the resin manufacturer. After removal of the tubing, postcuring is performed as required, and the springs are cut and ground to the finished length.

Of the resins studied, the most promising were epoxides and polyesters. These resins are better suited for spring applications on the basis of torsional moduli, temperature sensitivity, and ease of handling. In general, the polyesters are more sensitive to elevated temperatures than the epoxy resins, but the epoxy materials vary widely in this respect.

Springs made from polyester resins with glass fiber reinforcement showed good energy recovery properties after short periods of storage at −40°F., but these properties were adversely affected by 13 days' exposure to 135°F. while under stress. The best results were obtained with an epoxy resin cured with m-phenylenediamine. Springs made of this material had torsional moduli of rigidity of the order of 1.0×10^6 lb/in^2. In 2-inch lengths they deflected ½ inch under a static load of 25 lb. Three-inch springs of this type retained 40 per cent of their original energy when compressed to their solid length and stored at 135°F. for 13 days.

When the glass-epoxy springs were tested for recoverable energy a second time, higher values were invariably obtained. This characteristic "work tempering" of the epoxide resins was also demonstrated in torsion tests on nonreinforced plastic rods. An improvement of as much as 120 percent over the original available energy was indicated. Preloading the epoxide spring during storage or within 30 days before use would make it possible to utilize this property of the material.

The mechanical and thermal properties of the plastic springs can be varied widely by proper choice of materials and dimensions. For example, stiffer and probably more brittle springs result when the glass content is increased. At the same time a high degree of homogeneity in static properties can be achieved. Under a load of 25 pounds, 100 of the epoxy-resin springs had an average deflection of 0.53 inch with a standard deviation of 0.05 inch.

[1] For further details, see *Reinforced plastic springs*, by Frank W. Reinhart and Sanford B. Newman, Product Engineering (in press).

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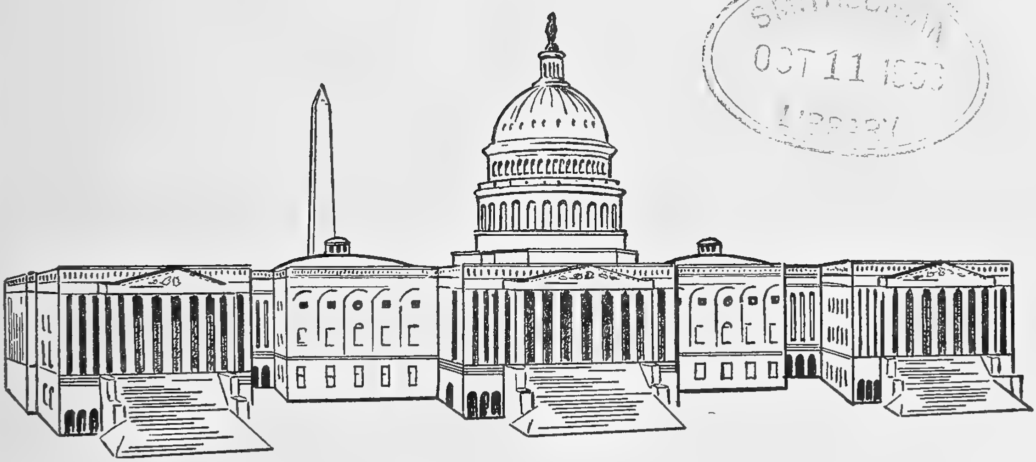

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Editorial

SCIENCE AND WITCHCRAFT

The U. S. Department of Agriculture said in 1898 (Farmers' Bulletin No. 79):

"The fertilizer industry in this country has grown to these proportions within fifty years. It was but natural that a business growing so rapidly and offering such opportunities and temptations for fraud and imposition should have early become a field for extensive operations of unscrupulous and dishonest men. Fraud became so prevalent as the industry developed in one State after another that there was an urgent demand both from the consumers of fertilizers and from honest manufacturers and dealers in fertilizers for laws providing for the inspection of fertilizers with a view to the prevention or the detection and punishment of fraud."

* * * * *

"The man who peddles a worthless 'formula' at an exorbitant price or exploits under a high-sounding name a mixture which has little or no value as a fertilizer is still abroad in the land."

* * * * *

"There are two claims which generally characterize the representations of the companies and agents selling these questionable goods:

(1) The process of manufacture is a secret one, having been 'discovered' by some one who is generally unknown either to science or practice.

(2) The 'fertilizer,' or 'food,' either contains ingredients of which the whole world, outside of a favored few, is ignorant, or else certain ingredients are so wonderfully compounded as to produce marvelous results."

* * * * *

A Federal Trade Commission hearing examiner, in a 1956 decision, said:

"From the record as a whole, it appears that we may here be confronted with a device operating upon a principle unknown to or unrecognized by present-day science. The strongest indications of this possibility lie in the scientific testimony in support of the complaint, wherein the scientists admitted that they did not understand the theory upon which the Evis Water Conditioner purports to operate."

". . . we must not take the risk of interfering with the development of a device which may prove to be the first practical application of a scientific principle heretofore undiscovered."

* * * * *

One of the tests of the Evis Water Conditioner consisted in washing eight identical glasses in warm soapy water. Four were rinsed in "treated" water, four in untreated water, and allowed to dry. Two persons examined the glasses and picked the four dirtiest and the four cleanest. Two of the dirtiest had been rinsed in "treated" water, two were controls; and, of course, there was the same division among the cleanest glasses. The examiner said, "It appears that the tests . . . as to water stains prove nothing, because the negative and positive thereof were exactly equal."

We wonder what would have happened in 1898 if a "fertilizer" manufacturer selling sand and clay (with plant food so cleverly compounded as to defy chemical analysis) had submitted to a plot test and claimed that since half of the treated plots grew better than the control average, it proved his product worked half the time, even if it was not effective on all soils!

* * * * *

In the Scientific Monthly, May 1953, an article on "The Involuntary Destruction of Science in the USSR" states:

". . . when the final authorities who control science are not scientists themselves, sooner or later quacks will flourish and ultimately dominate the field. Even with the very best intentions, those who are not scientists cannot decide scientific questions and cannot, in the last analysis, even choose between scientists and charlatans. It is only when science is free and autonomous, when enlightened scientific opinion is the court of last appeal, that impostors can be exposed as they arise. Otherwise quackery will flourish, for the plausible over-simplifications of quackery have always had a great popular appeal."

BACTERIOLOGY.—*Pertussis and pertussis vaccine control.*[1] MARGARET PITTMAN, National Institutes of Health.

There is a tradition, that after the president of the Washington Academy of Sciences has fulfilled his responsibilities and relinquished the office, he emerges from retirement one month later to address the members. The selection of a subject, that might be of interest to the membership, which represents so many varied fields of science, was not easy. Recently one of the little known activities of the government, that function behind the scenes, was suddenly brought to the attention of the people in connection with the control of poliomyelitis vaccine. Because of the current concern, it was thought that a talk about the control of another product, pertussis vaccine, and the apparent effect of control on the death and case rates of pertussis, commonly known as whooping cough, would be of some interest.

The Federal control of interstate shipment and export and import of biologic products began July 1, 1902, with the enactment of Public Law 244, commonly known as the "Biologic Law." This law was consolidated with other laws relating to the Public Health Service in 1944, in Public Law 410, now known as the "Public Health Service Act." The original law in essence provides that certain biological products may be prepared only by inspected and licensed laboratories and that appropriate regulations must be promulgated to control the safety, purity, and potency of such products.

The need for the control of safety was emphasized in 1900 by the tragic death of a number of children in St. Louis. The children died from tetanus. They had been ill from diphtheria and were treated with antidiphtheria serum. It was shown later that the serum had been collected from a horse in the incubation stage of tetanus and that the serum contained tetanus toxin.

The functions of the biologic control law are carried out by the Division of Biologics Standards, until recently the Laboratory of Biologics Control, of the National Institutes of Health under the administration of the Secretary of the Department of Health, Education, and Welfare through the Surgeon General of the Public Health Service.

This evening, I shall discuss the relative importance of pertussis as a communicable disease of childhood and the possible influence of the establishment of a standard of potency for pertussis vaccine, on the accelerated decrease in death and case rates that has followed.

PERTUSSIS MORTALITY: COMPARISON WITH FIVE COMMUNICABLE DISEASES

Pertussis has ranked among the topmost highly fatal communicable diseases of childhood, yet it has not claimed as much attention as some of the other acute infectious diseases. It has been lightly regarded by the public and even by some physicians (cited by Gordon and Hood, 1951). Perhaps it was because people saw the relatively mild cases in the older children of school age but seldom the baby sick in bed. It was one of the communicable diseases that children were expected to contract sooner or later.

In Fig. 1 is shown the yearly death rates, per 100,000 population, of pertussis from 1900 to 1954 inclusive, in the United States Registration Area, in comparison with the rates for diphtheria and measles. The statistics are based on reports that vary in completeness, not only from one State to another but within a State. Records from cities as a whole have been more nearly complete than those from rural areas. In the early part of the century, a number of States were not included in the Registration Area. All but two were included by 1925. The data, however, serve as a basis for determining the relative positions of the diseases.

There has been a marked decline in the death rates of each of the three diseases. The most rapid occurred with diphtheria; from 1900 to 1925 there was a significant decline while the death rates for pertussis and measles, which were comparable, remained relatively stable. After 1925 there were marked declinations in the death rates of both per-

[1] Address of the Retiring President of the Washington Academy of Sciences, presented before the Academy on February 16, 1956.

tussis and measles but somewhat less for pertussis than measles until 1951 when the death rates of pertussis fell below those of measles. Since 1934 the death rate of pertussis has exceeded that of diphtheria. It should be noted that the most rapid decline in the pertussis death rate began after 1943. In the next ten years the decline was greater than one log, more than had occurred in the 43 years previously.

Pertussis is singular among the communicable diseases in its marked predilection for attack of infants and young children and for a higher death rate in the first year of life. The death rates, per 100,000 population, for the three youngest age groups, from 1940 to 1954, inclusive, are given in Fig. 2. Rates for the 10 to 14 age group were omitted; they did not exceed 0.1 and have been below 0.1 since 1947. During the 15-year period, the death rates for the under 1-year age group ran about one log above those for the 1 to 4 year group and more than two logs above those for the 5 to 9 year group. The steep decline in death rates for all ages since 1943, noted in Fig. 1, is also evident here for each of the age groups, especially for the two youngest age groups. For the under 1 year

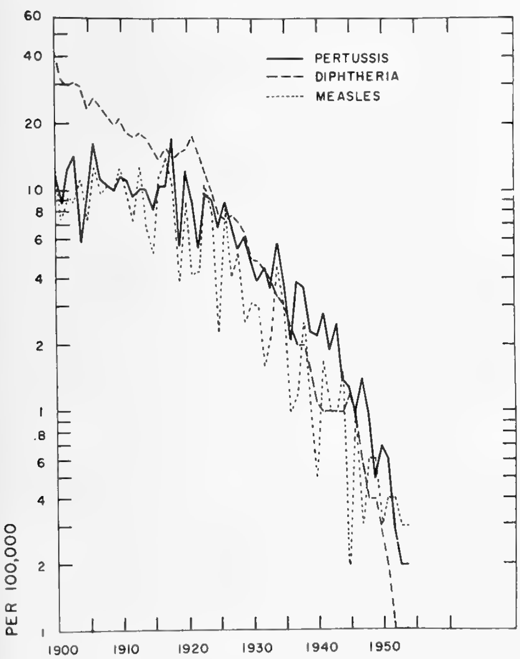

FIG. 1.—Death rate of pertussis, diphtheria, and measles, U. S. Registration Area, 1900 to 1954.

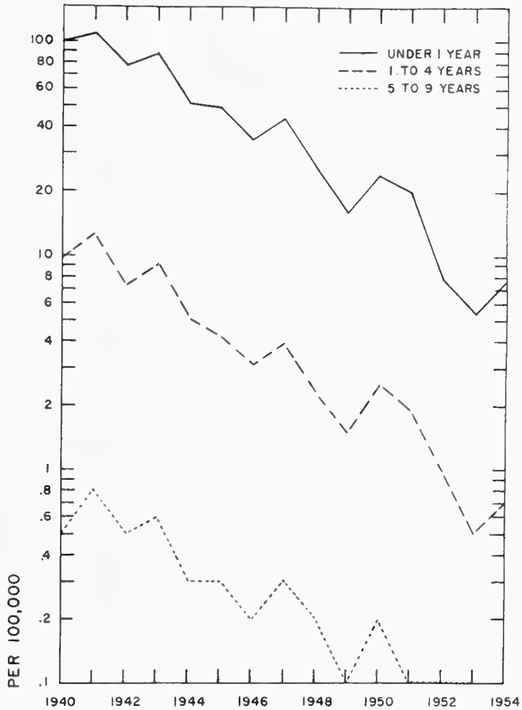

FIG. 2.—Death rate of pertussis by age, U. S. Registration Area, 1940 to 1954.

of age the decline was from around 100 to 7.5 and for 1 to 4 years from around 10 to 0.7.

Since the greatest number of deaths caused by pertussis occur in children under one year of age, the relative importance of pertussis as a communicable disease for this age group can be observed only by comparing the rate with those of the other diseases for the same age group. In Fig. 3 is shown the yearly death rates, per 100,000 population, of six communicable diseases for the under 1-year age group for the years 1940 to 1954, inclusive. The curve for pertussis is the same as the one shown at the top of Fig. 2. During the 15-year period there was a marked decline in the rates for diphtheria and a lesser decline for measles while there were no significant over-all changes in the trends for scarlet fever and streptococcus sore throat, poliomyelitis, and meningococcus infections. Although there was a rapid decline, the pertussis rate remained above those of all of the other five diseases until 1952 when it fell below the meningococcus infection rate.

In table 1, 5-year mean death rates of the six communicable diseases for the under

Table 1.—Five-Year Mean Death Rates per 100,000 Population for Six Communicable Diseases for Under One Year and All Ages, U. S. Registration Area: 1940 to 1954

	1940 to 1944		1945 to 1948		1950 to 1954	
	Under 1 yr.	All ages	Under 1 yr.	All ages	Under 1 yr.	All ages
Pertussis	84.7	2.2	33.8	1.0	12.9	0.4
Measles	16.2	1.1	6.5	0.5	3.9	0.3
Scarlet fever*	1.1	0.3	0.6	0.1	1.0	0.2
Diphtheria	4.4	1.0	2.2	0.7	0.4	0.2
Poliomyelitis	2.0	0.7	2.0	1.1	2.3	1.2
Meningococcus infections	9.0	1.2	8.9	0.8	9.8	0.7
Ratio of death rate of pertussis to the sum of death rates of 5 other infections						
	2.6	0.5	1.7	0.3	0.7	0.15

* Streptococcus septic sore throat is included.

1-year age group are compared with those for all ages. The excessive death rate of pertussis for the young age group in each period is clearly evident. In the first period, 1940 to 1944, the pertussis rate for under 1 year of age was 2.6 times that of the sum of the other five diseases; 10 years later, however, it was only 0.7 of the sum. In the first period the pertussis rate for all ages ranked first: From almost twofold to more than sevenfold greater than that of the other five diseases. Ten years later it ranked third: Below meningococcus infections and poliomyelitis death rates and not more than twofold greater than the rates of any of the diseases. The ratio of the pertussis death rate for all ages to the sum of the rates for the other five diseases declined in the same magnitude as for the under 1-year age group, from 0.5 to 0.15. Declination for both groups was steeper between the periods 1945 to 1949 and 1950 to 1954 than between 1940 to 1944 and 1945 to 1949.

MORBIDITY

In 1943 Dauer summarized the reported case and death rates of the States for 1925 through 1939 and for seven States and two cities for 1910 through 1939. It was shown that there was a rise in the rates of the reported cases after the death rates had started to decline. This was attributed to improved reporting of cases rather than to an actual increase in incidence. The number of cases per death gradually increased from an average of 10 cases per death in 1910 to approximately 100 for the 5-year period 1935 to 1939. For the seven States the highest case rates occurred either in the 5-year periods 1930 to 1934 or 1935 to 1939, while the highest death rates occurred in the periods 1910 to 1914 or 1915 to 1919. The case and death rates for three of the States, to which we have added the rates from 1940 to 1954, are shown graphically in Fig. 4. There was no significant change in the case rates until after the period 1940 to 1944, at which time a marked decline started. At the same time the slope of the curve of the death rates became steeper. In Fig. 1 it was shown that the highest death rate for any single year from 1900 to 1954 in the total Registration Area was in 1920, and that after this date there was a trend downward which was accelerated after 1943.

The data for the total Registration Area given in Table 2 show a similar decline in death and case rates as was demonstrated in Fig. 4. The decline in mortality began after 1920 and was accelerated after the 3-year

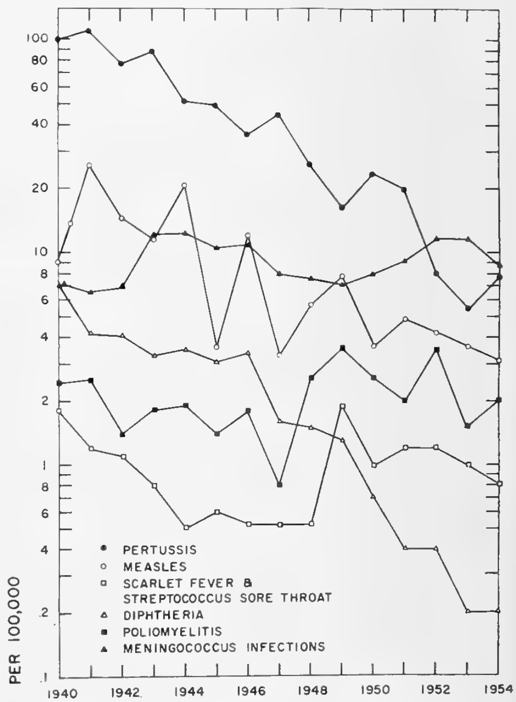

Fig. 3.—Death rates of six communicable diseases for under 1 year of age, U. S. Registration Area, 1940–1954.

period 1943 to 1945. The decline in case rates started after 1940 and was accelerated after the period 1943 to 1945. In the interval between the 3-year periods 1943 to 1945 and 1953 to 1955 the case rate declined from 109.1 to 33.5, a decline of about 70 percent. During the same period the death rates declined from 1.7 to 0.2, a decline of about 90 percent.

Another illustration of the morbidity decline is shown in Fig. 5. The actual number of cases reported, not the rates, for the past 18 years are given. During this period the susceptible population was almost doubled by the increase in births during and since the war. The reported cases of poliomyelitis are included for comparative purposes.

No discussion about pertussis would be complete without mentioning the sequelae, especially in infants, that may follow recovery. The most important one is neurological damage which may be manifested by retardation in learning and in behavior disorders (Levy and Perry, 1948; Schachter, 1953; Annell, 1953). Schachter found that two-thirds of 200 young children following non-complicated pertussis in infancy showed various character disorders. Annell, in a study of the more than seven hundred children, found that emotional instability, delinquency, and other behavior disorders occurred more frequently in those who have had pertussis than in those that had not had the infection.

TABLE 2.—PERTUSSIS DEATH AND CASE RATES PER 100,000 POPULATION, U. S. REGISTRATION AREA

Years	Death		Case	
	Rate	Reduction	Rate	Reduction
		Percent		*Percent*
1908–10	10.8			
1918–20	11.7	0		
1928–30	5.5	53	143.7	
1938–40	2.7	51	151.6	0
1943–45	1.7	37	109.1	28
1948–50	.7	59	59.3	46
1953–55	.2*	71	33.5	44

* Estimated death rate for 1955, 0.2, the same as 1954; Number of cases in 1955 was the same as in 1954.

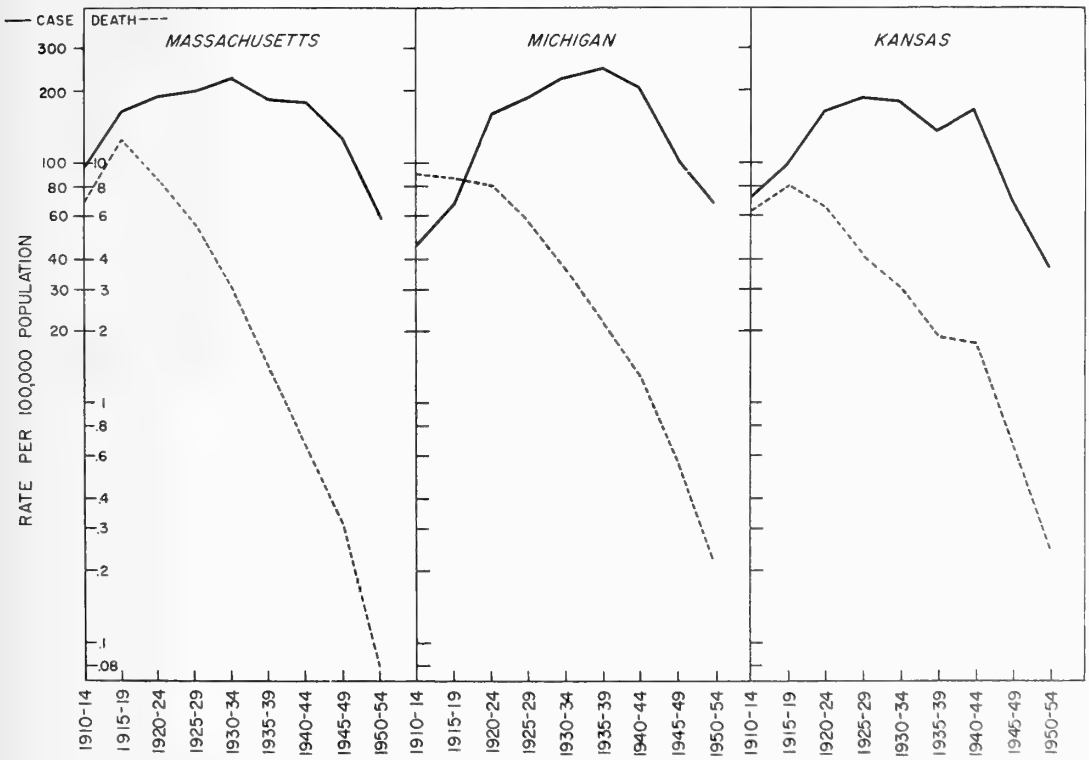

FIG. 4.—Reported case and death rates in three States, 1910 to 1954.

PERTUSSIS VACCINE

The pertussis bacterium, *Bordetella pertussis*, was not isolated until 1906, after many attempts had failed. Shortly afterward vaccines were prepared and used both to prevent the disease and to treat it. In the earliest available records of federal licensed products, January 1914, pertussis vaccine is listed. The Council of Pharmacy and Chemistry of the American Medical Association admitted pertussis vaccine to New and Nonofficial Remedies in 1914. Results from the use of vaccine, however, were so unsatisfactory that the Council omitted pertussis vaccine from New and Nonofficial Remedies in 1931. In the same year a significant contribution was made to the knowledge of the organism which enabled workers to select better strains of bacteria for the preparation of vaccine (Leslie and Gardner, 1931). Within the next few years there appeared several papers that presented convincing evidence that pertussis vaccine could be effective in protecting children against the disease. On the other hand, failures to obtain significant protection continued to appear through 1945. The vaccine was listed again in New and Nonofficial Remedies in 1944. By this time vaccines were being used quite extensively in the United States.

During the controversial years there was no satisfactory laboratory method to measure the protective activity of the vaccines, hence no U. S. Standard of Potency. We had to wait until someone discovered how to fatally infect a mouse with *B. pertussis*. Different workers tried the usual test tube and animal protection tests to measure the antibody response of animals. The former included agglutination, precipitation, complement fixation and opsonocytophagic index determinations. These tests showed that the animals had responded by producing antibodies to the antigens injected but there was no definite assurance that the antibodies were protective.

The protective tests in laboratory animals were not satisfactory because of inability to produce a fatal infection in laboratory animals. Mice could be killed if they were injected intraperitoneally with about 1,000 million organisms but death was largely caused by toxicity and not infection. The slight amount of protection that could be obtained was antitoxic and not antibacterial in nature. Since pertussis is a respiratory disease, attempts were made to induce infection by injecting the culture intranasally. Infections were induced but very few mice died except when near toxic doses of bacteria were used. A few workers reported some success with both routes of injection but no one was successful in standardizing the procedures with reference to potency evaluation of vaccines.

A new method of approach to the evalua-

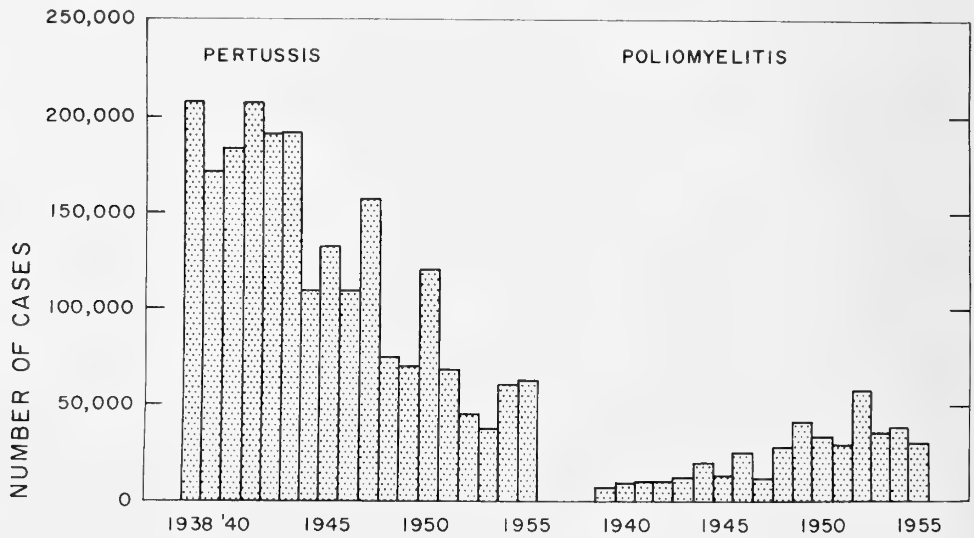

FIG. 5.—Reported cases of pertussis and poliomyelitis in the United States, 1941–1955.

tion of pertussis vaccine was opened in 1943. Dr. John F. Norton, of the Upjohn Company, in some protection tests, tried infecting mice by the intracerebral route. The results were very encouraging. He did not publish his findings but reported them, in 1944, to the Laboratory of Biologics Control and Dr. Pearl Kendrick, of the Michigan State Laboratories. I had just started on the problem of developing a U. S. Standard of Potency. Dr. Kendrick with Dr. Grace Eldering had previously carried out some successful field trials of pertussis vaccines. They were at the time actively engaged in studying protective test. Through close cooperation rapid progress was made towards the development of a protective test. In March 19, 1945, the National Institutes of Health notified the manufacturers of pertussis vaccine of the promising results and asked them to carry on independent investigations so that more data could be accumulated. That fall the majority of the manufacturers collaborated in a study under the direction of Dr. Kendrick to determine if comparable results could be obtained in different laboratories. The manufacturers were very anxious to have a standard potency test and through the American Drug Manufacturers Association were contributing toward the support of this study.

On January 5, 1946, the National Institutes of Health issued "a tentative mouse protection test for determining the antigenicity of pertussis vaccine." This test later became the official test. It differs from the one used in the collaborative study in that mice were given only one immunizing dose of vaccine instead of two. Experience in our laboratory had shown that reliable results could be obtained with one dose. This shortened the test from 33 to 28 days.

On May 27, 1948, minimum requirements for pertussis vaccine were issued to be effective January 1, 1949. This interval permitted time for the manufacturer to make adjustments in production and control methods. Most of the manufacturers, however, had already made such changes as had been indicated, and were before 1948, testing each lot for potency.

The need for potency evaluation of pertussis vaccine was demonstrated in the early part of our study. In 1945 and 1946 we tested samples of vaccines from fourteen manufacturers in the United States. It was found that the bacteria in lots of vaccines from three manufacturers had no detectable potency while those with demonstrable activity, from other manufacturers, showed as much as 10 fold variation not only between manufacturers but between lots of the same manufacturer. The manufacturers, grateful for the information, make quick adjustments in production.

It may have been noted that the period when the potency test was being developed and vaccines were for the first time being tested for potency, was the same period when an increase in the decline of both death and case rates started. The coincidence suggests to one that general improvement in the potency of vaccines was a contributory factor to the declines. Other possible factors will be discussed later.

The adoption of a standard of potency in 1949 did not solve all the problems. All lots of vaccine had a certain amount of mouse protective activity but there was considerable variation in the potency of the doses of vaccine recommended for human immunization. From the beginning of the use of all kinds of bacterial vaccines, the human dosage has been measured in numbers of bacteria. For pertussis vaccines, containing no mineral adjuvant such as alum, the numbers reported, to be effective, have ranged all the way from 22,000 million to 140,000 million. In 1949, the recommended total human immunizing dose of the different licensed pertussis vaccine products, without adjuvant, ranged from 60,000 million to 100,000 million bacteria. This variation introduced about a twofold chance for a difference in potency but the greatest chance for variation was in the bacteria themselves. The bacteria in some lots were four times more potent than in others. In the mouse test, the potency of the bacteria was determined by comparing the number of bacteria in the respective doses of the vaccine under test and the reference vaccine that protected 50 percent of the mice. Potency was satisfactory if the number of bacteria in the ED_{50} of the vaccine did not exceed the number in the ED_{50} of the reference.

Although aware of variations, we did not know how much of the mouse measured potency was required to protect children. If fact we did not know if there was any relation between mouse protection and human protection. Previous experiences with other products evaluated by animal tests, however, gave us confidence that a vaccine that had mouse protective activity would be better for children that one that had none. A field trial was planned but the Korean War interfered with obtaining federal support. Pertussis was not a war problem. In 1951 the Medical Research Council of England published a report of the first results obtained in a field study that was in progress. Protection afforded children was not correlated with the number of bacteria in the total dose administered. Two lots given in a total dose of 60,000 million afforded significantly better protection than others that were given in doses ranging from 90,000 million to 112,000 million.

With the best information available to us in 1952, a value of 12 units was assigned to that amount of the U. S. reference vaccine estimated to be sufficient to afford significant protection to a child. The number for the unit value was arbitrarily selected because it was divisible by 2, 3, and 4, the number of single doses in the total doses, then being recommended. The reference was designated as the U. S. Standard Pertussis Vaccine. It was freeze-dried and is used now only for standardization of working standard lots or for special comparative studies.

After a value was assigned to the reference we were able to determine the extent of potency variations that had been occurring in the lots of vaccines submitted to the National Institutes of Health for release. Data on 878 lots submitted during a 27 months' period were analyzed (Pittman, 1954). It was found that products containing the same number of bacteria showed as much as a fourfold difference in potency per total human dose. Some products containing high counts were less potent than others containing lower counts. There was an over all difference of 6.2-fold in the average value of lots of different manufacturers' products.

Since August 1953 it has been required that each lot of vaccine contains 12 units per recommended total human immunizing dose. This is one of the few products for which an upper as well as a lower limit has been placed on the amount of the protective activity per dose. With most other products, potency may exceed but in no case may it fall short of the minimum required. The upper limit for pertussis vaccine was adopted with the hopes of reducing untoward reactions such as fever, malaise, vomiting, local soreness, and the rare fatal encephalopathy. It was considered that an amount in excess of that needed to afford protection should not be used. Since this date, the number of complaints, received at the Division of Biologics Standards, of untoward reactions have been significantly reduced. No death has been reported to us. Eleven had been reported from 1944 through 1952, four of which occurred in 1952. No doubt, there have been other influential factors, one of which is that the manufacturer's accompanying circular of each product containing pertussis vaccine, now gives contraindications for injections.

Two papers, recently published, suggest that the mouse potency value assigned to 12 units is near the effective dose. One (Felton and Verwey, 1955) was the first report of a field trial in which the laboratory value of the vaccine was given. The two lots employed contained approximately 15 units per total human dose. Significant protection against pertussis was obtained. The other paper (Jaffe, 1955) suggests that low unit vaccines may not be effective. Dr. Jaffe, of the Department of Health of the District of Columbia, observed, from February 1, 1953, to March 15, 1954, 100 culturally proven cases of pertussis in two child-health clinics. Sixty-four of the cases had had completed courses of vaccination and 16 more had had at least one inoculation. Through the cooperation of the manufacturers, we were able to evaluate the potency of 90 per cent of the containers of vaccine from which it was estimated that these children would have been vaccinated. Only 41 per cent of the containers had 12 units per total dose, 34.5 per cent had values as low as 5.5 to 6.5 units, while the remaining 25 per cent had values ranging from 7.3 to 9.6 units. The lots had been released under the first minimum requirements.

Lest one gain the impression that the potency evaluation of pertussis vaccine is simple, it should be mentioned that the test as designed has a 1 in 20 probable error of about log 0.3. If each part of the test is carefully standardized, however, reproducible results are usually obtained. For an exact evaluation, we find that three tests are usually adequate. For routine work we seldom have to do more than one test to obtain satisfactory agreement with the test submitted by the manufacturer. Because of the probable variation in the test, limits of 8 and 36 units were set for an acceptable lot. The lower limit may be too low. If the protocol of a lot submitted, however, gives a borderline value, low or high, the lot is tested in our laboratory. A lot with a true high value will seldom pass the freedom-from-toxicity test. Frequent check is made irrespective of the manufacturer's results, so that more than 50 percent of all lots submitted are tested. All inspection samples are tested. An example of the potency evaluation of two lots of vaccine is given in Table 3.

Biologic products standards cannot be defined or measured with the same degree of accuracy as are physical standards. The products are organic chemicals largely of unknown composition. They are subject to change by the methods of preparation, the preservatives, and the time of storage. Further the measurement of activity is generally determined by the response of a biological system, usually animals, which may show wide variations in response.

TABLE 3.—POTENCY EVALUATION OF TWO LOTS OF PERTUSSIS VACCINE

Vaccine Number	Dose per mouse ml.	S/n	ED_{50}	Potency: Multiple of Standard per ml.	Potency: Units 1.0 ml.	Potency: Units Total dose
						1.5 ml.
X_1	.03125 .00625 .00125	14/16 8/16 2/16	.00625 ml. ± log 0.125 log 1.39* ± 0.61	.79	9.9	14.8
						3.0 ml.
X_2	.0625 .0125 .0025	15/16 11/16 3/16	.00722 ml. ± log 0.125 log 1.53* ± 0.67	.68	8.5	25.5
Standard	.02 .004 .0008	15/16 5/16 2/16	.00493 ml. ± log 0.118 log 1.64* ± 0.70		12.5	

* Slope of the curve.

Besides being of value in determining the potency of a finished pertussis vaccine, the test has been very valuable for selecting ways of improving the vaccine, for example: Selection of strains of bacteria with high antigenic properties, the development of simpler or better media, determination of the effect of preservatives and detoxifying agents on potency, and the purification of antigens.

The production of pertussis vaccine is complicated. The organism is quite exacting in nutritional requirements and it produces a thermolabile toxin. It has, as do all gram negative bacteria, an endotoxin. Very little is known about nutritional requirements in relation to protective antigens. One of the biggest problems is detoxification without affecting antigenicity. Physical or chemical agents that hasten detoxification may injure the protective antigen. This may be detected at once or only after 6 months or more in storage. An understanding of the enzyme activity of the bacterium might be a key to the solution of some of the problems.

In the United States, pertussis vaccine is frequently combined with diphtheria and tetanus toxoids and about 70 percent of all lots released contain a mineral adjuvant. Adjuvants are used to enhance the antibody response to a given amount of antigen. Recently a problem of toxicity caused by a mineral adjuvant was encountered. Studies with diphtheria toxoid have indicated that aluminum phosphate was better than alum. When the recommended amounts of the adjuvant were used in products containing pertussis vaccine, a lot frequently failed to pass the pertussis vaccine freedom-from-toxicity test. Adjustments were made by reducing the amount of adjuvant and no doubt without loss of the potentiating effect on the toxoids as pertussis vaccine itself acts as an adjuvant.

We look forward to the day when purified preparations of the protective antigen will be available. Two partially purified preparations have been prepared in different laboratories (Pennell and Thiele, 1951, and

Pillemer, et al, 1954). The antigens differ markedly in one respect. One induces higher agglutinin antibodies than the parent whole-cell vaccine (Felton and Verwey, 1955). The other one contains practically no agglutinogen (Evans and Perkins, 1955). Both are capable of protecting mice against intracerebral infection. The former was found to be effective in protecting children against pertussis. We await the results to be obtained from the latter antigen which is on field trial in England.

DISCUSSION

It was suggested earlier that the establishment of the U. S. Standard of Potency for pertussis vaccine was an influential factor in the reduction of both death and case rates of pertussis. It has ever been as Magill, 1955, recently stated that "the physician or the medicine man of each age has attributed the control and cure of each disease during his own particular era to the therapeutic procedures in vogue". Today there is a tendency for immunologists to attribute the decline of infectious diseases to an induced immunological state. Let us look at history.

Many infectious diseases have shown cycles of high incidence followed by low incidence. Between 1850 and 1860 diphtheria became much more prevalent and malignant, the change was so marked that the physicians of the day often spoke of it as a "new" disease. Mortality rose to extraordinary heights and remained there for about 30 years, around 1885, then a consistent decline began. This was before the introduction of antitoxin. The rate of decline was increased after toxoid vaccination came into general use.

The cycles of pandemic influenza strikingly illustrate changes in incidence. Further, with this disease is illustrated the shift from endemic to epidemic and from epidemic to endemic periods between pandemics. It has been shown that the antigenic pattern of the virus may change from one epidemic to another epidemic.

In figure 1 we observed the decline in the death rate of measles against which an immunizing antigen had not been used. In the same figure there was shown the decline in pertussis fatality rate before pertussis vaccine was in general use. In 1943, Dauer suggested that if the mortality continues to decline at the same rate as it did from 1925 to 1940, it will be difficult to show statistically that a prophylactic procedure has any effect in reducing mortality from pertussis.

In the 15 years since his analysis, pertussis vaccine has come into general use, and in the last ten years there has been an over-all improvement in the potency of vaccine. During this time there has been an accelerated decline in mortality and for the first time a decline in morbidity.

Although the use of improved vaccine no doubt has had some influence on the decline, it appears that we may have been observing the downward trend of a cycle. In the older writings, some dating back to Hippocrates, there appear descriptions of some diseases in such detail that certain of the common communicable diseases can be readily identified. The first known written description of whooping cough was by Ballonius in 1578. It is difficult to understand how a disease characterized by the paroxysmal cough that does not occur in any other infectious disease and with the high fatality rate observed at the turn of the century, could have escaped description. Could it be that pertussis was once a mild disease and that we are approaching a period when it will be again a mild and less frequently recognized disease?

We have observed that there was a significant decline in deaths long before there was a decline in the number of reported cases. This could be interpreted as a reduction in the severity of the infection. Dr. Jaffe's observations of 100 bacteriologically proven cases of pertussis is compatible with a change in the severity of the infection. Most of her cases were mild. None were hospitalized and all recovered. The only significant complication was one middle ear infection. With an apparent change in the severity of the disease, no doubt many cases are not being reported. If so, this would have contributed to the decline in reported cases. As of January this year, pertussis has been omitted from the weekly telegraphic reports of the States.

Whatever is the cause for the decline in pertussis, be it a change in the antigen of the microorganism, a change in the immunological condition of the host, the use of antipertussis serum or antibiotics, neither of which effect an immediate relief of symptoms but may arrest progression and shorten the duration of the disease, or other factors, it is suggestive that a state of equilibrium is being established between the microbe and the host. Nevertheless, we should not cease trying to prepare the most effective prophylactic vaccine free from undesirable activity or stop fundamental research both on a bacterium which has so many individual characteristics and which induces a disease with many anomalies (Gordon and Hood, 1951) and on the mechanism whereby in a local disease such marked neurological complications may occur.

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In every explanation of natural phenomena, we are compelled to leave the sphere of sense perceptions, and to pass to things which are not the objects of sense, and are defined only by abstract conceptions.—Helmholtz.

PHYSICS.—*Cosmological theories—ancient and modern.*[1] R. M. PAGE, Naval Research Laboratory. (Communicated by C. H. Page.)

(Received May 24, 1956)

In the month of December 1955 radio astronomers of the Naval Research Laboratory had their high-resolution radio telescope focused on Cygnus A. They were constructing a power spectrum across the region of the hydrogen spectrum line at 21 cm wavelength. They were looking for a dip or absorption line in the spectrum, which would occur if the energy received were passing through or were eclipsed from a hydrogen cloud. Furthermore, they were looking specifically for such an absorption line at a wavelength longer than 21 cm, which would occur if the hydrogen cloud were associated with Cygnus A source and therefore moving as Cygnus A is believed to move relative to the earth. On December 27 they found exactly what they were looking for. And when, by careful measurement and calculation, they derived the apparent velocity of recession from the earth, they found it to be 16,700 km per second. This agrees with a similar conclusion based on optical red-shift data to within less than 1 percent.

Let us look for a moment at what is back of this remarkable observation. It can hardly be called a new scientific discovery, since it was so confidently expected on the basis of all our other knowledge concerning our universe. Nor can those who conducted the experiment be said to be superior to other radio astronomers because they made the observation, since the experiment was made possible by the fine precision instruments made available to them. What were these instruments, and how did they come into being?

The instruments consisted primarily of a large, precision-built radio antenna, an accurately controlled servo-driven antenna mount, a high-gain, highly stable, selective, tunable, radio-frequency receiver, and a precision frequency control. These are all products of a relatively new field of endeavor, radio research and engineering. A considerable portion was built after the war, based in part on the results of wartime research. As a radio astronomy facility it has been in existence less than 10 years.

May we now turn to the much larger subject, our other knowledge concerning our universe which prompted the radio astronomers to look in the direction of Cygnus A, for the hydrogen radio frequency absorption line, at an augmented wavelength? The hydrogen absorption line at radio frequency was first observed in 1954 by radio astronomers of the Naval Research Laboratory using the apparatus just mentioned. Its existence was expected because the hydrogen radio-frequency emission line had been observed, first at Harvard University in March 1951, and subsequently in Holland and Australia.

Now we ask the question: What led to the hydrogen emission line observation at Harvard in 1951? The answer is simple. The radio astronomers there were looking specifically for that signal. They were looking for it because they had the precision radio astronomy instrumentation capable of detecting it if it were there, and the Dutch astronomer H. C. van de Hulst had predicted seven years earlier, in 1944, that such line should exist. In fact, van de Hulst was at Harvard at the time the observation was made, and I should not be surprised if he actually stimulated the Harvard astronomers to conduct the experiment, if, indeed, he did not himself participate in it.

But now we face another question: What led van de Hulst to make such a prediction? A commonly accepted model of the hydrogen atom is a proton nucleus about which orbits one electron. Both proton and electron spin on their own axes. The two spin axes of any one hydrogen atom at any particular time may be either parallel or antiparallel, i.e., while the proton spins in one direction of rotation, the electron may spin either in the same or in the opposite direction of rotation. Since both proton and electron are charged particles, their spin axes are also their magnetic axes. When their magnetic axes are

[1] A lecture given before the Philosophical Society of Washington on January 27, 1956.

parallel they repell each other and the electron orbit is slightly enlarged, resulting in a slightly increased potential energy state. When their magnetic axes are antiparallel, they attract each other, resulting in a slightly decreased potential energy state. The energy difference between these two states, when the electron is in the base orbit, was calculated by van de Hulst and divided by Planck's constant to yield the frequency value 1,420,405,000 cycles per second, or approximately 21 cm wavelength. To radiate energy at this wavelength, the hydrogen atoms must receive energy from some external source, in sufficiently large units to raise the atomic potential energy from the lower to the higher of these two levels, or, in terms of our model, to reverse the direction of the spin axis of the electron relative to the proton. Then, since this is not a stable state of affairs for the atom, the spin axis will flip back to its normal state, and in the process, radiate one quantum of energy at a wavelength of 21 cm. Van de Hulst then called attention to the possibility of this mechanism.

To trace to their origins the concepts on which van de Hulst made his suggestion would be far too involved for present treatment. It would lead us back through atomic theory, electricity and magnetism, optics, classical and statistical mechanics, mathematics of almost every branch, and a large array of scientific instruments. We shall simply leave it at that.

Thus far we have dealt only with one of the three questions we raised: Why were the radio astronomers last December looking for a hydrogen absorption line in the region of 21 cm wavelength? Let us now turn to a second one of the three questions: Why were they looking for an elongated wavelength?

The answer again is simple. The visible light we receive from distant galaxies is similarly elongated in wavelength. Let us explore the basis of this simple but somewhat categorical answer. We just considered a hydrogen atom to be a proton nucleus with an electron circling around it in one of several possible orbits. The atoms of all the other elements are likewise considered as consisting of nuclei in which protons predominate, and about which a number of electrons circle in a number of possible orbits. And as in the hydrogen atom, so in all atoms, energy may be absorbed in moving one or more electrons from their normal orbits to orbits of higher potential energy, whereupon the normal state will restore itself with the release of the absorbed energy in the form of electromagnetic radiation, at a frequency which is directly proportional to the energy difference between the two levels involved. The atoms of each element have a pattern of electron orbits which differs from the corresponding patterns of all other elements. When an element is excited so as to produce these energy transfers, the pattern of frequencies radiated is a "fingerprint" of that element. The pattern of frequencies is obtained by passing light from the excited element through a spectrometer, which separates the incident light into its frequency components and indicates the intensity of each frequency present. When light from distant nebulae is caught in an astronomical telescope and focused on a spectrometer, the spectra or "fingerprints" of known elements are found, but the wavelengths of all the spectrum lines from most of the nebulae are elongated. The light, in other words, is shifted toward the red end of the spectrum. Scientists have taxed their imaginations to explain this red-shift, and the only suggestion that satisfies is that it is produced by the Doppler effect of relative motion. In other words, the galaxies are moving away from us.

Now we could probe much more deeply into the origins of all the concepts touched upon but lightly here, of how J. J. Thomson discovered the electron, of how Ernest Rutherford discovered the hydrogen nucleus and postulated the basic structure of our present atomic model, of how R. A. Millikan measured the charge of the electron, of how Max Planck developed the quantum theory and arrived at the constant of proportionality between energy and frequency, of how Nils Bohr applied this theory to Rutherford's atomic model to give us our present atomic theory, of how the spectrometer works and what led to its invention, and of all the science and engineering that is associated with the invention and operation of astronomical telescopes, and of photosensitive emulsions, and the optics and chemistry and mechanics of their use in both telescope and spectrometer. Many books have been written on these subjects, and to most of us they have become such an "old story" that we tend to take them for granted and forget the extent of our indebtedness to a long succession of technological developments in instrumentation for scientific observation which provided the means for all the scientific discoveries mentioned here, and from which we have inherited a galaxy of precision instruments that would completely mystify the ancients. But in these instruments, their skillful use, and the careful and clever interpretation of the data they provide, lies the answer to the question: "Why were the radio astronomers looking for an elongation of the hydrogen line wavelength that is normally 21 cm?"

We come now to the third question: Why were they using Cygnus A as a source for making this measurement? The answer to this leads into cosmological theory, the foundation for which has been partly developed in answering the other two questions. Cygnus A was unknown to astronomy until discovered by radio in 1948. It was then thought to be a part of our own galaxy, although the possibility of its being extra galactic was pointed out. When the 200-inch optical telescope was turned in its direction to investigate, Cygnus A was found to be two galaxies in collision, with the red-shift in its spectrum indicating a distance of tens of millions of light years. Needless to say, this discovery created considerable excitement in astronomy, particularly in the field of radio astronomy, and it became a matter of great interest to determine whether a frequency shift in the radio frequency hydrogen line might be found to correspond to the optical red-shift.

We have shown how distant galaxies appear to be flying away from us as sparks from the blacksmith's anvil. We have stated that more remote ones appear to be receding faster, but we have said nothing about why we think the greater apparent velocities are associated with greater distances. How do we measure these distances anyway? Let us start with the shorter distances, say a few tens or hundreds of light years. First, we must have a reference distance, or "measuring stick." This is the diameter of the earth's orbit about the sun. By recording the difference in position of a nearby star relatve to the remote stellar background between two measurements made six months and some 186 million miles apart, the distance to that star can be calculated. This method of measurement gives good results out to about 100 light years, less accurate but usable results to several hundred light years, and can reach about 5,000 stars. For greater distances a particular type of star called a Cepheid variable is used. A Cepheid variable is a star that pulsates in brightness with a period of from a few hours to many days. The absolute brightness of such a star has been found to be directly proportional to its period of pulsation. The constant of proportionality was determined by observing the periods and apparent brightnesses of Cepheid variables in our vicinity, where distances could be determined by triangulation and by star motions. Actually there are two types of Cepheid variables, blue giants and red giants. For a given period of pulsation, the red giants are about 1½ magnitudes brighter than the blue giants. This "double standard" was not fully appreciated and accepted until only two or three years ago. It was the discovery that the Cepheid variables near us, used for calibration, were all blue, while the remote ones used for distance measurement were red giants, making the measuring stick in use more than twice as long as it was thought to be, that doubled all remote astronomical distance and time estimates only just recently. Gamow gives the factor as 2.8.

Cepheid variables are available for determining astronomical distances as far as they may be resolved as individual stars and their variations measured with telescope and photomultiplier. With the 200-inch telescope, this is about 20-million light years. Now we have one measuring technique that takes us out to 100 light years, and another that takes us out to 20-million light years. Yet another is needed for the many galaxies visible to the telescope but beyond the range at which individual stars may be resolved.

We have in fact two such measuring techniques. The first is apparent brightness.

Nearly all galaxies seem to have the same absolute total brightness within a factor of approximately two from the mean value. By assuming mean absolute brightness and measuring apparent brightness, distance may be calculated hopefully within a factor of two. The other technique uses the spectrum red-shift. Since those galaxies whose distances may be measured by Cepheid variables which they contain show a red-shift proportional to their distance from us, it is not unreasonable to assume that this law of red-shift holds for greater distances, at least within certain limits. Red-shifts have been measured out to a shift of a little over 20 percent, corresponding to a recession velocity of 38,000 miles a second, and a distance of about a billion light years if the law holds that far. For greater distances, apparent brightness remains the only clue to distance. On that basis the present maximum reach of the 200-inch telescope is approximately 2 billion light years. It must be remembered, however, that at that distance we see galaxies as they appeared 2 billion years ago—time enough for significant changes to occur in their brightness. Also, if the law of red-shift holds at that distance, indicated recession velocities would be on the order of one half the velocity of light, and relativistic effects may be present. No one has yet been sufficiently daring to suggest what influence these effects might have on apparent brightness, if, indeed the elementary spectra or "fingerprints" of the atoms themselves may not be altered.

All this while we have been explaining why radio astronomers made a certain observation last December. In so doing, we have reviewed enough elementary astronomical observations to discuss modern theories pertaining to the nature and origin of the universe. We start with the assumption that the laws of nature are uniform and consistent throughout all space and all time. If remote bodies are receding from us they must at some time in the past have been much closer to us and closer together. In fact, if their relative velocities are proportional to their relative distances, extrapolation backward in time should yield a definite time in the past when all the matter of the universe was tightly packed in one place, from which it is exploding like one great super atomic bomb. This extrapolation places the time of explosion about 4 to 5 billion years ago. This view is held by a number of scientists, one of whom, George Gamow, has given us a fairly detailed account of how it might have happened. We will not attempt to probe into the scientific bases of this account, as Gamow and others have done, but rather attempt to describe a probable sequence of events.

In the original tightly compressed state, which is the earliest state science can know anything about, the temperature would be too high for matter to exist at all, and all the sum total of the matter and energy of the universe would be in the form of radiant energy. Thus the earliest phenomenon that can be postulated with any scientific foundation is a blinding flash of light intense beyond the capabilities of human imagination to conceive. On expanding from its point of origin, it would cool, at first with extreme rapidity. Five minutes after the first generation of this energy, the temperature would have cooled down to a billion degrees. At this temperature, protons, neutrons, and electrons could exist, but not atoms. In the succeeding 25 minutes all the chemical elements would be formed, for at the end of the first half hour the temperature would have dropped too low for nuclear reactions to take place. Calculations of the relative abundance of the elements that would result from such a process agrees remarkably well with what is found to exist today. Also, the state of decay of radioactive elements indicates that they were originally formed about 5 billion years ago.

Today the mass density of matter in the universe far exceeds the mass density of radiation. If, as has been postulated, the universe started out as all radiation, there must have been a time when the total mass density was equally divided between radiation and matter. On this subject let me quote from Gamow. "Computing the mass densities of radiation and of matter at various epochs, we can find the date of the great event when matter took over from radiation, i.e., surpassed it in mass density. The date was about the year 250,000,000 A.B. (After the Beginning). The temperature of space was then about 170 degrees absolute, and the density both of radiation and of matter was comparable with the present density of interstellar gas. The Universe, in short, was dark and cool." This statement appeared in the March 1954 *Scientific American*.

The gradual transition from radiation to matter has been likened to slow precipitation of a solid from solution. As matter gained the ascendency over radiation, it began to react to the forces of turbulence and gravitational attraction, and formed into great clouds of gas. In time these clouds contracted by gravitational attraction to form the beginnings of galaxies. But turbulence, consisting of eddies within eddies ad infinitum, produced many secondary and tertiary centers of contraction, so that the clouds of gas "coagulated" into small "lumps," which in turn fell into larger ones, until whole hierarchies of suns and planets and satellites were formed. The pressures created by gravitational attraction produced local heating, the larger accumulations becoming quite hot. The maximum temperature thus produced in any star depends on the mass of the star. To reach surface incandescence requires a mass about 2,000 times that of the earth. Some galaxies are imbedded in gas and still growing. They are blue in color and spiral in form. Others have used up all their gas, and are cooling off. They are red in color and globular in form.

We have given in brief outline one of the two principal modern theories of cosmology. It is based on observed physical phenomena and analogous mathematical models. Whether the present hyperbolic expansion was matched by a corresponding hyperbolic contraction before the point of maximum concentration, or whether the primeval flash of light was an original creation must forever remain beyond the reach of science to decide. The fact remains that this theory provides a satisfactory scientific explanation for an amazingly wide variety of observed phenomena. Furthermore, it yields a value for the age of the universe which is remarkably consistent with no less than 12 other and mutually independent indications of that age. Space does not permit exploration of all these other methods, for we have other theories to consider.

One of these other theories is also a modern one, having originated only a few years ago, before discovery of the two populations of Cepheid variables. Two objections were raised to the "explosive" theory. One was the discrepancy in the age of the universe dictated by the theory as it then appeared. The other was that it tended to support the Biblical account of creation, a situation some found to be unpalatable. So in 1948, Bondi and Gold, as well as Hoyle, advanced a "steady-state" theory, in which matter is created continuously, one proton at a time, throughout the universe, to replenish the fleeing supply. A mathematical model has been constructed on this concept and made to fit present observations. It must be recognized, however, that the steady state theory is pure conjecture and has not a single experiment or physical observation to support it that does not also support the explosion theory. Furthermore, instead of disagreeing by a factor of 2 or 3 with other methods in indicating the age of the universe, it makes the universe eternal. Since its introduction, however, the correction to the astronomical measuring rod has brought the explosive theory of Eddington, Lemaître, Gamow, and von Weizsacker into complete harmony with other methods of age determination. That leaves only one argument for the continuous theory over the explosive theory: namely, it appears to contradict the Biblical statement of creation. Even in this matter however, it does not fully escape criticism. If matter has to be created out of nothing ultimately, is it any greater miracle to create one neutron at a time, than to do it all at once? Certainly there is difference in degree, or in rate of generation if you please, but where is the difference in *kind*? The whole argument reminds me of the heart specialist who was called on to treat a patient with a broken leg. The doctor treated him for a weak heart because he didn't like to mess with broken bones. I do not mean to ridicule any man who is honestly searching for truth. I am only pointing out that the temptation to interpret observations so as to make them support conclusions already reached is as dangerous as it is difficult to avoid. Let me hasten to add that I make no pretense of immunity from the hazard.

Now let us return to our explosive model and speculate on still greater distances. If the law of red-shifts does in fact arise from the flight of the galaxies, then at the distance of 5 billion light years the velocity of recession will equal the velocity of light. Any galaxies beyond this limit would have to be fleeing from us at an even greater velocity, and their light would never reach us at all. Thus we have an astronomical horizon beyond which we can never see with any possible kind of instrument.

We have no reason to assume, however, that the earth is located at a point of origin of galactic motion. Were we far removed from such a point, all galaxies would still appear to be receding from us. Assuming such an origin to exist, let us transfer our velocity reference point from the earth to the locale in space where it all started. From that point the universe moves away in all directions with all possible velocities. If the highest velocity of expansion is much less than the velocity of light, the outer boundary of the universe at any one time would be nebulous and diffuse. If, on the other hand, the original energy was such as to produce velocities greater than the velocity of light in the absence of relativistic effects, the presence of those relativistic effects would restrain the velocities to less than the speed of light, and the momentum would be maintained by the corresponding relativistic increase in mass. The result might be a "piling up" of galaxies at the outer boundary of the expanding universe, moving outward as a spherical shell or sort of "shock wave" of light at very nearly, if not exactly, the velocity of light. Such a shell would hardly be visible at the point of origin, but part of it might be visible at points far out from the origin. If this be the case, then, if the earth is sufficiently far removed from the primeval origin, and if telescopes are made capable of seeing far enough, it should be possible to find an increasing density of galaxies in the direction of least distance to the shell or outer boundary. The mathematical model which seems consistent with this concept is described under the title of "curved space," in which the radius of curvature in our universe is said to be 5 billion light years.

Let us now recapitulate the model we have been describing in terms of the origin and evolution of the earth. We start with the phenomenal burst of radiant energy, the solvent for all matter, and call it the birth of our universe. In the first 30 minutes we see all the elementary particles formed and organized into atomic nucleii. Then nothing but cooling and expanding as matter continues to precipitate out of radiation, until all is dark and cold. Then, slowly at first, a great cloud begins to form out of the turbulence, and separate itself from other similarly forming clouds as they all shrink into more dense masses of gas. Then coagulating lumps of liquids and solids begin to form, and little lumps fall into bigger lumps, until certain large ones begin to draw to themselves everything near them. And since the whole cloud was rotating as a part of the general turbulence, all the bodies were also rotating as they formed, the speed of rotation of each body increasing as matter was drawn together in smaller volumes. And as the large bodies grew larger, pressures at their centers increased, with corresponding increase in temperature, until the larger ones became incandescent, shining one by one, all through the galactic system. One of these stars was our sun, and when it "lit up" it illuminated a host of planets with their satellites. One of these planets was the earth, which had coagulated from a little whirlpool of gas within the greater "whirlpool" of the solar system, which in turn was part of the turbulence of the whole galaxy. When the earth reached its maximum temperature, it was too hot to retain water, so all the water of the oceans and the moisture of the soil existed as a dense shroud of steam completely enveloping the earth and continuous right down to the earth's surface. And as the earth cooled, the steam condensed into pools of hot water on the surface. Eventually the moisture in the air dropped below the saturation point, and the fog began to rise, leaving a clear separation between the water surface and the cloud blanket overhead.

much as we see it occasionally now. Then the wet land began to become dry by evaporation, and conditions were favorable for the appearance of vegetation. When vegetation appeared, it sustained itself by reproduction, according to laws of heredity that have been the subject of much study since Mendel's time. The mechanism seems to be that each kind of plant has its seed within itself and reproduces after its kind.

As moisture continued to condense and fall as rain to the earth, the cloud blanket became thinner and ultimately broke up. Then for the first time the sun, moon, and stars were visible on the surface of the earth, and available for telling the time of day and the seasons of the year.

By now we should have a fairly good bird's-eye view of what our universe is and how it got to be that way, according to the most probable modern scientific speculation. Let us turn now to some other cosmologies, pausing first to contrast the scientific atmospheres of past and present. Science to us is a partnership between philosophy and technology. We more familiarly refer to these two aspects today as theory and experiment. This partnership was first seriously joined by Sir Isaac Newton and has been growing with accelerating fruitfulness ever since, particularly as mathematics became increasingly a major tool of both. Before Newton's time, fruitful interactions between the two were rare. When we probe farther back to the Greeks and the Egyptians, the Hebrews and the Babylonians, it was as if neither was aware of the existence of the other, unless to spurn it as a degrading influence on mankind. Even had the thought occurred to form such a partnership, the crude technology of ancient times was a poor match for the philosophical conviction that all natural phenomena were direct actions by conscious gods, whose behavior was as capricious as that of men. It is important that we recognize this when dealing with ancient cosmologies, and maintain a sympathetic attitude as we attempt to place outselves in the position of ancient philosophers.

There are many cosmologies among the mythologies of antiquity. We can not discuss them all, but we will examine two of them. First we will review what has been called the Babylonian Genesis, the *Enuma Elish* ("When above"):

> When above the heaven had not (yet) been named,
> (And) below the earth had not (yet) been called by a name;
> (When) only Apsu privemal, their begetter, (existed),
> (And) mother Ti'amat, who gave birth to them all;
> (When) their waters (still) mingled together,
> (And) no dry land had been formed (and) not (even) a marsh could be seen;
> When none of the gods had been brought into being,
> (When) they had not (yet) been called by (their) names, and
> (their) destinies had not (yet) been fixed;
> Then were the gods created in the midst of them.

The created gods were the sons and grandsons, daughters and granddaughters of Apsu and Ti'amat. But the children always became greater than their parents, and they also became mischievous and annoying, as younger generations sometimes do, until the old grandparents, Apsu and Ti'amat, could not rest. Finally Apsu decided to put an end to the annoyance:

> Apsu opened his mouth
> And said to Ti'amat, the holy (?) one:
> "Their way is annoying to me,
> By day I cannot rest, by night I cannot sleep;
> I will destroy (them) and put an end to their way,
> That silence be established, and then let us rest!"
> When Ti'amat heard this,
> She was wroth and cried out to her husband;
> She cried out and raged furiously, she alone.
> (For) the malice (of Apsu) disturbed her heart.
> "Why should we destroy that which we have brought forth?
> Their way is indeed very annoying, but let us take it good humoredly!"

But Apsu would not be dissuaded, and he plotted to kill his children. But the plot leaked out, and he himself was killed by his own offspring. In ensuing conflicts, Ti'amat was slain by Marduke, who drained out her blood and let the wind carry it away. He then split her body in two, made the vault of heaven from one half, and from the other half, made the earth. Gods who had supported Ti'amat were enslaved. When they complained of their slavery, the kind-hearted Marduke took their leader's blood and mixed it with clay to make man. Then he assigned to men the task of serving the gods, and set the captive gods free.

This whole account is recorded in cuneiform writing on clay tablets. It consists of seven tablets, totaling over a thousand lines in all, of which approximately 800 or 900 have been recorded and translated. It is representative of the general character of most mythological cosmologies. As one might expect, it bears no real similarity to our own modern cosmology. Under the circumstances, this is not surprising.

Now permit me to review just one more ancient cosmology. This one I will give in an unpublished translation, since the published translations are old, words change their meaning from generation to generation, and recent findings of archeology and philology have added to our concepts of what the originals really meant. This is the cosmology of the ancient Hebrews, and in one form or another may have been nearly contemporaneous with the Babylonian. I paraphrase freely, in the attempt to recapture the original thought as determined by the work of modern scholars, making liberal use of the terminology of modern cosmology.

In beginning, Gods created the heaven and the earth. And the earth was without form, and nebulous, and darkness reigned throughout all space. And the Spirit of God was brooding upon the face of the waters. And God said "Let there be light," and light appeared. And God saw the light, that it was good. And God divided time into periods of light and darkness. And God called the time of light Day, and the time of darkness he called Night. And this completed the first epoch of the creation of the earth.

And God said "Let there be an expanse of clear space in the midst of the waters, and let it divide one part from another." And God made the expanse of clear space above the earth, and divided the waters which were under the clear space from the waters which were above the clear space. And God called the expanse of clear space Heaven. And this ended the second epoch of the creation of the earth.

And God said, "Let all water under the heaven be gathered together into one bed, and let the dry land appear." And it was so. And God said, "Let the earth bring forth grass, the herb yielding seed, and the tree yielding fruit; whose seed was in itself, after his kind." And God saw that it was good. And this ended the third epoch of the creation of the earth.

And God said, "Let there be lights in the expanse of heaven to divide day from night, and for indication of the seasons, days, and years, and let them shine in heaven to give their light on the earth." And God caused to shine on the earth two great lights, the greater for daytime, the lesser for night time. The stars also he made to shine on the earth from the expanse of heaven.

There is more in this Hebrew cosmology with which we will not concern ourselves at this time, since it deals with a quite different realm of science than we are considering. I should point out, however, that the account of the appearance of lights for indicating times and seasons does not make reference to original creation of the lights at this time, but rather the making available of the lights to the earth, such as would occur by a clearing away of the clouds of moisture around the earth.

I think this very cursory review suggests a parallelism between the Hebrew cosmogony and our own. This parallelism is rendered even more remarkable by its striking contrast to the corresponding Babylonian version. It is true that some students of ancient records have attempted to show an extensive parallelism between the Babylonian and the Hebrew cosmogonies. Close scrutiny, however, shows the points of similarity to be purely superficial, and of far less consequence than the overwhelming weight of the contrasts. On the other hand, the amazing consistency between the concepts of Hebrew cosmogony and our own poses a question which science has not answered: How did those ancient Hebrews without aid of telescope, spectrometer, electronics, atomic theory, mathematics, and all the other components of the foundations of modern cosmology, come into possession of the comprehension of prehistoric nature exhibited in their cosmogony?

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Let us remember, please, that the search for the constitution of the world is one of the greatest and noblest problems presented by nature.—G. Galilei.

PHARMACOLOGY.—*Some metabolic patterns observed after morphine administration in the rabbit.* Louis Levy, Georgetown Medical School.[1] (Communicated by Theodore Koppanyi.)

Recent investigations concerning the mechanism of action of morphine on the enzymatic level (*1, 2*) arrive at the conclusion that there is little correlation between the pharmacological action of morphine and its action on the enzyme systems studied. All attempts to describe the action of morphine on an enzymatic level have shown inconsistent patterns of enzyme inhibition, or require concentrations of morphine much higher than found to be effective in the intact animal (*3*).

A further review of the literature revealed that there have been very few studies recently on the chemical constituents of the blood in morphinized animals. During the past decade many new tools for chemical analysis of the body fluids have become available. A great advantage of these techniques and methods is their ability to identify small quantities of substances. Perhaps one of the simplest and most sensitive methods has been paper chromatography. This technique was used throughout this investigation for qualitative determination of blood constituents.

METHODS

Albino rabbits weighing 2 to 3 kgm were used throughout the experiments. All injections of morphine were given subcutaneously as the sulfate salt. Blood was taken from the marginal ear vein in all experiments. Before all sugar determinations, food was withheld for 18 hours. Preliminary experiments revealed that fasting was not necessary for reproducible results with blood amino acid nitrogen. Blood sugar was determined by the Somogyi-Nelson method (*4*), and blood amino-acid nitrogen was determined by the naphthoquinine method (*5*) after deproteinization as described by Hunter (*6*)

Ascending paper chromatography was used throughout the experiments. The deproteinized samples for sugar chromatography were dried at 50° C. and redissolved in absolute methanol. The samples were concentrated approximately twofold. The solvent system used was a mixture of n-butanol, pyridine, benzene and water (5:3:1:3). Aniline citrate was used to identify the aldoses, and orcinol, the ketoses.

Amino acids were identified, using 2-dimensional chromatography. The samples were deioned according to the method of Smith and Tuller (*7*) and then dried in a jet of air and concentrated tenfold. Eighty percent pyridine was the solvent used in one dimension and 70 percent ethanol in the other. A 0.2 percent ninhydrin solution in water—saturated butanol was used as the spray reagent to identify the amino acids. In identifying the individual amino acids, maps of known mixtures were used.

RESULTS AND DISCUSSION

The biochemical phase of morphine which has received the most attention has been the hyperglycemia observed in rats, rabbits, and dogs as well as certain other species after the administration of morphine. Because this was the most apparent biochemical lesion, and rabbits are particularly susceptible to this change, the first phase of this study concerned itself with the hyperglycemic response of rabbits to morphine.

Blood sugar determinations were made on eight fasting rabbits ½, 1, 2, and 4 hours after morphine. The hyperglycemia observed had been reported previously (*8*). This hyperglycemia disappeared after a week of daily injections, and even when the dose of morphine was elevated again, the rise in blood sugar was very slight.

After two weeks of daily injections of morphine sulfate, two of the rabbits were given nalorphine (10 mgm/kgm) daily instead of morphine at the time they were usually given the morphine. Two other rabbits were given daily saline placebos in place of the usual morphine. Blood sugar levels of these

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rabbits were determined daily as before. This treatment was kept up for one week; at the end of this time, a single injection of morphine sulfate (30 mgm/kgm) was again given to the rabbits.

During the week of nalorphine and placebo injections there was no significant rise in the blood sugar in either group of animals. Emerson and Phatak (*8*) as well as Phatak and David (*9*) in longer experimental periods claimed that when morphine administration was abruptly stopped in rabbits, there was a rise in the blood sugar. However, examination of these data reveals that the rise was very small. Nalorphine has been shown to precipitate withdrawal symptoms and if hyperglycemia is part of a withdrawal phenomenon in rabbits, it was not observed in this experiment. Therefore, if the return to normoglycemic response during continued morphine administration is indicative of addiction in the rabbit, withdrawal responses should have appeared in both the nalorphine animals and saline controls. Thus it appears that the tolerance to morphine hyperglycemia in rabbits is not synonymous with morphine addiction and can be considered a non-specific stress response.

Upon reinjection of morphine sulfate (30 mgm/kgm) both the nalorphine and placebo animals had quantitatively and qualitatively similar rises in blood sugar. The nalorphine animals had an average fasting blood sugar of 87 mgm/100 cc, and one hour after morphine it was at a maximum of 158 mgm/100 cc, a rise of 180 percent. The saline-treated animals had an average fasting blood sugar of 70 mgm/100 cc, and one hour after morphine it was at a maximum of 128 mgm/100 cc, a rise of 183 percent (Table 1). Thus it did not appear that the presence of nalorphine for one week conditioned the animal body to the presence of morphine with regard to the hyperglycemia. In acute experiments nalorphine has been shown to block the morphine hyperglycemia (*10*). In the experiments just described, the action of nalorphine had apparently worn off and it was no longer effective in blocking the rise in blood sugar.

The general methods for determining blood sugar depend on the reduction of some metallic ion by glucose. However, glucose is not the only substance in the blood which can reduce the usual copper reagents. Early reports (*11*, *12*) presented evidence of substances other than glucose present in the blood of morphinized animals which caused an apparent hyperglycemia.

Table 1.—Relative Blood Sugar Levels after Injection of Morphine, Nalorphine, and Saline

Treatment mgm./kgm	*Percent rise above control* (1 hr. samples)
	Percent
Morphine sulfate—20, 1st day	130
Morphine sulfate—20, 4th day	14
Morphine sulfate—30, 1st day	35
Morphine sulfate—30, 4th day	17
Nalorphine—10, 1st day	10
Saline placebo, 1st day	26
Nalorphine—10, 6th day	4
Saline placebo, 6th day	0
Morphine sulfate—30, after nalorphine	80
Morphine sulfate—30, after saline	83

Paper chromatograms of the samples used in blood-sugar determination revealed only one spot when aniline citrate was the spray reagent. This reagent reacts with aldohexoses and aldopentoses. This spot was glucose and was obviously darker after the morphine injection than before, indicating that glucose was the reducing substance causing the hyperglycemia. Three different solvent systems were tried and eight different spray reagents were used and all revealed the same patterns.

The next experiment was designed to obtain some information concerning protein and/or amino acid metabolism. Kruger, Eddy, and Sumwalt state in their review (*13*); "The evidence is sufficient to indicate deep-seated disturbances in the nitrogen economy of the body." Although this was written 14 years ago, a review of the literature reveals no work has been done during the interim on the nitrogen economy of the body after morphine administration. With this in mind and also the possibility that some mechanism might be revealed, a study of the effect of morphine on the blood amino acids was undertaken.

Blood samples were obtained before and 1 hour after subcutaneous injections of 20 mgm/kgm of morphine sulfate on a different group of rabbits. The amino-acid nitrogen before injection was 10.1 mgm percent and

1 hour after morphine it was 9.1 percent. This 1 milligram difference was significant to the 0.1 percent level using the "t" test.

Paper chromatograms revealed at least 20 different identifiable amino acids. After morphine, these 20 amino acids were still present, although obviously in lower concentration. The chromatograms indicated that there was no qualitative change in amino-acid distribution after morphine.

The physiological significance and interpretation of changes in blood amino acid nitrogen is still in question, and the literature on the subject is very limited. However, a drop in amino-acid nitrogen has been shown to occur when epinephrine is given to animals (*14*). Since the rise in blood sugar after morphine has been shown to be caused by a release of epinephrine (*15*), the fall in blood amino acid nitrogen could also be attributed to this epinephrine rise.

SUMMARY

Through the use of chromatography, glucose was found to be the major reducing substance in the blood, causing the morphine hyperglycemia. Previously reported withdrawal hyperglycemia was not observed in this short-term experiment. Hyperglycemia was also believed to be a result of increased secretion of epinephrine. There was a lowering of blood amino acid nitrogen, which was considered a response to elevated epinephrine levels in the animal. Since there was no qualitatively observable change in any single amino acid as revealed by two-dimensional paper chromatography, it is believed that the fall in amino-acid nitrogen is nonspecific with regard to individual amino acids.

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Nature in her inscrutable wisdom has set limits which she never oversteps.—Jean Rey.

HELMINTHOLOGY.—*A review of the cestode genus* Echeneibothrium. R. T. Young, University of Maryland. (Communicated by E. W. Price.)

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This paper is an attempt to clarify the taxonomy of the cestode genus *Echeneibothrium* (family Phyllobothriidae; type species, *minimum* van Beneden, 1850). This genus, described by van Beneden in 1850, comprises at least 18 recognizable species common in selachian hosts. It has been in need of review for some time.

Van Beneden based his genus on material from *Trygon pastinaca* (= *Dasyatis pastinaca*). Prior to his account, however, Rudolphi (1819) had described *Bothriocephalus tumidulus* (= *Tetrabothrius tumidulus*), now recognized as *Echeneibothrium tumidulum* from the same host. He described the genus as having four bothridia borne on long pedicels extremely variable in form. These have regular "replis" over the whole extent of the organ which resemble the "lamelles" on the head of an *Echeneis* whence the generic name. In classifying the species of *Echeneibothrium* these ridges, and the consequent number and arrangement of loculi, are usually considered important; but in view of the statement of Woodland (1927, p. 520) that in *E. maculatum* the ridges separating the loculi are temporary, and that therefore the latter "are often entirely absent or at least invisible," some question arises regarding the importance of this feature in classification.

Echeneibothrium is a very variable genus, which accounts largely for the confusion in classification of its species. Van Beneden (1850, p. 113) says of the bothridia that they are "extraordinairement variables dans leur forme," and Beauchamp (1905, p. 520) says: "Ni le nombre des alvéoles . . .ni la forme générale de la bothridie, ni la présence ou l'absence de myzorhynchus . . . ne sont des charactères au dessus de tout critique. Enfin le longueur du cou et la loi de croissance des anneaux sont charactères de varieté d'individu plutôt que d'espèce. Il en résulte qu'il n'y a peutêtre pas dans le genre une seule espèce qui puisse être nettement distinguée des autres."

This statement is perhaps somewhat exaggerated, but it emphasizes the need for caution in defining and describing species in this genus.

RELATION TO OTHER GENERA

Rudolphi (1819) described *Bothriocephalus tumidulus*, Leuckart (1819) *B. echeneis*, Diesing (1863) *Tetrabothrius sphaerocephalum*, van Beneden (1850) *Tetrabothrium variabile*, Linton (1890) *Rhinebothrium*, Shipley and Hornell (1906) *Tiarobothrium*, and Baer (1948) *Caulobothrium*, all of which are probably synonymous with *Echeneibothrium*. Joyeux and Baer (1936) recognized the synonymy of the latter with *Rhinebothrium*, as did Southwell (1925), but Baer (1948) accepted *Rhinebothrium* as a genus distinct from *Echeneibothrium*, splitting the latter into three genera, viz: *Echeneibothrium* proper, *Rhinebothrium*, and *Caulobothrium*. According to this author (l.c., p. 83) the first of these is restricted to European forms, while the two latter occur in *Dasyatis centrura* from Woods Hole, Mass. In the European species a myzorhynchus is always present, while in the specimens from Woods Hole there is never the "moindre trace" of one. Beauchamp (l.c., p. 520) says the myzorhynchus can be "complètement invisible quand il est rétracté et ne crée pas alors un élargissement particulier de la tête." And Joyeux and Baer (l.c.) speak of a "petit" myzorhynchus in *E. minimum*, *tumidulum*, and *julievansium*, while van Beneden (l.c.) says that in the first of these it is "peu développé." Its value therefore as a specific, much less a generic character, is questionable.

Baer (l.c., p. 98) defines *Rhinebothrium* as lacking testes between the genital atrium and the ovary on the poral side of the proglottid. But on page 94 he apparently contradicts himself by stating that "les testicules . . . . contrairement à ce que nous avons observé dans les autres espèces, occupent toute la face dorsale de l'anneau jusqu'à l'ovaire . . . en arriere de l'atrium genitale et des testicules se trouvent toujours entre celui-ci et l'ovaire *dans la moitié porale du segment*" (italics are the writer's). In *Caulobothrium* the testes occupy this space. In *Rhinebothrium* the longitudinal musculature is reduced to a single subcuticular layer, while in *Caulobothrium* there is, in addition to the subcuticular layer, a parenchymal layer outside of the vitellaria but within the subcuticular layer. In *Rhinebothrium* the vitellaria are restricted to two lateral bands, while in *Caulobothrium* they encroach laterally on the dorsal and ventral faces of the medullary parenchyma (p. 96). In the writer's opinion these differences are not sufficient to divide the genus *Echeneibothrium* into three genera.

Echeneibothrium approaches most nearly to *Anthobothrium*, and the relationship is strengthened by the fact that in at least one species of the latter genus, *Spongiobothrium variable* (Linton, 1889) (= *Anthobothrium variabile*) the bothridia have a series of incomplete divisions resembling the loculi of the former.

Discobothrium fallax van Beneden, 1871, has been referred by Monticelli (1890) to *Echeneibothrium variabile*, a reference supported by Olsson (1893) but opposed by Lönnberg (l.c.), who maintained the distinctness of the two species.[1] Southwell (l.c.) regards it as an interesting link between the Tetraphillidea and the Cyclophyllidea, but in 1930 he considers *Discobothrium* and *Echeneibothrium* to be distinct.

Yamaguti (1934), recognizing the genus *Discobothrium*, includes in it the species *japonicum*, (which he describes as new) from *Narke japonica*. Braun (1894-1900) considers *D. fallax* a valid species on the basis of Lönnberg's opinion. It is also listed as a distinct species by Joyeux and Baer (l.c.). These authors give the absence of bothridia as one of the characters of the Cephalobothriidae, although they describe the "quatre petites ventouses situées en arrière" of the myzorhynchus which may perhaps represent reduced bothridia. Wardle and McLeod (1952, pp. 283-4) describe "four bothridia (at the base of the holdfast) borne on long stalks and very mobile." They list *fallax* as a distinct species in the genus *Echeneibothrium*, considering the "resemblance between *fallax* and *Echeneibothrium variable* . . . sufficiently close to make the inclusion of *fallax* within the genus imperative" (p. 240). Beauchamp (l.c., p. 521) agrees with Lönnberg, and Woodland (l.c., p. 532) considers "*Echeneibothrium variable* . . . definitely distinguished from *Discobothrium fallax* on anatomical grounds", the latter being renamed *E. fallax* in which the bothridia "usually show but few indications of loculi" (l.c., p. 523). Though Beauchamp (l.c., p. 509) says of the bothridium that "il ne présente aucune espèce d'alvéoles ou de replis transversaux" yet it is a fact that "very distinct loculi are often to be found." (Woodland, l.c., p. 524). Southwell (l.c., p. 336) says that while he was unable to obtain a specimen of *fallax* "there is little . . . doubt that the genera *Discobothrium* and *Echeneibothrium* are different but closely related."

In view of these conflicting opinions the writer considers it best to place *Discobothrium fallax* among genera and species inquirendae.

LIST OF SPECIES

1. **Echeneibothrium flexile** (Linton, 1890)

This species was described as *Rhinebothrium flexile* in *Trygon centrura* (= *Dasyatis centrura*) from Woods Hole, Mass. There are 38–42 loculi in the bothridia which are borne on long stalks and characterized by a hinge in the middle, giving the appearance of two bothridia on one stalk. The bothridial halves face each other when contracted. A myzorhynchus is apparently absent. Testes 10 in number. Ovarial lobes very long "extending nearly to the middle of the segment" (Linton l.c., p. 770).

2. **Echeneibothrium variabile** van Beneden, 1850

This species, from *Raja clavata, R batis, and R. rubus*, is characterized by a definite myzorhynchus. According to van Beneden the strobile reaches a length of 100 mm, with at least 100 segments, but Beauchamp (l.c.) gives the length as only 25–30 mm with many fewer segments. Joyeux and Baer (l.c.) give the number of testes as 20–27, but in figure 14, plate 3, of his

[1] This statement is based on one by Southwell (l. c., p. 335). While Lönnberg lists *?Discobothrium fallax* and *Echeneibothrium variabile* specifically he makes no statement as to whether these are the same or different species and is apparently in doubt about this.

1850 publication van Beneden shows only 16 testes. The cirrus sack is very long (22 mm), reaching the middle of the segment. The bothridia are rather strongly pedunculate, with approximately 8 loculi according to Linton (l.c.), but van Beneden's figure 6, plate 3 (1850), shows 20 loculi. The cirrus is spined according to Linton (1889), or "couvert des mêmes asperités" according to van Beneden (1850, p. 117). Linton considers this species synonymous with *Echeneibothrium sphaerocephalum* of Diesing (1863).

3. **Echeneibothrium tumidulum** (Rudolphi, 1819) Syn. *Bothriocephalus tumidulus*.

From *Trygon* (= *Dasyatis*) *pastinaca*.

Rudolphi's account of *Bothriocephalus tumidulus* is so brief as to render identification difficult. He apparently had only segments to examine. The bothridia have one long, and several transverse septa and are swollen. According to Dujardin (1845, p. 620) the bothridia are sometimes "puisque contigues, réunies en une masse globuleuse, quelquefois . . . divisés chacun en deux lobes petaloïdes, oblongues et plissés." These differences emphasize the variable form of the worm, any given specimen reflecting the form at the moment of fixation.

Carus (1885) identifies it with both E. *variabile* and E *minimum* and with *Bothriocephalus echeneis* of Leuckart (1819). Southwell (1925) considers it identical with *E. variabile*. Wardle and McLeod (l.c., p. 240) describe it as "an extremely variable form . . . (including) all the non-rostellate forms in which each bothridium has a double series of loculi." They, however, and Joyeux and Baer (l.c.) recognize it as a distinct species, but Baer (l.c., p. 90) finds it "une espèce collective qu'il est impossible de reconnaître, which is the view of the writer.

4. **Echeneibothrium longicolle** (Linton, 1890) Syn. *Rhinebothrium longicolle*.

This species, from *Myliobatis freminvillei* and *Dasyatis centrura*, is characterized by the large number of testes (150–180) and by the long, well-marked neck, which Baer (l.c., p. 93) defines as a "pédoncule céphalique (whose) structure histologique est bien la même que celle du scolex et non que celle du strobile, (and by) une puissante musculature longitudinale . . . interne du parenchyme corticale . . . in addition to the subcuticular muscles of other species. The cirrus pouch is very long and narrow (0.35–0.36 by 0.037–0.073 mm). In its well-defined neck it resembles *Echeneibothrium urobatidium* (Young, 1955), but as stated there it differs in many important respects from the latter.

5. **Echeneibothrium palombii** (Baer, 1948) Syn. *Rhinebothrium palombii*.

This species from *Dasyatis violacea* is characterized by the single row of 20–22 loculi, by the size of its cirrus sack (0.36 mm long) and by the number of testes (95–100).

6. **Echeneibothrium maccallumi** (Linton, 1924) Syn. *Rhinebothrium maccallumi*.

This species, from *Dasyatis centrura*, is characterized by its few testes (4 or 5), although Southwell (1925) considers it synonymous with *E. tumidulum*, which has 20–25 testes according to Joyeux and Baer (l.c.).

7. **Echeneibothrium burgeri** (Baer, 1948) Syn. *Rhinebothrium burgeri*.

Baer does not give the host of this species, merely stating that it was collected at Woods Hole. According to him it is very near *E. flexile*. The difference in number of testes (30–35 in *burgeri* vs. 14–18 in *flexile*), however, would seem to be distinctive, unless this is a matter of development solely.

8. **Echeneibothrium shipleyi** (Southwell, 1912) Syn. *Rhinebothrium shipleyi*.

Southwell first reported this as a distinct species from *Trygon* (= *Dasyatis kuhli*). Later (1925) he relegated it to synonymy with *Echeneibothrium minimum* because of transverse septa only in the bothridia. Yamaguti (1934, p. 63), however, "on the basis of material from *Dasyatis akajei* which corresponds to Southwell's original description" held that his species was "unquestionably valid." There is no myzorhynchus or neck. Southwell (1930, p. 215) states that "immediately posterior to the head (there) is a swollen bulbous portion, triangular in shape, with the apex passing into the proglottides."

Since *E. shipleyi* has 130 segments, whereas *E. minimum* has only 15, and has over 40 testes, while minimum has about 20 only, the writer agrees with Yamaguti.

9. **Echeneibothrium cancellatum** (Linton, 1890) Syn. *Rhinebothrium cancellatum.*

This species from *Rhinoptera javanica* has three rows of loculi in the bothridia which are mounted on short pedicels, two lateral rows and one median, producing about 21 loculi. Southwell (1925) and Wardle and McLeod (l.c.) accept this species as valid, but some doubt as to its status arises from the observations of Woodland on *Echeneibothrium maculatum.* And Linton himself says (p. 772) "I am in doubt as to whether the number of loculi is always constant." But he goes on to say (p. 775) "the difference between the bothria of *R. cancellatum* and *E. tumidulum* is too profound to admit of reconciliation. No median row of loculi occurs in any of the published figures of *E. tumidulum* . . . while in *R. cancellatum* it is very evident." The cirrus pouch extends a little past the median line, enlarging at its interior end where its diameter nearly equals the segment length. The cirrus is heavily spined, especially at the base, where some of the spines are 0.008 mm long by 0.003 mm broad with sharply recurved and hooked ends. In this respect it suggests *E. minimum*, but the arrangement of the loculi in the bothridia is apparently very different. This and the heavily spined cirrus appear to determine it as a valid species.

10. **Echeneibothrium trifidum** Shipley and Hornell, 1906

This species, from *Trygon walga* (= *Dasyatis walga.*), is characterized by the Y-shaped bothridia with the anterior half cleft longitudinally and divided into 9 loculi in each half, while the basal part has 9 also or 27 in all, viz; 9 large and 18 small. The bothridia are stalked and there is no myzorhynchus.

11. **Echeneibothrium minimum** van Beneden, 1850

This species from *Trygon pastinaca* (= *Dasyatis pastinaca*) has been given as the type of the genus *Echeneibothrium* by Southwell (1925) and Braun (1894–1900), although, so far as the writer can discover, van Beneden did not specify any species as a generic type. He described it as 15–17 mm long and so "grêle" that it was with difficulty discernible to the naked eye. It has only 15 segments. The bothridia are divided "en 8 ou 10 lames qui peuvent se séparer au milieu." A characteristic feature are the heavy spines on the base of the cirrus. "Le bulbe, qui est situé au milieu des quatre appendices, est en génerale peu prononcé dans cette espèce. Des plis se forment sur toute la longeuer des bothridies, et se divisent parfois au milieu par un profond sillon."

12. **Echeneibothrium rankini** (Baer, 1948) Syn. *Rhinebothrium rankini.*

Baer does not record the host of the single specimen on which he based his description further than stating that it came from Woods Hole. He says it most nearly resembles *shipleyi*, both species having a single row of loculi. He considers it to be distinguished "facilement de toutes les autres du genre" (l.c., p. 88), distinguishing it mainly by the size of the cirrus pouch "qui est presque deux fois plus grande chez *R. shipleyi* que chez *R. rankini.*" The proportions which he gives in his table on p. 98 however do not bear out his statement. In *shipleyi* the pouch measures 0.4/0.024 mm, while in *rankini* it measures 0.216/0.09. These figures indicate that in the former the pouch was more extended, while in the latter it was more compressed. Were the shape of the pouch in each species similar it is most likely that the size (i.e., volume) in each would be similar. For this reason, and because Baer's description was based on a single specimen, the writer considers it probable that the two species are identical.

13. **Echeneibothrium julievansium** Woodland, 1927

This species, from *Raja maculata*, based on a single immature specimen, was differentiated from E. *variabile* by the shape of the progottids and the presence of two pairs of excretory vessels, which latter fact was, in Woodland's opinion, "sufficient to disprove the identity" of these two species. In *variabile* there is, according to Woodland, only a single vessel, which is unusual in cestodes, the presence of two pairs of vessels being the usual arrangement. This suggests the possibility of a mistake by Woodland in overlooking the dorsal vessels in *variabile*, they being small and in some cases difficult to detect. Joyeux and Baer (l.c.) recognize E. *julievansium* as a valid species which, according to them, is characterized "par le fait que les quatre bothridies sont globuleuses." (p. 87). It is also recognized by Wardle and McLeod (l.c.) on the basis of its suckerlike bothridia. Not having seen any specimens the present writer hesitates to give it a definite status, preferring to place it in the class of species inquirendae.

14. **Echeneibothrium maculatum** Woodland, 1927

A prominent, permanent "rostellum" (myzorhynchus) is given by Woodland as a characteristic of this species from *Raja maculata*. This has, however, been described for several other species, and, as van Beneden (1850) and Beauchamp (l.c.) have pointed out, the variability of this organ, and the uncertainty even as to its presence, militate against its use as a means of specific determination. The writer finds no character sufficiently definite to determine this as a distinct species, and it is accordingly relegated to the group of species inquirendae.

15. **Echeneibothrium austrinum** Linton, 1924

Linton gives the host of this species as a "large skate (from) Mossel Bay." Southwell (1925) considers it identical with *E. tumidulum*. Linton describes it as having a myzorhynchus and a subglobular scolex with the "bothria united at base, . . . nearly circular in outline and provided with small loculi" (p. 14) indeterminate in number. There is no neck. The cirrus is "armed with closely set spines. Vitellaria massive at side mainly in front of the level of the cirrus pouch, but also continuing to the end of the proglottides" (p. 15). The length of two strobiles was 24 and 32 mm, respectively, while two scolices measured 0.21 and 0.26 mm in diameter. In the writer's opinion there is nothing distinctive in Linton's description and he believes this form should be placed among species inquirendae.

16. **Echeneibothrium insignia** (Southwell, 1911)
Syn. *Rhinebothrium insignia*.

In his monograph Southwell (1925) stated that on reexamination of his material he believed this species from *Trygon* (= *Dasyatis*) *warnak* to be identical with *Echeneibothrium flexile*, but Baer (l.c., p. 95, footnote 1) has pointed out that Southwell's figure 138 is totally different from his figure 139 in the form of the ovary, and especially in the number and distribution of the testes, though both of these figures refer to *E. flexile* (= *R. insignia*). In the light of these uncertainties the writer is inclined to refer *insignia* to species inquirendae.

17. **Echeneibothrium javanicum** Shipley and Hornell, 1906

This species is described by these authors as 9–12 mm long with a neck that occupies one-third to one-half the length of the strobile, pedunculate bothridia divided into 29 loculi by two long, and several transverse ridges, lacking a myzorhynchus and with a cirrus minutely spined. In its three rows of loculi it resembles *E. cancellatum*, both from the same host, *Rhinoptera javanica*, but the heavily spined cirrus of *cancellatum* distinguishes clearly between these two species.

18. **Echeneibothrium hornelli,** new name for **T. javanicum** Shipley and Hornell, 1906
Syn. *Tiarabothrium javanicum*.

This species is described as 11–12 mm long with sessile bothridia divided into 12 loculi by transverse septa only. The neck has a definite collar and the cirrus is minutely spined. It also is a parasite of *Rhinoptera javanica*. Regarding it Southwell (1925, p. 212) says: "the species . . . appears to be indistinguishable from *E. minimum* . . . except that in the former there is a well-developed myzorhynchus", apparently overlooking the characteristic cirrus in the latter species. The description of this species is inadequate for a comparison with others and the writer accordingly refers it to the list of species inquirendae.

19. **Echeneibothrium trigonis** Shipley and Hornell, 1906

In this species from *Trygon walga* (= *Dasyatis walga*) the bothridia are sessile and are divided into 7 or 8 loculi by transverse partitions only. It varies in length from 8 to 15 mm. The "stout, unsegmented neck is a good deal broader than the succeeding segmented parts" (p. 81). The authors do not describe the cirrus or give the testes number so that an exact comparison with other species is impossible.

20. **Echeneibothrium myzorhynchum** Hart, 1936

This species, from *Raja binoculata*, is defined by the author as possessing a well-developed myzorhynchus, pedunculate bothridia with ten transverse loculi and ten or twelve testes located in the anterior part of the proglottid. It has a maximum length of 15 mm, with 64 distinct proglottids. The author states (p. 495) that it "is separated from all species of *Echeneibothrium* excepting *E. minimum* . . . by the fact that the bothridia are divided only by transverse septa," but his figure 6 shows a longitudinal septum very clearly, with nine pairs of loculi and two at the ends, making 20 in all. In its large myzorhynchus and cirrus sack it resembles *E. variabile* but is smaller (15 mm and 64 proglottids compared with 35–70 mm, according to Joyeux and Baer, and at least 100 segments according to van Beneden in *variabile*). Hart does not give the number of specimens examined by him, so that it is doubtful how comprehensive his data are. Another similarity between *myzorhynchum* and *variabile* is the spiny cirrus.

Whether the differences in size and testis number are sufficient to separate these two species is, in the writer's opinion, doubtful, so that he prefers to relegate *myzorhynchum* to species inquirendae.

21. **Echeneibothrium dubium** van Beneden, 1858

From *Raja batis*. Van Beneden lists the characters separating *E. dubium* from *E. minimum* and *E. variabile* as follows: (1) In *dubium* the bothridia are borne on long peduncles and have few (6–8) areolae; (2) the myzorhynchus is more slender than in *variabile*; (3) the form of the spines on the cirrus is different from that in *minimum* and *variabile*; (4) it occurs in a different host. In van Beneden's figures 3 and 12 the spines on the cirrus of *E. dubium* are shown in comparison with those of *E. minimum*. Both are of about the same length, those of the latter being somewhat stouter. Whether these differences are sufficient to separate the two species is, in the opinion of the writer, doubtful, and he is therefore in agreement with Southwell (1925) who considers *dubium* and *minimum* synonymous, in spite of the opinion of Joyeux and Baer (l.c.) who consider *dubium* a distinct species.

22. **Echeneibothrium sphaerocephalum** (Deslongchamps, 1824)

Syn. *Bothriocephalus sphaerocephalus.*

According to Diesing (1863) this species, from *Raja clavata*, has oval, pedunculate, multiloculate bothridia, with transverse septa and a spherical myzorhynchus. It measures 25–50 mm. No figure is given and, from the brief account, identification is impossible.

23. **Echeneibothrium gracile** Zschokke, 1889

This species, from *Dasyatis clavata*, measures up to 12 mm in length. The bothridia are borne on short, thick stalks and are divided into 14–18 loculi by a longitudinal and several transverse septa. There is a short, swollen myzorhynchus. The cirrus pouch extends to the middle of the segments, which are 30–50 in number. The end of the cirrus is spined. There are not over 25 large testes situated in front of the genital ducts. In the absence of any distinguishing features the writer regards this as one of species inquirendae.

24. **Echeneibothrium tobigei** Yamaguti, 1934

According to Baer (l.c.) this species, from *Myliobatis tobigei*, is very close to, if not identical with *Rhinebothrium longicolle*, the presence of a vaginal sphincter in the latter and its absence? in the former being apparently the only distinguishing? feature. Length of neck (36 mm in *tobigei*, 7 mm in *longicolle*) is another difference, but to what extent this was determined by the state of contraction or expansion in specimens of the two species is uncertain. According to Yamaguti the bothridia have transverse partitions only which would seem to separate it from *longicolle*, but his figure 92, page 61, shows a double row with a median partition. The testis number is 140–160. In the writer's opinion the two are synonymous.

25. **Echeneibothrium ceylonicum**, Shipley and Hornell, 1906

In this species, from *Trygon walga* (= *Dasyatis walga*), the bothridia are mounted on short stalks and have 14 loculi. It has a neck of fair length, and the strobile is 8 to 25 mm long. The gonopore is "median." Southwell (1925) identifies it with *tumidulum*. Since the latter is probably a complex of species it is fairly safe to identify it with any one of a number of others.

26. **Echeneibothrium ceylonicum** (Shipley and Hornell, 1906)

Syn. *Rhinebothrium ceylonicum.*

The second of these species from *Trygon* (= *Dasyatis*) *Kuhli* and *T. walga* is described as having the bothridia mounted on very short stalks "if indeed they exist at all. Each bothridium is divided by a long and several transverse partitions into about 20 loculi. Southwell (1925) places it in *Phyllobothrium lactuca*, the production of apparent areolae being due to the "folding and frilling of the somewhat thickened margin of the bothridium in precisely the manner shown by van

Beneden" in the latter species. These two species, *E. ceylonicum* and *R. ceylonicum*, are, in the opinion of the writer, synonyms and homonyms, and since *R. ceylonicum* has priority over *E. ceylonicum*,[2] the former name must stand for both species which, in the writer's judgement, lack any characteristic features and are therefore relegated to the status of species inquirendae

27. **Echeneibothrium affine** Olsson, 1867

This species from *Raja radiata* and *R. batis* is also, in the writer's opinion, not well enough defined to entitle it to specific rank. It is therefore allocated to species inquirendae.

28. **Echeneibothrium walga** Shipley and Hornell, 1906

One specimen only, which was ripe, was found by these authors in *Trygon* (= *Dasyatis*) *walga*. It was 7 mm long. Each bothridium is hinged in the middle similar to those of *E. flexile*, and each is divided by a long and several transverse partitions into about 24 loculi. While only a single specimen was available for study the hinged bothridia apparently make this identical with *E. flexile*, which is the view of Southwell (1925, 1930).

29. **Echeneibothrium myliobatis-aquilae** Diesing, 1863

Neither Diesing or Wedl (1855) gives any account of this species other than a description of the eggs. Zschokke (1889) found fragments of a worm in *Mylibatis aquila* which he thought might belong to this species, but he could not definitely locate it in *Echeneibothrium*.

30. **Tritaphros retzii** Lönnberg, 1889

This species, from *Raja clavata*, is considered by Southwell (1925) as possibly synonymous with *E. tumidulum*, but a comparison of his figures 132 and 133 shows at a glance the improbability of such a comparison. It may be identical with *Trilocularia gracilis* (Olsson 1869).

31. **Echeneibothrium** sp. Beauchamp, 1905

This species, from *Raja punctata* and *R. macrorhynchus*, is characterized by a large, extremely variable myzorhynchus. In certain aspects it resembles *E. dubium* of van Beneden (1858) but differs therefrom in the number of its loculi and segments. The bothridia are "à peu près semblables" to those of *E. variabile*, but when elongated their transverse folds may disappear (p. 525). The loculi are 6 or 7 in number on each side. The neck, separated from the strobile by a slight constriction, is "très grêle ainsi que le corps." No details of internal structure are given and, in the light of Beauchamp's uncertainty as to its classification and the lack of more adequate data, the writer must relegate it to the list of species inquirendae.

[2] See Shipley and Hornell (l. c., pp. 71 and 82).

32. **Echeneibothrium simplex** Shipley and Hornell, 1906

In this species, from *Trygon walga* (= *Dasyatis walga*), the loculi are restricted to the borders of the bothridia. Southwell (1925) considers it synonymous with *Anthobothrium, variabile* an opinion with which the writer concurs.

33. **Echeneibothrium bifidum** Yamaguti, 1952

This species is of interest as the only one recorded thus far in teleosts, to the writer's knowledge. He has, however, found specimens of the genus in an *Atherinops* in southern California and in toadfish (*Opsanus tau*) in the Gulf of Mexico and Chesapeake Bay, the latter of which is awaiting description. It seems remarkable that there are not more records of the genus in teleosts, since it occurs commonly in selachians which prey upon the latter.

Yamaguti's description was based on a single specimen from *Trachurus trachurus*. In its 12–13 transverse, and two longitudinal septa in the bothridia it suggests *E. cancellatum*, but the bilobed bothridia set it apart from that or any other species known to the writer with the possible exception of *E. flexile* and of *E. bi-lobatum* Young, 1955.

34. **Echeneibothrium multorchidum** Young, 1954

This species occurs in the stingray (*Urobatis halleri*) in southern California. It is characterized by the number of testes together with the stalked bothridia which are divided into about 38 loculi by one long, and several transverse partitions. There is no evident myzorhynchus. It shows considerable resemblance to *Rhinebothrium burgeri* (Baer, 1948), but differs from the latter in size and in number of loculi (38 vs. 48–50 in *burgeri*). Available specimens of *E. multorchidum* were not ripe, but it apparently is much shorter and has fewer segments than the former.

35. **Echeneibothrium urobatidium** Young, 1955

This species also occurs commonly in the stingray. It is apparently one of the complex hitherto included in the species *E. tumidulum* but differs from the published accounts of the latter in three respects: (1) Form of strobile. In *tumidulum* the anterior proglottids are conspicuously wider than long, while in *urobatidium* the difference is not nearly so noticeable. (2) The number of proglottids is much smaller in the latter than in the former (about 50 in *urobatidium*, over 200 in *tumidulum*). (3) The testes are 10–12 in *urobatidium*, 20 in *tumidulum*. In its distinct neck it resembles *Echeneibothrium longicolle* but differs from the latter in testis number and in other important respects.

36. **Echeneibothrium bilobatum** Young, 1955

This curious little species from *Urobatis halleri*, a description of which was based on a single immature specimen, resembles *E. flexile* and *E. bifidum* in the bi-lobed bothridia. The two lobes however are different in size, which clearly sets it off from either. It is peculiar in the small number of testes judging from the single specimen available, which are arranged in a single line. In this respect it resembles *E. maccallumi* but differs from the latter in its bi-lobed bothridia and in other ways. It is similar to *E. minimum* and *E. shipleyi* in having transverse septa only in the bothridia, but is very distinct from them in other respects. There is no evident myzorhynchus or distinct neck. There were about 25 proglottids in the specimen observed.

37. **Echeneibothrium** sp.

An *Echeneibothrium* occurs commonly in the toadfish reference to which has already been made.[3] The cysts containing the scolices are located mostly around the rectum. The bothridia have transverse septa only dividing them into about 22 loculi and are borne on stalks about one-half the length of the bothridia themselves.

38. **Echeneibothrium octorchis** Riser, 1955

This species, from *Raja montereyensis*, is characterized by its few (7–9) testes and small strobile. It has 10 loculi in the bothridia which are armed, as are the pedicels, with small curved hooks. The cirrus is covered with fine hairs.

39. **Echeneibothrium dolichoophorum** Riser, 1955

This species, from *Raja rhina*, is characterized by its large myzorhynchus and the long, narrow ovarian wings. The bothridia are 10-loculate.

[3] See p. 256.

40. **Echeneibothrium macrascum** Riser, 1955

In this species from *Raja montereyensis* the pedicels are attached to the posterior borders of the bothridia. There is a massive cirrus sack and a long, much-coiled ejaculatory duct.

SYNONYMY

The following table gives the various synonymies found in the literature:

Echeneibothrium flexile:

- *Rhinebothrium flexile* Linton, 1890
- *Rhinebothrium insignia* Southwell, 1911
- *Echeneibothrium walga* Shipley and Hornell, 1906

Echeneibothrium tumidulum:

- *Bothriocephalus (Tetrabochrium) tumidulus* Rudolphi, 1819
- *Bothriocephalus echeneis* Leuckart, 1819
- *Echeneibothrium variabile* van Beneden, 1850
- *Echeneibothrium affine* Olsson, 1867
- *Echeneibothrium gracile* Zschokke, 1889
- *Echeneibothrium ceylonicum* Shipley and Hornell, 1906
- *Echeneibothrium austrinum* Linton, 1924
- *Echeneibothrium minimum* van Beneden, 1850
- *Rhinebothrium maccallumi* Linton, 1924
- *Rhinebothrium longicolle* Linton, 1890
- *Tritaphros retzii* Lönnberg, 1889
- *Petalocephalus tumidulus*

Echeneibothrium walga:

- *Rhinebothrium flexile* Linton, 1890

Echeneibothrium insignia:

- *Caulobothrium insignia* Baer, 1948
- *Rhinebothrium insignia* Southwell, 1911
- *Echeneibothrium flexile*

Echeneibothrium minimum:

- *Echeneibothrium sphaerocephalum* (Deslongchamps, 1824), Diesing, 1863
- *Echeneibothrium trigonis* Shipley and Hornell, 1906
- *Tiarabothrium javanicum* ibid.,
- *Rhinebothrium shiplyei* Southwell, 1912
- *Rhinebothrium palombii* Baer, 1948
- *Echeneibothrium dubium* Beneden, 1858
- *Anthobothrium ceylonicum* Southwell, 1912

Echeneibothrium cancellatum:

- *Rhinebothrium cancellatum* Linton, 1890
- *Echeneibothrium javanicum* Shipley and Hornell, 1906

Echeneibothrium sphaerocephalum:

- *Bothriocephalus sphaerocephalus* Deslongchamps, 1824
- *Tetrabothrius sphaerocephalum* Diesing, 1863
- *Echeneibothrium variabile* van Beneden, 1850

Echeneibothrium variabile:
Echeneibothrium sphaerocephalum Diesing, 1863
Bothriocephalus echeneis Leuckart, 1819
Tetrabothrium variabile (van Beneden, 1850), Diesing, 1854

Echeneibothrium tobigei:
Rhinebothrium longicolle Linton, 1890

Echeneibothrium simplex:
Anthobothrium variabile (Linton, 1889), Southwell, 1925

Echeneibothrium longicolle:
Rhinebothrium longicolle Linton, 1890
Caulobothrium longicolle Baer, 1948

Echeneibothrium ceylonicum:
Rhinebothrium ceylonicum Shipley and Hornell, 1906; *Phillobothrium lactuca* Beneden, 1850

Echeneibothrium palombii:
Rhinebothrium palombii Baer, 1948

Echeneibothrium fallax:
Discobothrium fallax Beneden, 1871
Echeneibothrium variabile (Monticelli, 1890)

Echeneibothrium maccallumi:
Rhinebothrium maccallumi Linton, 1924
Echeneibothrium tumidulum Rudolphi, 1819

Echeneibothrium burgeri:
Rhinebothrium burgeri Baer, 1948

Echeneibothrium shipleyi:
Rhinebothrium shipleyi Southwell, 1912
Echeneibothrium minimum

Echeneibothrium rankini:
Rhinebothrium rankini Baer, 1948

Echeneibothrium austrinum:
Echeneibothrium tumidulum.

SUMMARY

In this paper a discussion has been given of the genus *Echeneibothrium*, its relation to other genera, and a list of species hitherto described, 18 of which are recognized by the writer. The following key should aid in their identification.

Bothridia hinged........................(1) *flexile*
Bothridia not hinged........................A
A. Bothridia lobed........................B
Bothridia not lobed........................C
B. Lobes equal........................(2) *bifidum*
Lobes unequal........................(3) *bilobatum*
C. Bothridia tripartite........................(4) *trifidum*
Bothridia entire........................D
D. Bothridia with transverse partitions only...E
Bothridia with both transverse and long partitions........................G
E. Base of cirrus with heavy spines, 15 segments (5) *minimum*
Base of cirrus without such spines........F
F. 10 loculi,[4] about 40 testes.........(6) *shipleyi*
20–22 loculi,[4] 95–100 testes........(7) *palombii*
G. Myzorhynchus large[5]........................H
Myzorhynchus absent or small..............I
H. Testes more than 16..............(8) *variabile*
Testes less than 16, ovary with long wings (9) *doliochoophorum*
I. Bothridia with loculi in 3 rows............J
Bothridia with loculi in 2 rows............K
J. Cirrus heavily spined........(10) *cancellatum*
Cirrus minutely spined........(11) *javanicum*
K. Testes more than 100...........(12) *longicolle*
Testes less than 100........................L
L. Testes 30 or more........................M
Testes less than 30........................N
M. Bothridia with 48–50 loculi,[4] length 8 mm (13) *burgeri*
Bothridia with 38 loculi,[4] smaller (14) *multorchidium*
N. Testes 20–23..................(15) *macrascum*
Testes 10–12..................(16) *urobatidium*
Testes 7–9........................(17) *octorchis*
Testes 4 or 5..................(18) *maccallumi*

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[4] See p. 256.
[5] While the variability of the myzorhynchus militates against its use in classification, it seems to be the best means for this purpose here.

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The practical man is the man who practices the errors of his forefathers.—Huxley.

GEOLOGY.—*A hydrologic budget in relation to the climate and geology of the Beaverdam Creek basin, Eastern Shore of Maryland.*[1] GORDON E. ANDREASEN and WILLIAM C. RASMUSSEN. (Communicated by A. N. Sayre.)

(Received June 27, 1956)

The Beaverdam Creek basin on the Eastern Shore of Maryland was selected for a detailed quantitative study of the hydrologic cycle. The object was to determine the apportionment of precipitation into direct surface runoff, ground-water recharge (and, later, ground-water discharge in the form of surface runoff), and evapotranspiration. The land surface, the soils, and the ground-water conditions are representative of much of the sandy portion of the Atlantic Coastal Plain, and the humid mesothermal climate is typical of the eastern United States.

The drainage basin, covering an area of 19.5 square miles, is relatively flat, consisting of low marine terraces. The ground-water reservoir that is of significance extends from the land surface to depths of 75 to 175 feet below the surface; it is underlain by a relatively impermeable clayey silt which prevents appreciable water loss through leakage into deeper aquifers, or gain by leakage from them.

Weekly measurements of precipitation, total stream runoff, surface-water storage, ground-water stage, and soil resistivity (the latter as a guide to soil-moisture content) were made during a 2-year period, April 1, 1950, to March 28, 1952. Instrumentation consisted primarily of 25 driven observation wells, 12 rain gages, a stream-gaging station, 5 staff gages on surface streams, and 3 soil-resistivity stations.

The hydrologic measurements are summarized in two budgets, a total budget and a ground-water budget. The total budget of the hydrologic cycle is represented by the equation

$$P = R + ET \pm \Delta SW \pm \Delta SM \pm \Delta GW$$

where P is precipitation, R is runoff in streams, ET is evapotranspiration, ΔSW is change in surface-water storage, ΔSM is change in soil-moisture storage, and ΔGW is change in ground-water storage. The last term, ΔGW, is a function of ground-water stage, or

$$\Delta GW = Y_g \cdot H$$

where H is ground-water stage and Y_g is the gravity yield, or yield under transient drainage of the saturated sediments. The quantities ET and Y_g are unmeasured but not entirely unknown. They are arrived at by a method of convergent approximations, presented as one of the contributions of this paper.

The ground-water budget is represented by the equation

$$G_r = D \pm \Delta H \cdot Y_g + ET_G$$

in which G_r is ground-water recharge, D is ground-water runoff, ΔH is the change in mean ground-water stage, Y_g is gravity yield, and ET_G is the ground-water evapotranspiration. The qualtities G_r and D for each were derived from the hydrograph of the mean ground-water stage and from extrapolated ground-water recession curves and base-flow rating curves (obtained by plotting the mean ground-water stage against the base flow of the stream). The weekly difference between the mean ground-water stage, ΔH, multiplied by the gravity yield, Y_g, gives the net change in ground-water storage. The equation was then solved for ET_G. This method is presented as a second contribution.

The total precipitation during the 2-year period (104 weeks) was 82.83 inches, of which 29.88 inches ran off in the creek, 50.24 inches was evaporated and transpired, and 2.71 inches went into a gain in storage. The change in ground-water storage was 2.66 inches, that in surface-water storage, 0.04 inch, and that in soil-moisture storage, 0.01 inch.

Ground-water recharge totaled 42.63 inches disposed of as follows: ground-water runoff into the creek, 21.46 inches; ET_G

[1] Abstract of a paper presented on January 25, 1956, before the Geological Society of Washington.

19.45 inches; and $\Delta H \cdot Y_g$ (GW), +1.72 inches (different from figure of 2.71 given above because based on a period of 104.4 weeks instead of exactly 104 weeks).

It is concluded that abundant rainfall and high infiltration rates provide this portion of the Atlantic Coastal Plain with large quantities of water, which are discharged about equally in the form of runoff and by evapotranspiration. Recovery of water discharged by nonbeneficial plants, or as unused streamflow, would permit great expansion of water facilities for irrigation, industry, or municipal supply.

E. D. Merrill

Elmer Drew Merrill was for his time probably the most widely known botanist in the world. At the International Botanical Congress at Amsterdam in 1935 he literally sat in the center of the world's leaders in plant taxonomy and, through his directorship of important botanical institutions, of persons engaged in botany generally. In 1954 he was honorary president of the Eighth International Botanical Congress at Paris. On the occasion of his seventieth birthday he was called the 'American Linnaeus' for the breadth and detail of his mastery of the field of plant classification, for his originality and ability in methodological and administrative work, and for his ready desire to assist his fellow workers the world over in what was then described as an "often astonishingly effective way."

What may be Merrill's place in the history of botany as written a hundred years from now? Will it be his invention of the 'Merrill case' (cf. Torreya **26:** 50–54. 1926), a highly useful storage carton designed during his Manila years for herbarium filing? Will he be remembered for advocating the naming of periodicals with single word titles? Though he did not originate it he certainly traditionalized the practice in *Hilgardia*, *Brittonia*, and *Arnoldia*. Or will workers using the loose-leaf ledger form of *Index Kewensis* in our larger botanical libraries recall the man who initiated this clever device? Certainly those who use the offset reprint editions of hard-to-obtain botanical titles, like those of Rafinesque and Gronovius, will owe him a debt of gratitude. Taxonomists of the Twenty-first Century engaged in tracing types and in writing floras of southeast Asia and Polynesia will be using his commentaries on the works of Blanco, Loureiro, and Rumphius, not forgetting the bibliographies that he, sometimes in collaboration with Dr. E. H. Walker, assembled. Perhaps by that time there will be such urgent need of these bibliographic tools, from the increment of publication down the years, that their now oft-times reluctant financing will have yielded to ready support. Merrill's *Index Rafinesquianus* (1949) will have stood for a century beside essential tools of the taxonomist, and his labor in bringing together all the vicarious names published by that unhappy and confounding naturalist Rafinesque will be appreciated.

It will be particularly interesting to learn the Twenty-first Century's verdict on his most controversial innovation: herbarium inserts of taxonomic literature. Will its "great utility and eminent practicability" have been realized? Will his insistence that to incorporate the references into the herbarium adds a card catalog and a library to the herbarium thus making a single working unit for the taxonomist be gainsaid? In 1937 Merrill declared, "I am convinced that this innovation is one of the most important advances made in herbarium technique in the last few decades." Or will his best known memento be that graceful, feather-leaved, smooth-trunked palm *Adonidia merrillii* named for him by Beccari? With its spectacular bunches of bright red fruits each resembling a plum, this palm is a native of Palawan, P. I., and now grown on the streets of Manila, but only as a novelty in our southern Gulf Coast cities. Perhaps a hundred years from now it will decorate our gardens as a commonplace. Will 'Merrill's palm' be a part of daily speech tomorrow with as slight awareness of its association as 'Johnson grass' is today?

Of the numerous tribe of Merrills of Maine, whose roots took hold on this continent in 1635, Elmer Drew Merrill was one of twins born on October 15, 1876, the last of a family of five children. The four boys milked the cows, planted, weeded, and hoed potatoes, and dragged the fields for rocks, rocks, and more rocks. At Maine State

College (later the University of Maine) he came under the influence of Prof. F. L. Harvey. In 1898 he took his B. S. degree and returned as an assistant in natural sciences the next fall. In July 1899 he accepted the position of assistant agrostologist at Washington under F. Lamson-Scribner. It seems from the frank autobiographical sketch that Merrill has left us (Asa Gray Bull., n. s., **2:** 335–370. 1953) that Lamson-Scribner's confidence in him far exceeded his own. Though he accomplished a good deal at his government job and might well have remained in the service in Washington, the opening of the Bureau of Agriculture in Manila enticed him to take a position as botanist there. Again he was strongly encouraged by Lamson-Scribner. He left New York on February 22, 1902, for Manila to remain, with few respites, for 22 years. During those years he explored all parts of that archipelago, as well as parts of Java, Borneo, the Malay Peninsula, and southern and eastern China. Merrill described approximately 4,000 species of plants based principally on this experience. The quintescence of these years went into *Plant life of the Pacific world* (1945), a book which Fairfield Osborn aptly described as "an extraordinary accomplishment."

Merrill was always alert to weeds. When he arrived in Manila he found very few plant collections at hand for comparison with the specimens he brought back to the laboratory. He set about collecting the weeds of the Bureau of Agriculture grounds, only to discover that in many instances the endemic plants of southeast Asia were much better known taxonomically than these shifting populations of the sidewalks. Years later he carried his study of immigrant plants much further, checking the collections made on Cook's voyages in the South Pacific to determine the date of introduction of these weeds. In large part his quest was successful, and his last book, *The botany of Cook's voyages* (1954), musters his data in highly readable though somewhat repetitious chapters, and documents the proposition that "pre-Columbian civilizations in America were based absolutely and wholly on a strictly American agriculture, which in turn was based wholly on native American plants." Merrill wrote persuasively, and in this book as in the 23 essays gathered by Dr. Verdoorn and published in 1946 as *Merrilliana* (Chronica Botanica **10:** 127–394) his skill is attested. The plant geographer and ethnobotanist cannot afford to ignore them.

Detailed accounts of his life will appear, but there remains a facet of Dr. Merrill's life that may slip away as those who knew him personally follow him into history: the warm enthusiasm he lived for our enticing science. This was both an international and a personal quality, as the Dutch botanist Dr. Lanjouw has pointed out, and endeared him to a wide circle of men. If he believed a project was a worthy one, he spared no time nor effort actively to push for its completion. Writing hundreds of letters of recommendation sponsoring candidates for fellowships, grants-in-aid, and positions far and near, imaginatively arranging funds for a graduate student to make a field trip that he appreciated so well would stimulate years of productive botanical work, making introductions for distant workers who but for his interest would have continued to work in isolation—these were some of the ways that Dr. Merrill implemented his spirit of service in science. However, it would not be factual to omit he did nettle some of his associates: I remember Professor Jepson's wrath when, in his bumptious enthusiasm, Merrill broke into a supper party that Jepson had planned for a few select friends at a small pub on Kew Green. His professional colleagues, not a little piqued with envy at Merrill's tenacious work habits, gave slight support to many of his expansive plans as being unrealistic and too meddlesome in the research programs of others. Anyway, innovators are irksome. 'To get-the-job-done' philosophy as often as not forgets the cushion in the chair.

The governor-general of the Philippine Islands, Leonard Wood, wrote a judgment of Merrill in 1924 which may well stand: "You have done first class work in everything you have attempted and have gained the confidence, respect and support of those with whom you have come in contact." After a full year of conferences and research abroad in 1951 he slowed down appreciably. He felt he "really should finish certain projects without too much delay." "And yet," he wrote, "I am not ready to agree entirely with the last sentence of Thackeray's *Vanity Fair*: 'Come children, let us shut up the box and the puppets, for our play is played out.'"

JOSEPH EWAN

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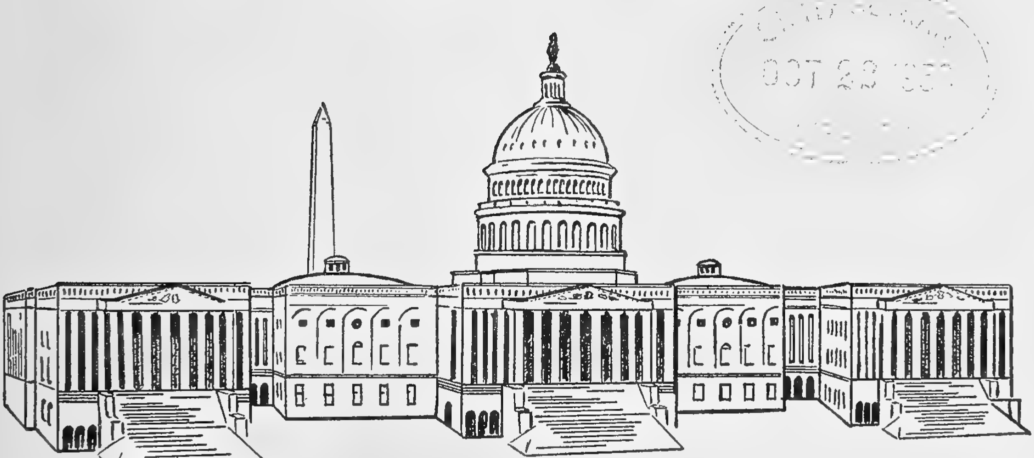

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PHYSICS.—*Incomplete equilibrium and temperature measurement.* C. M. Herzfeld, National Bureau of Standards.

(Received August 3, 1956)

ABSTRACT

The concept of temperature is discussed from the points of view of classical thermodynamics and statistical mechanics. The relation between relaxation phenomena and temperature measurement is explained, and several examples discussed qualitatively. Some methods for the measurement of temperature are examined in terms of the relation between relaxation and temperature. The methods considered cover several distinct types of situations encountered at high temperatures, and estimates are given of the reliability of the more modern methods.

INTRODUCTION

Interest in temperature and in its measurement is growing rapidly. This in large part is because of two recent trends. First, technology makes growing demands on scientific technique because of the high temperatures obtained in jet and rocket motors, and in nuclear devices. Second, progress in the statistical mechanics of nonequilibrium phenomena is opening new areas to scientific study. This article summarizes some aspects of the interplay of these trends. To do this we outline first the thermodynamic definition of temperature. Then we present the viewpoint of statistical mechanics, and last we apply this to a number of recent scientific and technical problems.

The detailed statistical mechanical theory requires considerable technical background, but it seems possible and desirable to bring the underlying ideas to a wide audience by discussing a number of recent applications of the theory to temperature measurements. The literature on the subject is very extensive, therefore we give chiefly references to review articles and symposia where the interested reader can find more details.

TEMPERATURE IN CLASSICAL THERMODYNAMICS

The problem of defining temperature is old and vexing. The usual procedure [*1*] starts with the notions "hotter" and "colder," assumes that they are given directly by experience, and does not attempt to define them. (Every logical system has primitive ideas which must be assumed without full definitions.) Two bodies are then said to be in thermal equilibrium if, when brought into close contact, they do not change their hotness or coldness. The so-called zeroth law of thermodynamics asserts that two bodies in thermal equilibrium with a third are in thermal equilibrium with each other. This permits one to choose a "standard body" and say that all bodies in thermal equilibrium with the standard have a particular property in common with it, namely the temperature. Some *empirical* temperature scale is then chosen, based, for example, on the thermal expansion of a metal or of a gas. The *thermodynamic* temperature scale is usually defined using an idealized steam engine running on a Carnot cycle. This steam engine and its cycle are a logical device for showing that the thermodynamic temperature is best considered the reciprocal integrating factor which changes the heat absorbed by the working gas in the engine, δQ (an *inexact* differential), into the *exact* differential dS, the entropy increase:

$$dS = \frac{1}{T}\,\delta Q. \qquad (1)$$

This approach can be generalized to any process and cycle, and makes possible a description of processes which does not depend on the paths taken but only on their end points.

The most rigorous discussion of temperature viewed as an integrating factor is due to Caratheodory [*2*]. His theory sheds much light on classical thermodynamics, but a description of it is out of place here.

The logically rigorous arguments establishing thermodynamic temperature apply to no *realizable* situations whatever because the temperature is defined only for *equilibrium* states and *reversible* processes. No actual system can be in perfect equilibrium, and every realizable process is irreversible. Many realizable systems are so close to equilibrium that ordinary thermodynamics can be used to calculate their properties. To find a justification for applying thermodynamics to real processes, and at the same time to explain why such application works so often, the viewpoint must be changed slightly, and in particular the notion of rates of processes must be introduced. The notion of rate is foreign to classical thermodynamics, but an examination of the concept of temperature in statistical mechanics will indicate how to use the results of thermodynamics.

TEMPERATURE IN STATISTICAL MECHANICS

Statistical mechanics studies systems which are composed of very many particles and have very many degrees of freedom. One gram of hydrogen gas at 0°C. and atmospheric pressure has approximately 18×10^{23} classical degrees of freedom. If one takes into account also the quantum degrees of freedom of the nuclear spin the total number is four times the above. Each state of each molecule has a characteristic total energy. Statistical mechanics shows [*3*] that, at equilibrium, the ratio of the average number N_i of molecules in the ith state, to the average number N_j in the jth state is given by

$$N_i = N_j e^{-W_{ij}/kT} \tag{2}$$

where W_{ij} is the difference in the energy of the states, k is the Boltzmann constant, and T the absolute temperature. The factor $e^{-W_{ij}/kT}$ is the Boltzmann factor, a distribution function giving the relative population of all the states of the system. This definition of T is fundamentally the same both in classical and quantum systems. In the classical case W_i can take on any value in a continuous range of numbers, and in the quantum case it can take only values from a set of discrete numbers. The simple arguments required to establish (2) apply again only to equilibrium systems.

Systems whose distribution functions differ from the Boltzmann type are the subject of irreversible statistical mechanics [*4*]. There it can be shown that systems whose distribution functions differ from the Boltzmann type change in such a way as to approach a Boltzmann distribution, in other words they approach equilibrium. If the initial departure from a Boltzmann distribution is not too great, then the differential equations which govern the changes in population may be fairly simple [*5*]:

$$\frac{dN_i}{dt} = f(N_i, N_{i\pm 1}, \cdots) \tag{3}$$

where N_i is the population of the ith state. The function $f\ (N_i, N_{i\pm 1}, \cdots)$ involves each population only to the first power if the system is sufficiently simple. Each N_i is multiplied by a characteristic rate constant which depends on the mechanism by which equilibrium is reached (such as collisions). For very simple systems these rate constants are related, and equation (3) can be rewritten:

$$\frac{dN_i}{dt} = \frac{1}{\tau} \sum_j a_j N_j \tag{4}$$

where τ is the so-called relaxation time, a constant which is characteristic of the system and gives the rate with which the system "relaxes" to the equilibrium distribution. A large τ means a slow approach to equilibrium. The sets of differential equations resulting from (4) can then be solved and the behavior of the system followed in time as it approaches equilibrium [*6*].

These ideas can now be applied to the study of temperatures. As an example consider a gas of atoms in a container, the whole immersed in a cool bath. Two rates will be important: First, the rate at which the gas would relax from a nonequilibrium distribution if the container walls were perfect insulators. The mechanism for this is the collision of the molecules, and τ_i is its relaxation time (i for internal). Second, the rate at which the container wall conducts heat away from the gas. Let this rate be characterized by a relaxation time τ_e (e for external). The actual changes in the system are then governed by the ratio τ_i/τ_e as well as by the initial conditions. If τ_i/τ_e is very small, the gas loses energy slowly through the walls but readjusts its distribution function continuously, which will then be practically of Boltzmann type, and at any one time the temperature of the gas will be a quite definite quantity which changes slowly in time because of the heat leak. This is the type of situation required for calorimetric work. If τ_i/τ_e is large, however, the heat leaks away faster than the gas can readjust. Temperature gradients are then set up in the gas, which start convection. The resulting complicated changes in the gas cannot be treated in detail by present statistical mechanical theory. In small portions of the gas, however, local equilibrium will exist, so that different portions of gas may have well-defined, though different, temperatures.

Or consider a solid at a temperature near 0°K. This solid consists of atoms which vibrate about their equilibrium positions (system A) and of the nuclear spins of the atoms (system B). Let the time for A to come to equilibrium with itself be τ_A, similarly for B, τ_B. Let the interaction of the systems be characterized by τ_{AB}, and let $\tau_B \ll \tau_{AB} \gg \tau_A$. Now remove some energy from the spin system B, say by isothermal magnetization followed by adiabatic demagnetization. Then the spins will come to equilibrium with each other very rapidly and their magnetic susceptibility will indicate a very low temperature. However, they interact so poorly with the lattice (τ_{AB} is large, of the order of hours) that the lattice temperature is essentially unaffected, and it makes sense to speak separately of a spin temperature T_S and a lattice temperature T_L, which are defined by equation (2) or by an analogous one.

Another type of example is afforded by a polyatomic gas in an ideally insulating enclosure. The motions of each molecule can be described to a good approximation by treating each type of degree of freedom separately, i.e., translation of the molecule as a whole, vibrations of the molecule, and its rotations. The total energy is the sum of the translational (W_t), the vibrational (W_v), and the rotational energy (W_r). The distribution functions may then be written [7]:

$$\left.\begin{aligned} N_{tvr} &= Ce^{-W/kT} \\ &= Ce^{-[W_t+W_v+W_r]/kT} \\ &= C(e^{-W_t/kT_t})(e^{-W_v/kT_v})(e^{-W_r/kT_r}). \end{aligned}\right\} \quad (5)$$

At equilibrium the same values of T will occur in each factor, *i.e.*, $T_t = T_v = T_r$. It happens, however, in many physical processes that one type of motion is affected more than another. For example, an ultrasonic wave passing through a gas may "heat up" the translations and rotations of the molecules without affecting the vibrations. It therefore becomes useful to inquire about relaxation times for distributing energy among the rotational motions, or for exchanging rotational and vibrational energy, and so on.

Many temperature measurement methods determine in effect a distribution function for a particular type of degree of freedom. Thus an important spectroscopic method [8] determines the relative populations of the different rotational states in the OH molecule. Only if τ_{ri} for this case is small will the distribution function indicate a unique rotational temperature T_r, and only if the exchange of rotational energy with the other forms of energy is rapid will this T_r indicate accurately an overall temperature.

To summarize: All temperatures actually measured are partial or effective temperatures. The custom of denoting partial temperatures with T^*, or "T", or $T_{\text{effective}}$ is therefore really redundant. These special notations serve, however, a very useful function by stressing the non-equilibrium features of the system under study. Their use is therefore a matter of emphasis and convenience.

METHODS OF TEMPERATURE MEASUREMENT

We shall now indicate how these ideas have been applied to a variety of recent problems. All examples are from high temperature fields though the same fundamental considerations apply to all temperature regions.

1. *Temperature from the population of atomic levels.* It is possible to introduce small amounts of metal vapor into hot gases by adding, for example, Na salts, Cu salts, or Fe carbonyl. The metal atoms interact with the species in the gas and may come to thermal equilibrium with the gas. Excited states of the metal atoms will then become populated in accordance with the Boltzmann factor. The atoms will return to their ground states or other lower states by radiation, and the relative intensities of the lines emitted can be used to estimate the relative populations of the levels involved, and hence the temperature of the atoms. If adequate equilibrium obtains, the method can be very useful. The method requires knowledge of the optical transition probabilities of the metal atom. The detailed conditions for a successful application of the method are described by Sobolev [*9*], who measured flame temperatures of about 3,000°K. with an estimated uncertainty of about 1.3 per cent.

In many experimental situations it is unlikely that adequate equilibrium is obtained. In fact it may happen that this method measures some T^* of the system reliably because the atomic populations may come to equilibrium with some degrees of freedom of the system but not the others. Gaydon [*10*] mentions circumstances where atomic excitation measures T_{vibr} of some molecular species in a flame.

The method has to be carefully checked before its results can be accepted, particularly when applied to systems undergoing chemical reactions. This is because unstable chemical species which occur as intermediates of chemical reactions often excite some atoms with preference into certain levels, and so produce distributions which are far removed from equilibrium [*11*]. In such cases the method is not reliable at present.

2. *Temperature from Doppler line width.* The motion of a molecule along the line of observation while it radiates shifts the wave lengths at which the radiation is observed relative to the wave lengths observed for a stationary molecule. This effect, known as the Doppler effect, broadens the spectral lines which are observed, and gives the lines a characteristic shape [*12*]. This provides a method useful in principle for measuring the velocity distribution (hence the translational energy distribution) of the molecules. The method does not require any knowledge of the molecular or atomic structure of the species beyond knowledge of molecular or atomic weight. With it the translational temperature of CH in a low pressure flame was found to be about 3,500°K ± 600°K., an uncertainty of about 20 per cent [*13*].

The method is not accurate. The main difficulty is that Doppler broadening is a small effect and may be masked by other effects such as collision broadening. To use the method fully, equipment of the highest resolving power should be used. When this is done, the whole contour of the spectral line can be determined. This allows one to infer the actual existing velocity distribution, if other effects on the line shape can either be ignored or taken into account.

3. *Temperature from vibrational spectra.* In systems in equilibrium the vibrational degrees of freedom of gas molecules are in equilibrium with each other and with the rest of the system. Therefore the relative populations of the vibrational levels are given by the Boltzmann factor, and a measurement of relative intensities of spectral lines associated with different vibrational levels will allow a determination of the temperature [*14*]. In other cases the vibrational degrees of freedom may be in equilibrium with each other without being in equilibrium with the rest of the system. In such cases a determination of relative populations of vibrational levels allows a determination of T_{vibr}.

Several types of methods are in use. In one method the emission of radiation from a complete *unresolved* vibration-rotation band is compared with the emission from a standard source [*15*]. The method is said to be good to about 2.5 per cent near 2000°K.

Another method consists of measuring the relative intensities of emission lines belonging to the same rotational levels of different vibrational levels [*16*]. Experimental uncertainties are said to be about 10 per cent of T_{vib} near 2,500°K.

Both methods require directly the quantum mechanical transition probabilities. These are difficult to calculate, though they have been obtained for OH [*17*], C_2 [*18*], and a few other molecules. In general these transition probabilities must be obtained from experiment when the species are known to be in equilibrium at a given temperature. Once they are known, they can be applied to calculations of nonequilibrium or partial equilibrium situations.

A thorough discussion of these methods and some variations is given by Smit [*19*].

4. *Temperature from rotational spectra.* Several methods are currently used to determine temperature from rotational spectra. Most of these depend on the comparison of relative intensities of rotational lines and on the relative populations inferred from the intensities [*8*].

Thorough reviews of methods based on rotational spectra have been given by Dieke and coworkers [*20*].

The relative transition probabilities are required for this method. They can be calculated with good accuracy for many diatomic molecules and can be determined experimentally for cases where calculations are difficult.

Several distinct ways are used to calculate temperatures from intensities. We do not give the details of these methods. The two most common methods are the "log intensity" method and the "iso-intensity" method [*20*]. If the observed lines are absorbed strongly the data may give fictitious indications of non-equilibrium population of levels. A recent method by Kostkowski and Broida [*21*] makes possible the determination of reliable temperatures even in the case of large absorption.

The experimental uncertainties in the determined temperatures vary greatly from one case to another. Uncertainties as small as 1% at 3000°K have been reported, while attempts have been made to apply the method where uncertainties are close to 100 per cent [*11*].

5. *Temperature from optical pyrometers.* This method consists of comparing the brightness of the object whose temperature is to be measured with that of a standard whose brightness is known from calibration as a function of temperature. Two main variations are in use: one-color pyrometry where brightness is compared at one wavelength, and 2-color pyrometry where brightness is compared at two wavelengths. If the system to be studied is in internal equilibrium, and if its emissivity is known at the wavelengths of comparison, then either method is reliable and gives good values of T. In practice neither of these two conditions is likely to be fulfilled.

In flames the continuous radiation emitted which is usually used in pyrometer methods comes from small incandescent solid particles of carbon. Recent studies [*22*] have shown that these carbon particles are in equilibrium with the surrounding gas. The carbon particles, however, are so small (about one wavelength of visible light in diameter) that their size strongly affects their optical properties. To determine flame temperatures accurately using this method, the effect of particle size must be taken into account. In some cases, temperatures obtained with pyrometers from carbon particles in flames have been found to agree well with temperatures from line reversal techniques [*23*]. In other cases comparisons have been worked out between such pyrometrically measured temperatures and black-body temperatures [*24*].

Pyrometric methods are particularly useful as empirical control devices when no explicit correlation can be made between the measurement and an equilibrium temperature. If, e.g., the emissivity of the system is unknown, or if no partial equilibrium can be found in the system, then the pyrometer can be used to good advantage as a control device. In many industrial applications of pyrometry this is the exact attitude adopted.

6. *Temperatures from thermocouples.* Ther-

mocouples measure temperature by generating an e.m.f. across their open terminals when the measuring junction is at a different temperature than the reference junction. The generated e.m.f. is a function of the temperature, therefore a calibration must be available covering the whole temperature range to be measured [*25*].

Two problems of thermocouple construction and use are of particular relevance to our present point of view. One arises in the measurement of the temperatures of hot gases through a container wall, and the problem is to have the thermocouple follow temperature changes in the gas rapidly. For metal walls this does not seem to be too difficult. For plastic or refractory walls a large time lag may be introduced by the poor thermal conductivity of the wall material. However, special methods of design have been found which make possible adequate heat contact between the thermocouple in the wall and the gas [*26*].

A second application of thermocouples where the approach to equilibrium is a significant problem is the measurement of temperatures of gases having large bulk flow velocities, such as in super- and hypersonic wind-tunnels, in exhausts of jets, etc. A problem here is to devise an arrangement of the thermocouple which measures the stagnation temperature of the gas. This means that a sample of the gas must be stopped rapidly enough to be sensibly adiabatic, yet slowly enough for the gas to come to internal equilibrium. The thermocouple is then exposed to the gas sample just prepared. A thorough survey of such devices is given by Eber [*26*]. Well-designed thermocouple probes have recovery factors of about 0.95 which are furthermore independent of Mach number in the range of stream velocity employed. (The recovery factor is the fraction of the theoretical temperature rise on stagnation, which can be accomplished experimentally.)

With suitable construction and calibration equilibrium temperatures can be measured. But even in the absence of calibration, and with poor design, thermocouple probes can be used as empirical control devices.

7. *Temperature from the velocity of sound.* The velocity of sound through any medium is a function of temperature. Therefore the velocity of sound may be used to measure the temperature. The method is particularly useful in gases and can be used under conditions where many other methods fail or are inconvenient [*27*, *28*, *29*]. The velocity of sound in a gas is a function not only of the temperature, but also of $\gamma = C_p/C_v$ and of the molecular weight of the gas. This puts a number of restrictions on the method. At high frequencies of sound γ appears to change because the molecules cannot come to equilibrium in the time of one period of the sound wave if the frequency is too high. Furthermore, if the gas is not in equilibrium the value of γ may depend on the details of the processes in the system in a complicated way. Therefore the theory of the propagation of sound in a non-equilibrium gas is complicated. The measured velocity of sound is an average velocity averaged over all the gas in the path of the sound wave. If strong local temperature variations are to be expected the method loses some of its power. Under circumstances where the gas is not homogeneous and is not in well-defined partial equilibria with respect to some of the important processes, the method can at present only be used as a control device.

An alternative method involves the measurement of the velocity of shock waves through gases. The shock waves are generated by a spark and their velocity determined by a photographic method. This method is subject to the same types of limitations mentioned above, except that a photographic method may enable one to determine *local* velocities instead of one single average velocity as above.

8. *Control devices and further progress.* Many systems encountered in technology are so complex that very little can be said about relaxation times and about partial equilibrium. It is then difficult to define temperature, but it is important to realize that even in extremely complex situations measurement gives *some* information. For example, the transit time of an ultrasonic wave in the exhaust gases of a jet engine does give an indication of the state of the gases. It gives, however, only one "bit of information," while perhaps several hundred bits would be required to describe the system.

Thus it is futile to hope that the one observed bit will adequately specify all the variables. The most fruitful approach would seem to be the selection of several quite distinct temperature measurement methods which are reasonably easy to use under the circumstances: say, pyrometer, spectral-line reversal, and transit time of ultrasound, giving three independent control parameters. While none of these will, strictly speaking, measure temperatures, they will specify several different properties of the system. In this way a fairly thorough control of the system should be possible, and the dependence of the control parameters on experimental conditions would guide further experimentation. At the same time experience is gained in the study of really complex systems, and thus the groundwork laid for further advances in the fundamental understanding of nonequilibrium processes. This in turn will make possible the further extension of the concept of temperature.

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ENTOMOLOGY.—*Type specimens of mosquitoes in the United States National Museum: III, The genera* Anopheles *and* Chagasia *(Diptera, Culicidae)*.[1]

ALAN STONE, Entomology Research Branch, U. S. Department of Agriculture, and KENNETH L. KNIGHT, Bureau of Medicine and Surgery, U. S. Department of the Navy.[2]

(Received May 8, 1956)

The introductory remarks in the first paper of this series, particularly those on early, possibly questionable holotypes, also apply to this one. Following our treatment of nominal taxa requiring special attention we present a list of those in the collection based on unique specimens or for which holotypes were clearly designated.

Genus **Anopheles** Meigen

Anopheles apicimacula Dyar and Knab, Proc. Biol. Soc. Washington **19:** 136. 1906.

Of the 26 original specimens of this species, 22 are in the collection. One female only, from Livingston, Guatemala, May 11, bears a type label, and this we consider the holotype. This specimen was designated as lectotype in Russell, Rozeboom, and Stone (1943, p. 31) although we now feel that this lectotype designation was not necessary, as explained in the introduction to this series.

Anopheles atropos Dyar and Knab, Proc. Biol. Soc. Washington **19:** 160. 1906.

The syntype series of this species consisted of seven female specimens from the Florida Keys, collected by H. Byrd. All these are in the collection and all are labeled "Type No. 10029 U.S. N.M." We select as lectotype one of the best of these specimens.

Anopheles (*Kerteszia*) *bambusicolus* Komp, Ann. Ent. Soc. Amer. **30:** 515. 1937.

The syntype series of this species consisted of three females with associated larval skins. These specimens stand in the collection all bearing the labels "La Union, Int. de Meta, Colombia, Sept. 1935. Jorg Boshell / On bamboo / Cotype No. 53075." There are four larval skins on slides, but since the pinned specimens are not numbered these skins cannot be associated with individual specimens. Two of the pinned specimens are *Anopheles bambusicolus* Komp, and we select the better one as lectotype. The third is a specimen of *Culex chryselatus* Dyar and Knab and has been transferred to that species in the collection.

Anopheles barberi Coquillett, Can. Ent. **35:** 310. 1903.

This species was described from three females collected on Plummers Island, Md., August 14, 1902, and August 17 and 19, 1903. Only one of these specimens, dated August 17, is in the collection, and it bears the type label and Coquillett's determination label. We consider this specimen to be the holotype.

Anopheles bellator Dyar and Knab, Proc. Biol. Soc. Washington **19:** 160. 1906.

The original three specimens of this species are in the collection, consisting of one male and two females, all labeled "Type No. 10027 U.S.N.M." We select as lectotype the male labeled "44.1 / Trinidad, W.I. Jan. / Aug. Busck Collector / See slide No. 314 / Slide #659 / bellator." The terminalia are on slide no. 314, and one front tarsus is on slide no. 659. The pupal skin from which this specimen came has also been mounted on a slide.

Anopheles (*Dendropaedium*) *bellator* race *bromelicola* Dyar and Knab, Ins. Insc. Mens. **13:** 27. 1925.

The two female syntypes of this, from Manoa, Orinoca River, Venezuela, are in the collection, each bearing only the labels "Manoa Woods Jan 10 / Type No. —— U.S.N.M." We select one of these as lectotype.

[1] Earlier papers in this series are: *I, The genera* Armigeres, Psorophora, *and* Haemagogus, Journ. Washington Acad. Sci. **45:** 282–289. 1955; *II, The genus* Aedes, *ibid.* **46:** 213–228. 1956.

[2] Studies upon which this paper is based were conducted under an exchange of funds from the Office of Naval Research (Biological Science Division) to the Smithsonian Institution. The opinions or assertions contained here are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

Anopheles (*Anopheles*) *chiriquiensis* Komp, Proc. Ent. Soc. Washington **38:** 156. 1936.

Both sexes and the larva of this species were originally described, but no type material was mentioned. The collection contains one male and one female labeled "Anopheles chiriquiensis Komp / Volcan de Chiriqui, Panamá II.7.35 6500 ft / Cotype No. 51882 U.S.N.M. / W.H.W. Komp." The male is labeled #1, and this has dissected terminalia mounted on a slide. There is a second female of the original material, not labeled as cotype, and one larval skin, not associated by label with any specific adult. We select the male as lectotype.

Anopheles (*Nyssorhynchus*) *darlingi* Root, Amer. Journ. Hyg. **6:** 706. 1926.

The lectotype male of this species, selected by Stone in Ross and Roberts (1943, p. 30), is in the collection.

Anopheles (*Nyssorhynchus*) *davisi* Paterson and Shannon, Terc. Reun. Soc. Arg. Mosq. de Embarcación: 5. 1927.

This species was described from 6 larvae, 50 females, and 2 males from Trez Pozos, Embarcación, Salta, Argentina. The collection contains a larval slide and two male terminalia slides bearing the original data, and four pinned females collected at the proper time but at Bella Vista, Embarcación, not Trez Pozos. The larva and one of the male slides were labeled "Type" by Shannon, but the adults from which the male terminalia came are not in the collection. There is no indication in the original publication as to where the types were to be deposited, and it is quite possible that there are more and better specimens of the syntype series in Argentina. Because of this, it seems advisable to defer selection of a lectotype.

Anopheles (*Nyssorhynchus*) *dunhami* Causey, Journ. Nat. Malaria Soc. **4:** 231–234. 1945.

The original description of this species states, "The type specimens have been forwarded to the National Museum in Washington, D. C." There is no statement as to the number of specimens involved, although the species was collected in large numbers on animal bait in Tefé, Amazonas, Brazil, and the female, male, egg, and larva are described. The collection contains a male labeled type and a female labeled paratype, both reared from eggs laid by a female collected in Tefé, Amazonas, Brazil. We consider this male, with terminalia mounted on a slide, to be the holotype.

Anopheles earlei Vargas, Bol. Ofic. Sanit. Panamericana **22:** 8. 1943.

The original description of this species designated a male holotype with the dissected terminalia mounted on two slides and a female allotype. The type locality was given as being Jefferson County, Wis. The type was collected July 10, the allotype July 13. These specimens are in the collection bearing these data. For this reason the statement in Vargas and Matheson (1948, p. 27) that "El tipo macho fue de Cayuta Lake, Nueva York" is erroneous.

Anopheles eiseni Coquillett, Journ. New York Ent. Soc. **10:** 192. 1902.

This species was described from one female and two males. Two of the original specimens are in the collection, one of the males not being found. The female only bears a type label and it also bears Coquillett's determination label. This specimen we consider to be the holotype.

Cellia flava Ludlow, Can. Ent. **40:** 32. 1908.

This species was described from four specimens, which are in the collection, bearing unnumbered type labels. These specimens are all females, although the original description includes both sexes. We select as lectotype the specimen bearing the label "Cellia flava Ludl. Type" and some indecipherable words. There are other specimens from Tayabas, the type locality, including males, that might have been before Ludlow when she described the species.

Myzomyia flavirostris Ludlow, Psyche **21:** 30. 1914.

It is not clear from the original description that this species was based on more than one specimen, but the collection has four females bearing unnumbered type labels. Only one has an additional label, as follows: "*M. funesta* Giles dark *flavirostris*. Camp Wilhelm, Tayabas, P. I. Type. Nov." The word "*flavirostris*" is written in pencil, and the word "Type" is apparently written with a different pen from the rest of the label. This specimen is the best of the four and we select it as lectotype.

Anopheles formosus Ludlow, Can. Ent. **41:** 22. 1909.

This species was presumably described from a single female, but it is not clearly so stated in the original description. We consider the single female, with the labels "Type No. 27781 U.S. N.M. / Anopheles formosus Ludl. Type C.S.L. Camp John Hay. Benguet, P. I. Mch 20, 1908" as the holotype.

Anopheles (*Kerteszia*) *homunculus* Komp, Ann. Ent. Soc. Amer. **30:** 509. 1937.

The syntype series of this species consisted of three females and one male. The collection now has two females and one male labeled as cotypes, associated with three numbered larval skins on one slide and the terminalia of the male on another slide. We select as lectotype the male with the associated larval skin no. 3, collected by Komp at Restrepo, Colombia, September 9, 1935.

Culex hyemalis Fitch, Amer. Journ. Agr. and Sci. **5:** 281. 1847.

The original description gives no indication of any type material, stating merely that the species is "met with in the last days of autumn and again for a short time in the first days of spring" and "is a somewhat rare insect." The collection contains a single female bearing the labels "6850 / Type No. ——— U.S.N.M. / Fitch Collection / Anopheles Meigen hyemalis Fitch New York." Not knowing whether any other Fitch specimens of this species are in existence, we select this specimen as lectotype.

Myzomyia rossi var. *indefinita* Ludlow, Can. Ent. **36:** 299. 1904.

This variety was described from an indefinite number of specimens from a variety of localities in the Philippines, some of them not named. The collection contains the following syntypes, or presumable syntypes: (1) Four females, each bearing the red label "Type No. 27779 U.S.N.M." (one of these specimens bears the label in Ludlow's hand "Myzomyia indefinita Ludl. P. I. Type C.S.L.); (2) two females labeled only "M. indefinita Ludlow Cotype"; and (3) nine specimens labeled only "Guimaras Isl. P. I. Dr. LeWald." These latter may not have been of the original Guimaras Island material, but they probably were. Most of the specimens are in very poor condition, particularly those of the first series, and except for the third series mentioned above, none bear any label for a specific locality in the Philippines. Since one of the best specimens, and one that agrees well with the original description and the current concept of the species, is one of the two of series (2) above, we select this one as lectotype.

Anopheles lewisi Ludlow, Psyche **27:** 14. 1920.

Aitken (1945, p. 308) designated lectotypes from the syntype series on which this name is based. This designation is somewhat obscure, since it appears that Aitken is referring to *lewisi* in making these selections but he uses two U. S. National Museum numbers. For the lectoholotype male he refers to U. S. National Museum no. 77812, which presumably refers to U.S.N.M. Type no. 27812, the number for the syntype series of *lewisi*; for the lectoallotype he says, "*A. Lewisi* (U. S. National Museum no. 77813)" which he may have intended to mean U.S.N.M. Type no. 27813, the type number for the two syntype females of *Anopheles selengensis* Ludlow. The collection contains a male and female of *lewisi*, labeled by Aitken as lectoholotype and lectoallotype respectively and a female of *selengensis* labeled lectoholotype, all collected at the same place and date. We accept the male lectotype for *lewisi*, and here designate as the lectotype of *selengensis* the female labeled by Aitken.

Stethomyia lewisi Shannon, Proc. Ent. Soc. Washington **33:** 154. 1931.

The male holotype, female allotype, and a female paratype were said to have been deposited in the U. S. National Museum collection. We have found no pinned specimens bearing type data, but there are two slides of fragments of male terminalia from the type locality, Rio Curupire, Bahia, Brazil. One of these slides has one complete set of terminalia and a portion of another, and the other has dissected claspettes. These slides are not labeled as types, and it would be impossible to tell which fragments belong to the holotype male, if any do. We can either assume that the type is lost or that the type is present in part but unlabeled.

Anopheles malefactor Dyar and Knab, Journ. New York Ent. Soc. **15:** 198. 1907.

The seven specimens on which this species was based are all in the collection and each bears the label "Type No. 10877 U.S.N.M." We select as lectotype a female which also bears the labels "136.1 / Rio Chagres, Panama / Collected by August Busck / Anopheles malefactor D. & K. Type." There is a slide of the pupal skin and a portion of the abdomen of the larval skin. The fifth hind tarsomere is entirely white in this specimen, as given in the original description. Some of the other syntypes have a rather narrow dark ring on this tarsomere.

Anopheles neivai Howard, Dyar and Knab, Mosquitoes of North and Central America and the West Indies **4:** 966. 1917.

Although in the original description this species was said to have been found from Panama northward to southern Mexico, and localities are given in two places in Panama, two in Costa Rica, and one in Mexico, there are only three specimens in the collection under this name that can be considered to be of the original material. One of these, a female, bears the labels "344.1 / Type No. 20440 U.S.N.M. / neivai!" The number refers to Jennings' collection notes which state that the data for this number are "Fort San Felipe, Porto Bello Bay [Panama], June 2, 1908." The pupal skin and larval head capsule are mounted on a slide. This specimen we select as lectotype. A second female, from Panama, bears the label "Paratype No. 20440 U.S.N.M.," and a third one, from Estrella, Costa Rica, bears a determination label but no type label.

Anopheles occidentalis Dyar and Knab, Proc. Biol. Soc. Washington **19:** 159. 1906.

Most of the 118 original specimens of this species are in the collection, but only one, from Stanford University, California, May 26, 1903, bears a type label, and so we consider this to be the holotype. This specimen is in excellent condition. Aitken (1945, p. 285) has discussed the two species involved in the original series of this species.

Anopheles oiketorakras Osorno-Mesa, Caldasia **4:** 431–446, 1947.

This species was described from a male and a female designated as types, and other adults designated as paratypes. We select as lectotype the male "type" labeled "Bogotá, Colombia, S. A. Monserate, 2700–2840 m., III.13.46."

Myzomyia parangensis Ludlow, Psyche **21:** 129. 1914.

This species was described from more than one specimen, but the exact number was not stated. There are two females in the collection, each bearing the label "Type No. 27778 U.S.N.M." One is in excellent condition and bears the additional label "*Myzomyia parangensis* Ludl. Port of Parang, Mindanao, P. I., Oct. Nov. Types." The second is in poor condition and bears no additional label. Presumably the one label was intended for both. We select the first specimen as lectotype.

Anopheles philippinensis Ludlow, Journ. New York Ent. Soc. **10:** 129. 1902.

The number of specimens on which this species was based was not stated. Two females in the collection each bear the label "Type No. 27703 U.S.N.M." and one of them the label "Nyssorhynchus philippinensis Ludl. San Jose, Abra, P. I. Sept. 1, 1901. Type." Both of the specimens are in very poor condition, with hind legs missing. The one with palpi shows the terminal pale band on each palpus equal in length to the preapical dark band, and both specimens show a patch of pale scales on the sternopleuron, in both respects differing from the key characters used by Puri (1949). The specimen bearing Ludlow's original type label is in the worse condition, but the other is not much better. We refrain from selecting a lectotype because the specimens are in such poor condition that such selection would serve little purpose. The wing pattern differs slightly between the two specimens. If a lectotype is to be selected it should be only after a very thorough study of the species or species complex over its whole range.

Anopheles pseudobarbirostris Ludlow, Journ. New York Ent. Soc. **10:** 129. 1902.

The number of specimens on which this species was based was not stated. Two females in the collection each bears the label "Type No. 27782 U.S.N.M." and one of them the label "*Myzorhynchus pseudobarbirostris* Ludl. Type, Hagonoy, Bulacan, P. I. Oct. 2, 1901. Kellogg. Type." We designate this latter specimen as lectotype of the species.

Anopheles selengensis Ludlow, Psyche **27:** 77. 1920.

See remarks under *Anopheles lewisi* Ludlow.

Anopheles (*Nyssorhynchus*) *strodei* Root, Amer. Journ. Hyg. **6:** 711, 1926.

A male and a female of this species from the type locality are in the collection. We select as lectotype the male bearing a square of red paper and the labels "Agua Limpa, Braz. Mar. 27, 1925. No. 64 / Anopheles strodei Root types." The female bears the same data.

Myzomyia thorntonii Ludlow, Can. Ent. **36:** 69. 1904.

The collection contains three females of this species marked as types. Two of these each bear the label "Type No. 27780 U.S.N.M." put on by Dyar and one of these bears the additional label, in Ludlow's hand, "Myzomyia thorntonii Ludl. Cottabatto, Mindanao, P. I. June. Type C.S.L." The second specimen bears no data label, but Dyar entered both in the type book as being from the same locality. The third specimens bears an unnumbered type label and the label "M. Thorntoni Ludlow cotype" with no further data. Since Ludlow mentioned only two specimens, from two different localities, it is evident that some mislabeling has occurred. None of these specimens are in very good condition but they appear to be conspecific. We select as lectotype the specimen bearing the numbered type label and the collection data.

Anopheles vestitipennis Dyar and Knab, Proc. Biol. Soc. Washington **19:** 136. 1906.

The lectotype female designated by Stone in Russell, Rozeboom, and Stone (1943, p. 34) is in the collection.

The following taxa are based either on unique specimens or on clearly designated holotypes:

Anopheles (*Stethomyia*) *acanthotorynus* Komp, 1937
Anopheles (*Nyssorhynchus*) *anomalophyllus* Komp, 1936
Anopheles (*Kerteszia*) *anoplus* Komp, 1937
Anopheles lindesayi var. *benguetensis* King, 1931
Anopheles crucians var. *bradleyi* King, 1939
Anopheles (*Myzomyia*) *clowi* Rozeboom and Knight, 1946
Anopheles (*Myzomyia*) *cristatus* King and Baisas, 1936
Anopheles (*Nyssorhynchus*) *emilianus* Komp, 1941
Anopheles (*A.*) *fluminensis* Root, 1927
Anopheles crucians var. *georgianus* King, 1939
Anopheles (*Nyssorhynchus*) *goeldii* Rozeboom and Gabaldon, 1941
Anopheles gorgasi Dyar and Knab, 1907
Anopheles (*Nyssorhynchus*) *guarani* Shannon, 1928
Anopheles koliensis Owen, 1945
Anopheles nimbus var. *kompi* Edwards, 1930
Anopheles vagus var. *limosus* King, 1932
Chagasia lineata Ludlow, 1908
Anopheles litoralis King, 1932
Anopheles (*Myzomyia*) *lungae* Belkin and Schlosser, 1944
Anopheles (*Myzomyia*) *nataliae* Belkin, 1945
Anopheles (*Stethomyia*) *niveopalpis* Ludlow, 1919
Stethomyia pallida Ludlow, 1905
Anopheles perplexens Ludlow, 1907
Anopheles punctimacula Dyar and Knab, 1906
Anopheles (*Myzomyia*) *leucosphyrus* var. *riparis* King and Baisas, 1936
Anopheles (*A.*) *samarensis* Rozeboom, 1951
Anopheles (*A.*) *saperoi* Bohart and Ingram, 1946
Anopheles (*Nyssorhynchus*) *sawyeri* Causey, Deane, Deane, and Sampaio, 1943
Anopheles (*A.*) *shannoni* Davis, 1931
Anopheles (*Myzomyia*) *solomonis* Belkin, Knight, and Rozeboom, 1945
Anopheles strigimacula Dyar and Knab, 1906

Genus **Chagasia** Cruz

Chagasia rozeboomi Causey, Deane and Deane, Amer. Journ. Hyg. **39:** 3. 1944; Journ. Nat. Malaria Soc. **4:** 341–350. 1945.

The first description of this species was of the egg only and there is probably no type specimen in existence. In 1945 the authors described the adults, larva, and pupa, and state that "Type specimens are deposited in the National Museum in Washington, D. C. U.S.A." A female in the collection bears the labels "Type specimen collected in Crato, Ceara, Brazil / Type No. 58039 U.S.N.M. / Chagasia rozeboomi Causey Deane and Deane 1944." Since the species was originally described from the egg alone, however, we must consider this specimen as a pseudotype.

The following species are based on unique holotype specimens:

Anopheles (*Chagasia*) *bathanus* Dyar, 1928
Chagasia bonneae Root, 1927

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ZOOLOGY.—*Some polychaete worms of the families Hesionidae, Syllidae, and Nereidae from the east coast of North America, West Indies, and Gulf of Mexico.*[1] Marian H. Pettibone, University of New Hampshire. (Communicated by Fenner A. Chace, Jr.)

(Received June 14, 1956)

In connection with a study in progress on the polychaetes of the New England region, a species of Hesionidae is herein revised, resulting in a new genus and new combination; a new species of each of the Syllidae and Nereidae are described. From the West Indies and Gulf of Mexico region, a new species of Nereidae is described and supplementary descriptions are given for two other nereid species. The major part of the work was done at the United States National Museum, where the types are deposited.

Family Hesionidae

Parahesione, n. gen.

Diagnosis.—Prostomium with two lateral antennae, two smooth, unjointed palps, two pairs of eyes. Tentacular segments 3, somewhat fused; tentacular cirri 6 pairs (3 pairs on each side). Parapodia distinctly biramous; notopodia forming distinct lobes below the cirrophores of the dorsal cirri, with numerous capillary notosetae; neuropodia with numerous compound setae with blades long and slender. Anal cirri two, long. Proboscis with numerous fine papillae around the opening, without jaws.

Type.—*Podarke luteola* Webster, 1880 (= *Hesione agilis* Webster and Benedict, 1884).

Parahesione resembles *Syllidea* Quatrefages, *Micropodarke* Okuda, and *Nereimyra* Blainville (= *Castalia* Savigny) in the absence of a median antenna, the presence of 2 palps and 6 pairs of tentacular cirri. It differs from them in that the notopodia are well developed and distinct from the cirrophores of the dorsal cirri, with a distinct bundle of numerous notosetae; the palps are smooth, not biarticulate; also the shape of the neuropodia and probosces differ markedly.

Parahesione luteola (Webster, 1880), n. comb.

Fig. 1, *a–c*

Podarke luteola Webster, 1880, pp. 107–108 (figures referred to not published); 1886, pp. 135–136, pl. 5, figs. 19–20 (repeat of Webster, 1880, plus figures).

Hesione agilis Webster and Benedict, 1884, pp. 707–709, pl. 1, figs. 9–11.

The revision of the species is based on the following: (1) The description of *Podarke luteola* Webster, 1880, 1886, based on a single specimen (11 mm long, 45 segments) found on an oystershell in Great Egg Harbor, N. J.; the type specimen is not available; (2) the description and type specimens of *Hesione agilis* Webster and Benedict, 1884 (U.S.N.M. no. 430), found in sandy mud near the high water mark in Wellfleet, Mass.; the types include several small specimens (up to 2.5 mm long, 18 setigers); (3) several specimens collected at Wellfleet Harbor, Mass., on the sandy flats, living commensally in the burrows of *Upogebia affinis* (Say); they move rapidly and easily escape notice; they were up to 15 mm long, 4 mm wide including setae, 37 setigers.

Description.—Length up to 15 mm, width including setae up to 4 mm, segments 18–45. Body widest in the middle, tapering gradually anteriorly and posteriorly, flattened dorsoventrally. Prostomium (Fig. 1, *a*) much wider than long, with 2 pairs dark red eyes, crescentric, closely approximated on each side; two pairs of similar anterior appendages, both pairs delicate, subulate, with very short basal ceratophores; of these anterior appendages, the lateral antennae are slightly more dorsal in position; the palps are smooth, not biarticulate as in many hesionids; a median antenna is lacking (for *Podarke luteola*, Webster indicated it was lost). Three tentacular segments somewhat fused dorsally, usually only one distinct; the 3 pairs of tentacular cirri on each side with short cylindrical basal cirrophores emerging from a common base, lateral to and somewhat fused with the prostomium; styles variable in length, the upper ones longer than the lower ones (some may reach segment 10), readily lost and renewed.

Parapodia, dorsal cirri, and setae all very long (Fig. 1, *c*). Parapodia distinctly biramous; notopodium a stout papilla below the base of the dorsal cirrus; notosetae numerous, forming a close-set bundle, long (longer than the neurosetae), slender, capillary, transversely striated.

[1] This study was aided by a grant from the National Science Foundation (NSF-G2012).

Neuropodia stout, elongated, terminating above in a conical acicular process, diagonally truncate below; neurosetae form a fan-shaped group, compound, stem very long with transverse markings, appendages short and long, entire. Dorsal cirri with short cylindrical basal cirrophores; styles very long (longer than the setae), delicate, tapering uniformly, articulate. Ventral cirri delicate, conical, tapering to slender tips, extending slightly beyond the tips of the neuropodial lobes. Anal cirri long, similar to the dorsal cirri (Fig. 1, *b*). Proboscis eversible, with larger basal portion and narrower distal portion, with numerous fine papillae around the opening, without jaws. Color: Colorless (small specimens) to reddish yellow, parapodia green and yellow, cirri white; greenish (preserved).

Family Syllidae

Genus **Brania** Quatrefages, 1866

Brania wellfleetensis, n. sp.

Fig. 2, *a–c*

The species is based on a single specimen collected at low water, Wellfleet Harbor, on the Cape Cod Bay side, Massachusetts, on sandy bottom among tubes of *Diopatra cuprea* (Bosc), August 25, 1953 (U.S.N.M. no. 27783); another specimen was collected at Chappaquoit, Buzzards Bay, Mass., in muddy sand (U.S.N.M. no. 27784).

Description.—Length up to 7 mm, width up to 0.4 mm, segments 38–39. Body tiny, slender, threadlike, cylindrical, widest in the middle, tapering slightly anteriorly and posteriorly, colorless. Prostomium oval, wider than long, with 2 pairs of eyes, anterior pair slightly larger and more lateral, with little extra pigment lateral to the posterior pair of eyes; antennae subulate, wider basally, tapering to more slender tips; median antenna attached posteriorly on prostomium between posterior pair of eyes, about double the length of the prostomium; lateral antennae attached anteriorly on prostomium, anterior to the anterior pair of eyes, extending about as far distally as the median antenna; palps large, prominent, fused on basal third, free distally; the palps may be elongated (Fig. 2, *b*, sketched from life) or somewhat contracted (Fig. 2, *a*, preserved). Tentacular segment more or less distinct, with 2 pairs of tentacular cirri, subequal, similar in shape and length to the median antenna. Uniramous parapodia with setae all compound, except in the last 6 or so posterior segments where there is an upper and lower simple seta (looks like a compound seta that has lost its appendage and become somewhat worn); setae compound falcigerous, with blades short, finely spinous, with tips hooked and entire (Fig. 2, *c*). First pair dorsal cirri equal in length to tentacular cirri; dorsal cirri lacking on setiger 2; rest of dorsal cirri slightly longer than setal tips. Ventral cirri extend to about the tips of the parapodial lobes. Anal cirri 2, about as long as last 3 segments. Pharynx long, occupying setigers 1–4, may be somewhat coiled when body is contracted; proventriculus occupying setigers 5 to 8.

Remarks.—*Brania wellfleetensis* differs from *Brania clavata* (Claparède), which includes *Grubea websteri* Verrill and is known from the New England region, in the following:

	B. clavata	*B. wellfleetensis*
Parapodial setae	Two kinds: single upper simple one; compound setae with blades shorter to longer, with tips finely bidentate.	Setae all compound (except for some simple setae in last 6 or so posterior segments), with tips of blades entire.
Prostomium	With a pair of small ocular spots near the lateral antennae, in addition to the 4 larger eyes.	Without ocular spots.
Dorsal cirri on setiger 2	Present.	Absent.

Distribution.—Massachusetts (Wellfleet Harbor, Chappaquoit). In low water.

Family Nereidae

Nereis (Nereis) grayi, n. sp.

Fig. 3, *a–g*

The species is based on two specimens collected at Hadley Harbor, Uncatena Island in the Woods Hole area, Massachusetts, August 1952 (U.S.N.M. no. 27781, 27782). They were collected by Milton Gray, after whom the species is named. They were found in the thick muddy tubes of the large maldanid, *Maldanopsis elongata* (Verrill). Whether or not they lived commensally with the maldanid or occupied the tube secondarily is difficult to say. An examination of numerous tubes later failed to reveal any of the nereids.

Description.—Length up to 60 mm or more, width up to 5 mm, segments up to 150 or more. Body long, slender, tapering very gradually posteriorly, somewhat flattened dorsoventrally, colorless. Prostomium (Fig. 3, *a*) typical nereid shape, being widest on posterior third, tapering gradually anteriorly to a truncate tip; frontal antennae subulate, at the corners of the truncate tip; palps with basal part large and bulbous, with retractile tip; 4 eyes rather small, subequal, on posterior third of prostomium. Tentacular segment about same length as the following segments; tentacular cirri slender, tapering, the posterior dorsal pair longest, extending to about setiger 8. Anal segment with a pair of short anal cirri.

Parapodia (Fig. 3, *d*, *e*) biramous, except for the first two uniramous pairs, similar throughout the length of the body; they are long, making up about two-thirds the width of the body. Notopodium with 2 subequal, elongated, conical, pointed ligules; neuropodium with bluntly conical setigerous lobe, with a slightly shorter, conical, pointed lower ligule. Both dorsal and ventral cirri are shorter than the ligules. Notosetae of anterior region homogomph spinigers, rather few in number (about 8 in each notopodium), with rather short blades; beginning on about setiger 27, notopodia with few (1–2), homogomph falcigers with oval blades (Fig. 3, *g*). Upper group of neurosetae homogomph spinigers with long slender blades and few heterogomph falcigers (may be lacking on some parapodia); lower group of neurosetae heterogomph spinigers with rather short blades and heterogomph falcigers with rather long blades (Fig. 3, *f*). Acicula dark amber-colored. Proboscis (Fig. 3, *a–c*) with a pair of brown amber-colored jaws, each with about 12 teeth, with paragnaths few in number and small in size; on the maxillary ring: area II with 2 to 3 very small ones; area IV with triangular group of 10 to 13 slightly larger ones; on the oral ring, area VI with 3 to 4 small ones; paragnaths lacking on the other areas.

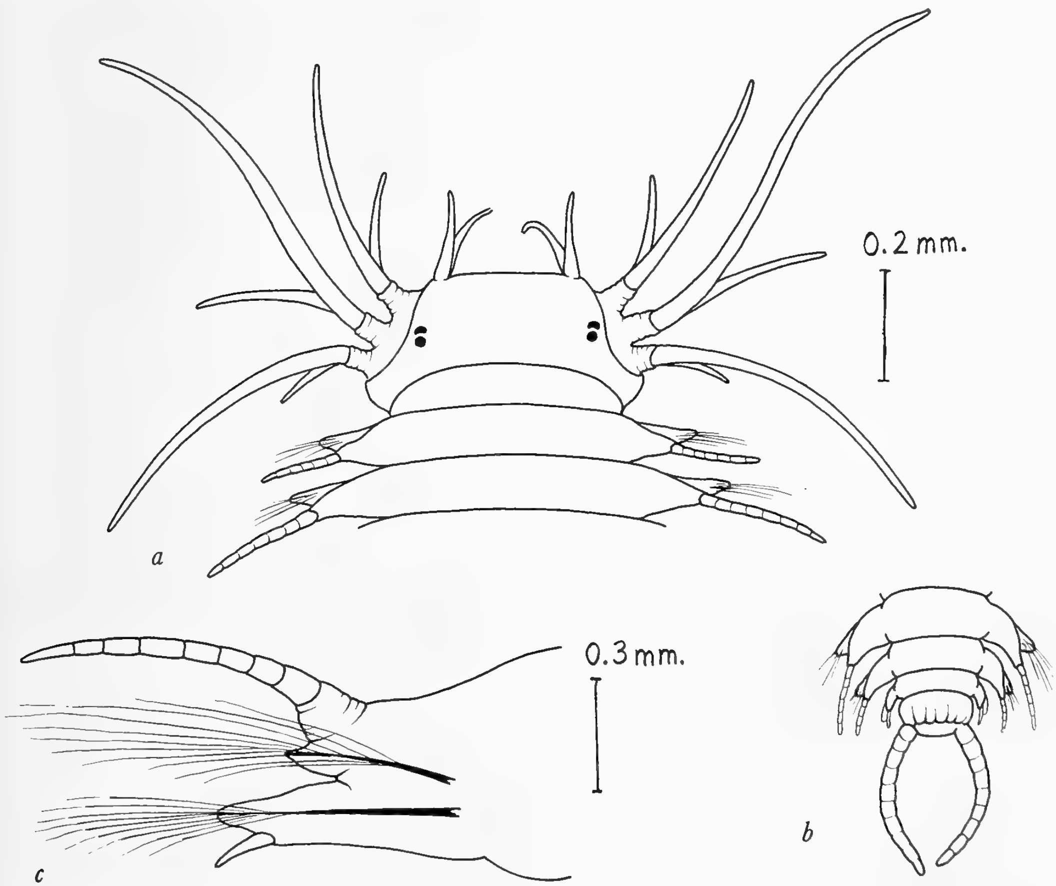

FIG. 1.—*Parahesione luteola*, n. comb.: *a*, Dorsal view anterior end; *b*, dorsal view posterior end; *c*, parapodium.

Remarks.—*Nereis grayi* resembles *Nereis* (*Eunereis*) *longissima* Johnston rather closely, including the parapodia and the few paragnaths on the proboscis; they differ in the following:

	N. longissima	*N. grayi*
Paragnaths	Confined to small group on area VI of oral ring, without paragnaths on maxillary ring.	Small group on areas II and IV of maxillary ring; small group on area VI of oral ring.
Tentacular cirri	Shorter, longest reach about setiger 3.	Longer, longest reach about setiger 8.
Notopodial homogomph falcigers	Begin on about setiger 65.	Begin on about setiger 27.

Distribution.—Massachusetts (Woods Hole region). In low water.

Nereis egregicirrata Treadwell, 1924

Fig. 4, *a*; 5, *a–d*

Nereis (*Leptonereis*) *egregicirrata* Treadwell, 1924, pp. 13–14, fig. 24 (part; English Harbor, Antigua, submarine light, July 1918).

Nereis egregicirrata Treadwell, 1939, p. 233, fig. 56 (Santa Barbara, Porto Rico).

The following description is based on 5 specimens in the original type material (2 male and 3 female heteronereids, U.S.N.M. no. 20324) and a male heteronereid collected by M. Jean Allen at Parguera, Porto Rico, from reef in front of the Laboratory, March 23, 1955. The atokous form is unknown.

Description of male and female heteronereids.—Body divided into two distinct regions: anterior unmodified, with the usual type of setae; posterior modified with the usual type of setae replaced by swimming setae and the development of lamellae instead of ligules. Prostomium (Fig. 4, *a*) with anterior part bent down ventrally, thus the frontal antennae and palps are not visible dorsally; four eyes large, subequal, purple, with distinct lenses, the two on each side closely appressed. Tentacular cirri 4 pairs, 3 of which are rather short, somewhat articulated, fourth pair longer, may extend to setiger 5, distinctly to slightly articulated. Parapodia of anterior unmodified region (Fig. 5, *a*, *c*) with dorsal cirri subulate, longer than the ligules; notopodia with upper and lower conical to rounded ligules, with a third, shorter (supraacicular) ligule between them, with homogomph spinigerous setae; neuropodia with conical setigerous lobe with anterior and posterior lips, with lower conical ligule; upper group of neurosetae homogomph spinigers and heterogomph falcigers; lower group of neurosetae heterogomph spinigers and falcigers; heterogomph falcigers with short blades, similar to Fig. 6, *c*; ventral cirri subulate, about same length or slightly shorter than the neuropodial ligule; acicula dark amber-colored. Proboscis with amber-colored jaws each with about 12 teeth; with conical paragnaths on both maxillary and oral rings (exact arrangement?). Color (in alcohol): With faint transverse brownish bands dorsally and with darker glandular areas dorsally at bases of parapodia. The male and female heteronereids differ in the following:

	Male heteronereid	*Female heteronereid*
Length	Up to 13 mm.	Up to 14 mm
Width	Up to 1.5 mm in anterior region; up to 2.5 mm in posterior region	Up to 1 mm in anterior region; up to 2 mm in posterior region
Number of setigers in anterior unmodified region	18	26
Number of setigers in posterior modified region	About 67	About 90
Total number of setigers	About 85	About 116
Posterior end	Anal segment papillated (anal cirri broken off)	Pair of long articulated anal cirri; anal segment papillated
Dorsal cirri of anterior region	First 7 pairs modified (fig. 4, a): first 5 and seventh pairs elongate, cylindrical, with asymmetrical tips; sixth pair enormously elongate with bulbous base and long style (up to 4 mm long)	First 7 pairs modified, get gradually longer anterior to posterior
Ventral cirri of anterior region	First 5 pairs clubbed	Same
Parapodia of modified region, with with swimming setae	Fig. 5, *b*.	Fig. 5, *d*.
	Dorsal cirri with slight indication of annulations or crenulations	Dorsal cirri smooth, not crenulate
	Extra lamella above base of dorsal cirrus	Same, smaller
	Unequally bilobed supraacicular notopodial lamella	Single digitiform supraacicular lamella
	Unequally bilobed subacicular notopodial lamella	Single subacicular notopodial lamella
	Large postsetal neuropodial lamella	Same, smaller
	Unequally bilobed lower neuropodial lamella	Single lower neuropodial lamella
	Ventral cirri with bilobed lamella above and large lamella below	Ventral cirri with single lamella above and smaller lamella below

Remarks.—The types of *Nereis* (*Leptonereis*) *egregicirrata* Treadwell were collected by submarine light at English Harbor, Antigua, by the Barbados-Antigua Expedition from the University of Iowa. The nine specimens present in the type material are a mixture of male and female heteronereids of at least two species. Since the description is confusing, being based on more than one species, I have selected as lectotype for *N. egregicirrata* one of the two male heteronereids with the enormously elongated dorsal cirri on setiger 6, as figured by Treadwell (1924, fig. 24). The rest of the specimens were separated as follows:

Anterior notopodia with 3 ligules (Fig. 5, *a*, *c*):
Male heteronereids: With enormously elongated dorsal cirri on setiger 6 (Fig. 4, *a*; fig. 24 in Treadwell, 1924); dorsal cirri of modified region crenulate (Fig. 5, *b*); anterior unmodified region with 18 setigers.—Lectotype and paratype of *N. egregicirrata*, 2 specimens.

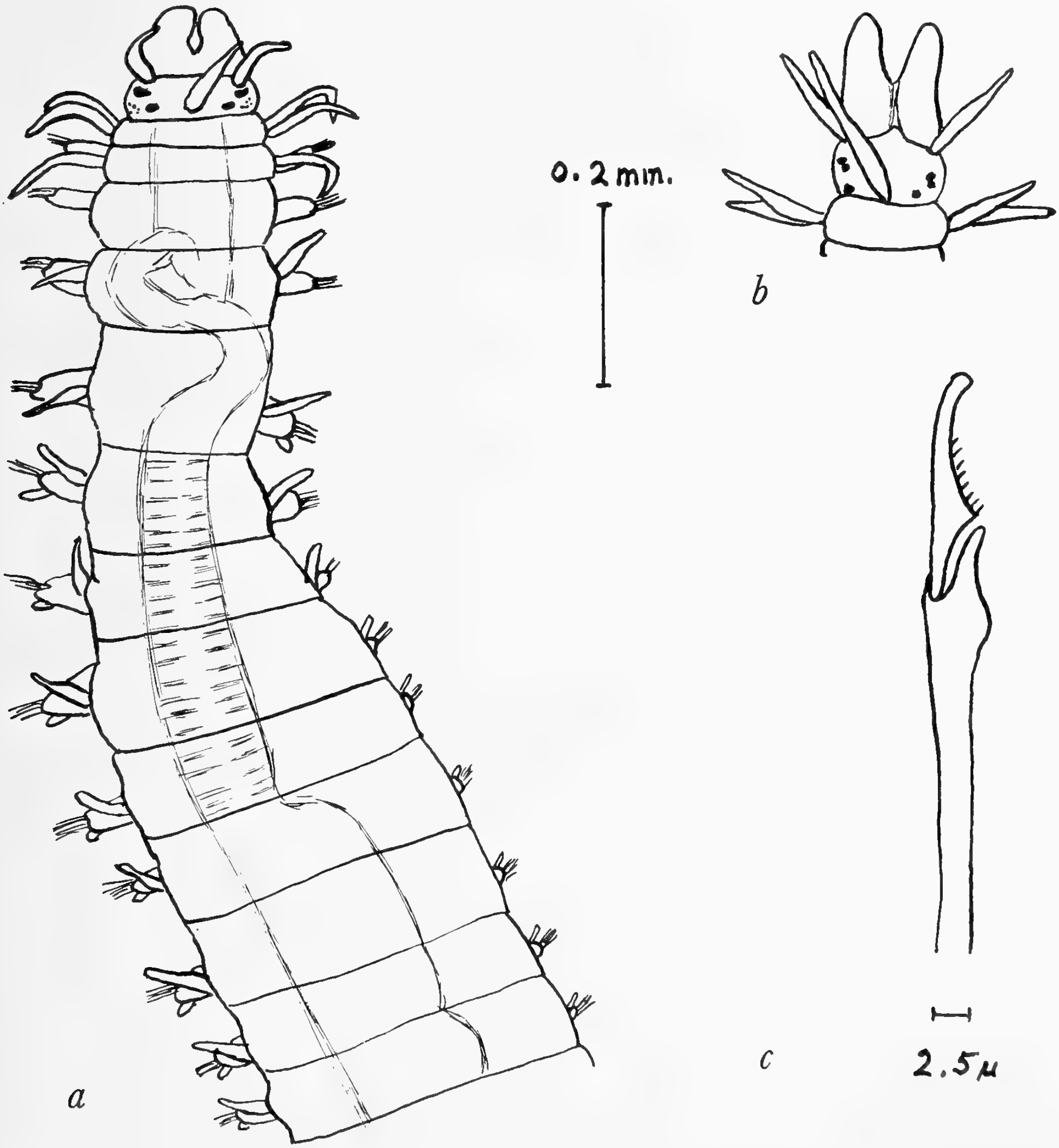

FIG. 2.—*Brania wellfleetensis*, n.sp.: *a*, Dorsal view anterior end; *b*, dorsal view prostomium, sketched from life; *c*, compound falcigerous seta.

Female heteronereids: Dorsal cirri of modified region smooth, not crenulate (Fig. 5, *d*); anterior unmodified region with 26 setigers. —Paratypes of *N. egregicirrata*, 3 specimens.

Anterior notopodia with 2 ligules (Fig. 6, *a*):

Male heteronereids: Dorsal cirri of modified region crenulate (Fig. 6, *h*); anterior unmodified region with 14 setigers.—Paratypes of *N. allenae*, n. sp., 3 specimens.

Female heteronereid: Dorsal cirri of modified region smooth, not crenulate (Fig. 6, *g*); anterior unmodified region with 26 setigers, filled with large yolky eggs (Fig. 4, *d*).—Paratype of *N. allenae*, n. sp., 1 specimen.

The species was originally placed in the subgenus *Leptonereis* because of the supposed absence of paragnaths. Treadwell, 1939, indicated that paragnaths were present and referred it to *Nereis*. The males and females of the two species are superficially similar and agree in the following: They are all small, less than 15 mm long; they are mostly faintly transversely banded with darker glandular areas at the dorsal bases of some of the parapodia; the anterior part of the prostomium is bent ventrally, so that the palps and frontal antennae are not visible dorsally; the 4 eyes are large, purple, subequal, with prominent lenses.

Nereis egregicirrata suggests a resemblance to *Nereis articulata* Ehlers, 1887, from off Sand Key, Fla., 120 fathoms. The type of the latter in the Museum of Comparative Zoology, Harvard, was

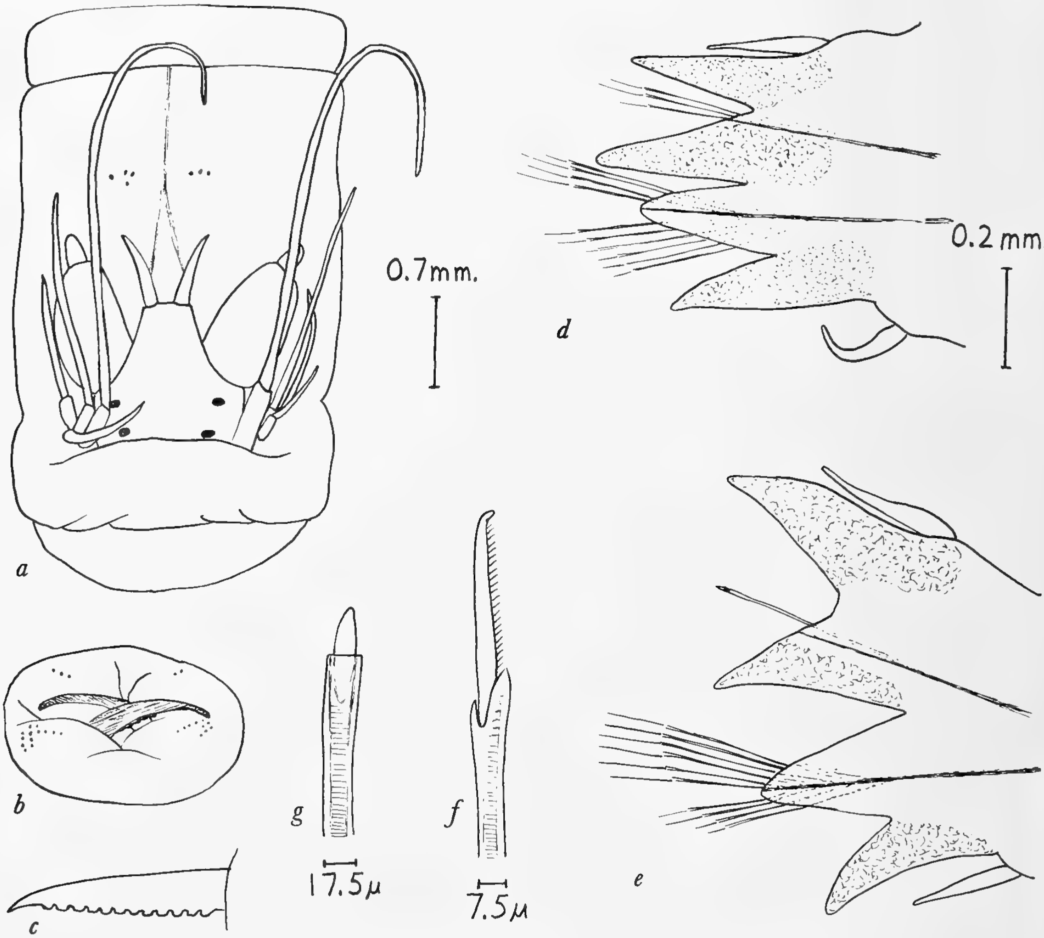

FIG. 3.—*Nereis grayi* n.sp.: *a*, Dorsal view anterior end, with proboscis partially extended; paragnaths of area VI on oral ring are shown; *b*, frontal view of extended proboscis showing maxillary ring with paragnaths on areas II (upper) and IV (lower) and jaws; *c*, one of the jaws showing the arrangement of teeth; *d*, parapodium from anterior region of body; *e*, same, from middle region; *f*, a lower neuropodial heterogomph falciger from anterior parapodium; *g*, a notopodial homogomph falciger from middle parapodium.

examined for comparison; it is a single small atokous form in very poor condition—it is brittle, brown, with pharynx and most of the setae missing. The species agree in that the tentacular cirri are articulated, the parapodia seem similar; also they have glands at the bases of the parapodia. A similar type of elongated dorsal cirri for the male heteronereid is reported for *Nereis abnormis* Horst, 1924, p. 163, from the Netherlands East Indies; in this case, it is the dorsal cirri of the seventh setiger that is enlarged instead of the sixth as in *N. egregicirrata.*

Distribution.—West Indies: Antigua, Puerto Rico; in surface waters (March, July).

Nereis allenae, n. sp.

Figs. 4, *b–f*; 6, *a–h*

The description is based on the following: Type (U.S.N.M. no. 27778): A single female heteronereid massed with unusually large eggs

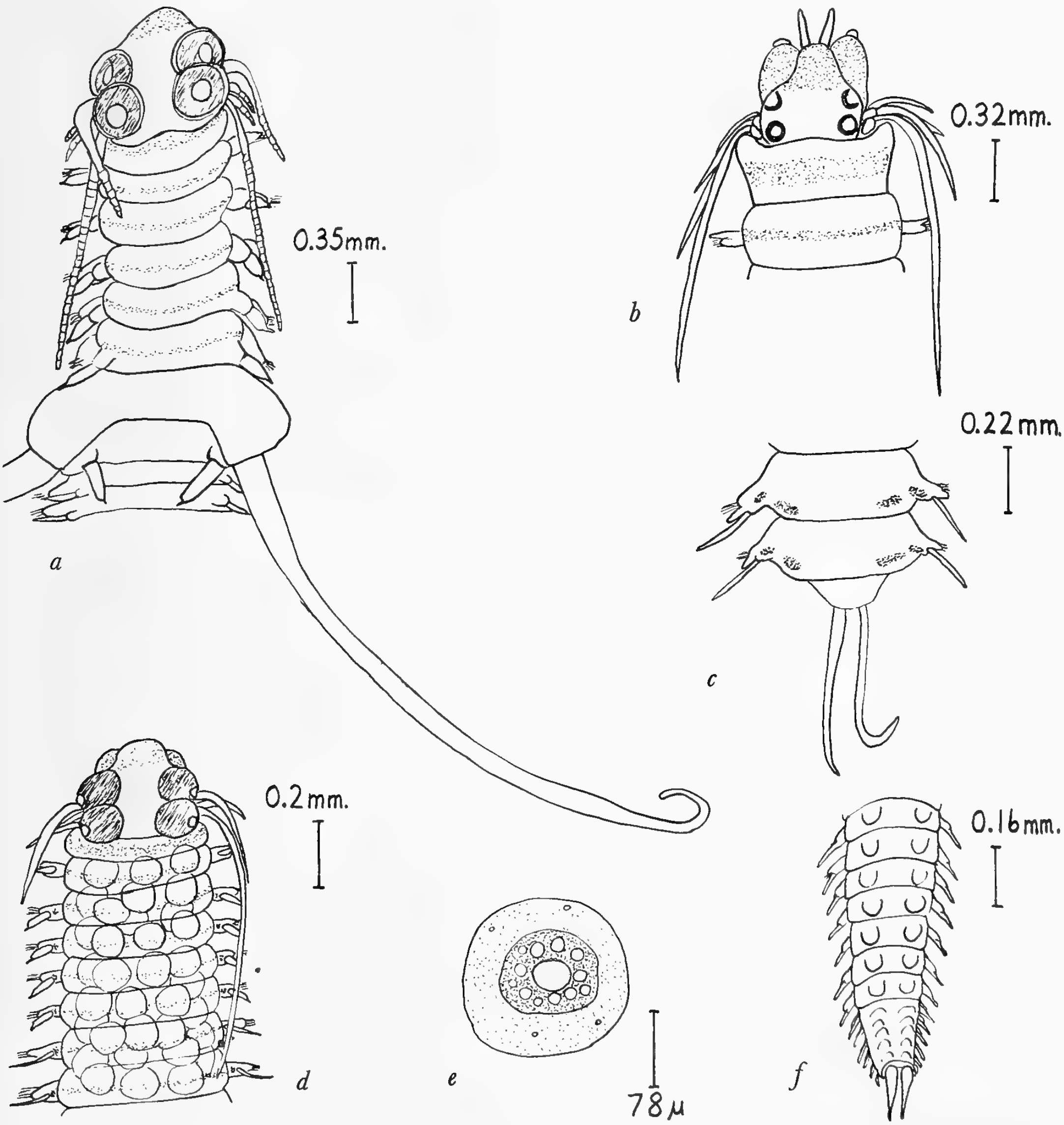

Fig. 4.—*Nereis egregicirrata: a,* Dorsal view anterior end of male heteronereid showing enormously elongated dorsal cirri on setiger 6. *Nereis allenae,* n.sp.: *b,* Dorsal view anterior end of atokous form; *c,* dorsal view posterior end of same; *d,* dorsal view anterior end of female heteronereid; *e,* one of large yolky eggs of same; *f,* dorsal view posterior end of male heteronereid.

from reef between the Laboratory and Caballo Blanco Island, Parguera, Porto Rico, evening, 15 September 1955, collected by M. Jean Allen, after whom the species is named; it is unusual in that the eggs were laid in short alga-like strings; paratypes (U.S.N.M. no. 27779): a single female heteronereid (massed with large eggs) and 3 male heteronereids removed from the type material of *Nereis egregicirrata* Treadwell (see above), collected at submarine light, English Harbor, Antigua, July 1918; paratypes (U.S.N.M. no. 27780): 3 atokous specimens which were mixed with other species, collected from Pelican Island, Barbados, from the Barbados-Antigua Expedition, 1918.

Description of the atokous form.—Length up to 27 mm, width up to 1 mm, segments about 80. Body long, slender, slightly flattened dorsoventrally, tapered gradually posteriorly. Prostomium (Fig. 4, *b*) widest basally, narrowed on anterior half; frontal antennae slender, palps bulbous with retractile tips, of about same length as antennae; 4 eyes on posterior half of prostomium, violet, rather large, subequal. Tentacular segment of about same length as following segments; tentacular cirri short to longer, the longest reach setiger 4. Posterior end (Fig. 4, *c*) with bulbous anal segment, with pair of long anal cirri. Parapodia (Fig. 6, *a*, *b*) similar throughout the length of the body. Dorsal cirri much longer than the ligules; notopodium with 2 rounded to conical ligules, with small acicular lobe on upper side of lower ligule (no distinct middle ligule), with homogomph spinigerous setae (without homogomph falcigers in middle and posterior part of body); neuropodium with conical setigerous lobe with anterior and posterior lips, with conical lower ligule; upper group of neurosetae homogomph spinigers and heterogomph falcigers; lower group of neurosetae heterogomph spinigers and falcigers; heterogomph falcigers of anterior region with short blades (Fig. 6, *c*); in middle and posterior regions, upper group of neurosetae with homogomph spinigers and few (1–3) heterogomph

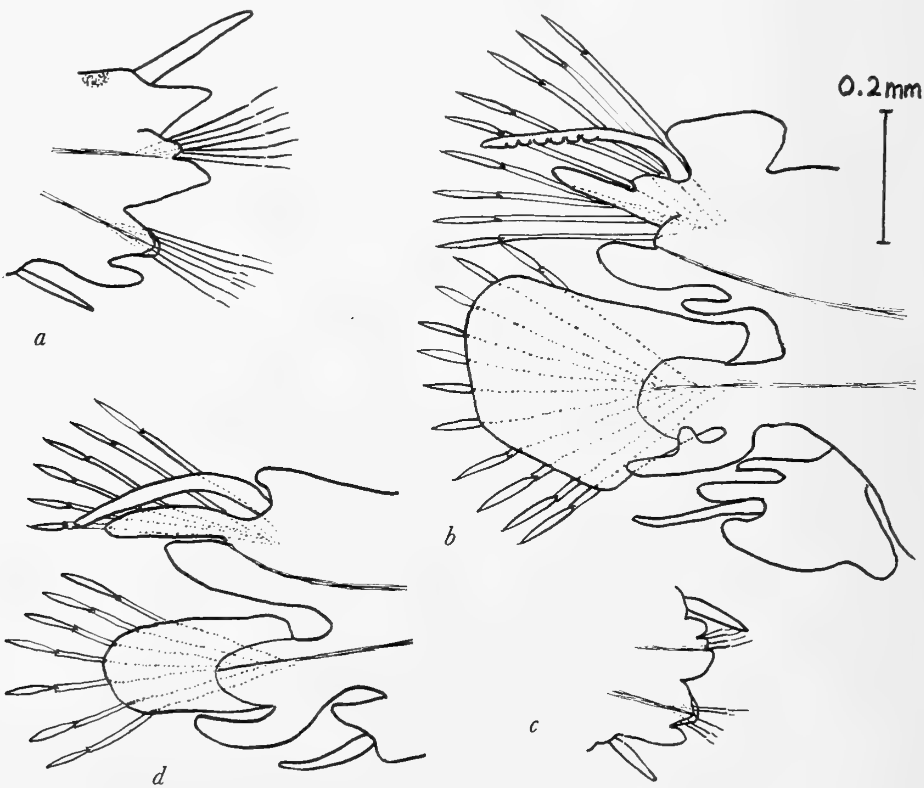

FIG. 5.—*Nereis egregicirrata: a*, Parapodium from anterior unmodified region of male heteronereid; *b*, parapodium from posterior modified region of same; *c*, parapodium from anterior unmodified region of female heteronereid; *d*, parapodium from posterior modified region of same. (All parapodia drawn to same scale.)

falcigers that are stouter than the others (Fig. 6, *d*); lower group of falcigers more slender with short blades (Fig. 6, *e*); acicula dark amber-colored. Proboscis with dark amber-colored jaws, with conical amber-colored paragnaths on both maxillary and oral rings (exact arrangement?). Color (in alcohol): With brownish pigment on anterior part of prostomium including palps, with a wide band on the tentacular segment and narrow transverse bands both dorsally and

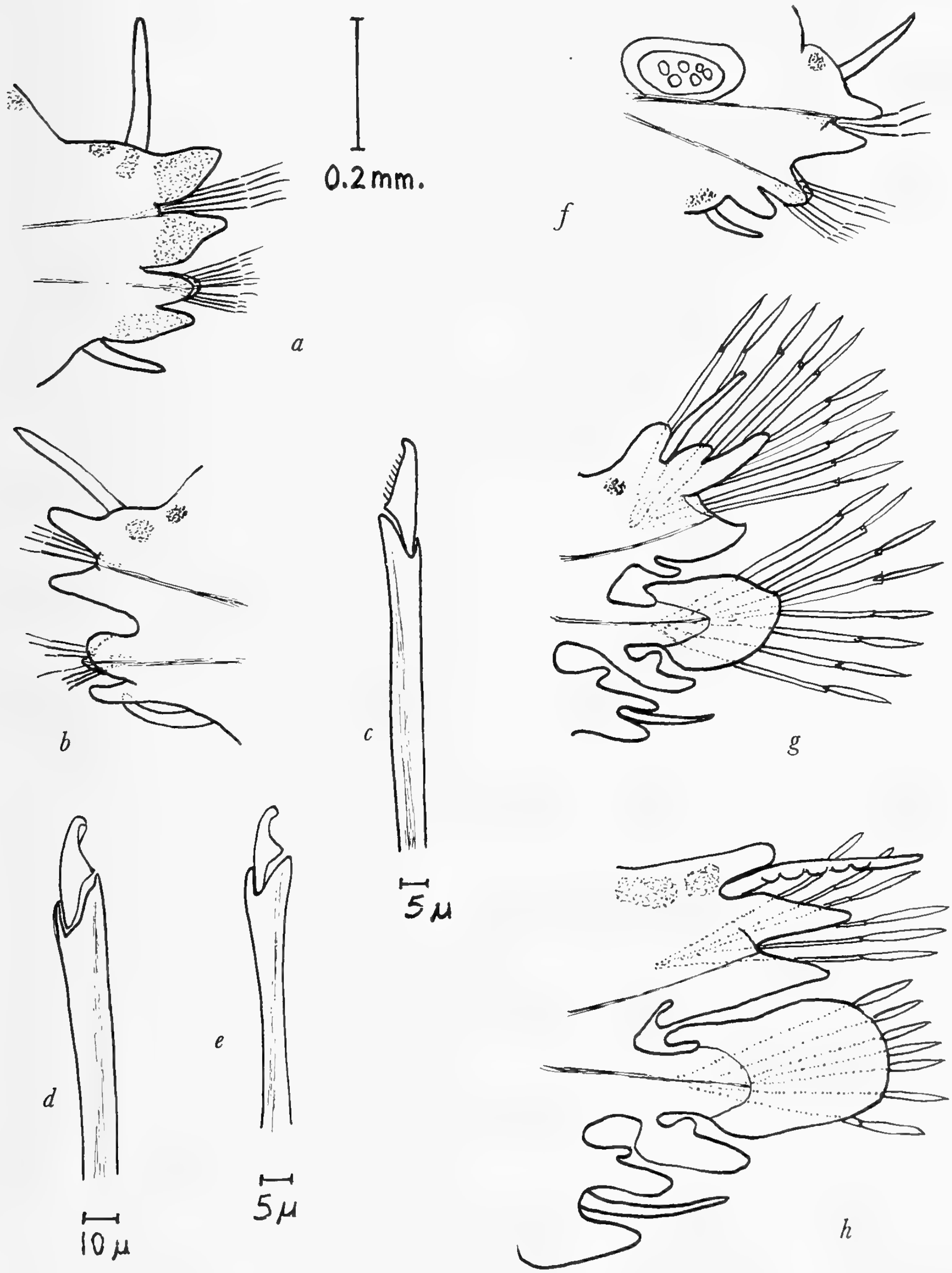

Fig. 6.—*Nereis allenae*, n.sp.: *a*, Parapodium from anterior region of atokous form; *b*, same, from middle region of body; *c*, heterogomph falcigerous seta from anterior parapodium of atokous form; *d*, heterogomph falcigerous seta from upper group of neurosetae from middle parapodium of atokous form; *e*, same, from lower group of neurosetae; *f*, parapodium from anterior part of body of female heteronereid; *g*, same, from posterior modified region; *h*, parapodium from modified region of male heteronereid. (All parapodia drawn to same scale.)

ventrally on most of the segments; also brownish glandular areas laterally within the body—at the bases of the parapodia dorsally and ventrally, at the bases of the dorsal and ventral cirri, and in the ligules (Fig. 4, *b*, *c*).

Description of male and female heteronereids.—Body divided into two distinct regions: anterior unmodified, with the usual type of setae; posterior modified, with the usual type of setae replaced by swimming setae and the development of lamellae instead of ligules; in addition in the male, there is a posterior "tail" region of about 12 segments which lack the modified parapodia; also there are paired dorsal knobs on the last 19 or so segments, giving the "tail" a characteristic aspect (Fig. 4, *f*). Prostomium (Fig. 4, *d*) with anterior part bent down ventrally, thus the frontal antennae and palps are not visible dorsally; four eyes large, bulging, subequal, purple, with distinct lenses, the 2 on each side closely appressed. Tentacular segment of female with lower 2 pairs of tentacular cirri short, upper anterior pair extending to setiger 2, upper posterior pair extending to setiger 7; in the males, the tentacular cirri were broken off except for one rather short pair. Parapodia of anterior unmodified region (Fig. 6, *f*) similar to atokous form. In the female, the body wall of the anterior unmodified segments is very thin, transparent; this region is massed with large yolky eggs (about 160 μ in diameter); the eggs have an outer finely granular portion and an inner denser portion with the large nucleus and a number of large oil globules (Fig. 4, *d*, *e*); these eggs were reported by the collector as being laid in short alga-like strings; the eggs made up a single row of cells, some strings with approximately 30 eggs; within about an hour after laying, the "jelly" holding the eggs together had dissolved. The male and female heteronereids differ in the following:

	Male heteronereid	*Female heteronereid*
Length	Up to 12 mm.	Up to 14 mm
Width	Up to 1.5 mm in anterior region; up to 2.5 mm in posterior region	Up to 1.5 mm in anterior region; up to 2 mm in posterior region
Number of setigers in anterior unmodified region	14	26
Number of setigers in posterior modified region	About 46 plus 12 in "tail"	About 55
Total number of setigers	About 72	About 81
Posterior end	Pair of dorsal papillae (ventral anal cirri missing); with a pair of dorsal knobs on the last 19 or so segments (Fig. 4, *f*)	Bulbous anal segment (anal cirri missing)
Dorsal cirri of anterior region	First 7 pairs elongated, clubbed, become longer posteriorly	First 5 pairs slightly modified, clubbed
Ventral cirri of anterior region	First 4 pairs clubbed	First 5 pairs slightly modified, clubbed
Parapodia of modified region with swimming setae	Fig. 6, *h*	Fig. 6, *g*
	Dorsal cirri crenulate on lower margin	Dorsal cirri smooth, not crenulate
	Extra lamella above base of dorsal cirrus	Same
	Single supraacicular notopodial lamella	Unequally bilobed supraacicular notopodial lamella
	Single large subacicular notopodial lamella	Unequally bilobed subacicular notopodial lamella
	Large rounded postsetal neuropodial lamella	Same, smaller
	Unequally bilobed lower neuropodial lamella	Same
	Ventral cirri with bilobed lamella above and large lamella below	Same, smaller
Color	Not banded; dark glands at bases of parapodia dorsally	Pigmented on anterior part of prostomium and palps, wide band on tentacular segment, with narrow transverse bands on rest of segments dorsally and ventrally, with darker spots at the bases of the parapodia and bases of the dorsal and ventral cirri.

Distribution.—West Indies: Porto Rico, Antigua, Barbados; heteronereids at surface (July, September).

Nereis (Nereis) pelagica Linné, 1758

Nereis largoensis Treadwell, 1931, p. 3.—not Behre, 1950, p. 12.
Nereis pelagica largoensis Hartman, 1956, pp. 255, 280.

Remarks.—The type of *Nereis largoensis* Treadwell, 1931, from Key Largo, Florida, deposited in the American Museum of Natural History, was examined. It has been referred to *Nereis pelagica largoensis* by Hartman, 1956. In comparing it with specimens of the more northern *N. pelagica*, it seems to be identical; the paragnath arrangement falls within the variation found in *N. pelagica*; the posterior notopodial lobes are no more enlarged than is found in the more northern forms. The record of *N. largoensis* from Grand Isle, La., by Behre, 1950, was based on specimens deposited in the United States National Museum and identified by Treadwell; on examination, they proved to be *occidentalis* and not *largoensis*.

Distribution.—Widely distributed in the Arctic. Also Iceland, Norway to Mediterranean; Hudson Bay to Long Island Sound, Florida (Key Largo); Bering Sea to Panamá; north Japan Sea to Japan; South Atlantic (Tristan da Cunha, Kerguelen, Magellan Straits). In low water to 609 fathoms.

Nereis (Nereis) occidentalis Hartman, 1945

Fig. 7, *a–d*; 8, *a–g*

Nereis pelagica occidentalis Hartman, 1945, p. 20, pl. 4, figs. 1–6; 1951, p. 46.—Behre, 1950, p. 12.
Neanthes oligohalina Rioja, 1946, p. 207, pl. 1, figs. 3–6; pl. 2, figs. 13–19.
Nereis largoensis Behre, 1950, p. 12.—Hartman, 1951, p. 45, pl. 13, fig. 5 (part; from Grand Isle, La.); not Treadwell, 1931.

Heteronereid epitokous forms of this species (including a single female and 7 males) were collected by Joseph P. Breuer and sent into the Museum for identification; they were collected in Laguna Madre, 25 miles north of Port Isabel, Tex., at night under light, April 15, 1956. The females have not been described previously and the males only partially. They are described herein and compared with the atokous form. The known distribution of the species is extended from collections in the United States National Museum.

Description of atokous form.—Length up to 50 mm, width up to 4 mm, segments about 80. Prostomium of the typical nereid form, with the 4 eyes rather large, subequal. Tentacular segment with 4 pairs of tentacular cirri, the longest reach setigers 3 to 8. Parapodia of anterior region (Fig. 8, *a*) with ligules short and rounded; the ligules become slightly more elongated and conical in the middle and posterior regions (Fig. 8, *b*, *c*). Notopodium with 2 ligules, with a very small supraacicular setigerous lobe between them (not a distinct third ligule); neuropodium with a rounded to conical setigerous lobe and a lower ligule. Dorsal cirri longer than the ligules, ventral cirri slightly shorter. Notosetae of anterior region consist of homogomph spinigers; in the middle and posterior regions, the notosetae become fewer in number, with few (1–2) homogomph falcigers in addition to the spinigers; homogomph falcigers with short blades, with recurved tip and spinous edge (spines may be worn; Fig. 7, *c*, *d*). Upper group of neurosetae homogomph spinigers and heterogomph falcigers; lower group of neurosetae heterogomph spinigers and falcigers; hetero-

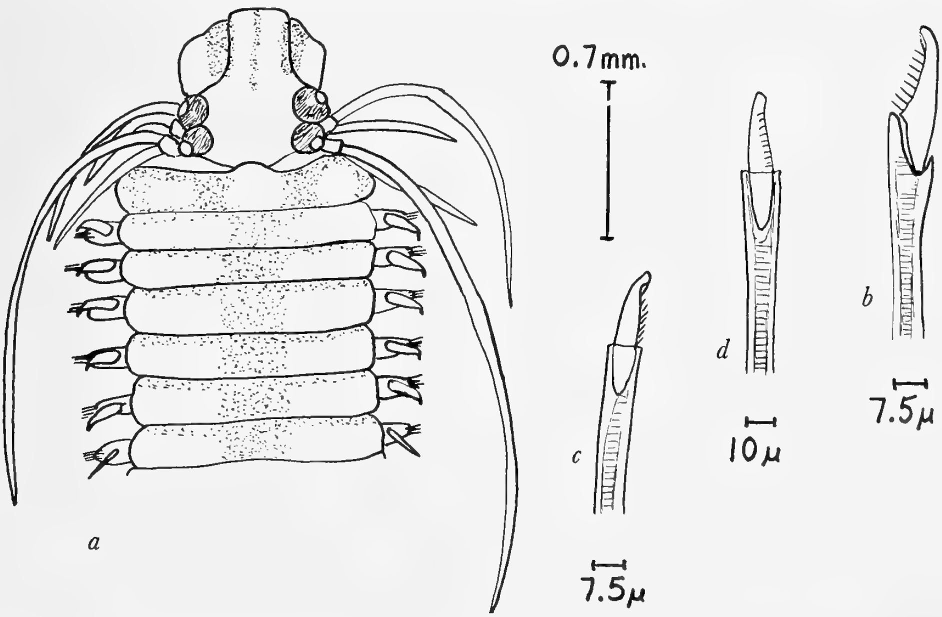

FIG. 7.—*Nereis occidentalis: a*, Dorsal view anterior end of female heteronereid; *b*, heterogomph falcigerous neuroseta from anterior region of atokous specimen; *c*, homogomph falcigerous notoseta from posterior region of atokous specimen; *d*, same, from slightly different angle.

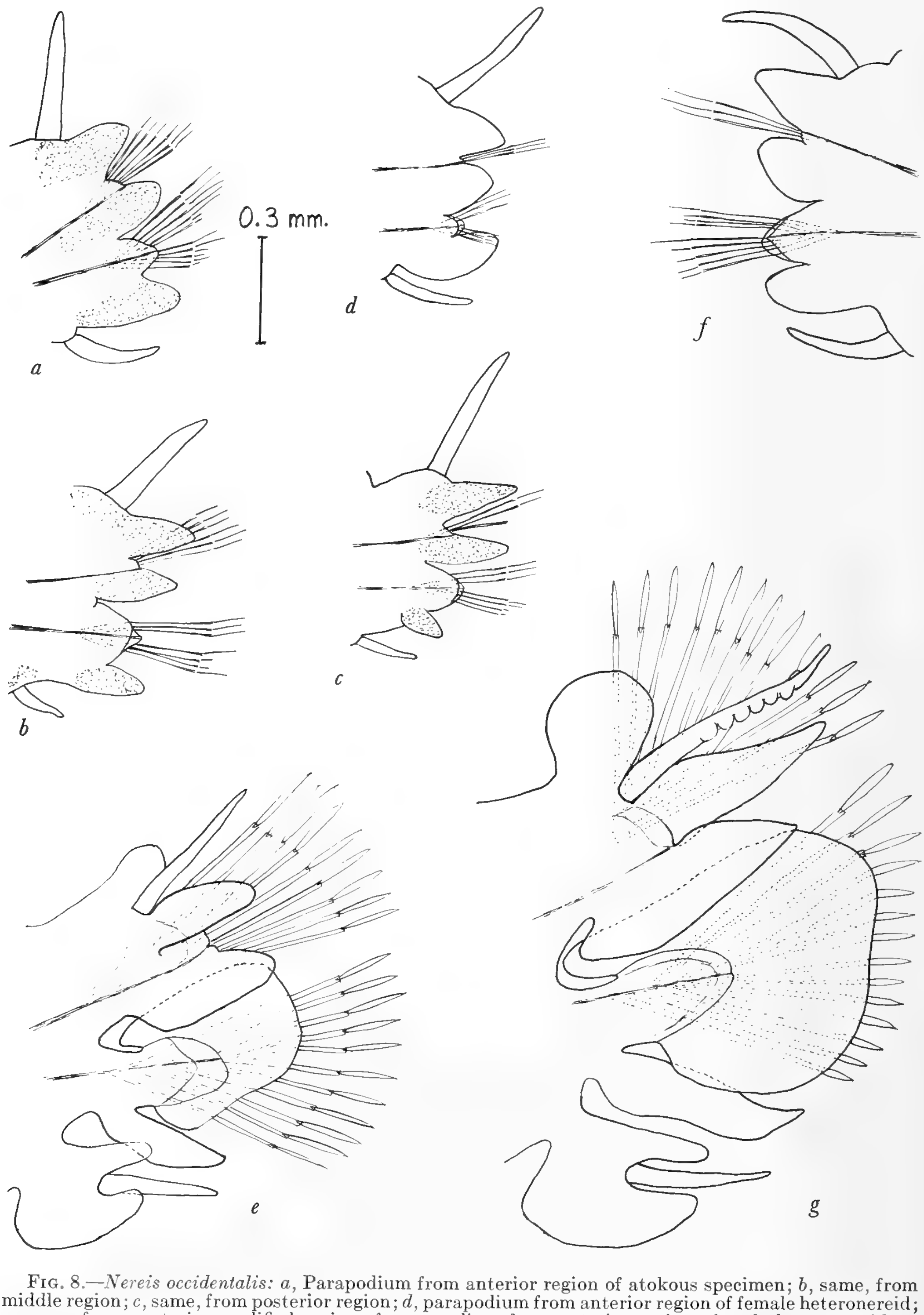

FIG. 8.—*Nereis occidentalis: a*, Parapodium from anterior region of atokous specimen; *b*, same, from middle region; *c*, same, from posterior region; *d*, parapodium from anterior region of female heteronereid; *e*, same, from posterior modified region; *f*, parapodium from anterior region of male heteronereid; *g*, same, from posterior modified region. (All parapodia drawn to same scale.)

gomph falcigers with rather short blades with recurved tip and spinous edge (Fig. 7, *b*). Acicula black. Proboscis with dark amber-colored jaws, each with 7–8 teeth; paragnaths conical, dark, those of maxillary ring smaller than those of oral ring, arranged as follows: area I, 1–4 (8–12 small ones in var. *oligohalina*); area II, crescent-shaped area of 2 rows; area III, elliptical group of 4–5 rows; area IV, arched group of 3–4 rows; area V, 0 (rarely 1, in var. *oligohalina*); area VI, usually 4 (3–6); areas VII–VIII, continuous, 2–3 rows, subequal, do not get smaller basally. Color (in alcohol): Dusky on prostomium, especially on area in front of eyes, and on some of the anterior body segments.

Description of the male and female heteronereids.—Body divided into two regions in the male: anterior region with unmodified segments, posterior region with modified parapodia with swimming setae and lamellae instead of ligules; in addition in the female, there is a short posterior or "tail" region of unmodified segments. Anterior part of prostomium (Fig. 7, *a*) may or may not be bent ventrally, thus the frontal antennae and palps may be only partially visible dorsally; eyes large, bulging (not as much as in some species of nereids). Parapodia of anterior unmodified region similar to atokous form (Fig. 8, *d, f*). In life, they were described as bright red in color and active swimmers. The male and female heteronereids differ in the following:

	Male heteronereid	*Female heteronereid*
Length	Up to 30 mm.	Up to 23 mm
Width	Up to 3 mm in anterior region; up to 4 mm in modified region.	Up to 2 mm in anterior region; up to 3 mm in modified region.
Number of setigers in anterior unmodified region	16	25
Number of setigers in posterior region	About 75	About 50, plus 15 in "tail"
Total number of setigers	About 90	About 90
Tentacular cirri	Longest reach setigers 4–6	Longest reach setiger 10
Anterior dorsal cirri	First 7–8 pairs clubbed.	First 5 pairs clubbed.
Anterior ventral cirri	First 5 pairs clubbed.	Same
Posterior end	Anal segment a papillated disk, with double row of numerous papillae, with or without pair of long anal cirri (may be broken off).	Anal segment bulbous, slightly crenulate, with anal cirri missing.
Color (in alcohol)	Pigmented dusky area on prostomium anterior to eyes; slight amount on anterior segments.	Same on prostomium; anterior half of anterior unmodified region darkly pigmented (fig. 7, *a*)
Parapodium of modified region	Fig. 8, *g*	Fig. 8, *e*
	Dorsal cirri crenulate with few large crenulations.	Dorsal cirri smooth, not crenulate.
	Rounded lamella above dorsal cirrus.	Elongated lamella above dorsal cirrus.
	Digitiform notopodial lamella below dorsal cirrus.	Same, shorter.
	Subacicular digitiform notopodial lamella.	Same.
	Large rounded postsetal lamella.	Same, smaller.
	Elongated digitiform lower neuropodial lamella.	Same.
	Elongated lamella above and rounded lamella below ventral cirrus.	Same.

Biology.—*Nereis occidentalis* is found intertidally and dredged in shallow depths. It is found on mud flats and sandy shoals, among ascidian and sponge masses, tube masses of maldanids, as *Petaloproctus*, oyster clusters and between shells of mussels, as *Mytilus*; it is found on piles, scrapings from floating buoys, and washed from sea weeds. The species evidently has a wide salinity tolerance, as it has been found in estuaries along with *Nereis succinea* (Frey and Leuckart). Epitokes have been found swarming at the surface in April in Texas (Corpus Christi, April 29, 1950, Hartman, 1951; Laguna Madre, April 15, 1956, collected by J. P. Breuer); early epitokes have been found in North Carolina in June (Beaufort, Hartman, 1945).

Records.—North Carolina (Beaufort), Florida (Port St. Joe, Gullport), Louisiana (Grand Isle), Texas (Corpus Christi, Laguna Madre), Mexico (Veracruz, Tecolutla), Porto Rico (Arroyo, Ensenada Honda, Culebra).

Distribution.—West Indies (Porto Rico), North Carolina, Gulf of Mexico (Florida to Mexico). In low water and shallow waters; sexual epitokes at surface.

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LOW TEMPERATURE STORAGE OF FREE RADICALS

The National Bureau of Standards has developed a technique for capturing and storing large numbers of highly reactive molecular fragments at temperatures near absolute zero. By this method unstable atoms and free radicals, known to exist but momentarily in flames and hot gases, are produced in an electric discharge, frozen into immobility, and trapped in solid form. Because these atoms are frozen in the excited state, they can be conveniently studied by optical spectroscopy.

In experiments to date the Bureau has produced solids containing atomic nitrogen and oxygen, and possibly atomic hydrogen and an unstable hydroxy (OH) molecule. These solids have very unusual properties, emitting bright glows, blue "flames," and colored flashes of light. When warmed 20° or 30°, they combine very actively, relasing large quantities of stored energy, principally as heat. Other possible fields of application include solid state physics and basic chemistry. Here the trapped atoms could be used as powerful probes into the solids containing them. From a study of their properties, information could be obtained about the arrangement of the atoms and molecules in the solid and about the forces acting on them. Similarly the mechanism of diffusion of atoms and of reactions between atoms and molecules could be studied.

These experiments were begun at NBS in 1954 by H. P. Broida and J. R. Pellam[1] and are being continued by H. P. Broida, A. Bass, and O. Lutes[2] of the Bureau's temperature measurements laboratory. C. M. Herzfeld of NBS is carrying out theoretical investigations[3] on the systems. The research is supported chiefly by the Office of Naval Research and the U. S. Air Force through the Office of Scientific Research of the Air Research and Development Command.

Within the last five years several methods have been developed in other laboratories for stabilizing free radicals at low temperatures. However, the present technique has the advantage that the free radicals are stored in highly excited states as a result of the electric discharge, making it possible to study and analyze them by spectroscopic techniques. Also, since the radicals are collected at much lower temperatures than in previous methods, they can be stored longer in the uncombined form.

In this method gases containing molecules

[1] Broida, H. P., and Pellam, J. R., Phys. Rev. **95:** 845, 1954; Broida, H. P., and Pellam, J. R., Journ. Chem. Phys. **23:** 409, 1955.

[2] Bass, A. M., and Broida, H. P., Phys. Rev. **101:** 1740, 1956; Broida, H. P., and Lutes, O. S., Journ. Chem. Phys. **24:** 484, 1956.

[3] Herzfeld, C. M., and Broida, H. P., Phys. Rev. **101:** 606, 1955.

of nitrogen, hydrogen, oxygen, or water are first passed through a high-frequency electric discharge, then frozen very suddenly at 4.2°K, just a few degrees above absolute zero.

The discharge is maintained in a waveguide resonator by a 2450-Mc power supply. From the resonator, a glass tube leads the resulting molecular fragments into an evacuated metal vessel containing a cold surface in contact with a liquid helium bath. To prevent solidification of the discharge products at temperatures above 4.2°K, the gases are carried to the cold surface through a passageway that is kept near room temperature by contact with warm helium gas. When the gases reach the cold surface, they freeze into solid form there.

Various techniques can then be used to study the resulting solids. Through windows in the metal vessel, a number of spectrographs of different types can be aimed at the cold surface, and the light given off by the solids frozen on the surface can be analyzed. To study the light absorbed by the solids, the gases are condensed on a transparent cold surface, and light is passed through the windows of the vessel, the condensed material, the cold surface, and finally into the spectroscopes. To determine the heat evolved by recombination of atoms, the gases are condensed into a small, simple low-temperature calorimeter, and the heat evolved by the material as it warms up is measured.

Because the free radicals produced by this method can be kept unchanged for many hours, a more detailed study of their properties has been possible than in previous work. For example, during the discharge through nitrogen the condensed solid emits a bright green glow, which tends to become yellow at high flow rates. The spectra obtained from this glow show that the structure of the solid condensed from the discharge differs from that of ordinary solid nitrogen. In fact, each atom of the condensed nitrogen forms a very loosely bound complex with some neighboring molecule, and this complex has properties that differ from those of the separate atom and molecule. The evidence shows that the complex is a definite unit. By analyzing its spectra, the forces holding it together can be studied.

Brilliant blue flashes are also observed from the solid surface during the nitrogen discharge. These flashes are thought to be due to local warming. After the flow of nitrogen is stopped, the discharge goes out and a green afterglow from the cold collected material persists for several minutes, decaying with a half-life of about 15 seconds. When the green afterglow has disappeared, sudden warming of the vessel walls (to between 25° and 35°K) causes a blue "flame" which appears to "burn" through the condensed material. The light and heat thus given off are evidently due to recombination of the atoms into molecules. When the light is analyzed spectroscopically, it gives information about the structure of the molecule just formed and about the forces acting between two atoms. The reaction of a nitrogen atom with an oxygen atom can also be studied in this way.

When oxygen is passed through the discharge, a clear, glassy deposit is obtained which has rather complex absorption spectra. Upon warming this material to about 20°K, the original deposit evaporates and a solid violet material condenses on the surface. This substance has been identified as a mixture of oxygen and ozone. Further warming of the violet substance produces ozone in large quantities. Initiation of chemical reactions in this way, by warming the frozen material, indicates the possibility of opening up a new field of very low temperature chemistry. Because of the high chemical activity of the free radicals, new chemical compounds might be formed by this process.

Low-temperature condensates have also been obtained from hydrogen and water. While the solids formed show complex behavior similar to that of nitrogen and oxygen, the results are still incompletely understood.

One science only will one genius fit,
So vast is art, so narrow human wit.
—Pope

NEMATOLOGY.—Paratylenchus projectus, *new species* (*Nematoda, Criconematidae*), *with a key to the species of* Paratylenchus.[1] W. R. Jenkins, University of Maryland. (Communicated by R. Bamford.)

(Received July 11, 1956)

In July 1955, root and soil samples were collected from a pasture in Prince Georges County, Md., in an effort to determine the cause of stunted growth and general decline of grasses in this field. Examination revealed that a new species of *Paratylenchus* was present in large numbers.

To determine parasitism, specimens of this species were transferred to pots containing plants of tall fescue, *Festuca elatior* var. Kentucky 31, which were maintained under greenhouse conditions. Since the field under examination was used from time to time for growing tobacco, seedlings of *Nicotiana tabacum* L. were also inoculated with specimens of *Paratylenchus* n. sp. Both tall fescue and tobacco supported large population increases under these conditions.

It is probable that decline and failure of this pasture is due, at least in part, to *Paratylenchus* n. sp. Therefore, investigations are being conducted to determine pathogenic effects of this nematode on grasses and tobacco.

Paratylenchus projectus, n. sp.

Fig. 1

25 females: 373.0μ (289–475μ); a = 18.7 (15.6–20.8); b = 4.0 (3.5–4.9); c = 15.4 (11.3–19.5); V = 84.3 per cent (82.6–86.9 per cent); stylet = 31.8μ (24.8–37.1μ).

Males: Unknown.

Female.—The cuticle is marked by rather fine transverse striae about one micron apart. The lateral field occupies about two-fifths of the body diameter and is marked by four evenly-spaced incisures. The slightly-offset lip region is truncate with a median labial extension and is marked by three transverse striations. Neither amphids nor cervical papillae have been observed; however, phasmids are located in the lateral field anterior to the anus. The conspicuous excretory pore varies in its location from just behind the median swelling of the esophagus to the anterior end of the basal swelling of the esophagus, always on the ventral surface. There is an average of 50 postvulval annulations.

The buccal cavity is small and there is no sclerotized cephalic framework. The spear averages 31.8 microns and has prominent knobs which are somewhat flattened on the anterior surface. The dorsal esophageal gland opens into the lumen of the esophagus about one-fifth the spear-length behind the base of the spear. There is a typically criconematoid median bulb with a valvular apparatus behind which the duct of the ventral esophageal glands opens into the lumen of the esophagus. Posterior to the median bulb, there is a long and narrow isthmus about which lies the circumesophageal nerve ring. The terminal swelling of the esophagus is somewhat pyriform in shape. There is no cardia. The intestine, the cells of which are filled with many small, refractive inclusions, ends in a short rectum and obscure anus.

There is a single outstretched ovary which usually reaches to the anterior end of the intestine but has been observed as far anterior as the median esophageal bulb. The cap cell gives rise to several oogonia which are arranged in a double line. Only one egg, averaging 57.9μ by 13.2μ, was observed in the uterus at a time. The vulva is an anteriorly sloping, transverse slit flanked by lateral vulval membranes. No spermatheca or post-vulval uterine sac has been observed. There is a marked reduction in body diameter immediately behind the vulva.

Larvae were observed to have a small and indistinct esophagus. The median swelling was much reduced in size but did possess a large valvular apparatus.

The normal relaxed position was a ventral curving in both larvae and females.

Type host.—Soil about roots of pasture grass.

Type locality.—Upper Marlboro, Prince Georges County, Md.

Diagnosis.—The absence of males distinguishes *P. projectus* from *P. goodeyi* Oostenbrink, 1953, *P. hamatus* Thorne and Allen, 1950, *P. besoekianus* Bally and Reydon, 1931, *P. elachistus*

[1] Scientific Article no. *A571*, Contribution no. *2729*, of the University of Maryland Agriculture Experiment Station, Department of Botany.

Steiner, 1942, *P. minutus* Linford, 1949, *P. macrophallus* (de Man, 1880) Goodey, 1934, and *P. dianthus* Jenkins and Taylor, 1956.

This species differs in many ways from females of species in which no males have been reported. From *P. bukowinensis* Micoletzky, 1922, *P. projectus* can be distinguished by its slightly offset lip region which is truncated and bears three striations, in its lack of a post-vulval uterine sac, lateral vulval wings, and in the shape of the spear knobs.

P. projectus differs from both *P. nanus* Cobb,

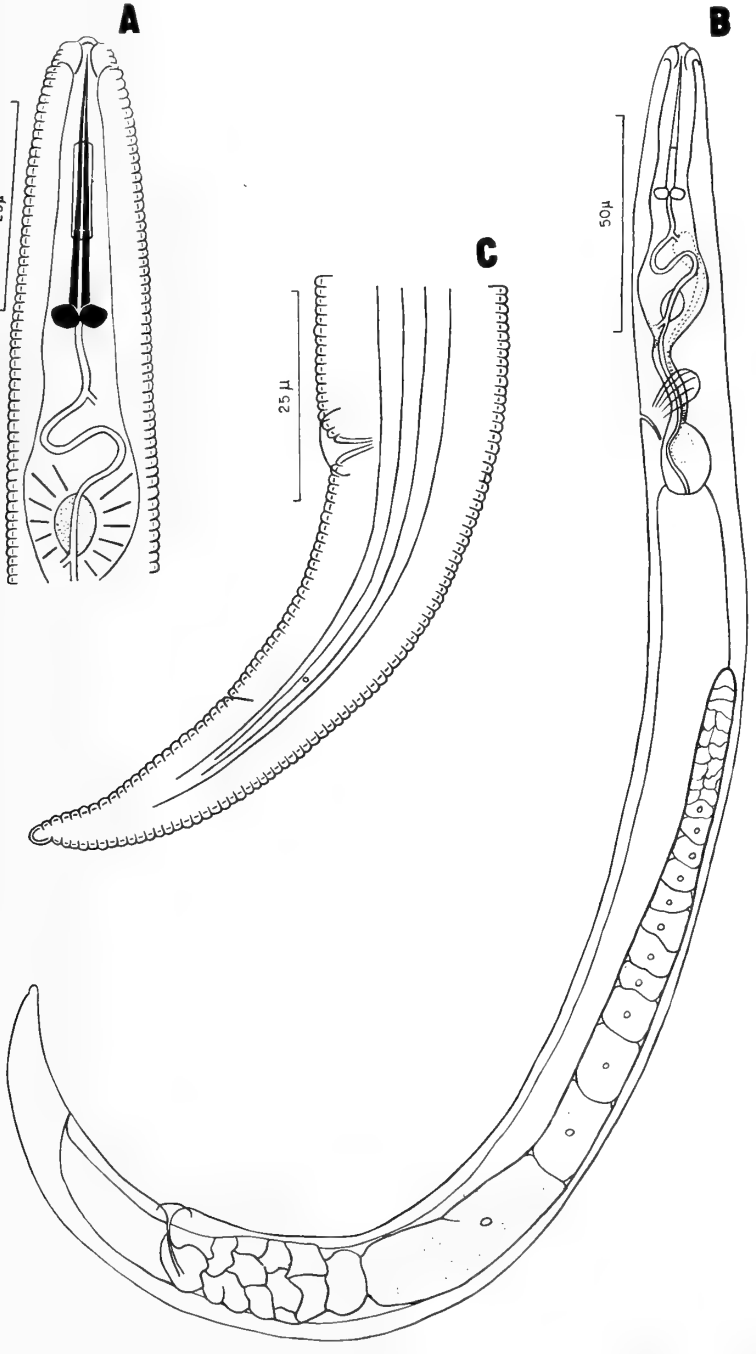

FIG. 1.—*Paratylenchus projectus*, n. sp.: A, Anterior portion; B, mature female; C, posterior portion.

1923 and *P. anceps* Cobb, 1923 in its offset, striated lip-region, its smaller spear which bears flattened knobs, and in its lack of a spermatheca. It differs further from *P. anceps* by having four incisures in the lateral field, while the latter has only two incisures.

P. curvitata van der Linde, 1938, is smaller than *P. projectus* (330μ as opposed to 373μ), has a much smaller spear (24μ as opposed to 31.8μ), and does not bear a median labial extension.

Because of the frequent occurrence of *Paratylenchus* species in soil about roots of plants, a key is presented to aid in the identification of described species. This key was devised from published descriptions and illustrations, not from personal examination of specimens of each species. It is based for the most part on female characteristics, because males are frequently unknown or exist in very small numbers.

KEY TO SPECIES OF PARATYLENCHUS MICOLETZKY, 1922

1. Lip region a truncated cone 2
   Lip region smooth and rounded 8
2. Lateral field marked by two incisures
   anceps Cobb, 1923
   Lateral field marked by four incisures 3
3. Postvulval uterine sac present 4
   Postvulval uterine sac absent 5
4. Female spear about 19μ long; male spear faded and indistinct
   besoekianus Bally and Reydon, 1931
   Female spear about 25μ long; males absent
   bukowinensis Micoletzky, 1922
5. Lateral vulval membranes present 6
   Lateral vulval membranes absent 7
6. Female lip region striated; males absent
   projectus, n. sp.
   Female lip region not striated; males present
   dianthus Jenkins and Taylor, 1956
7. Postvulval reduction in body diameter; males absent .... *curvitata* van der Linde, 1938
   No postvulval reduction in body diameter; males frequent
   macrophallus (deMan, 1880) Goodey, 1934
8. Females stout, spear 48–56μ
   goodeyi Oostenbrink, 1953
   Females typically slender 9
9. No marked postvulval reduction in body diameter.... *hamatus* Thorne and Allen, 1950
   Marked postvulval reduction in body diameter
   10
10. Females 360–410μ long; males absent
    nanus Cobb, 1923
    Females 234–310μ long; males frequent 11
11. Male with anal sheath surrounding spicula, tail convex-conoid.... *minutus* Linford, 1949
    Male without anal sheath, tail short and subacute .... *elachistus* Steiner, 1942

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The generality of men are so accustomed to judge of things by their senses that because air is invisible they ascribe but little to it, and think of it as but one remove from nothing.—R. Boyle (1673)

PHYSIOLOGY.—*Effect of sympathetic denervation of the urinary bladder in animals and man.*[1] E. H. INGERSOLL, L. L. JONES, and E. S. HEGRE, Medical College of Virginia. (Communicated by Paul H. Oehser.)

The reaction of the urinary bladder to denervation in the laboratory animal has been extensively reported, especially in the older literature, but it has been only in recent years that careful studies have been published in man. In fact, as Heimburger et al. (*1*) have pointed out, knowledge of the human bladder innervation has been taken largely from comparisons with experimental animals and from human dissections. In this study we will review the response of the viscus to division of the sympathetic outflow, first in animals and then in man.

Effect in the cat.—There is much difference of opinion as to the effect of section of the sympathetic fibers to the bladder, not only in the cat, but in other animals and in man as well. Neither Beattie (*2*) nor Nawrocki and Skabitschewsky (*3*) observed any change in bladder function following section of the hypogastric nerves in the cat. Some workers (*4*, *5*, *6*, *7*) found that division of the sympathetics did not interfere with bladder emptying but seemed to increase temporarily the frequency of micturition.

Elliott (*8*), in addition to observing increased frequency of bladder emptying, noted that the tone of the viscus was permanently increased following section of the sympathetic outflow. He observed that this tone was diminished only slightly by further section of the pelvic nerves. Similarly, Langworthy et al. (*9*, *10*, *11*) found an immediate decrease in vesical volume when the post ganglionic sympathetic fibers were cut on one side. This defect persisted for several weeks. Removal of the sympathetics on both sides, according to Langworthy, produced a more marked and lasting decrease in volume.

These findings have been difficult to correlate with what has been observed following electrical stimulation of the hypogastric nerves in the cat. We (*12*, *13*) have shown, as have others, that excitation of the sympathetic outflow to the bladder regularly evoked contractions of all portions of the detrusor muscle. True, this response was not a sustained one, lasting only a few seconds, and it was invariably followed by relaxation. It may be possible, as Gillilan (*14*) has suggested, that sympathetic fibers play a minor role in micturition, and only come into play in emergencies. However, the observed increase in frequency of micturition, together with the decrease in vesical size after sympathetic denervation, would tend to support the views of those who believe that the hypogastrics are not only the "filling" nerves of the bladder but are antagonistic in action to the parasympathic outflow (*8*, *15*, *16*, *17*, *18*, *19*, *20*, *21*).

Effect in the dog.—Most investigators (*2*, *22*, *23*, *24*, *25*, *26*) have found that section of the hypogastric nerves in the dog caused no interference with normal micturition. A few, such as Creevy (*7*), and Jacobson (*27*), have noted changes in vesical function after division of sympathetic nerves to the bladder. Removal of the hypogastrics, according to Creevy, produced a slight, transitory increase in frequency of micturition while Jacobson observed a prompt increase in vesical tone and an equally prompt decrease in bladder capacity. The vesical tone in Jacobson's dogs gradually decreased but never entirely returned to normal; functionally, however, he was unable to distinguish this type of preparation from the normal bladder as the ability to void was in no way impaired by the operation.

Effect in man.—Section of the hypogastric nerves in man at first was done on the premise (*28*) that the internal sphincter of the bladder had its motor innervation through the sympathetic nervous system, and that it became hypertonic owing to the imbalance caused by the removal of the parasympathetic inhibition. One of the difficulties with this theory has been that no conclusive evidence has ever been forthcoming to prove that the internal sphincter was innervated any differently than the re-

[1] This investigation was supported in part by research grant B-704 from the National Institute of Neurological Diseases and Blindness, National Institutes of Health, Public Health Service.

mainder of the detrusor muscle (*29*). Nevertheless, support was given to the theory of the antagonistic action of the two systems by Learmonth's investigations in man. In a series of papers (*20*, *30*, *31*) he reported that, following presacral neurectomy, both the muscles of the trigone and the internal sphincter relaxed. Learmonth concluded from his studies that sympathetic influences act as a continuous brake on contractions of the detrusor and, that following lesions of the sacral nerves, presacral neurectomy aided in the restoration of the functioning automatic bladder.

Other workers (*32*, *33*, *34*, *35*, *36*), too, have reported beneficial results from sympathetic denervation of the bladder in cases of neurogenic vesical dysfunction. In paraplegic patients with cervical or upper thoracic spinal cord injuries, anterior rhizotomy of the lower thoracic through the first sacral roots resulted in an increased bladder capacity (*37*). Likewise, Kuhn (*38*) reported that section of the same anterior spinal nerve roots in patients with hypertonic bladders reduced detrusor activity sufficiently to reclassify the bladders to that of the reflex type.[2]

Van Duzen (*40*), on the other hand, believed that presacral neurectomy was definitely harmful to the patient. Within a period of two months after the operation evidence of urinary retention, paralysis of the trigone muscles, and a spastic internal sphincter appeared.

Most investigators (*1*, *2*, *10*, *14*, *28*, *41*, *42*, *43*, *44*, *45*, *46*) have concluded that sympathetic denervation of the bladder has no effect in man, either on micturition or on any other bladder activity. They have discarded the idea that there is an antagonistic action between the two divisions of the autonomic nervous system and have decided that the parasympathetic components are the only ones that have any real influence on bladder function.

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ACADEMY MEMBERS RECEIVE HONORS

Dr. Richard K. Cook, National Bureau of Standards, formerly senior editor of this JOURNAL, has been elected President of the Acoustical Society of America for the term 1957–58. Dr. Cook's work in the physics of sound is nationally known. He is currently spending a year's leave of absence from NBS to conduct research at the Bell Telephone Laboratories.

* * * * *

Dr. Ladislaus L. Marton, of the National Bureau of Standards and WAS, has been elected to the Royal Academy of Belgium in recognition of his contributions to science. Dr. Marton will fill the vacancy left by the Dutch physicist, J. Verschaffelt, who died last year. He will be the only American physicist among the foreign members of the Academy.

The Royal Academy of Belgium recognizes outstanding achievement in science, literature, the arts, and other fields. Membership is limited to 90 regular members, 150 foreign members, and 30 correspondents. The Division of Sciences, to which Dr. Marton was elected, has 15 regular members, 5 correspondents, and 25 foreign members.

Dr. Marton has received international recognition for his work in electron optics, particularly relative to the development of the electron microscope. He is chief of the Electron Physics Section of the Atomic and Radiation Physics Division at the Bureau. This section does research on various aspects of the physics of the free electron. The work includes electron scattering in solids, electron interference, electron polarization, electron optics, and applications of some of these phenomena to other measuring techniques.

* * * * *

Dr. Francis B. Silsbee, chief of the Electricity and Electronics Division at the National Bureau of Standards, has been awarded the Department of Commerce Gold Medal for Exceptional Service. The award recognizes his "outstanding contributions to the fields of electricity, electrical engineering, and electrical measurement."

Since 1946 Dr. Silsbee has directed the Bureau work in electricity, which concerns the development, improvement, and dissemination of the standards of measurement for electrical quantities and the study of properties of materials that are important in electricity and magnetism. In 1954 the Bureau's basic electronic research and development programs were placed under his direction.

Dr. Silsbee's work in his 45 years at NBS has covered a wide range. In 1916, working in the newly discovered phenomenon of superconductivity at very low temperatures, he suggested a theoretical relationship between the values of critical currents and magnetic fields which is widely known today as the "Silsbee Hypothesis".

During World War I, he led NBS work on the development of spark plugs, magnetos and other aircraft ignition parts. In World War II, he was in charge of the later phases of the development of a special bomb director and guided research on the lighting hazards to nonmetallic aircraft.

Dr. Silsbee was born in Lawrence, Mass., in 1889 and received his B.S. in Electrical Engineering from Massachusetts Institute of Technology in 1910, and the following year he was awarded his master's degree there. In 1915 he received his Ph.D. in Physics from Harvard University.

He first joined the NBS staff in 1911 and was made Chief of the Electrical Instruments Section in 1939. In 1946 he was named to his present position.

He is a past president of Washington Academy of Sciences and of the Philosophical Society of Washington; a fellow of the American Physical Society, the American Institute of Electrical Engineers, and the American Association for the Advancement of Science; and has written numerous technical papers in his field.

* * * * *

Dr. Galen B. Schubauer, chief of the Fluid Mechanics Section of the Mechanics Division of the National Bureau of Standards, has been awarded the Department of Commerce Gold Medal for Exceptional Service. The award recognizes his "outstanding contributions to basic aerodynamics over the past 20 years."

Dr. Schubauer is known internationally for his contributions to the field of aerodynamics. His work on turbulence and air flow and in the development of instruments for measuring these phenomena has been vital in the development of modern high speed aircraft. Among the recent projects of Dr. Schubauer's section was a study of the accuracy of the hot-wire anemometer at speeds up to twice the speed of sound. The instrument has been basic in subsonic air speed research but it was not known whether it could be used at supersonic levels.

Born in Sparrows Point, Md., in 1904, Dr. Schubauer received his B.A. degree from Pennsylvania State College in 1928, M.S. from California Institute of Technology in 1930, and Ph.D. from John Hopkins University in 1934. He joined the NBS staff in 1929 and was made Chief of the Aerodynamics Section in 1946. In 1953 he was appointed to his present position when the Hydraulics and Aerodynamics Sections were combined.

He holds Institute of Aeronautical Sciences and Washington Academy of Science awards for his work. In addition to being a member of these two organizations Dr. Schubauer also belongs to the American Physical Society, Sigma Pi Sigma, Phi Kappa Phi, and Sigma Xi.

* * * * *

Dr. Lewis V. Judson, chief of the Length Section of the Optics and Metrology Division of the National Bureau of Standards, has been given the Department of Commerce Silver Medal for Meritorious Service. The Award recognizes Dr. Judson's "extremely competent performance for 38 years in the field of length standards and precise length determinations."

Dr. Judson is custodian of the National Standard of Length. In addition he is in charge of calibrations of measuring tapes, graduation and calibration of precision circles, research in thermal expansion of solids and interferometry in length measurements. The development of sieve specifications and calibrations; testing of haemacytometer chambers and accompanying cover glasses and surveyor's leveling rods: and calibration of many other precise measuring instruments are also under his supervision.

Dr. Judson joined the NBS staff in 1917 and was made Chief of the Length Section the following year. He is the author of some 60 articles in his field.

Born in Plainville, Conn., in 1893, Dr. Judson graduated from Clark University in 1916 and received a M.A. in physics there in the following year. He was awarded his Ph.D. in physics from Johns Hopkins University in 1925.

He is a member of the Philosophical Society of Washington, the Washington Academy of Sciences, the American Physical Society, the Optical Society of America, the American Congress of Surveying and Mapping, the American Geophysical Union, the American Society for Testing Materials, the American Association for the Advancement of Science, and the Société Francaise de Physique.

* * * * *

Dr. Herbert F. Schiefer, a textile physicist in the Organic and Fibrous Materials Division of the National Bureau of Standards, has been awarded the Department of Commerce Gold Medal for Exceptional Service. The award recognizes his "outstanding contributions to textile science and technology."

Dr. Schiefer is an internationally known authority in the textile field. In addition to his contributions at NBS, he served as technical advisor in 1950 to the Economic Cooperation Administration in Europe and in 1955 to the International Cooperation Administration in Asia. He was a delegate to the 1955 International Wool Research Conferences in Australia. In 1945 he served as scientific consultant to the Department of the Army in the first survey of the German textile industry after World War II. He took leave of absence from the Bureau in 1951–52 to serve as director of research and graduate instruction in the School of Textiles of North Carolina State College.

Dr. Schiefer has developed and invented many devices for testing the properties of fibers, yarns, and fabrics and a number are widely used by the textile industry today. He received the Harold DeWitt Smith Memorial Medal in 1950 from the American Society for Testing Materials for his pioneering work in textile research. His recent work has been concerned with new techniques for obtaining stress-strain relationships in yarns subjected to rapid impact loading and the measurment of a new basic property of textile fibers, the limiting breaking velocity. This property is of practical importance in the design of textiles for safety lines, parachute webbing, tire cord, and flexible body armor.

Dr. Schiefer came to the Bureau in 1929 from Des Moines University where he was head of the mathematics and physics department. He was educated at the University of Michigan, receiving his degree in Civil Engineering in 1924, his M.S. in Science in 1925, and a Ph.D. in astrophysics in 1928. During his last four years at Michigan he was instructor of engineering mathematics and astronomy.

Dr. Schiefer has written some 100 scientific papers and technical reports and holds three patents. He is a member of Tau Beta Pi, the Fiber Society (former president), Washington Philosophical Society, Washington Academy of Science, American Society for Testing Materials, and is a fellow of the British Textile Institute and the American Physical Society.

* * * * *

Herbert C. Vacher, head of the metallographic and X-ray diffraction laboratory, at the National Bureau of Standards, has been awarded the Department of Commerce Silver Medal for Meritorious Service for his contributions to the field of metallurgy.

A NBS staff member for 30 years, Mr. Vacher has conducted important research and written a number of articles on the mechanical properties and structures of metals and alloys. He also acts as a consultant in the mechanical metallurgy laboratory on projects which involve correlating the mechanical properties with the structure of metals. Mr. Vacher's earlier work at NBS involved the determination of gases in metals and physical chemistry of gas-metal equilibria. Such information is important in the manufacture of steel.

Born in Greensberg, La., in 1901, Mr. Vacher received his E.M. degree from the Texas School of Mines in 1922 and a M.S. in metallurgy in 1926 from the University of Nevada where he studied under a Challoner Fellowship.

He is a member of the American Institute of Mining and Metallurgical Engineers, the American Society for Metals, American Crystallographic Association, and the Washington Academy of Sciences.

ODDITIES OF NATURE

Among the most curious of insects are the "bagworms," which belong to the moth family.

The bagworm is a caterpillar. The female spends her entire life in a cocoonlike silken bag into whose texture she interweaves bits of leaves from the host plant. The bag grows as the worm grows, and in local species late in summer it becomes as much as 2 inches long. The bags of some tropical species are more than 7 inches long. The female remains wingless, and the bag in which she spends her life is attached to a twig of the host plant. At the end of summer she lays within the silken sack a mass of eggs which hatch late in spring. The males metamorphose into winged insects.

Dr. Frank Morton Jones, of Wilmington, Del., has just presented to the Smithsonian Institution one of the world's outstanding collections of these insects. Sixty years were spent in assembling this collection, which consists of 4,400 specimens. Of these 1,174 are adult, winged males, 2,133 are bags showing the many forms resulting from differences in food plants, and 830 are immature forms. There are also 1,000 microscope slides of important structures of these insects.

Bagworms are nearly worldwide in distribution. In this country they are chiefly pests of ornamental trees and shrubs, and are especially destructive to arborvitae. They are preyed upon by a number of other insects. The collection includes 273 such insect-parasites.

* * * * *

One of earth's most fantastic animals—the three-horned chameleon of East Africa—has just been added to the reptile collections of the Smithsonian Institution. It is sometimes described as a replica, in miniature, of the ancient monster dinosaur *Triceratops*, which has been extinct for about 75,000,000 years. The two, of course, are in no direct way related. The three-horned chameleon grows to a length exceeding 12 inches. The curious horns, an inch to an inch and a half long, protrude from the nose and between the eyes of the males. Females are hornless.

These chameleons are extremely pugnacious animals and sometimes use their horns in fights to the finish. At times the contests develop into tedious pushing matches, with the horns interlocked. At other times a really vigorous fighter will dispose of a weaker adversary in a few minutes. Males are brilliantly colored with blues, greens, and yellows. Uganda natives are terrified by the demoniacal-looking animals, which actually are harmless to man. The popular superstition is that if one happens to see one of these lizards when it is enraged and hissing the person will die in a few days. The curse of the chameleon may be partly averted, it is believed, by capturing and roasting it, and then wearing part of the burned body as a talisman. Still the unfortunate person is supposedly sure to die quite young.

The creature is most abundant in arid areas covered with low shrubs. It is an aerial acrobat and can leap as much as 2 feet from branch to branch. The chameleon has a prehensile tail, like that of various monkeys, and with the tip of this tail alone it can hang from a branch. It sits motionless for hours at a time and feeds almost exclusively on flies, butterflies, beetles, and bees which may come within reach of its darting tongue. The creature is a consummate bluffer. Apparently it never tries to hide or run when confronted with an enemy. Instead it tries to frighten the foe, including man, by inflating its body so that the otherwise loose skin is drawn taut.

* * * * *

Birds that hold fencing tournaments are the big-billed toucans of Barro Colorado Island, the Smithsonian Institution's tropical preserve in Gatun Lake, Panama Canal Zone. They fence with their formidable beaks but seem careful not to hurt one another. One scientist who studied Barro Colorado's bird life described the birds as follows:

"I saw fourteen toucans scattered about in a big leafless tree in the center of the jungle. Two appeared to be fencing. They stood in one spot and fenced with their bills for a half minute or so, rested, and were at it again. Presently they flew off into the forest and then I noticed two others that had now begun to fence. Then one of these flew away, and the remaining one picked a new opponent and fell to fencing again. . . . They did not move about much while fencing, although sometimes one climbed above the other as though to gain an advantage. They fenced against each other's beaks and never seemed to strike at the body. There was a fairly rapid give and take . . . the bills clattering loudly against each other."

These fencing toucans are among the more conspicuous birds of the island, particularly because of their call—a shrill, froglike "cree," which is repeated over and over again and can be heard half a mile away. The call is most frequent in the morning and late in the afternoon, but it stops abruptly at sunset.

Simplicity is the seal of truth. Nature is wonderfully simple, and the characteristic mark of a childlike simplicity is stamped upon all that is true and noble in nature.—SENDIVOGIUS (1650)

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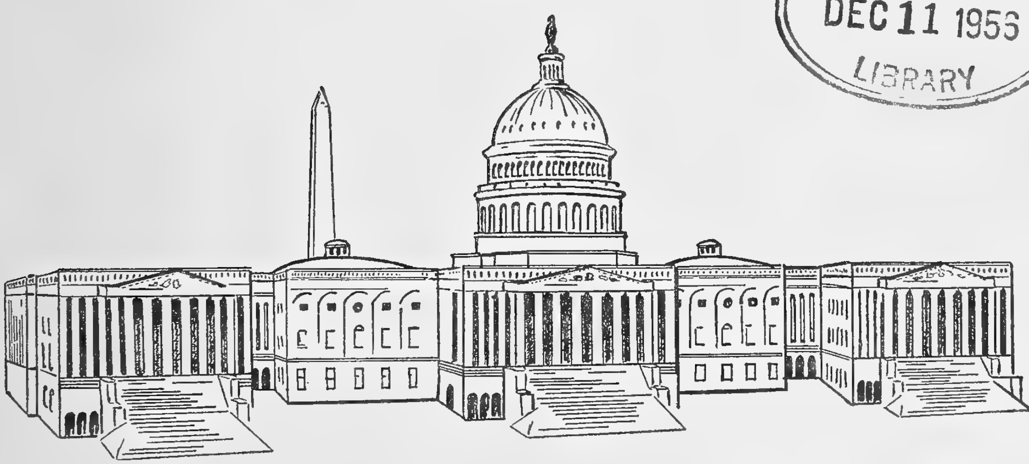

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PHYSICS.—*Transients in signal analysis.*[1] Edith L. R. Corliss, National Bureau of Standards. (Communicated by C. H. Page.)

(Received August 21, 1956)

Every signal analyzing system has some limiting inertia in its response; even in the ideal limit a certain amount of inertia is required to produce the needed degree of frequency or power level resolution. The error introduced may be represented by a limiting volume in a space whose Cartesian coordinates are frequency, time, and either power or a function of power. The transient error then becomes a least volume in this space, within which no information about the signal can be found. The experimenter cannot eliminate the transient error, but by choice of experimental conditions the distribution of errors can be controlled.

Regardless of whether a frequency or a time-correlation analysis of a signal is undertaken, the results are observed as output power levels. Hence the ability to resolve a change in power levels limits the discrimination that can be achieved for changes in frequency or intervals of time. The quantitative extent to which power level resolution affects resolution along the coordinates of frequency and time can be found from the natural properties of the analyzer. The discussion here is based on the common type of system whose behavior is described by a second-degree differential equation with constant coefficients.

In a previous paper (Corliss, 1955) we discussed the relationship between "figure of merit," Q, observation time interval, $\Delta\tau$, and power level discrimination, α, when the behavior of a linear series-resonant filter was adjusted to satisfy the condition that an analyzer should be able to change its indication by a factor of at least $e^{-\alpha}$ during the time interval $\Delta\tau$. From these considerations it followed that

$$Q \leqslant \frac{2\pi f_0 \Delta\tau}{\alpha} \tag{1}$$

and

$$\Delta f \Delta\tau \geqslant \frac{\alpha^{3/2}}{2\pi}. \tag{2}$$

Given that $\Delta\tau$ is the briefest duration of any signal component to be observed, Equation (1) shows how the Q of a filter must be adjusted as a function of its tuning in order to distribute the transient error uniformly over the frequency range.

Equations (1) and (2) also provide a measure of the largest number of band-pass filters that can be overlapped on adjacent channels to yield meaningful information about a rapidly changing signal.

Over a range of frequencies $\Delta f = f_u - f_l$ surrounding f_0, the frequency to which the filter is tuned, the change in filter response does not exceed the smallest detectable power level change. For a set of filters overlapped at these limits of power resolution, the limiting number of filters yielding meaningful information between f_t and f_b, the high- and low-frequency range limits, respectively, is given by

$$n_l - 1 \leqslant \frac{f_t - f_b}{\Delta_f} = \frac{2\pi\Delta\tau}{\alpha^{3/2}}\,(f_t - f_b).$$

(The limits yield $n_l - 1$ rather than n_l be-

[1] This work was part of a program of basic instrumentation research and development supported by ONR, AEC, AFOSR, and NBS.

cause one-half of a filterextends beyond each end of the frequency range as defined here.)

A common practice in using parallel channels of band-pass filters is to overlap adjacent filters at their half-power points, so that their integrated response has a flat characteristic. For this condition, $\Delta f = f_0/Q$ and the number of filters becomes

$$n_2 - 1 = \frac{f_t - f_b}{\Delta f} = \frac{2\pi\Delta\tau(f_t - f_b)}{\alpha}.$$

The ratio of this number to the maximum usable number of filters depends only on the power level resolution, i.e.,

$$\frac{n_2 - 1}{n_l - 1} = \alpha^{1/2}.$$

If we are willing to take a "yes-no" type of analysis from the filter, then for a set of filters overlapped at their half-power points we can choose as a compatible condition that $\alpha = \ln 2$, i.e., the power declines at least to one-half its initial value during the observation interval $\Delta\tau$ and we get as the number of filters for this case

$$n_b - 1 = \frac{2\pi\Delta\tau(f_t - f_b)}{\ln 2}.$$

Under these conditions n_b invites comparison with the number of "bits" available in a given bandwidth during the time interval $\Delta\tau$.

By scanning the tuning of a filter, the spectrum of a signal can be studied by means of a single metering channel. When one scans by sweeping the tuning of a filter over the frequency range to be covered, the filter shows a rather complicated response.[2] One can, however, obtain quantitative results from simple theory by recognizing that an additional multiplicative factor must be used to account for the spreading of the filter's transient response caused by scanning. The spreading occurs because the incoming signal beats with the ringing of the filter. In the following discussion, the spreading factor is omitted.

The functioning of a scanning filter can be compared with a parallel channel set of band-pass filters by calculating the effective number of band-pass filters that will provide the same resolution as the scanning filter.

Various types of scanning functions can be used depending upon the nature of the selectivity characteristic desired. If one wishes to have a constant Q (constant percentage bandwidth), the condition that the transient error is to be uniform throughout the range of frequencies swept over can be satisfied by scanning at a rate proportional to the square of the instantaneous

[2] Lewis, 1932; Hok, 1948; Barber and Ursell, 1948; Marique, 1952; Herrero, 1953; Batten et al., 1954.

SCANNING RATE	Q FIGURE OF MERIT FOR SELECTIVITY	(n_2-1) NUMBER OF FILTERS OVERLAPPED AT HALF-POWER POINTS	K SCANNING PARAMETER	$\Delta\tau$ OBSERVATION INTERVAL
NO SCAN	$\leq \frac{2\pi f_0 \Delta\tau_0}{\alpha}$	$\frac{2\pi\Delta\tau_0(f_t-f_b)}{\alpha}$	0	$\Delta\tau_0 = \frac{\alpha Q}{2\pi f_0}$
UNIFORM SCAN $\frac{df}{dt}=k$	$\leq\sqrt{\frac{2\pi\tau}{\alpha(f_t-f_b)}}\,f_0$	$\sqrt{\frac{2\pi\tau(f_t-f_b)}{\alpha}}$	$\frac{f_t-f_b}{\tau}$	$\frac{\alpha\tau}{2\pi(f_t-f_b)}$
LOGARITHMIC SCAN $\frac{df}{dt}=kf_0$	$\leq\sqrt{\frac{2\pi\tau}{\alpha\ln(f_t/f_b)}}\sqrt{f_0}$	$2\sqrt{\frac{2\pi\tau}{\alpha\ln(f_t/f_b)}}\,(\sqrt{f_t}-\sqrt{f_b})$	$\frac{\ln(f_t/f_b)}{\tau}$	$\frac{1}{\sqrt{f_0}}\sqrt{\frac{\alpha\tau}{2\pi\ln(f_t/f_b)}}$
QUADRATIC SCAN $\frac{df}{dt}=kf_0^2$	$\leq\sqrt{\frac{2\pi\tau}{\alpha(1/f_b-1/f_t)}}$	$\sqrt{\frac{2\pi\tau}{\alpha(1/f_b-1/f_t)}}\,\ln\left(\frac{f_t}{f_b}\right)$	$\frac{1/f_b-1/f_t}{\tau}$	$\frac{1}{f_0}\sqrt{\frac{\alpha\tau}{2\pi(1/f_b-1/f_t)}}$

center tuning of the filter. When one wishes to scan through the frequency range with a filter whose bandwidth is a constant number of cycles per second, this implies a Q directly proportional to the center tuning of the filter and a uniform transient error results from scanning at a constant rate, independent of frequency. A commercial scanning filter, the Panoramic Analyzer, sweeps logarithmically over its frequency range; when it is adjusted to uniform transient response, its instantaneous Q is proportional to the square root of its instantaneous tuning. This gives a range of Q with frequency which is intermediate between constant frequency bandwidth and constant percentage bandwidth.

The accompanying table (p. 306) summarizes the results of calculations on the basis of a uniform distribution of transient power level discrimination error, i.e., α = constant. The table gives Q, the figure of merit, k, the scanning rate parameter, and n_2, the equivalent number of filters overlapped at their half-power points, in terms of the scanning time τ, the scanning bandwidth limits f_b and f_t, and the time-attenuation parameter α. To facilitate adjustment of the response time of an analyzer to the least duration of any signal component to be observed, the tabulation also includes $\Delta\tau$, the observation time interval for a single filter.

Similar considerations apply to the requisite integration times of correlation analyzers. For a synchronous detector equipped with an R-C integrator of time-constant τ, the equivalent Q for a synchronous period T is given by

$$Q_0 = \frac{\pi\tau}{T}.$$

This result is due to Selgin (1951).

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NEWS OF MEMBERS

Dr. G. Arthur Cooper has been appointed head curator of the Department of Geology of the U. S. National Museum, Smithsonian Institution, succeeding the late Dr. William F. Foshag. Dr. Cooper will continue to serve as curator of invertebrate paleontology and paleobotany. He is a former senior editor of this Journal.

Dr. Ferdinand G. Brickwedde, former secretary of the Washington Academy of Sciences, chief of the Heat and Power Division of the National Bureau of Standards, is the new dean of the College of Chemistry and Physics at Pennsylvania State University.

PALEONTOLOGY.—*An acanthodian fish from the lower Permian of Texas.*[1]
David H. Dunkle, U. S. National Museum, and Sergius H. Mamay, U. S. Geological Survey.

(Received August 16, 1956)

While engaged in U. S. Geological Survey field work during the Spring of 1955 Mamay, accompanied by E. L. Yochelson, collected the complete remains of a small acanthodian fish. The specimen and the details of its occurrence seem of sufficient interest to warrant a published account, particularly since, insofar as we are aware, no other complete specimens have yet been recorded from the Permian of the Western Hemisphere.

The fossil was found in an outcrop on the Emily Irish land grant, approximately 18 miles south-southeast of Seymour, in Baylor County, Tex. According to the revised geologic map of Baylor County, published in 1937 by the Texas Bureau of Economic Geology, this outcrop lies within the boundaries of the Belle Plains formation of the lower Permian Wichita group. The exact position of the fossiliferous horizon within the Belle Plains formation is uncertain. However, it is mapped as lying beneath an unnamed limestone member which itself is overlain by the Beaverburk limestone member of Garrett, Lloyd, and Laskey (1930) of the Belle Plains formation. From these facts, the bed is presumed to be a correlative of the Valera shale member, which occupies a position at about the middle of the Belle Plains formation in Coleman County, Tex., 120 miles to the south.

On a cosmopolitan basis, fossil remains referred to the Acanthodii present a maximum stratigraphic range of from upper Silurian to lower Permian. Nielsen (1932) has reported fragmentary acanthodian fossils from the lower Permian of East Greenland. However, the youngest previous record of this group of fishes in the United States known to us is from the Middle Pennsylvanian: *Acanthodes* (*Acanthoessus*) *marshi* Eastman (1902) and *A. beecheri* Eastman (loc. cit.). The newly reported discovery thus provides definite evidence that the distribution of this group of placodermatous fishes is much the same in the Western Hemisphere as in the Eastern.

The fish (U.S.N.M. no. 21318) is scaleless and impressed as little more than a rusty carbonaceous film on a dark grey and very fine-grained shale. Recovered in part and counterpart, the body outline and fin positions are clearly discernible, nonetheless, and the gross characteristics of the form can be determined.

As preserved, probably lacking some small portion of the epichordal lobe of the caudal fin, the specimen possesses an axial length of about 37 mm and a maximum body depth of 4.5 mm. A very slenderly fusiform body habit is thus displayed. Reflecting the general body shape, the head is also slender and long; its length from snout to origin of the pectoral spine apparently contained $4\frac{1}{2}$ times in the overall axial length of the specimen. The position of the orbits are exhibited and a trace of either the preopercular or opercular sensory canal is preserved. Unfortunately, no other structures of the skull or branchial apparatus can be determined.

Fin positions are denoted by the impression of delicate spines which are extremely narrow relative to their lengths. No tissue of this armament remains but the impressions show each to have been marked by one longitudinal groove along the side. Dorsal and anal fin spines are single, situated very far posteriorly with the larger anal one slightly in advance. The heterocercal caudal fin is indicated to be moderately clefted and with the hypochordal lobe appreciably shorter than the dorsal body extension. Neither pectoral nor pelvic spines are preserved in their entirety. The pectoral one, however, is noticeably more robust and presumably longer than the pelvic. The latter is inserted nearer the pectoral appendage than to the anal.

[1] Published with the permission of the Secretary, Smithsonian Institution, and the Director, U. S. Geological Survey.

Fig. 1. *Acanthodes* sp. (U.S.N.M. no. 21318): Photograph of specimen as exposed in lateral view. × 4.

This combination of characteristics is that of the genotypic material of *Acanthodes* from the Rotliegende of Lebach, Germany. While probably distinct from the Middle Pennsylvanian forms from Illinois mentioned above (Eastman, 1902, and Gregory, 1951), no species assignment is made for this specimen from Texas. Woodward (1891) customarily grouped all of the *Acanthodes* from Lebach under *A. bronni* Agassiz. Watson (1937) called attention to the wide differences between the numerous series of Lebach specimens. The variants, however, were left unnamed because of either the difficulty or impossibility of locating the Agassiz types. Therefore there seems to be no adequate basis, as yet, of evaluating material falling within such a range of variation, or for making a specific identification of the presently discussed specimen.

The specimen was found in association with an extremely rich and diverse terrestrial floral assemblage, description of which is currently being prepared for publication by Mamay. The flora is dominated in large part by pecopterid ferns of the type that was prevalent in Late Pennsylvanian coal swamps. However, various callipterids, sphenopterids, *Tingia*-like foliage and *Gigantopteris americana* White also constitute conspicuous elements in the flora, with lycopsids and sphenopsids showing only a minor representation.

Although this shale bed contains a great profusion of plant remains, animal fossils are by contrast extremely rare. The most common of these are estherid remains, which occasionally occur in fairly rich local concentrations. However, the fish specimen under discussion represents the only vertebrate fossil found by the collectors although perhaps as much as three cubic yards of matrix was split and carefully examined; furthermore, a large collection made in 1940 by Charles B. Read of the U. S. Geological Survey at the same locality is completely lacking in vertebrate remains.

Both the abundance and condition of the plant material suggest deposition of the enclosing sediments in relatively quiet, undisturbed, fresh or possibly brackish water. Although the matrix is very friable and must be handled carefully, it has been possible to expose many large and unbroken leaf specimens. The state of preservation of this delicate foliage discourages the possibility that it could have been subjected to transportation over considerable distances from its original habitat, or to much agitation in the waters in which it was deposited. It is quite likely, then, that the fossiliferous bed represents the bottom of a quiet pool or an extremely sluggish stream.

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MAUNA LOA OBSERVATORY

A unique high-altitude observatory on the slope of the Hawaiian volcano, Mauna Loa, was dedicated on June 28 for joint use by the National Bureau of Standards and the U. S. Weather Bureau. Located at a height of 11,134 feet in the Tropics, where the upper atmosphere is very clear and usually of low moisture content, the new observatory offers special advantages for many types of astronomical and upper-air studies. It will make possible continuous observation of atmospheric phenomena with manned instruments in place of the unmanned meteorological balloons that have been used for the most part in high-altitude work.

The dedication ceremonies were arranged by R. L. Fox of the Weather Bureau, and J. B. Cox, president of the Geophysical Society of Hawaii, acted as master of ceremonies. After introductory remarks by Governor S. W. King of Hawaii, J. W. Steiner of the Weather Bureau gave some highlights on the new facility. Ralph Stair and C. C. Kiess of NBS then spoke on research potentials of the observatory and its use in studying the planet Mars. Prof. W. B. Steiger of the University of Hawaii commented on the importance of the observatory to geophysics, and Mr. Fox discussed the past, present, and future of the observatory.

The new observatory is expected to provide valuable data in a variety of fields. Its advantages as a high-altitude observatory are due largely to the fact that it is situated well above the bulk of the dust and moisture contained in the earth's atmosphere. At the latitude of Hawaii a "trade wind inversion layer" usually traps the dust and moisture below about 8,000 feet. Other important advantages are its ready accessibility and relatively warm climate. Most of the other comparable observatory sites are buried in snow during winter and part of the summer. Also, the Mauna Loa observatory has the required altitude without the ruggedness that imparts turbulence to the surrounding air, and it is situated at a key point for studying the huge air masses of the tropics. The chief research results to be expected are improved long-range weather forecasting and greater knowledge of solar and atmospheric radiation. Because the air masses of the Pacific are responsible for much of the weather that occurs in other parts of the world, data on these air masses may make it possible to forecast conditions in distant places.

There is some evidence that the ozone content of the lower atmosphere in the Tropics is associated with the formation of the large low-pressure areas that produce typhoons. Continuous measurement of atmospheric ozone may thus be of assistance in forecasting typhoons in advance.

The observatory also offers possibilities for study of cosmic rays, total solar radiation, snow crystals, air glows, and possibly radioactive fallout. In July, C. C. Kiess and C. H. Corliss of NBS began a study of the moisture content of the planet Mars under the auspices of the National Geographic Society. They used spectroscopic techniques to investigate the light reflected to the earth from Mars. The advantageous location of the Mauna Loa observatory made it possible to reduce the effect of the earth's atmosphere on the planet's spectrum. During the coming year Ralph Stair of NBS expects to begin a study at Mauna Loa on the distribution of the spectral energy from the sun. Such information will be of value in determining the effect of the sun's rays in connection with high-altitude equipment, space flights, and man-made satellites. This work will also furnish data on the solar constant and information on solar intensities which may be useful in many fields.

The observatory is a concrete-block structure costing $25,000, and is situated about 2,500 feet below the summit of the mountain. The building contains five rooms in addition to a tower and a broad open platform for observational use. Present accommodations permit the use of the buildings by a maximum of six observers at any one time. A smaller structure was built at the summit in 1951–52, but the limited observations that were taken there were discontinued in 1954

BOTANY.—*The genus* Hilaria (*Gramineae*). Ernest R. Sohns, U. S. National Museum. (Communicated by Agnes Chase.)

(Received July 16, 1956)

Hilaria, named in honor of Auguste St. Hilaire, was described by Humboldt, Bonpland, and Kunth (1816) with one species (*H. cenchroides*) from Mexico. "Crescit in planitie montana regni Mexicana, inter Zelaya et Guanaxuato, locis subfrigidis, alt. 980 hexap. [Perennial] Floret Septembri."

According to the authors *Hilaria* resembled *Anthephora*, after which it was placed in taxonomic sequence. In the following 50 years at least three new generic names entered the literature, and all are considered synonyms of *Hilaria*. Among these is the genus *Pleuraphis*, established by Torrey (1824), with one species (*P. jamesii*) in honor of Dr. E. James. Some contemporary agrostologists recognize this genus as distinct from *Hilaria*. Presl (1830) described the genus *Hexarrhena*, with a single species (*H. cenchroides*), which he placed in the tribe Saccharinae, subtribe Hordeaceae. From his description and plate 45, there is no doubt that the species is *H. cenchroides* of Humboldt, Bonpland and Kunth. In 1866, Buckley described a new genus from Texas (*Schleropelta*) with one species *S. stolonifera*. The description applies to *H. belangeri* (*Anthephora belangeri* Steud.). By 1891, five species and two varieties of *Hilaria* had been described.

Taxonomists have differed in the assignment of the genus to tribes and subtribes. Steudel (1854) and Fournier (1886) put *Hilaria* in the tribe Phalarideae. Bentham (1881) divided the tribe Zoysieae into two subtribes (Anthephoreae and Euzoysieae) and placed the genus in the former. Bentham and Hooker (1883) and Hackel (1887) treated the genus as a member of the Zoysieae. Beal (1896), Bews (1929), Conzatti (1946), Hitchcock (1936) and Roshevits (1937) regarded this genus as belonging to the Zoysieae. Pilger (1954) placed *Hilaria* in the subfamily Eragrostoideae, subtribe Lappagineae Link. He also recognized *Pleuraphis* as a distinct genus.

I believe the genus is a very old and highly specialized one and that it does not belong in the tribe Zoysieae. It has no close generic relationship with any known North or South American genus. Cytogenetic techniques may help indicate evolutionary tendencies within the genus. For the present it is better to keep the genus in the Zoysieae than to erect a new tribe or subtribe. The accumulation of cytogenetic data, together with detailed taxonomic, morphological and anatomical studies in our known genera will enable us, eventually, to assign the genus *Hilaria* to its proper tribe.

The species of *Hilaria* are vegetatively remarkably uniform for both subgenera of the genus. They are mostly low, stoloniferous or nonstoloniferous plants with pistillate central spikelets or tall, rhizomatous bunch grasses with perfect central spikelets. The nine species and one variety at present known are endemics restricted to the mountains, dry plains and plateaus of the southwestern United States, Mexico and Guatemala. One species, *H. belangeri*, has been reported from Venezuela (cultivated in experiment plots). The inflorescence is spicate and composed of two to many fascicles. Each fascicle contains three spikelets, one central and two lateral spikelets. The central spikelet is 1-flowered and perfect in *H. jamesii*, *H. mutica* and *H. rigida*. One-flowered, pistillate central spikelets are characteristic of the other species. The lateral spikelets, appearing somewhat pedicellate, are all staminate and may have from one to five florets. Any one, or all of the lateral florets, may be sterile. The glumes in those species with perfect central spikelets may be papyraceous and scarcely fused at the base, or, in those species with pistillate central spikelets, the glumes are rigid, indurated and fused at the base. The fascicle pattern is the same for all species of the genus. Diagrammatic sketches of various fascicle patterns are presented in fig. 1.

Brown (1950) and Brown and Coe (1951) have been the pioneers in cytogenetic investigations in this genus. *H. belangeri* (collection no. 3394) was reported to have a chromosome number of 36, and *H. mutica* (collection no. 3279) a diploid number of 36 (n = 18). *H. belangeri* (Ozona Clone) has 36 chromosomes (n = 9), while *H. belangeri* (Eden no. 4 and Eden no. 6) has 72 chromosomes (n = 9). The phenomenon of ovule abortion in *H. belangeri*, *H. jamesii* and *H. mutica* is discussed also.

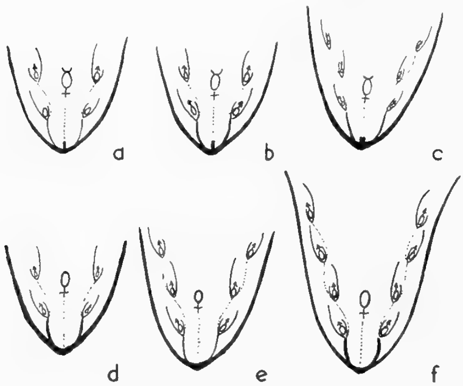


FIG. 1.—Fascicle diagrams in *Hilaria: a–c*, Fascicle types encountered in the subgenus Pleurapheae: central spikelets 1-flowered and perfect, lateral spikelets 2–3-flowered, all staminate or the lower sometimes sterile. *d–f*, fascicle types encountered in the subgenus Eu-Hilarieae: central spikelets 1-flowered and pistillate, lateral spikelets 1–5-flowered, all staminate or staminate and sterile intermixed. Only one glume of each lateral spikelet is represented.

The species of *Hilaria* are among the important forage grasses of the ranges in the southwestern United States and Mexico. The rapid spread of the stoloniferous species also makes them important soil binders. In the genus *Hilaria*, *H. belangeri* is probably the most important range species. *H. jamesii* and *H. mutica* are regarded as having medium grazing value and low to very low palatability. *Hilaria jamesii* is often the dominant grass in many parts of northern Arizona and New Mexico and in southern Colorado and Utah. When this species is young it is good forage for sheep. *H. mutica* is characteristic of level upland and desert valleys in which there are no really permanent streams, but these areas are occasionally overflowed during heavy storms. According to Goodding (mss.) the inflorescences are often infected with ergot. *Hilaria rigida* occupies the driest parts of the desert areas, particularly the Mojave Desert. It is encountered on sand dunes and rocky slopes. This species forms isolated clumps and is therefore an excellent grass for controlling blowing sand. It is a highly prized grass in southern Nevada and in the region of Kingman, Arizona.

This paper is part of a continuing series contributing toward a revision of the Grasses of Mexico; therefore, only Mexican specimens are cited, except where the type was collected in the United States. All figures, unless otherwise indicated, were drawn by the author.

KEY TO SPECIES OF HILARIA

A. Fascicles with thin, papyraceous glumes, these not conspicuously fused and indurated at the base; the central spikelet 1-flowered and perfect [subgenus Pleurapheae].
  B. Culms felty-pubescent; glumes of the central spikelet narrow, plumose, deeply cleft into few to several acuminate, ciliate lobes and slender awns; glumes of the lateral spikelets thin, long-ciliate, 2–4-lobed at the summit .... 3. *H. rigida*
  BB. Culms not felty-pubescent.
    C. Glumes of the lateral spikelets acute, usually with a single awn....1. *H. jamesii*
    CC. Glumes of the lateral spikelets thin, broadened upwards, the tips finely laciniate........................2. *H. mutica*

AA. Fascicle with thickened asymmetric glumes, conspicuously fused and indurated at the base; the central spikelets 1-flowered and pistillate [subgenus Eu-Hilarieae].
  D. Spikes pale and usually slender (if thick, then the glumes papillose-pilose between the nerves); sometimes violaceous from the accumulation of anthocyanin pigmentation; scabrous black glands may be present, but usually not abundant.
    E. Plants stoloniferous, blades mostly basal.
      F. Glumes scabrous; awns short, slightly divergent, thick, conspicuously ciliate on the margins, the cilia often retrorse .... 6. *H. ciliata*
      FF. Glumes variously textured; awns not ciliate on the margins.
        G. Fascicles 5–6 mm long.
          H. Glumes usually with one, rarely more, awns, margins conspicuously hyaline; plants wiry, densely tufted .... 4. *H. belangeri*
          HH. First glume of the central spikelet thick, terminating

in 2–5 awns, margins not hyaline; glumes of the central spikelet thick, terminating in 2–4 awns; plants not wiry or densely tufted
7. *H. hintonii*

GG. Fascicles 8–10 mm long; glumes conspicuously papillose-pilose between the nerves, the lemmas sparingly pilose on the back toward the tip
8. *H. semplei*

EE. Plants apparently non-stoloniferous; blades long, flat; ligule 2.5–3 mm long; spikes scarcely exceeding the blades
4a. *H. belangeri* var. *longifolia*

DD. Spikes mostly gray to black; coloration resulting either from numerous scabrous black glands or the accumulation of anthocyanin pigmentation, or both.

I. Spikes slender; fascicles 6.5–8 mm long; glumes narrow at the base, as long as the florets, dark gray to almost black, the margins hyaline and conspicuously lighter in color; lateral spikelets 2-flowered
9. *H. swallenii*

II. Spikes usually thick; fascicles 4–7.5 mm long; glumes broader at the base, shorter than the florets, the margins not conspicuously lighter in color nor hyaline; lateral spikelets 2–4-flowered (rarely 5-flowered)....5. *H. cenchroides*

1. **Hilaria jamesii** (Torr.) Benth., Journ. Linn. Soc., Bot. **19:** 62. 1881.
Pleuraphis jamesii Torr., Ann. Lyc. New York **1:** 148. *pl. 10.* 1824.

Perennial, tufted, rhizomatous; culms erect, 20–65 cm tall, nodes pubescent; sheaths glabrous or slightly scabrous, sparsely villous near the collar and behind the ligule; ligule 2–3 mm long, membranaceous, often laciniate; blades 2–20 cm long, 2–4 mm wide, involute when dry, scaberulous on the lower surface, scabrous on the upper between the nerves; spike thick, 2–6 cm long, rachis joints up to 6 mm long, angular, finely pubescent; fascicles 6–8 mm long, long-villous at the base; lateral spikelets 3-flowered, staminate; stamens 3, anthers of the first floret about 5 mm long; lodicules 2, 0.1–0.2 mm long; central spikelet 1-flowered, perfect; lodicules 2, about 0.2 mm long.

Distribution: Arizona, California, Colorado, Nevada, Texas, Utah, and Wyoming.

2. **Hilaria mutica** (Buckl.) Benth., Journ. Linn. Soc., Bot. **19:** 62. 1881.
Pleuraphis mutica Buckl., Proc. Acad. Nat. Sci. Philadelphia 1862: 95. 1862.

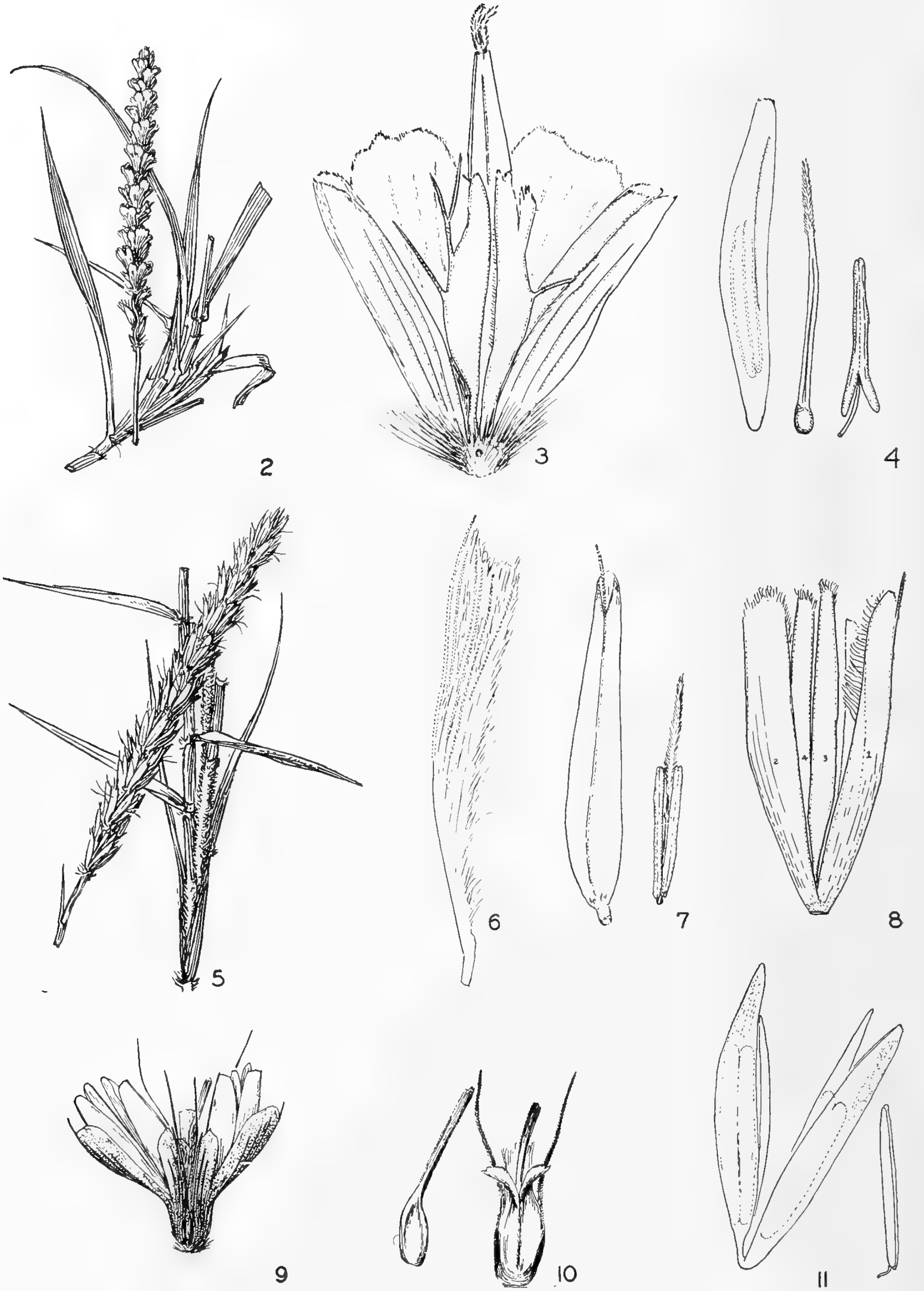
Perennial, tufted, rhizomatous; culms erect, 30–50 cm tall, nodes pubescent; sheaths striate, firm, scabrid, the lower overlapping the upper, shorter than the nodes, scabrous and sometimes sparsely papillose-pilose along the margins; ligule about 1 mm long, lacerate; blades up to 10 cm long, 2–4 mm wide, harshly short-scabrous on both surfaces, sometimes sparsely papillose-pilose on both surfaces; spike 4–8 cm long, joints of the spike slender, fascicles crowded; lateral spikelets 1 or 2-flowered (sometimes 3- or 4-flowered), staminate; lodicules 2, 0.1–0.2 mm long; glumes thin and broadened upward, the tips finely laciniate; central spikelet 1-flowered, perfect; lodicules 2, 0.1–0.2 mm long; glumes with one or more divergent awns from the back, the tips of the glumes lobed and finely laciniate.

Distribution: Arizona, Oklahoma, New Mexico, Texas, and northern Mexico.

MEXICO: Chihuahua: 10 km E. of Jiménez, *Harvey* 1348; Rancho Carretas, Chihuahua-Sonora Border, *Harvey* 1534; Meoqui, *LeSeur* 040; south of Chihuahua, *LeSeur* 0132; plains near Chihuahua, *Pringle* 485; 19 mi. northwest of Naica, *Shreve* 8080; 31 miles northeast of Camargo, *Shreve* 8895; Sta. Eulalia Plains, *Wilkinson* 55. Coahuila: Road to Don Martin Dam, *Harvey* 926; El Berrendo, near Múzquiz, *Harvey* 1175; 100 km west of Cuatro Ciénegas, *Harvey* 1254; *Johnson*, September 12, 1906; Músquiz-Santa Anna, *Marsh* 497; Del Carmen Mountains, *Marsh* 853; Torreon, *Palmer* 506; . . . between Hacienda La Rosa and Hacienda Lechuguilla, *Wynd and Mueller* 61; eastern slope of the Sierra de San Manuel, *Wynd and Mueller* 481. Durango: 3 miles northeast of Bermejillo, *Johnston* 7788; 49 miles north of Bermejillo, *Morley* 618; 3 miles Northeast of Bermejillo, *Shreve* 8816. Sonora: 3 miles east of Agua Prieta, *Santos* 1751; 5 miles north of Fronteras, *Santos* 1775.

3. **Hilaria rigida** (Thurb.) Bentham, ex Scribn., Bull. Torrey Bot. Club **9:** 86. 1882.
Pleuraphis rigida Thurber, in S. Wats., Bot. California **2:** 293.8 180.

Perennial; culms decumbent or rhizomatous



FIGS. 2–11.—*Hilaria mutica:* 2, Inflorescence and base of plant, ×1 (drawn by M. W. Gill from Toumey specimen); 3, spikelet (Wright 760–2108, type); 4, floret of central spikelet, ovary and stamen (Le Seur 0132). *Hilaria rigida:* 5, Inflorescence and vegetative portion of plant, ×1 (drawn by M. W. Gill from Palmer (no. 494) specimen); 6, glume of central spikelet (Cooper 2230, type); 7, floret of central spikelet and essential organs (Cooper 2230, type); 8, florets of lateral spikelets (Keck 4232). *Hilaria belangeri:* 9, fascicle; 10, central spikelet and floret (both drawn by A. Chase from Hitchcock specimen); 11, florets of lateral spikelet and one stamen (Nealley 600). All figures, unless otherwise indicated, ×8.

at base, up to 2.5 m tall, woody felty-pubescent, upper nodes often pubescent; sheaths overlapping, glabrous or scabrous, a woolly line across the back at the collar; ligule about 1 mm long, woolly; blades 2–5 cm long or longer, 2–4 mm wide, slightly involute, glabrous or scabrous on the nerves on both surfaces, lower sheaths and blades sometimes tomentose-pubescent; spike 4–7 cm long, fascicles 6–12 mm long, densely bearded at the base; lateral spikelets 2 to 4-flowered, staminate (if 3 or 4-flowered, uppermost usually sterile); lodicules 2, 0.1–0.2 mm long; glumes of the lateral spikelets thin, long-ciliate, about 7-nerved, usually 2–4-lobed at the broad summit and with 1–3 nerves excurrent into slender awns, nerves sometimes obscure and scarcely excurrent (variable in the same inflorescence); central spikelet 1-flowered, perfect, distinctly pedicellate, equaling or exceeding the lateral spikelets, its narrow glumes deeply cleft into few to several acuminate ciliate lobes and slender awns; lemma often exceeding the glumes, thin, ciliate, 2-lobed, the midnerve excurrent as a short awn; stamens 3, anthers 4–4.5 mm long; stigmas 2, plumose, terminally exserted; lodicules 2, 0.1 mm long.

According to Watson (1880) this species was eaten avidly by pack animals.

Distribution: Arizona, California, Nevada, Utah, Lower California, and Sonora.

UNITED STATES: California: Fort Mojave, *Cooper* 2230 (Type).

MEXICO: Baja California: Canon Cantillas, *Orcutt* 1145. Chihuahua: Colonia Diaz, *Mearns* 406. Sonora: 50 miles south of Sonoyta on road to San Luis, *Keck* 4232.

4. **Hilaria belangeri** (Steud.) Nash, N. Amer. Fl. **17:** 135. 1912.
Anthephora belangeri Steud., Syn. Pl. Glum. **1:** 111. 1854.

Perennial, tufted, stoloniferous; culms 10 to 30 cm tall, erect, nodes villous; sheaths striate, glabrous, overlapping, upper sheaths shorter than the internodes; ligule 1.5 mm long, membranaceous; blades 3 to 10 cm long, flat or involute when dry, sparsely papillose-pilose on the margins and on the upper surface, tip involute; spike 2–4 cm long, fascicles 5–6 mm long; glumes firm, united below, scabrous, usually pale or sometimes violaceous, but not dark gray or black from glandular spots, rounded or pointed upwards, terminating in one or more antrorsely scabrous awns as long as or longer than the fascicle; lateral spikelets 2-flowered (rarely 3-flowered), staminate or sometimes one floret neuter; stamens 3, anthers of the lower floret 3–3.5 mm long; anthers of the upper floret 3.2–3.7 mm long; central spikelet 1-flowered, pistillate, as long or longer than the lateral spikelet.

Distribution: Arizona, California, New Mexico, Texas, and Mexico.

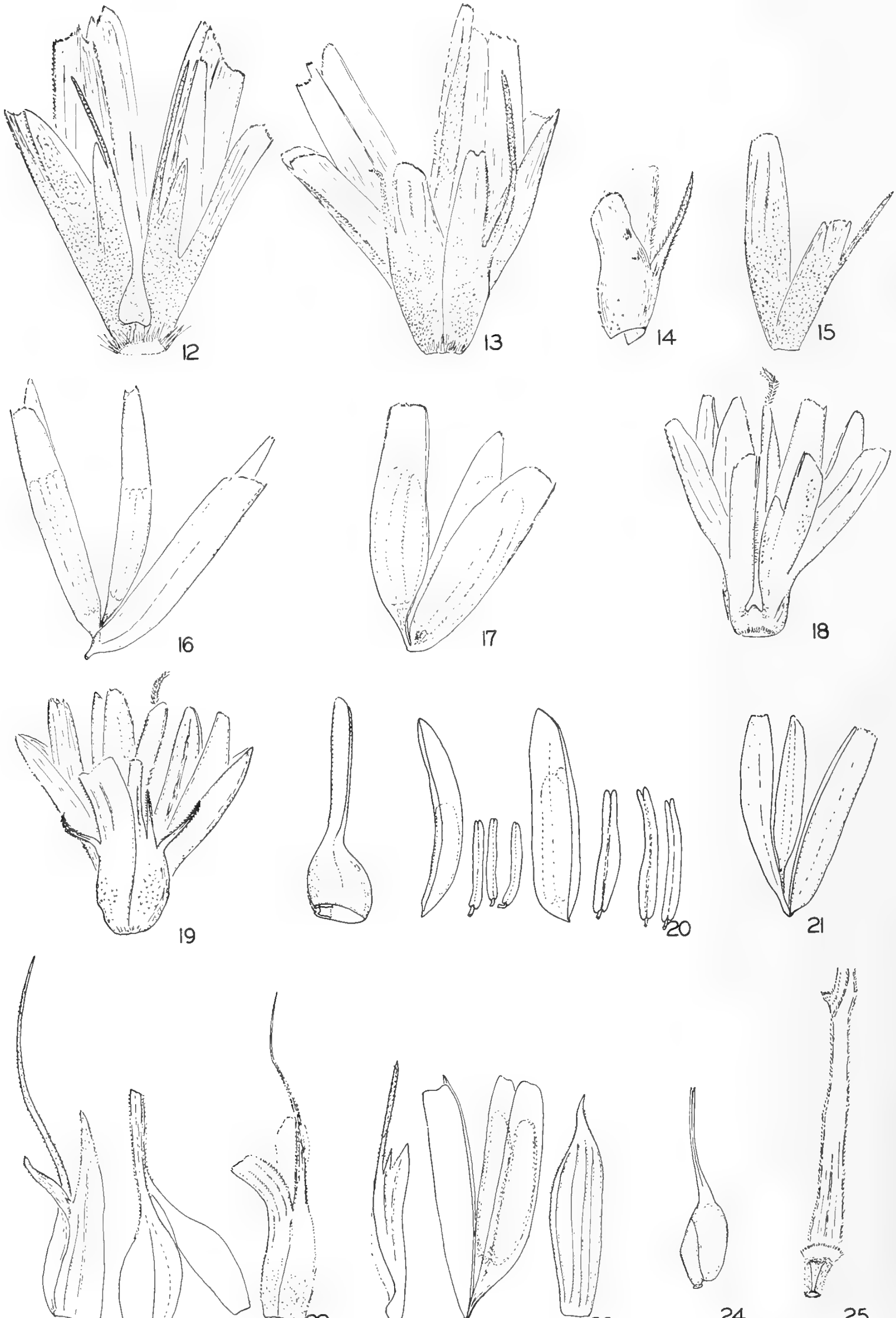
MEXICO: Aguascalientes: Aguascalientes, *Hitchcock* 7477. Baja California: La Champagna, Sierra de las Palmas, *Gentry* and *Fox* 11787. Chihuahua: Rancho Carretos, *Harvey* 1621. Guerrero: Coyuca, *Hinton* 6707. Michoacán: Apatzingan, *Leavenworth* 1521. México Temascaltepec, *Hinton* 4733. Morelos: Lava fields near Yautepec, *Pringle* 11225; between Xoxocotla and Alpuyec, *Sharp* 441358. Sonora: near Imuris, *Pennell* 20278; Hacienda de San Rafael, *Santos* 1782; 20 miles west of La Angostura, *Santos* 1802; Colonia Morelos, *Santos* 2032 [Sept. 15–Oct. 4, 1941]. Tamaulipas: Chamal, *Swallen* 1680, 1698.

4a. **Hilaria belangeri** var. **longifolia** (Vasey) Hitchc., Proc. Biol. Soc. Washington **41:** 162. 1928.
Hilaria cenchroides var. *longifolia* Vasey, Proc. Amer. Acad. Sci. **24:** 80. 1889; Beal, Grasses North America **2:** 69. 1896.

Perennial, tufted, apparently non-stoloniferous; culms erect, 30 cm or more tall, nodes villous; sheaths striate, scabrous, basal sheaths overlapping, upper sheaths shorter than the internodes; ligule 2.5–3 mm long, membranaceous; blades 3–15 cm long, up to 3.5 mm wide, flat, scabrous on both surfaces, sparsely papillose-pilose on the margins and upper surface, tip involute; spike 2–4 cm long, joints of the axis 3–5 mm long, flat, margins antrorsely short-pilose; fascicles 5–8 mm long, 5–12 per inflorescence; first glume of lateral spikelet with one long awn, the others half as long, free or fused; lateral spikelets 2-flowered, lower floret usually neuter, upper floret staminate; stamens 3, anthers about 3 mm long; central spikelet 1-flowered, pistillate.

Distribution: Arizona, Texas, and northwestern Mexico.

MEXICO: Sonora: Guaymas, *Palmer* 347 (type); Guaymas, *Hitchcock* 3558; Colonia Morelos, *Santos* 2032 [15 Sept. 1947].



FIGS. 12–25.—(See opposite page for legend).

5. **Hilaria cenchroides** H. B. K., Nov. Gen. & Sp. **1:** 117. *pl. 37.* 1816.

Perennial, tufted, stoloniferous; culms erect, 5–60 cm tall, nodes pilose; sheaths striate, overlapping, margins hyaline, the lower from sparsely to densely papillose-pilose, the upper glabrous and shorter than the internodes; ligule 1.5–2 mm long, laciniate; blades up to 10 cm long, to 4 mm wide, flat, involute on drying, slightly scabrous on the lower surface, very scabrous on the upper surface, sometimes also sparsely papillose-pilose, margins antrorsely scabrous; spikes 2–6 cm long, dark brown to purple in color; rachis joints scabrous-pubescent on the margins; fascicles 4–7.5 mm long; glumes usually shorter than the spikes, indurated and fused at the base; lateral spikelets 2–4-flowered (rarely 5 florets), staminate or some of them sterile; stamens 3, anthers 3–3.5 mm long, yellow; central spikelet 1-flowered, pistillate.

Distribution: Mexico to Guatemala.

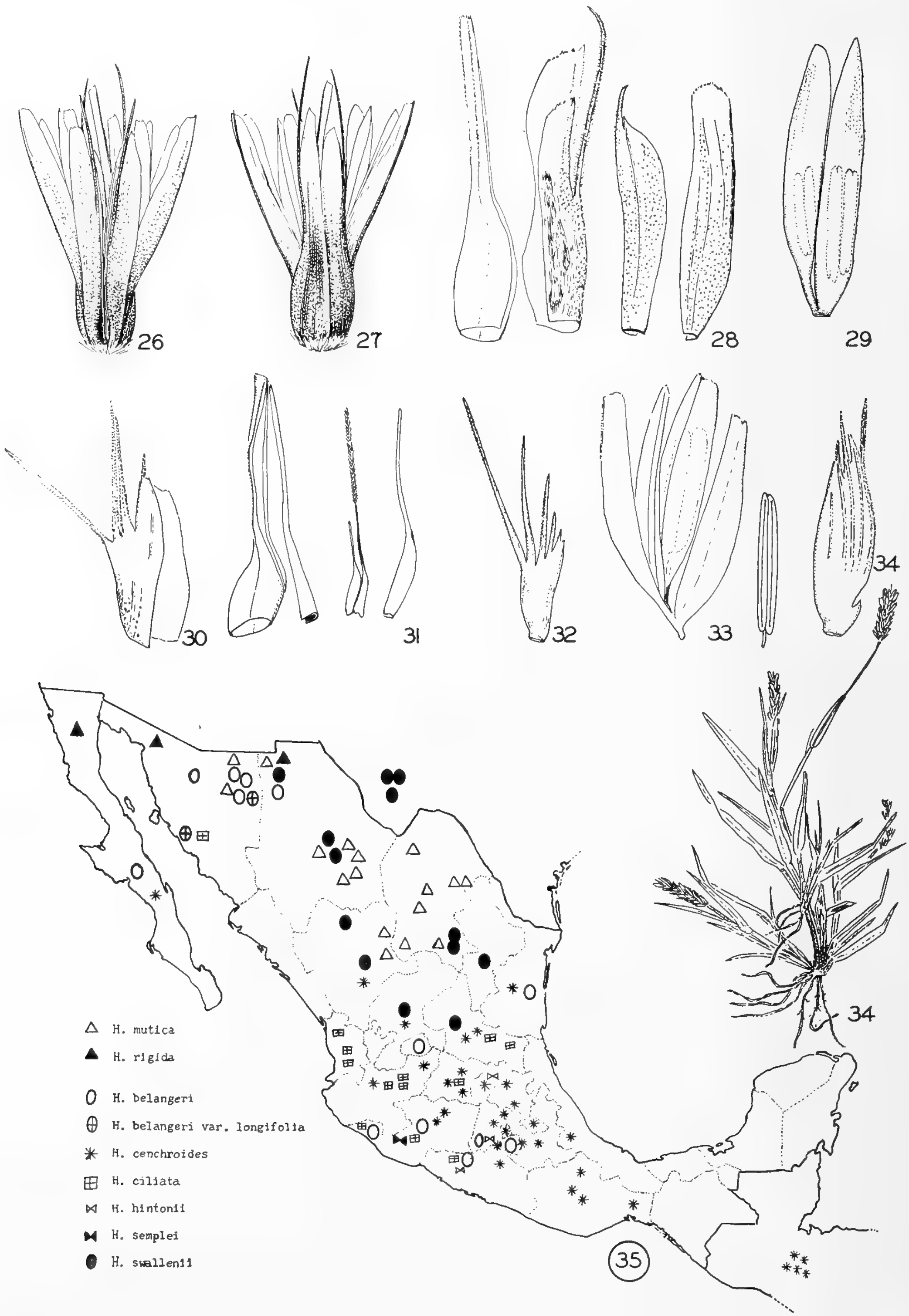
MEXICO: Baja California: 19 miles northeast of Comondu, *Shreve* 7120. Distrito Federal: Mixcoac, *Arsène* 8281; Camino de Toluca, *Balls* 5587; Mexico City, *Fisher* 70; San Ángel, *Fisher* 113; Xochimilco, *Hitchcock* 5889; Pedregal, *Hitchcock* 5950; Olivar, *Orcutt* 3591. Durango: Durango, *Hitchcock* 7580; *Palmer* 379, 541. Guanajuato: The Alameda, *Dugis*, July 1899; Acámbaro, *Hitchcock* 6939; Irapuato, *Hitchcock* 7430; 6 kms east of Guanajuato, *Sohns* 318. Guerrero: Santa Fé, *Hitchcock* 6687. Hidalgo: Jacala, *V. H. Chase* 7110, 7230; Pachuca, *Hitchcock* 6718 ½; Guadalupe, *Juzepczuk* 114; Puerto de la Zorra, *Moore* and *Wood* 3776. Jalisco: La Punta, *Hitchcock* 7000; San Nicolás, *Hitchcock* 7188; Guadalajara, *Hitchcock* 7268; Río Blanco, *Palmer* 197; Huejuquilla, *Rose* 2542; La Punta, *Shreve* 9289. México: Toluca, *Hitchcock* 6905; Molino de la Flor, *Matuda* 18932; Zumpango, *Matuda* 19723; San Gerónimo, *Matuda* 29247; Atizapan, *St. Pierre* 205; Tlalpan, *St. Pierre* 818; Mixcoac, *St. Pierre* 833, 881; San Ángel, *St. Pierre* 851; San Juan de Teotihuacan, *Santos* 2197; San Andreas, *Sohns* 190. Michoacán: Morelia, *Arsène* 5587; Zitácuaro, *Hinton* 13113. Morelos: Cuernavaca, *Hitchcock* 6861; *Ross*, June 1953. Oaxaca: Cerro del Fortin, *Conzatti* 3588; Oaxaca, *Hitchcock* 6096; Valle de Oaxaca, *Liebmann* 571; Tehuantepec, *Matuda* 311; Valle de Oaxaca, *Nelson* 1576; Valley of Cuicatlan, *Nelson* 1906; El Cerro de San Felipe del Agua, *Santos* 3208. Puebla: Fort de Loreto, *Arsène* 35; vicinity of Puebla, *Arsène* 284, 1019; Atlixco, *Nelson* 25/7/1893; San Francisco, *Nicolas* 15/8/1909; Cholula, *Nicolas* 14/7/1909. Querétaro: Querétaro, *Arsène* 10274, Querétaro, *Hitchcock* 5865, 5870; *Semple*, November 1955. San Luis Potosí: Cardenas, *Hitchcock* 5713; Alvarez, *Palmer* 165. Tamaulipas: Buena Vista Hacienda, *Wooton* 21/6/1919. Tlaxcala: San Cristóbal to Calpulalpan, *Sohns* 573. Veracruz: Santa Ana Chiautempan, *Arsène* 11/10/1908; Orizaba, *Hitchcock* 6353; *Mohr; Mueller* 2079; *Schaffner* 199. Zacatecas: Zacatecas, *Hitchcock* 7537.

GUATEMALA: Guatemala City, *Hitchcock* 9084; *de Koninck* 142; *Popenoe* 667; La Aurora, *Morales R.* 726.

6. **Hilaria ciliata** (Scribn.) Sohns, comb. nov.
Hilaria cenchroides var. *ciliata* Scribn., Proc. Acad. Nat. Sci. Philadelphia 1891: 293.

Perennial, tufted, sometimes stoloniferous; culms up to 45 cm tall, erect, sometimes finely pubescent below the lower nodes, otherwise glabrous; nodes pilose; sheaths striate, glabrous, the lower sometimes sparsely papillose-pilose, usually shorter than the internodes; ligule about 2.5 mm long, membranaceous; blades 1.5–15 cm long, up to 4 mm wide, scabrous on both surfaces and margins, occasionally sparsely papillose-pilose on both surfaces, sparsely papillose-pilose at the collar and behind the ligule; spike 3–5 cm long, joints of axis 2.5–3.5 mm long, finely ciliate on the margins, sometimes sparsely pilose; fascicles mostly less than 4 mm long (rarely to 5 mm); glumes fused at base, papillate-scabrous; the awns of the glumes of the central spikelets 1 or 2, these usually not exceeding the lobes,

Figs. 12–25.—*Hilaria cenchroides:* 12, Abaxial view of fascicle; 13, adaxial view of fascicle (both drawn from Galeotti 5689); 14, glume of central spikelet (Hinton 13113); 15, first and second glumes of lateral spikelet (Hinton 13113); 16, three florets from lateral spikelet (Hinton 13113); 17, two florets from lateral spikelet (Palmer 379). *Hilaria ciliata:* 18, Abaxial view of fascicle; 19, adaxial view of fascicle; 20, floret of central spikelet and first and second florets of lateral spikelets with stamens (all from Pringle 3128). *Hilaria belangeri* var. *longifolia:* 21, three florets of a lateral spikelet; 22, central spikelet; 23, lateral spikelet; 24, caryopsis; 25, rachis joint. All from Palmer 347. All figures ×8.



FIGS. 26–35.—(See opposite page for legend).

sometimes reflexed at maturity, short-ciliate on the margins, the cilia often retrorse; awns of the lateral spikelets inconspicuous; lateral spikelets 2-flowered, staminate; stamens 3, anthers of the upper floret 2.8–3 mm long; central spikelet 1-flowered, pistillate.

Distribution: Known only from Mexico.

MEXICO: COLIMA: Alzada, *Hitchcock* 7077; Armeria, *Hitchcock* 7022; Manzanillo, *Hitchcock* 833; *Palmer* 197, 1267. GUERRERO: Mina, *Hinton* 9310. JALISCO: Zapotlán, *Hitchcock* 7125; Guadalajara, *Hitchcock* 7370; Valley of the Rio Grande de Santiago at Atequiza, *Palmer* 3128 (Type). MICHOACÁN: Aguililla, *Hinton* 12093, 15213; Apatzingan, *Hinton* 12029; *Leavenworth* 1521, 1590; near Nueva Italia, *Sohns* 847. NAYARIT: Vicinity of Jalisco, *Ferris* 5818; Tepic, *Palmer* 1918; Acaponeta, *Rose, Standley and Russell* 14304. SAN LUIS POTOSÍ: Valley of the Río Tampaon, *V. H. Chase* 7530; Cardenas, *Hitchcock* 5774. SONORA: Palmer, s. n.

7. **Hilaria hintonii** Sohns, sp. nov.

Gramen perenne, stoloniferum; culmi 5–20 cm alti, nodi pubescenti; vaginae glabrae vel leviter pilosae; ligula 0.5–1 mm longa, membranacea; laminae 2–6 cm longae, usque ad 4 mm latae, planae, supra papilloso-pilosae, subtus glabrae vel interdum leviter papilloso-pilosae, margines scabrae; spicae 2–4 longae, articuli rachi plani, 1–4.5 mm longi; fasciculi 4–6.5 mm longi, glumae induratae, scaberulae; spiculae laterales bi- vel triflores, masculae; spicula intermedia uniflora, feminea.

Perennial, tufted, stoloniferous; culms 5–20 cm tall, erect; nodes pubescent; sheaths glabrous or sparingly pilose near the collar; ligule 0.5–1 mm long, membranaceous; blades 2–6 cm long, up to 4 mm wide, flat, thin, papillose-pilose on the upper surface, scabrous on the lower or sometimes sparsely papillose-pilose, margins scabrous, the tip acuminate; spikes 2–4 cm long, joints of the axis flat, 1–4.5 mm long, margins short ciliate; fascicles 4–6.5 mm long, the glumes indurated and fused at the base, scaberulous to sparsely glandular-spotted; first glumes of the lateral spikelets indurated at the base, the tips terminating in 3 or 4 awns, one of which is as long as the spikelets; second glumes of the lateral spikelets broad, indurated, terminating in 2 to 4 awns of approximately equal length; lateral spikelets 2–3-flowered, staminate, or the lower sometimes sterile, stamens 3, anthers 2.8–3 mm long; glumes of the central spikelet with more or less truncated tips and 2 or 3 prominent awns; central spikelet 1-flowered, pistillate.

This species is named in honor of the late Mr. G. B. Hinton, exceptional collector of Mexican grasses.

TYPE: Temascaltepec, Mexico; Luvianos, llano, 9/8/1933; *Hinton* 4502 (U.S.N.H. no. 1840874).

Distribution: Central Mexico.

MEXICO: GUERRERO: Coyuca, *Hinton* 6437. MÉXICO: Temascaltepec, *Hinton* 4502. QUERÉTARO: South of San Juan del Río, *Semple*, November 1955.

8. **Hilaria semplei** Sohns, sp. nov.

Gramen perenne, stoloniferum; culmi erecti, 20–35 cm alti, glabri; nodi papilloso-pilosi; vaginae striatae, internodiis breviores, inferiores papilloso-pilosae, superiores glabrae; ligula membranacea, 0.5–1 mm longa; laminae 2.5–15 cm longae, usque ad 2.5 mm latae, plana vel V-forma, utrinque papilloso-pilosae, margines scabrae; spicae 2–4 cm longae, articuli rachi 2.5–4.5 mm longi, plani,. margines ciliati; fasciculi 8–10 mm longi; glumae induratae, valde nervosae, internerviis papilloso-pilosae, aristae scabrae; spiculae laterales biflores, masculae; lemmata membranacea, summa tenuiter pilosi, leviter 3 vel 4-nerviis; spicula intermedia uniflora, feminea; lemma membranaceum, leviter 3-nerviis, 8–10 mm longum.

Perennial, tufted, stoloniferous; culms 20–35 cm tall, erect, glabrous; nodes papillose-pilose; sheaths striate, shorter than the internodes, the lower papillose-pilose, the upper glabrous; ligule 0.5–1 mm long, membranaceous; blades 2.5–15 cm long, up to 2.5 mm wide, slightly V-shaped in cross-section or flat, papillose-pilose on both surfaces, margins antrorsely scabrous, the tip

FIGS. 26–35.—*Hilaria swallenii:* 26, Abaxial view of fascicle; 27, adaxial view of fascicle (drawn by A. Chase from Young (No. 46) specimen); 28, lemma, glume of central spikelet, first and second glumes of lateral spikelet; 29, two florets of a lateral spikelet (both from Sperry T778). *Hilaria hintonii:* 30, glume of central spikelet; 31, two pistillate florets from central spikelet; 32, first glume of lateral spikelet; 33, three florets and a stamen from a lateral spikelet; 34, second glume of lateral spikelet and habit sketch of plant ($\times\frac{1}{2}$). All drawn from Hinton 4502. All figures $\times 8$. 35: Map of Mexico showing distribution of species of *Hilaria*.

FIGS. 36–50.—(See opposite page for legend).

involute; spike 2–4 cm long, joints of the axis 2.5–4.5 mm long, flat, the margins finely ciliate, rachis flaps prominent, tips finely ciliate; fascicles 8–10 mm long; glumes fused at base, strongly nerved, papillose-pilose between the nerves, awns prominent, antrorsely scabrous; lateral spikelets 2-flowered, the florets staminate, lemmas membranaceous, faintly 3- or 4-nerved, the tips sparingly pilose, paleas membranaceous, as long as the lemmas, 2-nerved; central spikelet 1-flowered, pistillate; lemma membranaceous, faintly 3-nerved, 8–10 mm long.

This species is named in honor of Dr. A. T. Semple, Food and Agricultural Organization of the United Nations.

Type: Dense heavy stands on very heavy clay soil; dominant grass over many areas; Llanos de Antuñez, about 12 miles east of Apatzingan, Michoacán, alt. 1,000 feet; November 1955, *A. T. Semple* (U.S.N.H. no. 2183565). Dry grasslands between Nueva Italia and Apatzingan, alt. 430 m., dominant grass; November 14, 1955; *Moore, Hernández X.* and *Porras H.* 5753.

9. **Hilaria swallenii** Cory, Wrightia **1:** 215. 1948.

Perennial, tufted, stoloniferous; culms erect, 10 to 30 cm tall, nodes villous; sheaths shorter than the internodes, slightly scabrous; ligule 2–2.2 mm long, membranaceous; blades mostly short, basal, up to 8 cm long, 1–2 mm wide, flat or involute when dry, scabrous on both surfaces; spike 1–4 cm long, gray to dark-brown in color, sparsely to densely provided with glands; rachis joints 4–6 mm long, sparsely short-scabrous on the margins and over the back; fascicles 6.5–8 mm long, 2 to 8 per spike, narrow, appressed, not conspicuously flabellate at maturity; glumes connate at base, margins usually hyaline and light gray to whitish; lateral spikelets 2-flowered, the lower floret usually sterile, the upper staminate, stamens 3, anthers 3–3.5 mm long; central spikelet 1-flowered, pistillate, the base of the lemma usually elliptic.

Distribution: Davis Mountains area of Texas and Mexico.

UNITED STATES: Texas: Músquiz Canyon, *Sperry* T778 (Type).

MEXICO: Chihuahua: 19 km North of Río San Pedro on Parral-Chihuahua Road, *Harvey* 1432; 2 km west of Carretas, *Harvey* 1568; near Chihuahua, *Pringle* 493. Coahuila: 3 miles southeast of Saltillo, *Johnston* 7251; 2 miles southeast of Saltillo, *Shreve* 8509. Durango: 5½ miles south of Ignacio Allende, *Gentry* 6915; near Torreón de las Canas, *Gentry* 8639. Nuevo Léon: Galena, *V. H. Chase* 7763. San Luis Potosí: Charcas, *Lundell* 5515; Charcas, *Whiting* 508, 528. Zacateas: Among cerros 6 miles southeast of Carboneras, *Gentry* 8504.

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Figs. 36–50.—*Hilaria semplei* Sohns, sp. nov.: 36, Habit sketch of plant, ×1½; 37, basal sheath and blade; 38, node; 39, junction of blade and sheath; 40, margin of blade; 41, fascicle; 42, glume of central spikelet; 43, floret of central spikelet; 44, palea and caryopsis; 45–46, first and second glumes of lateral spikelets; 47–48, lemma and palea of first floret; 49–50, palea and lemma of second floret. All figures ×8 and drawn from the type specimen.

ENTOMOLOGY.—*New Neotropical genera and species of apterous aradids (Hemiptera)*. CARL J. DRAKE, Iowa State College.

(Received August 15, 1956)

The present paper contains the descriptions of one new genus, one subgenus, and five species of apterous aradids from the Americas. The types have been deposited as stated in the descriptions. In the structural measurements, 80 units equal 1 mm.

Emydocoris montanus, n. sp.

Very broad, rather thick, obovate, narrowest across front margin of pronotum, above with a complicated pattern of high elevations and deep cavities, without lateral lobes or projections, dark ferrugineous without color markings, without vestiture. Head broad, subquadrate, width across eyes and median length subequal (2.25 mm). The lateral edges nearly parallel; lateral shelves very wide, long, depressed, with bases almost in contact with front margin of pronotum; eyes moderately large, subovate, about two-thirds as broad as long, each placed at middle of lateral side of lateral shelf, slightly inserted, about three-fifths of its width extending outward beyond the lateral side, the shelf behind the eyes broad; antenniferous tubercles stout, tapering anteriorly, slightly divergent; median longitudinal part of head elevated above lateral shelves, about one-third as wide as interocular space, strongly rugose above, projecting about one-third of its length beyond base of antennae; tylus moderately wide with superior surface smooth and longitudinally convex; juga surpassing tylus, dilated apically, meeting at midline in front of tylus. Labial sulcus deep, narrow, extending to collar; labium short, brownish, nearly attaining end of sulcus. Neck very short, constricted, rounded. Antennae and head subequal in length; antennal segment I quite stout, bent outward opposite apex of antenniferous tubercle; II shortest, slenderest; III slowly enlarged apically; IV subclavate; measurements—I, 45; II, 30; III, 54; IV, 50.

Pronotum a little narrower than mesonotum, narrower in front than behind, sloping obliquely downward anteriorly, approximately 2½ times as wide at base as median length (210:80), with outer sides of dorsal surface very strongly widely and rugosely elevated, strongly depressed between lateral elevations, with the large median plate divided at middle by a deep longitudinal furrow, separated behind from mesonotum by a transverse suture, the collar short, depressed, strongly constricted, with a small knob on each side. Mesonotum separated from metanotum by a strongly sinuate suture, narrower than pronotum, longest at middle, four times as wide at base as median length (longest at middle), with a very wide, convex and smooth median ridge, with lateral elevation not quite as large as on pronotum, with a deep transverse cavity on each side between median ridge and large lateral elevation. Metanotum not attaining outer margin of body, fused with abdominal tergites I–VI (inclusive) into a solid plate, the plate wider at base than behind, width at base (metanotum) and median length subequal, with transverse suture between tergites II and III faintly indicated, with median ridge widened and elevated posteriorly, abruptly widened on tergites II and III, thence posteriorly gently sloping downward, with glandular elevation at centre of widened hind part plainly visible, with dorsal surface of median ridges and elevations smooth and without complex sculpturing, narrowly depressed on each side of the highly elevated area between the longitudinal suture separating tergites from connexival segments, with a deep cavity on each side of median ridge just back of metanotum, with three knoblike structures in cavity just behind metanotum and five transverse ridges in narrowly depressed strip adjacent to each connexivum.

Connexiva slowly narrowed anteriorly, with segments I and II fused, other segments separated from one another by transverse sutures. Spiracles II to VII (inclusive) ventral, remotely removed from outer edge of their respective segments, spiracle VIII (genital segment) placed on apical end of a short, posteriorly-directed tubercle. Body beneath moderately convex; prosternum with a median longitudinal carina, separated from mesosternum by a transverse suture; mesosternum also with a visible suture behind it (probably not functional); metasternum fused with abdominal ventrites I–III (inclusive), other ventrites separated from one another by deep suture. Legs short, dark brownish ferrugineous with pale tarsi, the femora of all legs slightly flattened beneath and beset with two longitudinal rows (one row near anterior edge and other near posterior) of short, stout, tubercle-like teeth or pegs with rounded tops. Ostiolar canal tubular, extending obliquely upward posteriorly, with an ovate opening slightly above middle of pleura, not visible from dorsal aspect. Scutellum entirely absent, without trace of wings or wing pads.

Length, 8.75–9.20 mm; width, 4.75 mm.

Holotype (male) and *allotype* (female), Brasil, November 29, 1890, collected by Dr. Warburg, in collection of Zoologisches Museum, Zoologisches Staatsinstitut, Hamburg, Germany. *Paratype:* 1 specimen, same locality as type.

Separated from *Emydocoris testidinatus* Usinger (1941) by its larger size, antennal segments, short legs with all femora armed beneath, high elevations and deep cavities of dorsal surface (especially abdomen) and the large tubular ostiolar canal projecting obliquely upward with an ovate opening on outer side.

Reeceicus, n. gen.

Broadly ovate, unusually thick, beneath transversely convex, dorsally strongly longitudinally convex, rugged, humpbacked, adorned on median part of thorax and basal half of abdomen with large craggy protuberances and depressions, with thorax sloping downward anteriorly and abdomen downward posteriorly. Head very wide, subquadrate, not narrowed behind eyes; lateral shelves very wide, thin, with dorsal surfaces on much lower level than that of median longitudinal part of head, tilted upward laterally, with eyes rather small, longer than wide and placed near middle of outer edge of each shelf; tylus fairly wide, rugged; juga narrower, not exceeding tylus in front; neck short. Labial sulcus deep, rather narrow, not extending to neck; labium short, not attaining apex of sulcus. Antennae short, subequal to head in length; segment I short, moderately swollen, bent, not surpassing apices of tylus and juga; other segments also short, with IV a little swollen. Legs rather short, slender.

Pronotum much wider than head, about four times as wide as long, rugged, not excavated in front for reception of collar; collar short, constricted; mesonotum short, rugged, with transverse furrow separating it from pronotum and also from mesonotum (sutures seem to be fused); metanotum partly concealed by raised and overlapping base of abdomen. Thoracic divisions and abdominal tergites I to VI (inclusive) apparently conjointly fused but with a narrow, deep furrow between II and III. Abdomen distinctly broadly cordate, with apex narrow and rounded, with wide basal part a little raised and fused upon base of metanotum, thus together with craggy elevations giving body a distinctly hunchbacked appearance; connexival segments strongly curving inward at base, apparently with segment I represented (seven segments).

Spiracle II ventral, remotely removed from outer margin; III to VII (inclusive) lateral, plainly visible from above; VIII (genital segment) posterolateral, placed at apical end of rounded projection, visible from dorsal aspect.

Type species, *Reeceicus saileri*, n. gen. and n. sp.

This very curious genus differs greatly in a few respects from all other genera of apterous aradids. The body is very thick, broadly ovate, strongly longitudinally convex and distinctly hunchbacked in appearance; lateral sides deeply furrowed for the reception of legs; abdomen above broadly heart-shaped, narrowly rounded behind, with base wide, slightly elevated; connexival segments at base strongly curved inward and fused upon the basal part of metanotum. Connexival segment I appears to be represented as seven segments are visible. Spiracle II is ventral and remotely removed from lateral margin; III to VII (inclusive) placed on low half of the longitudinally divided (by narrow furrow) outer edge of connexiva. The head is rather similar in shape and appearance to *Emydocoris* Usinger (1944), but the smaller eyes, shape of body, location of spiracles and other striking differences separate at once the two genera. This genus and species are named in honor of Dr. Reece I. Sailer, who is in charge of the Hemiptera, U. S. National Museum.

Reeceicus saileri, n. sp.

Fig. 1

Moderately large, very thick, extremely longitudinally convex above, strongly rugged, with a distinctly humped back. Head subquadrate, with sides widening posteriorly, slightly angulately produced at latero-posterior corner, wider at base (100) than either across eyes (70) or between tips of antenniferous tubercules, each lateral shelf occupying one-

FIG. 1.—*Reeceicus saileri*, n. gen. and sp. Dorsal aspect of abdomen (× 32).

third of space between eyes; juga not surpassing tylus. Antennae short, measurements—I, 20; II, 16; III, 18; IV, 20. Labium short, brownish. Sides of thorax with an oblique, upright channel for reception of anterior femora; with an inverted V-shaped channel for reception of middle femora and tibiae, and the thorax and base of abdomen also with an inverted V-shaped channel for reception of hind femora and tibiae.

Pronotum almost twice as wide as base of head (185:100), nearly four times as wide at base as median length (200:50), not excavated in front for insertion of collar, with a subquadrate protubance at middle; mesonotum not longer than pronotum, with the protuberance of meso-metanotum higher and more deeply furrowed at middle than similar structure on pronotum. Abdomen broadly heart-shaped, widest near base, roundly narrowed posteriorly, rounded and narrowest behind, subtruncate at middle of front margin, tilted upward anteriorly, with base fused up on posterior part of metanotum, with connexiva curving inward and extending along anterior part of base of abdomen, with basal platelike protuberance large, trapezoidal (basal and apical margins parallel and long; sides obliquely widened apically), divided into four equal parts by three longitudinal furrows (median furrow and one on each side of it); tumid area behind furrow between tergites II and III quite large. Connexiva composed of seven segments (I present), curving strongly inward at base so as to occupy two-sevenths of basal margin on each side, thus leaving only three-sevenths of base at middle). Exterior margin of abdomen rather thick, with edge divided by a narrow longitudinal furrow, with stigmata III to VII (inclusive) placed on lower half of lateral edge, all spiracles (save II) visible from dorsal view.

Length, 4.50 mm; width, 2.90 mm.

Holotype (female), Yurimaguas, Peru, Drake Collection.

Glyptocoris verus, n. sp.

Large, broadly ovate, widest across middle of abdomen, narrowest across front margin of pronotum and there very little wider than head across eyes, reddish ferrugineous with abdomen darker and a small marginal spot on each side at base of all thoracic divisions and of all connexival segments pale or whitish flavous. Head quadrate, as wide across eyes as median length (86:88), strongly rugose above; lateral shelves thick, with dorsal surface on a slightly lower level than that of median longitudinal part of head, extending posteriorly behind eyes nearly the length of an eye before narrowing to neck, with an angulate lateral projection or tubercle behind each eye at postero-lateral end; median longitudinal part of head a little narrower than a lateral shelf, with a small tubercle on each side just in front of neck; tylus moderately stout, rugose, sloping downward at apex; juga surpassing tylus about as far as the distance between their apices. Labial sulcus short, wide, fairly deep, with edges and lateral sides closely coarsely granulate; labium barely attaining end of sulcus. Antennae longer than head, granulate; segment I stout, a little bent outward; IV subclavate, with short pale hairs on tip; measurements—I, 52, II, 32; III, 42; IV, 34. Legs slender, finely granulate.

Pronotum strongly narrowed anteriorly, much wider behind than in front, closely granulate on lateral sides, deeply rectangularly excavated on margin for reception of collar, with margin on each side projected anteriorly as far as anterior face of collar, deeply widely furrowed on median longitudinal line behind the middle, with a transverse furrow separating pronotum and mesonotum, twice as wide in front as median length, three times as wide at base as median length (160:50); mesonotum wider and shorter than pronotum, with a shallow furrow separating it from metanotum; metanotum longer than pronotum, with its hind margin elevated although fused with first two abdominal tergites; pro-, meso- and metanotum and abdominal tergites I and II conjointly fused, with a wide, median, longitudinal ridge extending uninterruptedly from base of pronotum to end of tergite II, with short lateral ridges on each side of median line of large median ridge. Abdomen above with tergites III to VI (inclusive) conjointly fused, sculptured on each side of low, wide, pale, median, longitudinal ridge; connexival segments I to III fused together, the others distinctly sutured from one another. Body beneath with sternal segments and first three abdominal ventrites conjoined together, other abdominal ventrites separated by sutures. Spiracles V, VI and VII lateral; VIII (genital) placed on end of posteriorly directed tubercle; and II, III and IV ventral, the latter subventral, III considerably removed from outer edge and II remotely removed, all three not visible from dorsal aspect. Male unknown.

Length, 6.20 mm; width, 3.10 mm.

Holotype (female) and 1 *paratype* (female), Guadeloupe Island, West Indies. Drake Collection.

Although somewhat atypical, this species fits better in the genus *Glyptocoris* than other genera of American apterous aradids. The thoracic divisions are distinguishable from one another, though fused together and also conjoined with first two abdominal tergites.

Aglaocoris comes, n. sp.

Small, rectangular in outline, reddish fuscous or reddish ferrugineous, without lateral lobes, coarsely granulate on lateral margins of thorax and abdomen. Head subtriangular, rapidly narrowed behind eyes, with a short neck, width across eyes and median longitudinal length subequal; eyes small, reddish, placed up on the outer end of a very short, slightly tilted-up pedicel; juga surpassing tylus, with tips blunt and feebly divergent, with dorsal surface on a much lower level than that of tylus; tylus rugose, fairly thick; lateral shelves and median part of head rather strongly rugulose, with dorsal surfaces on almost same horizontal level, the shelves thick and each about as wide as median part of head, with a small protuberance back of each eye; antenniferous tubercles stout, divergent, each terminating in a small fingerlike projection. Labial sulcus moderately wide, not extending to neck; labium not as long as sulcus. Antennae granulate, longer than head, with first segment slightly bent outward, measurements—I, 36; II, 30; III, 24; IV, 24. Legs moderately long, granulate.

Body nearly as wide in front as behind (72:75), slightly wider at middle (90), with median length nearly one and one-half times as long as median with (130:90). Pronotum more than four times as wide at base as median length, scarcely excavated in front for reception of collar, sulcate on median longutidinal line; collar smooth, short and with an encircling median ridge, marked off from mesonotum by a transverse furrow, fused with mesonotum. Pro-, meso-, and metanotum and abdominal tergites I and II conjointly fused, with a large median longitudinal ridge extending from base of pronotum almost to posterior margin of tergite II, the ridge strongly rugose, wider and higher on basal half. Abdomen with tergites III to VI (inclusive) fused together, with a tumid glandular elevation near the middle of the low, median, longitudinal ridge, with an intricate pattern of sculpturing on each side of median ridge; VII distinctly defined; connexival segments I, II and III grown together, without separating sutures, other segments sutured from one another and from abdominal tergites. Abdomen beneath with sternal division and ventrites I-III (inclusive) conjointly fused, other segments sutured from one another. Spiracles II to IV (inclusive), ventral, submarginal, each progressively anteriorly slightly farther removed from outer edge; V sublateral (ventral) and VI and VII lateral and VIII postero-lateral on end of a short rounded process, all four of which are visible from dorsal aspect. Abdominal ventrite VII beneath (one on each side) with a large ovately rounded, smooth, constricted at neck (distinctly bottle-shaped), ventrally-directed protuberance (male structre; not found in female).

Holotype (male) and 1 *paratype* (male), Three Rivers, Guadeloupe, West Indies, in Drake Collection.

Separated from *A. natalii* Drake and Maldonado by its smaller size, shorter eye-stalks, median longitudinal ridge on pronotum and the much larger and very differently shaped (flask-like) protuberance projected downward on the underside of ventrite VII (one on each side) in the male.

Asterocoris (Peggicoris) zeteki, n. subg. and n. sp.

Small, oblong (male) or obovate (female), dark reddish fuscous or ferrugineous. Head subtriangular, width across eyes and median longitudinal length subequal, sharply narrowed behind eyes, with the small elevation back of each eye beset with setalike, whitish hairs; tylus moderately stout, feebly narrowed anteriorly, with dorsal surface on a higher level than that of juga; juga scarcely exceeding tylus, each jugum with one or two, long, stiff, setalike hairs projecting anteriorly from its apex (sometimes hairs are rubbed off); median longitudinal part of head narrower than each lateral shelf, smooth, with a moderately large rounded elevation on median line between bases of lateral shelves; neck short, with a small tubercle on each side; eyes small, reddish, pedicellate, with short stalk slightly tilted upward; antenniferous tubercles short, stout, rounded apically. Labial sulcus very wide, short, shallow, not reaching to neck; labium brownish, not reaching to end of sulcus. Antennae long, reaching beyond pronotum; segment I very long, extending three-fourths of its length beyond apices of juga, rather densely clothed with stiff, setalike, whitish hairs which are as long as width of segment at their respective points or origin; other segments with shorter hairs; measurements—I, 74; II, 26; III, 34; IV, 30.

Pro-, meso-, and metanotum and abdominal tergites I and II fused together; median longitudinal ridge large and smooth, without transverse sutures, tapering a little anteriorly, extending from base of tergite II anteriorly to collar, with the thoracic divisions on each side of median ridge indicated by transverse furrows. Abdominal tergites III to VI (inclusive) conjointly fused, with a large, median longitudinal ridge, the sculptured areas on each side of ridge rather shallow; connexival segments (except I and II fused) separated from one another and from abdominal tergites by sutures. Body beneath with the three sternal divisions and first three abdominal segments conjointly fused, the other ventrites separated from one another by sutures. Ostiolar channel not extending upward to dorsal surface, thus not visible from above. Lateral margins of body with several small tufts of short, setalike, whitish hairs. Legs fairly long, slender, sparsely clothed with short, coarse, whitish hairs.

Spiracles placed up on top of small elevations, the elevations slightly higher in male than in female; spiracles II, III and IV ventral, not visible from dorsal aspect; V sublateral (ventral) and VI, VII and VIII (genital segment) lateral and all visible from above.

Length, 3.90–4.40 mm; width, 1.74–2.10 mm.

Holotype (male) and *allotype* (female), Barro Colorado, Canal Zone, Panama, 1948, take by means of Berlese funnel from forest litter, by James Zetek, in U. S. National Museum. *Paratypes:* 5 specimens, same labels as type. Named in honor of Mr. Zetek, who has collected so many rare and interesting insects in Panama.

The new subgenus *Peggicoris* differs from *Asterocoris*, s. str., by the lack of long lateral lobes on body, position of spiracles, short juga, fusion of thoracic divisions and location of ostiolar channel.

Aglaocoris cubanus, n. sp.

Small, oblong (male) or obovate (female), without lateral lobes, depressed above, finely shallowly sculptured. Head subtriangular, width across eyes and median length subequal (82:85); tylus moderately wide, rugose, with dorsal surface on a higher level than that of juga; juga thin, feebly surpassing tylus; lateral shelves nearly as wide as and with dorsal surface on same level as that of median longitudinal part of head; eyes small, pedicellate, with short stalk nearly horizontal; antenniferous tubercles moderately large, tapering anteriorly, with apices blunt; neck short, constricted, with a small tubercle on each side of outer edge of dorsal surface. Labial sulcus short, very wide, moderately deep, not extending to neck; labium scarcely attaining apex of sulcus. Antennae granulate, longer than head, with segment I extending three-fourths of its length beyond apices of juga, measurements—I, 40; II, 26; III, 30; IV, 24.

Pronotum strongly narrowed anteriorly, wider in front than width across eyes, deeply widely triangularly excavated in front for reception of large collar, with front margin beyond collar extending anteriorly as far as anterior margin of collar, with a small tubercle (one on each side) on antero-inner margin of front projection extending inward to collar; collar large, smooth, with a deep, median, encircling sulcus; mesonotum wider than and practically same length as pronotum, separated by furrows from both pro- and metanotum. Three thoracic divisions and abdominal tergites I and II bused together, with a very low, wide, median ridge extending from basal part of pronotum to apex of tergite II, with dorsal surface pretty much covered with many small, longitudinal ridges. Abdomen with tergites III to VI (inclusive) fused, shallowly sculptured, with a small discal elevation on low median ridge; connexival segments (save I and II fused) sutured from one another and also from tergites. Spiracles II, III and IV ventral, not visible from above; V subventral, scarcely visible from above; VI, VII and VIII (genital segment) all lateral and plainly visible from dorsal aspect. VII ventrite (male) with a small, rounded, bottle-shaped projection (one on each side; directed downward), with constricted neck.

Length, 4.75 mm (male) and 5.50 mm (female); width 2.20 mm (male) and 2.75 mm (female).

Holotype (male) and *allotype* (female), Cayamas, Cuba, in Drake Collection.

Distinguished from its congeners by shape of body, deeply broadly excised anterior margin of pronotum for reception of collar and by shape of male protuberances on underside of abdominal ventrite VII.

"PINE CONE" FISHES

There are fishes in the sea that when alive look like swimming pine cones. When dead and dried they actually could be mistaken at first sight for pine cones. They belong to quite a distinctive genus, *Monocentris*, which has an isolated niche in ocean life. They do not seem related to anything else.

A unique specimen taken off the Robinson Crusoe island, Juan Fernández, off the coast of Chile, by Dr. Edwyn P. Reed, chief of the biological service of the Chilean Fish and Game Department, has just been identified at the U. S. National Museum, Smithsonian Institution, by Dr. Leonard P. Schultz, curator of fishes, who has described it as a hitherto unknown species, the first of the entire family known in the American Pacific.

The "pine cones" are small fishes, the largest slightly more than 3 inches long. They are rare anywhere. The habitat with which they were associated was the tropical western and central Pacific until they were found at considerable depths in the eastern Pacific. One genus "carries lanterns," that is, luminous organs, on each side of the mouth, as do many other oceanic fishes.

HERPETOLOGY.—Hyla cinerea *in Maryland, Delaware, and Virginia, with notes on the taxonomic status of* Hyla cinerea evittata.[1] CLYDE F. REED, Baltimore, Md. (Communicated by Doris M. Cochran.)

(Received August 13, 1956)

The latest checklist of North American amphibians and reptiles, by Karl P. Schmidt (pp. 69–70, 1953), is quite inaccurate in its distribution of *Hyla cinerea* (Schneider). It states that *Hyla cinerea cinerea* ranges in the "lowlands of the Atlantic and Gulf States from Virginia to Texas; north in the Mississippi Basin to southern Illinois." The range for *Hyla cinerea evittata* Miller is given as "The Delmarva Peninsula, eastern Maryland and adjacent Virginia." From these two statements one would conclude that *evittata* was a distinct northern subspecies with geographic limitations. Schmidt has indicated such to be the case by calling *evittata* the northern green tree frog.

The purpose of this paper is to show that the taxon *evittata* should be reduced to the synonymy of *Hyla cinerea* (Schneider), since none of the characters upon which *evittata* was originally based hold up as distinguishing it as a biological entity from other populations of *Hyla cinerea*.

The problem developed from the instigation of the new taxon *Hyla evittata* by G. S. Miller, who separated *evittata* from *cinerea* on the basis of the absence of the lateral bright stripe in the former, as the name *evittata* implies, together with the characters a broader head and a higher snout.

Hyla evittata Miller, Proc. Biol. Soc. Washington **13:** 76. Sept. 28, 1899. Type adult male (in alcohol) U. S. Nat. Mus., Washington no. 26, 291, collected at "Four Mile Run, Alexandria County, Virginia," July 15, 1898, by Gerrit S. Miller, Jr., and Edward A. Preble.

There are several matters concerning the type that are misleading. First, the type label reads "Four Mile Run, D. C." The type specimen is accessioned as "Four Mile Run, Virginia." Four Mile Run is near the city of Alexandria, but I have been unable to find an Alexandria County, even in 1899. There was an Arlington County, in which Alexandria was a city. At the present Alexandria is an independent city (no county).

Second, the date on the type specimen is July 15, 1899, not July 15, 1898, as quoted in Miller's original publication, and by Wright and Wright (*Handbook of frogs and toads*, p. 310), which is a quotation of the original description. The type specimen is also accessioned as being collected July 15, 1899.

Third, the pagination for the description of the type of *Hyla evittata* is page 76, not page 75 as cited in Schmidt's checklist (p. 70), who gives the location of Four Mile Run as Fairfax County, Va. There is nothing to indicate the name of the new species on page 75. Besides, the description is really on page 76.

Fourth, the date of publication is September 28, 1899, not August 1899, as indicated on the type label.

Fifth, concerning the paratypes, at least those specimens designated as paratypes: There are four specimens in the U.S. National Museum which are designated as paratypes, collected at Four Mile Run, Va., July 15, 1898. U.S.N.M. nos. 66207, 66209, and 66210 have no stripes, while no. 66208 has a long stripe. These four specimens are referred to only by inference in the original article by Miller, and the museum numbers are not cited. However, Miller probably did have these specimens before him while describing the new species, and in the broadest sense of the term could be considered paratypes. However, from the measurements given below he did not include theirs with that of the type. When their measurements are included, the range is well within that of typical *Hyla cinerea*.

Three other specimens are also designated as paratypes, collected at Four Mile Run, Va., July 4, 1901. Since these could not have been seen at the time the new species was described (1899), they are topotypes and not paratypes, U.S.N.M. nos. 29652–29654. Two of these have no stripes, while the third has a white upper lip back to the axial of the jaw.

Sixth, Miller states concerning the general characteristics, "Like *Hyla cinerea* (Daudin), but with broader, deeper muzzle and normally un-

[1] Contribution to the Herpetology of Maryland and Delmarva, no. 4.

striped body and legs." *Hyla cinerea* was originally described by Schneider, Hist. Amph. **1:** 174. 1799, as *Calamita cinereus.* Daudin described *Hyla lateralis,* in Sonnini and Latreille, Hist. Nat. Rep. **2:** 180. 1802, from Charleston, S. C. This is considered a synonym of *Hyla cinerea* (Schneider).

Because of the confusion and uncertainity which accrues when these criteria are used in identifying specimens from Maryland, Delaware, and the main estuaries of the Chesapeake Bay, as the Potomac, Patuxent, Gunpowder (including Bird River and Dundee Creek), Elk, Sassafras, Choptank, Nanticoke, Pocomoke, York, and James Rivers, reviews of these criteria were made by Noble and Hassler (Copeia 1936(1): 63) for southern Maryland species and by Dunn (Proc. Biol. Soc. Washington **50:** 9–10. 1937) upon the stratus of *H. evittata,* based on 126 specimens from Virginia and Maryland.

In describing *Hyla evittata,* Miller (1899) had noted that the lateral strips may be reduced in length in some specimens of *Hyla cinerea.* This phenomenon was considered a rare variation by him. However, the short stripe occurs in nearly all the populations in our region, a situation which has lead to the belief that we are dealing with intermediates or hybrids. These concepts will be discussed later. There is a tendency for the more northern populations of *H. cinerea* to have some individuals with shorter or even no stripes. According to Miller it was head shape and not the body stripe which distinguished *evittata* from the typical form.

Noble and Hassler (Copeia 1936(1): 63) studied a population of *Hyla cinerea* (32 specimens from Cove Point, Calvert County, Md.) in which some lacked the light stripes along the sides of the body; some had only a tinge of white on the posterior part of the upper jaw; some had stripes which extended beyond the tympanum and faded out on the sides of the body. Specimens from Wilmington, North Carolina, reported by Myers (Copeia 1924, no. **131:** 60) and restudied in the American Museum by Noble and Hassler showed a similar situation (14 adults studied—2 without stripes, 4 with partial stripes, 8 with full stripes).

Seven statements in the original description of *Hyla evittata* lead one to think that Miller was not too sure that his was a new species. For example, "*Hyla evittata* is at once distinguishable from *H. cinerea* by the absence of the stripes on sides and legs, so conspicuous in the latter". Yet he cites specimens from Mississippi and Louisiana that have no stripes. "Except for the difference in the shape of the head, the two animals (the type and *H. cinerea* from Bay St. Louis, Mississippi) agree perfectly in form and dimensions." Dunn has discounted the value of the head measurements in separating two populations as subspecies. "*Hyla evittata* probably averages slightly larger than *H. cinerea.*" All that are mentioned in the paper are the measurements of the type and the *H. cinerea* specimen from Mississippi. Head and body lengths are the same—48 mm; hind leg—69 and 68; femur same—20; tibia same—21; tarsus same—11; hind foot—17 and 15; humerus—8 and 9; forearm—8 and 9; front foot same—10; greatest width of head—14 and 13. Concerning the eye to nostral measurements the type is 3.5 and *H. cinerea* 4; and the distance between the nostrils is 3.5 and 2.5. These figures would indicate the distance from the eye to the nostril was shorter in *H. evittata* than in *H. cinerea,* and that the distance between the nostrils was wider. However, if we include the same measurements of the seven specimens designated as the "paratypes" of *H. evittata,* we get a different ratio.

	Eye to nostril	Nostril to nostril
U.S.N.M. no. 66207	4.5	4.0
66208	4.0	3.0
66209	4.0	3.5
66210	4.0	3.5
29652	4.0	3.0
29653	4.0	3.5
29654	4.0	4.0

These figures indicate that the eye to nostril distance is 4.0 mm, which is the same as that for the *Hyla cinerea* compared with the type by Miller. The nostril-to-nostril measurement averages 3.5 mm. However, the nostril-to-nostril measurements on 20 specimens collected by Reed or Daffin in Maryland, Virginia, and Delaware average 3.5 mm also. So this variation is within the normal deviation of a population within the species.

"The granulation of the skin of belly and hind legs is identical in the two animals."

Noble and Hassler, as well as Dunn, concluded from their studies that *evittata* and *cinerea* could not be separated by the head width or slope to the snout. The former say that the series of *evittata* in the American Museum differ from the Cove Point specimens of *cinerea* in having a more vertical, less sloping profile to the snout. Concerning the width of the head, which is said to be broader in *evittata*, they state that their series of *cinerea* exhibited a great variation in width and no constant difference could be found. Dunn agreed with this conclusion and added that the type and topotypes of *H. evittata* could not be separated from Carolina *cinerea* with any degree of certainty. Dunn also noted that in many species of Hylidae the male has a sloping snout and the female a blunt one: this may be the case in *cinerea* and *evittata*. So far as is known to the present author, no one has sexed the museum specimens of *evittata* and *cinerea* now available for study, nor has anyone determined whether the sexes are morphologically dimorphic.

Having discounted the characteristics of the head as distinguishing *evittata* from *cinerea*. Dunn rested the status of *evittata* upon the lateral stripes. From his study of 126 specimens from Virginia and Maryland he reported 81 percent of the upper tidewater Potomac populations with no stripes or short ones; 41 percent of the other Maryland and Virginia specimens with no stripes or short ones; 25 per cent of the North Carolina specimens with no stripes or short ones; and all the Gulf coast specimens with long stripes. This population study would indicate that northern colonies have a tendency to decrease the length of the lateral stripes to the point of obliteration. That this factor alone constitutes the basis of a new species or even a new subspecies is not substantiated by the study of the specimens at hand.

Miller stated that unstriped specimens from Bay St. Louis, Miss., and from New Orleans, La., had been seen by him. Thus, all (as stated by Dunn) of the Gulf coast populations do not have long stripes. Also, specimens with no stripes have been reported from North Carolina (stated above, 25 per cent) and from Maryland and Virginia other than from the type locality of *H. evittata*. Thus, throughout most of the range of *Hyla cinerea* specimens with no stripes or with partial stripes have been found, with a tendency for those populations northward to exhibit a greater percentage of the population to have shortened or obliterated stripes.

Contradictory to Schmidt's distribution, Dunn concluded from his study of *evittata* and *cinerea* that "*H. cinerea evittata* is unknown from Delaware and from the eastern side of the Delmarva Peninsula." Dunn's *evittata* had no stripes, and on this basis his statement is likewise untenable in the light of collections by the author and Ralph Daffin. Daffin has collected *H. cinerea* with long and short stripes (in a proportion of 50–50) at Ocean Downs just west of Ocean City, which is very near the Atlantic Ocean on the eastern side of the Delmarva Peninsula, and the author has collected specimens with no stripes in Accomac County, Va., on the eastern side of the Delmarva Peninsula also. Selbyville, Sussex County, Del., is near the eastern coast.

Because of the occasional short stripe and long stripe in the same population, Conant (Publ. Soc., Nat. Hist. Delaware 1945: 4) concluded that the populations of *Hyla cinerea* inhabiting the Delmarva Peninsula were intermediate between the two subspecies. Some herpetologists have gone so far as to assume that there are two subspecies or species in our region and to call these populations hybrids, designating them as *Hyla cinerea cinerea* × *evittata*. Such conclusions have been based upon phenotypic characteristics and to the best of my knowledge have not been substantiated by experimentation nor even observation.

Beside the specimens in the United States National Museum which were carefully studied, including the type and topotypes of *Hyla evittata*, the author has collected and studied specimens from several new localities in Maryland, Delaware, and Virginia. The type locality for *H. evittata*, Four Mile Run, in Fairfax County, Va., was visited by the author on July 17, 1956. None of the frogs were heard calling at that time.

The material collected or studied by the author from Worcester and Wicomico Counties, Md., and from Accomac County, Va., indicates that all three striped types may be found in pure or mixed populations on the Delmarva Peninsula. The specimens from the Accomac County locality have no stripes; those from Ocean Downs have about 50–50 short and long stripes; and those from the Nanticoke River at Vienna (Wicomico-Dorchester County) have long stripes.

Representative specimens from localities in Maryland, Delaware, and the vicinity of the District of Columbia, including the type locality of *H. evittata* in Virginia, have been studied and are listed below. The most northern locality on the Delmarva Peninsula for *Hyla cinerea* is the Chesapeake and Delaware Canal which connects the Delaware River with the Elk River, which in turn leads to the Cheaspeake Bay. West of the Chesapeake Bay the most northern locality is in Baltimore County along the Chesapeake Bay along two estuaries of the Gunpowder River, Dundee Creek and Bird River, just north and east of Chase (Daffin 506–507 and Reed 1191).

Maryland: *St. Marys County*: Hay's Beach near Ridge (Cooper, l.c., 1953); *Charles County*: Nanjemoy Swamp near Riverside, July 1935, Reed. *Calvert County*: Abundant between Cove Point and Solomons Island (Noble and Hassler, l.c., 1936, 32 specimens typical *cinerea*, Amer. Mus.); Cove Point (Putens, Bull. Nat. Hist. Maryland **6**(9): 57. 1936). *Anne Arundel County*: Ritchie Highway between Magothy and Severn Rivers, July 1956, Robert Simmons. *Baltimore County*: Dundee Creek and Bird River, near Chase along Grace's Quarters Road, June 25–26, 1956, Ralph Daffin 506–507, Reed 1191, Donald Lindsey 1–4. *Cecil County*: West end of Chesapeake-Delaware Canal, M. Joseph Cadbury (see Dunn, Proc. Biol. Soc. Washington **50:** 10. 1937). *Cecil-Kent County*: Georgetown, on Sassafras River, July 20, 1915, Paul Lorrilliere (as *H. evittata*) (see Fowler, Copeia 1915, no. **22:** 38) (note: Georgetown is in Kent County, which lies to the south of the Sassafras River, but the record states the specimen is from Cecil County). *Queen Annes County*: Near Centerville, June 23, 1938, R. H. McCauley (U.S.N.M. nos. 104446–50), and July 15, 1938, R. H. McCauley (U.S.N.M. nos. 104457). *Talbot County*: Easton, H. L. Clark, September 8, 1903 (U.S.N.M. no. 32106). *Dorchester County*: Cambridge, June 1928 (U.S.N.M. nos. 75287–8); Lloyds, W. P. Hay, June 1906 (U.S.N.M. nos. 36673–82), July 9, 1906 (U.S.N.M. nos. 100840–6), July 1907 (U.S.N.M. nos. 37833–7); Cambridge, September 1933, R. W. Jackson (U.S.N.M. no. 92598); Blackwater Refuge, 10 miles south of Cambridge. July 25, 1938, R. H. McCauley (U.S.N.M. nos. 104463–77). *Dorchester-Wicomico County*: Along Nanticoke River on both sides of the river, several large colonies, July 9, 1956, Reed 1150–51. *Worcester County*: Cedar Hall, June 27, 1938, R. H. McCauley (U.S.N.M. nos. 104451–6); pond 5 miles west of Ocean City at Ocean Downs, June 15, 1956, Ralph Daffin 458 and 545–554; swamp south of Pocomoke City, July 9, 1956, Reed; meadow, Girdletree, July 10, 1956, Reed.

Virginia–Eastern Shore: *Accomac County*: 2 miles south of Oak Hall, July 9, 1956, Reed 1107. *Accomac-Northampton County*: Exmore, June 1938, M. K. Brady (USNM nos. 75277–86).

Virginia—along Potomac River: *Fairfax County*: Four Mile Run (type locality for *Hyla evittata*), July 15, 1899 (not 1898, as stated by Wright and Wright in *Handbook of frogs and toads*, p. 310. Also there is no Alexandria County in Virginia), Gerrit S. Miller, Jr., and Edward A. Preble (U.S.N.M. no. 26291); paratypes, same locality, July 15, 1898 (U.S.N.M. nos. 66207–10), E. A. Preble, July 1898 (U.S.N.M. no. 45967); G. S. Miller, July 4, 1901 (U.S.N.M. nos. 29652–54); P. Bartsch, 1935 (U.S.N.M. no. 101170); Dyke, below Alexandria, September 17, 1898, G. S. Miller. (U.S.N.M. no. 66211); Alexandria, July 3, 1912, J. Hunter (U.S.N.M. nos. 58085–6); New Alexandria, E. T. Wherry, September 1923 (U.S.N.M. no. 66327); Dogue Creek, near Fort Belvoir, June 4, 1939, H. J. Cole (U.S.N.M. nos. 127467–85); Little Hunting Creek, May 28, 1911, W. D. Appel (U.S.N.M. nos. 55443–4); 1923, M. K. Brady (U.S.N.M. nos 66474–75); Mount Vernon, W. P. Hay, October 15, 1892 (U.S.N.M. nos. 39911–12); June 1893 (U.S.N.M. nos. 20891–33); E. A. Preble, October 28, 1900 (U.S.N.M. nos. 27742). *Prince William County*: Quantico, October 13, 1901, G. S. Miller (U.S.N.M. nos. 29620–21).

District of Columbia: Washington, July 1, 1933, I. E. Gray (U.S.N.M. no. 91745, as *cinerea*); Oxon Run Marsh, August 1935, Perrygo & East (U.S.N.M. nos. 101159–69, as *evittata*); Oxon Run, July 13, 1936, C. S. East (U.S.N.M. nos. 107690–9, as *evittata*); August 1935 (U.S.N.M. nos. 101434; 101159–69) (Oxon Run borders Prince Georges County to the south side of the District of Columbia).

Delaware: *Sussex County*: Meadow near Selbyville, July 10–11, 1956, Reed.

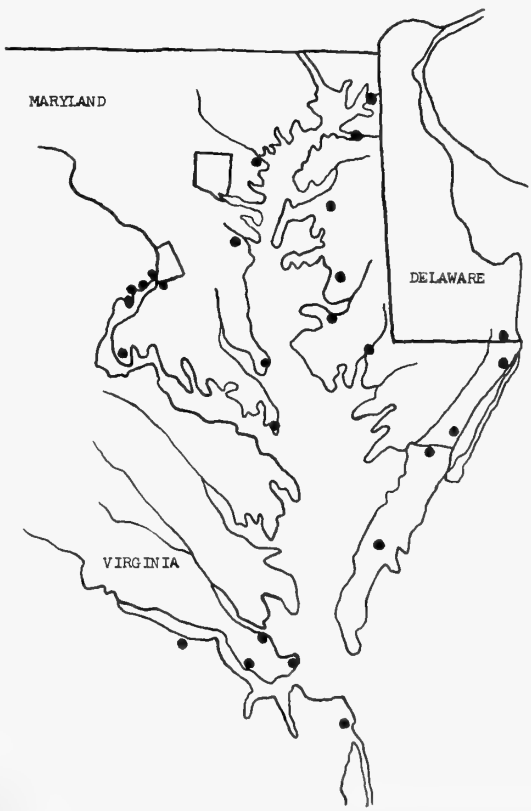


Fig. 1.—Distribution of *Hyla cinerea* (Schneider) in Maryland, Delaware, and Virginia.

For the Delmarva Peninsula, Roger Conant (Publ. Soc. Nat. Hist. Delaware 1945: 4) listed Cecil, Dorchester, Kent (Md.), Northampton, Sussex, Talbot, and Worcester Counties, without giving any specific records.

Hyla cinerea (Schneider), Garman, Bull. Illinois State Lab. Nat. Hist. **3:** 189. 1891, based on *Calamita cinereus* Schneider, *Hist. Amph.* **1:** 174. 1799. Syn.: *Hyla cinerea cinerea* Stejneger and Barbour, Checklist, ed. 2: 30. 1923; *Hyla bilineata* Shaw, Gen. Zool. 3: 136. 1802; *Hyla lateralis* Daudin, in Sonnini and Latreille, Hist. Nat. Rept. **2:** 180. 1802; *Hyla semifasciata* Hallowell, Proc. Acad. Nat. Sci. Philadelphia **8:** 307. 1856; *Hyla evittata* Miller, Proc. Biol. Soc. Washington **13:** 76. 1899; *Hyla cinerea evittata* Stejneger & Barbour, Checklist, ed. 2: 30. 1923.

Range: Delaware (Sussex County) and Maryland (Baltimore County & Cecil County) southward along the Potomac River and south to Florida, westward in the Gulf States to Texas; and north in the Mississippi Basin to southern Illinois.

Concerning the range of *Hyla cinerea* in Virginia, there seems to be a gap on the peninsula between the Potomac River and the Rappahannock River (Northern Neck) and the peninsula between the Rappahannock River and the York River. However, at the mouth of the York River, southward around on the James River and up to Surry County, Va., *Hyla cinerea* and specimens designated as *H. cinerea* × *evittata* have been collected. Also, across the mouth of the Chesapeake Bay in Princess Anne County, *Hyla cinerea* and the putative hybrids have been collected.

The author has collected four years on Northern Neck and has been unable to find *Hyla cinerea*. Several plants and animals are found on the southern side of the Potomac River but not on the northern side; as *Eumeces inexpectatus*, and the plants *Galax aphylla*, *Asarum virginicum*, and *Oxydendrum arboreum*. Several plants are known which range from the York–James Peninsula and Princess Anne County region to the eastern shore of Virginia, most notable being *Trillium pusillum* var. *virginianum*, *Xanthoxylum clava-herculis*, and *Baptisia alba*. *Hyla cinerea* also seems to follow this pattern of distribution, with the exception that it has migrated further northward and westward. Cypress went up the inner side of the Delmarva Peninsula into Pungoteague and up the Pocomoke River, as well as up the western shore of the Chesapeake Bay, especially up the Patuxent River. Specimens of *Hyla cinerea* from the two remaining peninsulas of Virginia are highly desirable to complete our picture for the distribution of *Hyla cinerea* in the Maryland–Virginia–Delware region.

The specimens studied from the lower Chesapeake Bay region of Virginia are listed below.

VIRGINIA: *York County*: Yorktown, June 22, 1948, R. L. Hoffman (U.S.N.M. nos. 131634–6), near mouth of York River. *Elizabeth City County*: Hampton, May 1903, G. S. Miller (U.S.N.M. nos. 31662–5); same, but grouped as *H. cinerea* X *evittata*, May 1903, G. S. Miller (U.S.N.M. nos. 31659–61). *Warwick County*: Menchville, August 2, 1949, R. L. Hoffman (U.S.N.M. nos. 131940–2). *Surry County*: A. H. Jennings, May 1917 (U.S.N.M. no. 59879), as *H. cinerea* X *evittata*. *Princess Anne County*: Virginia Beach, July 13, 1928, H. E. Ewing & C. S. East (U.S.N.M. nos. 75377–81); Sand Bridge, August 6, 1946, Hoffman & Kleinpeter (U.S.N.M. no. 133696); between Pungo and Sigma, August 1, 1946, Hoffman & Kleinpeter (U.S.N.M. no. 124860), as *H. cinerea* X *evittata*.

In conclusion, it is fairly well established that there exists no definite set of factors which would distinguish two distinct species or subspecies of *Hyla cinerea*. Therefore, taxonomically all specimens heretofore designated as *Hyla cinerea evittata* or *Hyla evittata* should be designated as *Hyla cinerea*.

The substitution of analogy for fact is the bane of chemical philosophy; the legitimate use of analogy is to connect facts together and to guide to new experiments.—H. DAVY

ZOOLOGY.—*Ostracoda from bromeliads in Jamaica and Florida.* Willis L. Tressler,[1] U. S. Navy Hydrographic Office.

The presence of a distinct fauna existing in the water entrapped in the leaf cups of bromeliads has been known for many years. Müller (1880) first reported upon this unique fauna from observations made in southern Brazil. An elaborate study of the bromeliad leaf-cup fauna was later made by Picado (1913), and since then reports have been made on the fauna of isolated regions. The present author (Tressler, 1941) summarized the findings of previous writers and reported on two ostracods which were found in leaf cups of bromeliads from Puerto Rico. Of these, one was a species of the little-known genus *Metacypris*, which was described as a new species (*Metacypris maracaoensis*); the other, *Candonopsis kingsleyii*, while known from several areas, was reported for the first time from bromeliads. Other ostracods previously reported from bromeliads include *Metacypris bromeliarum* (Müller, 1881) and two species imperfectly described by Picado (1913) from Costa Rica. The present paper adds two more species of Ostracoda to the bromeliad fauna and reports on new locations for two species already described from this habitat; *Candonopsis anisitsi* described from Paraguay by Daday (1905), previously has not been known from bromeliads, while a new species of Metacypris, *M. laesslei* is described for the first time. New locations are given for *Metacypris bromeliarum* and *M. maracaoensis*.

The present report is based upon an extensive collection made from bromeliad leaf cups by Dr. Albert M. Laessle of the Department of Biology, University of Florida, during the summer of 1952. Careful samplings were made of the outer and inner leaf cups of the same plant and from different plants in a number of widely separated areas on the island of Jamaica and from three areas in southern Florida. Nearly 100 samples were found to contain ostracods. In many instances a chemical analysis was made of the entrapped water.

The slides of the dissected specimens have been deposited in the U. S. National Museum as type specimens.

DISTRIBUTION AND ECOLOGY

Collections on the island of Jamaica were made from coastal areas of little or no elevation and from five regions located in the main central mountain chain extending east and west along the axis of the island. Here, elevations of 2,000 feet to 4,500 feet are found. Coastal areas include, from east to west, Ecclestown (800 feet) and Portland Parish (less than 1,000 feet), at the southern tip of the island; Union Hill (500 feet) in the north central portion; Hermitage Dam (1,500 feet) just north of Kingston; Lucca (slight elevation) and Negril (slight elevation) at the extreme western tip of the island. The mountainous areas, from east to west include Hardware Gap (4,500 feet), other areas in the Blue Mountains (elevations from 3,200 to 4,000 feet); Juan de Bolas (2,500 feet); Christiana (3,000 feet); and Mocho (2,000 feet).

The distribution of ostracod species identified appears to be irregular and conforms to no pattern of altitude or nature of the soil. Ecclestown, Union Hill, Christiana, Mocho, Lucca, and Negril are in limestone regions, while the others, namely, Portland Parish, the Blue Mountains, Hermitage Dam, and Juan de Bolas are in noncalcareous areas. The single new species described, *Metacypris laesslei*, appears to be restricted to elevations of 2,000 feet and over, being found only at Mocho, Christiana, Hardware Gap, and in St. Andrews Parish at Silver Hill Gap in the Blue Mountains.

A detailed report on the analysis of water samples taken from leaf cup reservoirs will be given in a final report on these collections by Dr. Laessle. It is sufficient for the purpose of the present taxonomic report to state that the ostracods were collected from water samples displaying a wide range of environmental conditions. Dissolved oxygen readings ranged from practically zero to 8 p.p.m.; carbon dioxide varied from 5 p.p.m. to 40 p.p.m., while pH readings ranged from pH 4.0 to 7.0 and averaged pH 5.0. Most

[1] The opinions expressed in this report are the author's own and do not reflect those of the Hydrographic Office or the U. S. Navy.

species of ostracods are very tolerant of wide fluctuations in environmental factors and will exist under conditions of oxygen depletion, pollution, and other unfavorable environmental conditions after other forms have perished. Some species are known to creep along the under surface of the surface film, apparently to secure oxygen. It is not surprising therefore that such a wide range of environmental factors was found throughout the collection of water samples and that ostracods were almost universally present in the collections.

Suborder Podocopa

Family Cypridae: Subfamily Cyprinae

Genus **Candonopsis** Vavra, 1891

Thin shelled forms, laterally compressed. Anterior antennae slender; posterior antennae, with penultimate segment subdivided, poorly developed natatory setae. Terminal segment of mandibular palp greatly produced. Maxillipeds with vibratory plate bearing three, thick, plumose setae; palp in male transformed into a prehensile organ for copulation. Dorsal margin of furca without setae. This genus contains only six species, all but one of which have been reported only from the Southern Hemisphere.

Candonopsis anisitsi Daday

Fig. 6

Candonopsis anisitsi Daday, Zool. **44:** 256, pl. 16, figs. 16–19, 20–26. 1905.

Specific characters.—Female: From the side elongated, height equal to about half the length; highest about three-fourths of the length from the anterior end. Dorsal margin gently rounded and sloping anteriorly; ventral margin indented. Anterior extremity somewhat less broadly rounded than posterior. From above, narrowly compressed. Terminal setae of third thoracic leg of equal length. Furca sixteen times longer than narrowest width; terminal and dorsal setae absent. Length 0.97–1.08 mm, height 0.48–0.53 mm. Color of preserved specimen, light.

Male: Similar to female in shape and structure of appendages. Height of shell somewhat greater in relation to length than female. Length 1.00–1.20 mm.

Remarks.—This species may easily be taken for *C. kingsleyi* on superficial examination but may be distinguished by the equal length of the terminal setae of the third thoracic leg.

Occurrence.—Males and females were found in all but four of the eleven widely separated areas which were sampled on the island of Jamaica. These areas were as follows: Portland Parish at an altitude of less than 1,000 feet, largely noncalcareous region on July 18 to July 24, 1952; the Wagwater River, just above Hermitage Dam, St. Andrews, at an elevation of 1,500 feet, noncalcareous region on July 31, 1952; Juan de Bolas, elevation 2,500 feet, noncalcareous region on August 1 to 7, 1952; near Christiana in Manchester Parish, elevations 3,000 feet, limestone region, on August 9 to 11 and August 27 to 29, 1952, and September 3, 1952; near Lucca, in the northwest portion of the island, in Westmoorland Parish, at a slight elevation, calcareous region, on September 1, 1952, near Mocho in the west central portion of the island, limestone region, elevation 2,000 feet, on August 15 and 18, 1952; and at the base of the John Crow Mountains near Eccelstown in the northwest corner of the island at 800 feet elevation, a calcareous region, on September 8, 1952. The species is evidently widely distributed over most of the island. It was not found at the higher elevations in the Blue Mountains nor in the north central portion.

Distribution.—The species was previously known only from Paraguay, where they were collected from pools formed by inundations of rivers.

Family Cytheridae

Genus **Metacypris** Brady and Robertson, 1870

Shells very broad and short; seen from the dorsal view, width about three-fourths the length. First antennae with five or six segments; second antennae 4-segmented; exopodite jointed. Mandibles with obscurely segmented palp. Maxilla with three masticatory processes and a short palp; branchial plate without aberrant or orally directed setae. Furca of female with three setae.

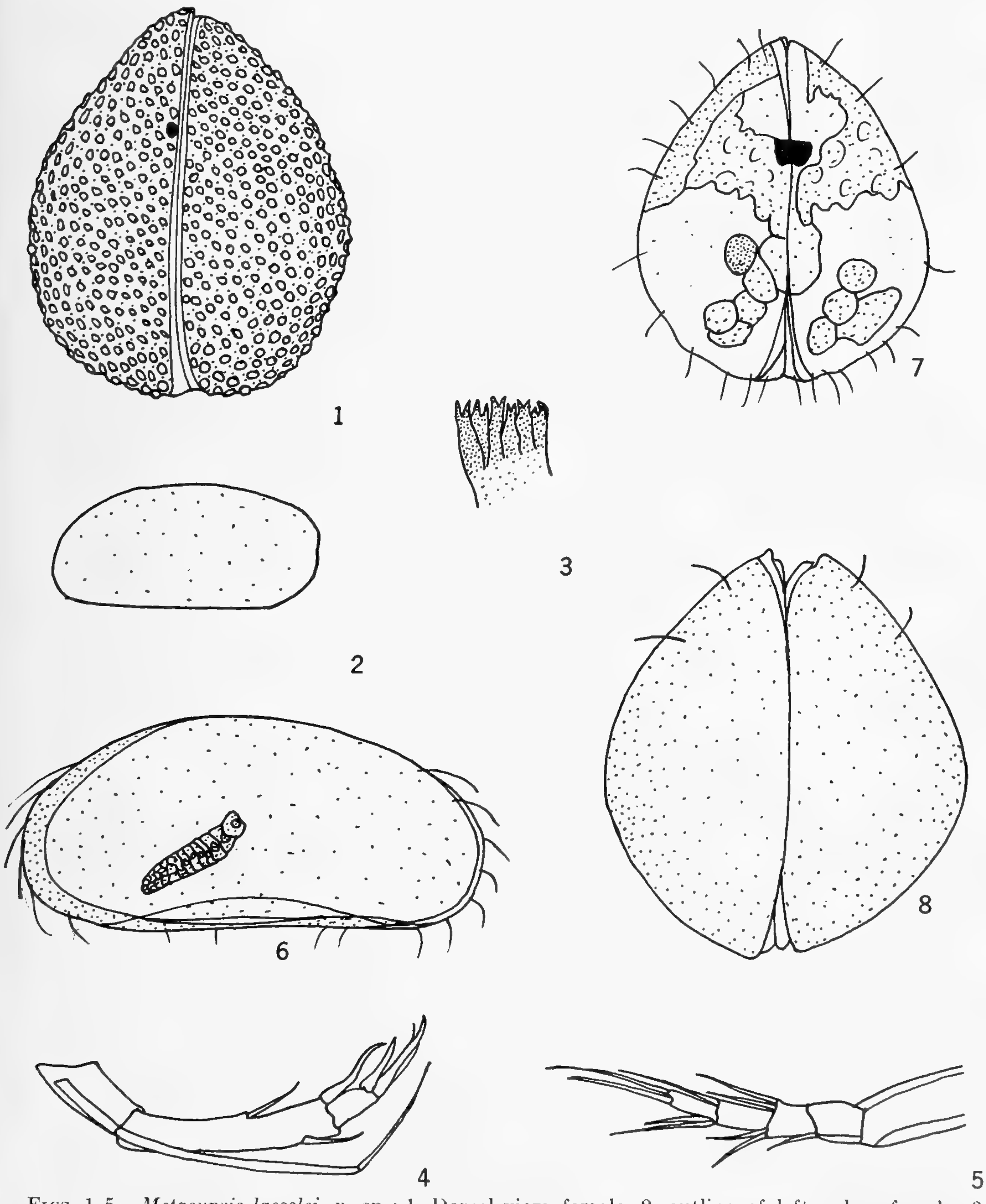
Metacypris bromeliarum (F. Müller)

Fig. 8

Elpidium bromeliarum F. Müller, Arch. Mus. Nac. Rio de Janeiro **4:** 27. 1881.
Metacypris bromeliarum G. W. Müller, Das Tierreich **31,** Ostracoda: 316. 1912.

Specific characters.—Female: Seen from the side, ovoid, height five-eighths length, highest in middle; anterior extremity considerably less broadly rounded than posterior; dorsal margin arched, sloping steeply to anterior end; ventral margin almost straight. Seen from above, very tumid, width four-fifths length; anterior end slightly more pointed than posterior. Surface of valves smooth with no pits and few hairs. Color brown. First antenna with five segments; dorsal border of first segment terminates in a thickly haired wart; spine on second segment reaches to middle of fourth segment. Second antenna with exopodite reaching to tips of terminal claws. Mandibular teeth, seven, not split. Length 0.84 mm, height 0.52 mm, width 0.74 mm.

Male: Unknown.



Figs. 1–5.—*Metacypris laesslei*, n. sp.: 1, Dorsal view, female; 2, outline of left valve, female; 3, mandibular teeth, female; 4, second antenna, female; 5, first antenna, female. Fig. 6.—*Candonopsis anisitsi* Daday. Fig. 7.—*Metacypris maracaoensis* Tressler. Fig. 8.—*Metacypris bromeliarum* (F. Müller).

Occurrence.—Females were widely distributed over the island being found in all but two of the eleven areas sampled. These locations were as follows: Portland Parish at an elevation of less than 1,000 feet, a largely noncalcareous region on July 18 to 24, 1952; Wagwater River, just above Hermitage Dam, St. Andrews, elevation 1,500 feet, noncalcareous region on August 1 to 7, 1952; near Christiana in Manchester Parish, elevation 3,000 feet, limestone region on August 9 to 11, 1952, and August 27 to 29, 1952; near Lucca in the northwest portion of the island in Westmoorland Parish, at a slight elevation, calcareous region, on September 1, 1952; near Nigril in the extreme western portion of the island at a slight elevation, calcareous region on September 2, 1952; and at the base of the John Crow Mountains near Ecclestown in the northeast corner of the island, elevation 800 feet, calcareous region on September 8, 1952.

Distribution.—This species has previously been reported only from leaf cups of bromeliads in southern Brazil.

Metacypris maracaoensis Tressler

Fig. 7

Metacypris maracaoensis Tressler, Journ. Washington Acad. Sci. **31** (6): 268. 1941.

Specific characters.—*Female:* Seen from the side, oval in shape with greatest height about one-half the length and highest in the middle. Dorsal margin arched; ventral margin straight. Posterior extremity more broadly rounded than anterior. From above, very broadly rounded posterior extremity and pointed anterior end. Large eyes, fused. Surface of valves smooth with a few scattered hairs. Color gray with a much darker area in the anterior half of the valve. A mass of polygonal areas in vicinity of the eyes. First antenna with five segments, the spine on the second segment reaching to middle of the fourth segment. Second antenna with exopodite reaching to tips of terminal claws. Mandible with eight teeth which are split. Length 0.72 mm, height 0.37 mm, width 0.65 mm.

Male: Unknown.

Remarks.—This species is similar to *M. cordata* but is larger, the valves are without pits, and the mandibular teeth are different, numbering only four or five in *M. cordata*.

Occurrence.—Numerous females were collected from bromeliad leaf cups near Immokalee, Collier County, Fla., in July 1953.

Distribution.—This species is known only from a similar habitat in the Maracao National Forest, Puerto Rico, where it was collected at an elevation of between 2,800 and 3,000 feet in January and December.

Metacypris laesslei, n. sp.

Figs. 1–5

Specific characters.—*Female:* Seen from the side, oval in outline, height equal to about five-eighths length, highest in middle. Dorsal margin arched, ventral margin straight. Anterior extremity less broadly rounded than posterior. From above, width equal to six-sevenths length, anterior end somewhat pointed, posterior end broadly rounded. Surface of valves covered with small pits and a few hairs. Color brown with darker brown spots. First antenna with five segments; spine on second segment reaches to terminal fourth of fourth segment. Second antenna with exopodite barely reaching to tips of terminal claws. Mandibular teeth split and seven in number. Length 0.78 mm, height 0.49 mm, width 0.66 mm.

Male: Unknown.

Remarks.—This species is similar in size and shape to *M. maracaoensis* but differs in the presence of pits on the valves and in the number of mandibular teeth.

Occurrence.—Numerous females were found in three locations on the island of Jamaica, namely, in the Blue Mountains in St. Andrews Parish at an elevation of 3,200 to 4,000 feet, noncalcareous region, on July 3 to 9, 1952; near Mocho, west-central portion of the island, in a limestone region at an elevation of 2,000 feet on August 15 to 18, 1952; and near Christiana, Manchester Parish, elevation 3,000 feet, limestone region, on August 27 to 29, 1952. Female holotype, U. S. N. M. no. 99387. Type locality, Blue Mountains, St. Andrews Parish, Jamaica.

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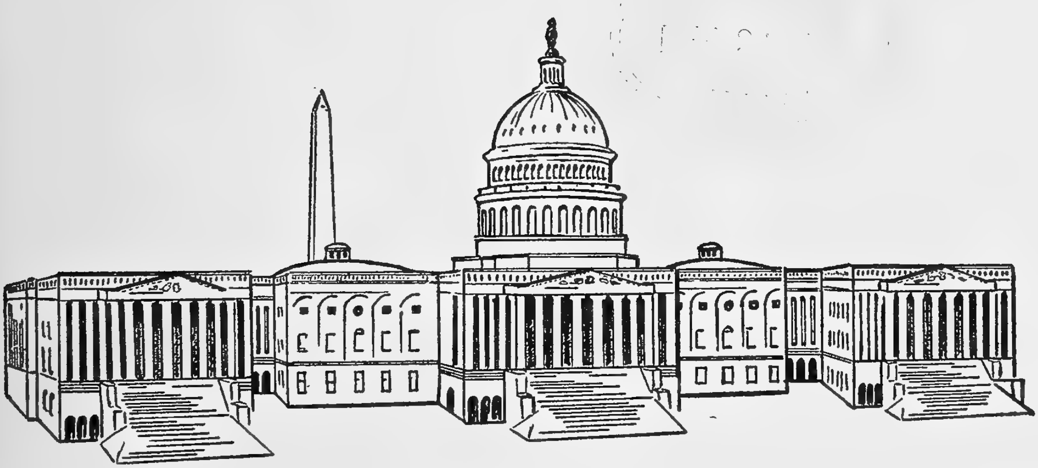

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MATHEMATICS.—*Unimodular matrices of order 2 that commute.*[1] Karl Goldberg, National Bureau of Standards. (Communicated by C. H. Page.)

(Received September 12, 1956)

We shall prove the following:

Theorem: Let A and B be rational integral unimodular matrices of order 2. Then A and B commute if and only if they are, within sign, powers of the same rational integral unimodular matrix.

A consequence of this theorem is: *Every abelian subgroup of the modular group is cyclic.*

The sufficiency is clear.

For the necessity it will be sufficient to find any matrix K such that $A = e_1K^m$ and $B = e_2K^n$ with m and n rational integers and $e_i = \pm 1$ for $i = 1, 2$. Let $(m, n) = s$, $m_0 = m/s$, $n_0 = n/s$ and $K_0 = K^s$. Then there exist rational integers a and b such that $am + bn = s$ so that

$$K_0 = K^s = K^{am+bn} = e_1^a e_2^b A^a B^b$$

is a rational integral unimodular matrix with the property that

$$A = e_1 K_0^{m_0} \quad \text{and} \quad B = e_2 K_0^{n_0}.$$

If A is scalar then $A = \pm B^0$, which satisfies the theorem trivially. In what follows we shall assume that A is nonscalar.

Since A is of order two and not scalar it is non-derogatory. Thus $AB = BA$ implies, see [1], that B is a polynomial in A, or that there exists numbers σ and ρ such that $B = \sigma A + \rho I$, where I is the identity matrix of order 2. If A is diagonal then B is diagonal and the fact that it is unimodular and not scalar implies $\sigma = \pm 1$ and $\rho = 0$. If A is not diagonal then we can compare off diagonal elements, to show that σ, and therefore ρ, must be rational, see [2]. It follows that there must be integers x, y and z relatively prime in pairs with $xz \neq 0$ such that

$$(1) \qquad zB = xA + yI.$$

If we denote the characteristic roots of A by α_1 and α_2 and those of B by β_1 and β_2 we have

$$(2) \qquad z\beta_i = x\alpha_i + y \qquad i = 1, 2.$$

From this equation we see that if the characteristic roots of A are irrational they lie in the same quadratic field as those of B. We shall treat this case first.

Since the characteristic roots of A are irrational they are distinct. Therefore there exists a non-singular matrix U such that

$$UAU^{-1} = \begin{pmatrix} \alpha_1 & 0 \\ 0 & \alpha_2 \end{pmatrix}.$$

Since A is unimodular α_1 is a unit in a quadratic field and so is, within sign, a power of μ the fundamental unit of that field if it is real or the primitive root of unity of highest period if it is complex. That is, for some rational integers m and $e_1 = \pm 1$ we have

$$\alpha_1 = e_1\mu^m \quad \text{and} \quad \alpha_2 = e_1\bar{\mu}^m$$

where $\bar{\mu}$ denotes the conjugate of μ.

We can rewrite this in matrix form by letting

$$\Lambda = \begin{pmatrix} \mu & 0 \\ 0 & \bar{\mu} \end{pmatrix}$$

to obtain $UAU^{-1} = e_1 \cdot \Lambda^m$ or

$$A = e_1(U^{-1}\Lambda U)^m.$$

[1] This work was supported in part by the Office of Naval Research.

Now if UAU^{-1} is diagonal so is UBU^{-1} as can be seen from equation (1). And because the characteristic roots of B are units in the same quadratic field as those of A there must be rational integers n and $e_2 = \pm 1$ such that $UBU^{-1} = e_2\Lambda^n$ or

$$B = e_2(U^{-1}\Lambda U)^m,$$

which completes the proof for the case of irrational characteristic roots.

If the characteristic roots of A are rational we have either

$$\alpha_1 = -\alpha_2 = \pm 1 \quad \text{or} \quad \alpha_1 = \alpha_2 = e_1 = \pm 1.$$

In the case of distinct rational roots, equation (2) and the fact that B is unimodular yields $x^2 = z^2 = 1$ and $y = 0$ or $A = \pm B$ which satisfies the theorem trivially.

In the case of equal roots there exists a non-singular matrix U such that

$$UAU^{-1} = e_1\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix} \quad e_1 = \pm 1$$

From equations (1) and (2) it is clear that

$$UBU^{-1} = e_2\begin{pmatrix} 1 & r \\ 0 & 1 \end{pmatrix} \quad e_2 = \pm 1, r = e_1 e_2 x z^{-1}$$

Let

$$K = U^{-1}\begin{pmatrix} 1 & z^{-1} \\ 0 & 1 \end{pmatrix} U.$$

Then

$$A = e_1 K^z$$

and

$$B = e_2 K^{e_1 e_2 x}$$

Since z and e_1e_2x are rational integers, this completes our proof.

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SURGE VOLTAGE BREAKDOWN IN A NONUNIFORM FIELD

A knowledge of high-voltage discharge phenomena is of primary importance in the design of electrical equipment. For example, an understanding of electrical breakdown in air makes possible accurate determination of safe and economic insulation requirements for high-voltage transformers and other apparatus. Information on discharge mechanisms is also of considerable value in electrical surge measurements carried out to provide data for the design of power systems.

Although several acceptable theories of breakdown in a uniform field have been developed,[1] the much more common problem of nonuniform field breakdown has been relatively unexplored. To provide data on this process, an investigation was recently conducted by J. H. Park and H. N. Cones, of the National Bureau of Standards.[2] Their results verify a difference, suggested by the data of earlier experimenters, between breakdown mechanisms in uniform and nonuniform fields.

Cathode-ray oscilloscope records and photographs of the discharges obtained by the Bureau reveal that in a nonuniform field discharge streamers (corona) are initiated by a sudden current rise (the first discharge pip). This current quickly decreases, remaining near zero unless complete breakdown is to occur. For gap lengths sufficiently short or for voltages sufficiently high, the first discharge pip is followed by a second rise in current which increases until breakdown occurs. Polarity also affects the gap spacing at which breakdown or discharge streamers occur and the speed of formation of these streamers.

The tests were conducted under usual laboratory conditions of pressure and humidity, and the nonuniform field was obtained by using electrodes of dissimilar geometry. The high-voltage electrode consisted of a circular plane,

[1] *Basic process of gaseous electronics*, by L. B. LOEB, chapters 8 and 9 (Univ. of California Press, 1955); *Theory of gaseous conduction and electronics*, by F. A. MAXFIELD and R. R. BENEDICT, page 270 (McGraw-Hill, 1941); and *The mechanism of the electric spark*, by L. B. LOEB and J. M. MEEK (Stanford University Press, 1941).

[2] For further technical details, see *Surge voltage breakdown of air in a nonuniform field*, by J. H. PARK and H. N. CONES, Journ. Res. NBS 56: 201. April 1956.

84 cm in diameter, made of an aluminum alloy. It was placed 86.4 cm above and parallel to the laboratory floor, which had a grounded metal grid imbedded in its surface and was used as a ground plane. The ground electrode was a sphere, 1.6 cm in diameter, mounted at the end of a conductor and located an adjustable distance beneath the center of the high-voltage plane electrode. The conductor, centered in a grounded tube, was connected to a coaxial cable, which terminated at a cathode ray oscillograph. This arrangement permitted an accurate measurement of prebreakdown current and computation of the initial electrical field.

Discharge phenomena were studied by holding the peak voltage of the applied surge at 145 kv and changing the gap spacing. Data were obtained under four conditions of applied voltage: a steeply rising surge with the sphere positive, a slowly rising surge with the sphere positive, a steeply rising surge with the sphere negative, a slowly rising surge with the sphere negative. For gap spacings less than 28 cm when the sphere is positive or 15 cm when the sphere is negative, complete breakdown between sphere and plane usually takes place.

The first discharge pip appeared at gap spacings up to 56 cm for a positive sphere and 46 cm for a negative sphere, but at these large spacings time delays were erratic. At gap spacings less than 46 cm with the sphere positive and 30 cm with the sphere negative a discharge generally appeared with little time lag—less than 0.1 μsec for a steeply rising surge and less than 1 μsec for a slowly rising surge.

In a case where breakdown would ordinarily occur, chopping the voltage after the first discharge rise prevented breakdown. The initial streamer patterns that formed when the voltage was chopped were similar in appearance to those obtained when there was no second discharge rise. In calculating the propagation velocity of the streamers, their length was determined from photographs, and their time of formation was taken as the interval between the start of the first discharge pip and the chopping. The mean streamer propagation velocity is 500 cm/μsec for sphere negative and 800 cm/μsec for sphere positive.

An analysis of streamer formation and channel development provides a more complete explanation of the mechanism leading to breakdown. Streamer photographs show where regions of high charge density have travelled from the sphere to the plane along the lines of force of the applied field. When the sphere is positive, a negative ion situated in the high-field region near the sphere can supply a free electron, which in ionizing neutral molecules forms an electron avalanche. The ionization or recombination process furnishes photons which liberate electrons in the nearby field. These electrons are attracted to the sphere, leaving regions of high positive space charge density near the surface of the sphere. The photo electrons liberated in the volume immediately ahead of the charged region are attracted to it so that the positive region moves from the sphere to the plate, creating a positive streamer.

If the initial streamer pattern produces a sufficiently high gradient, a channel starts to develop at the rate of 3 cm/μsec. As this channel forms, it serves as a good conductor from its origin at the sphere to its leading end. Breakdown takes place along a zigzag channel that has completely spanned the gap.

When the sphere is negative, the electron avalanches formed in the region near the sphere travel towards the plate, where they initiate positive streamers from the plate to the sphere. Electrons are then released from the sphere by high-energy photons impinging on it, positive ion bombardment, or field emission. Negative streamers are formed in much the same way as the positive ones, but in this case electrons repelled from the sphere cause a negative region to move toward the plate. A streamer formed when the sphere is positive has a higher velocity of propagation than a negative streamer because electrons move in the direction of the increasing gradient so that the electron avalanches develop faster. The positive streamer can be initiated over a longer gap than the negative streamer because avalanches can form positive streamers for lower applied gradients near the sphere when the sphere is positive.

For the negative sphere, a conducting channel starts out perpendicular to the plane but after a short distance changes its course and makes a zigzag path to the sphere. These channels either contact the sphere or connect with a channel development from the sphere. For shorter gap spacing or considerable overvoltage, breakdown occurs when an initial streamer develops into a conducting channel. The breakdown path is then less zigzag, seeming to follow a line of force.

PALEONTOLOGY.—Chiloguembelina, *a new Tertiary genus of the Heterohelicidae (Foraminifera).* ALFRED R. LOEBLICH, JR., and HELEN TAPPAN, U. S. National Museum.

(Received October 1, 1956)

Recent studies of planktonic Foraminifera by the writers have shown that some early Tertiary species previously referred to *Guembelina* Egger have characters not in keeping with that genus. As these species have both morphological distinctions and a differing geologic range, they are here considered to be distinctive and made the basis of a new generic name, *Chiloguembelina.*

Family HETEROHELICIDAE Cushman, 1927

Chiloguembelina Loeblich and Tappan, n. gen.

Type species.—Guembelina midwayensis Cushman, 1940.

Derivation.—Chilo, from *cheilos* Gr. n. lip, rim + *Guembelina,* genus of Foraminifera. Gender feminine.

Test free, flaring; inflated chambers biserially arranged, with a tendency to become somewhat twisted; sutures distinct, depressed; wall calcareous, finely perforate, radial in structure, surface smooth to hispid; aperture a broad low arch bordered with a produced necklike extension of the chamber, commonly this forms a more strongly developed flap at one side, so that the aperture appears to be directed toward one of the flat sides of the test.

Remarks.—Chiloguembelina differs from *Guembelina* Egger in the presence of the apertural necklike extension from the final chamber, in the tendency to develop a twisted test and an asymmetrical aperture, directed toward the flat side instead of the edge of the test. Unlike true *Guembelina,* it does not have an early coiled portion in the microspheric generation, all specimens being wholly biserial throughout.

Chiloguembelina is found only in post-Cretaceous strata, in the Paleocene and Eocene. In addition to the type species, *Guembelina crinita* Glaessner, *G. cubensis* var. *heterostoma* Bermudez, *G. mauriciana* Howe and Roberts, *G. trinitatensis* Cushman and Renz, *G. venezuelana* Nuttall, and *G. goodwini* Cushman also should be placed in *Chiloguembelina.*

Chiloguembelina midwayensis (Cushman)

Gümbelina midwayensis Cushman, Contr. Cushman Lab. Foram. Res. **16:** p. 65, pl. 11, fig. 15. 1940.

Gümbelina morsei Kline, Mississippi Geol. Survey Bull. 53, p. 44, pl. 7, fig. 12. 1943.

Test free, small, flaring; the 4 to 6 pairs of inflated to subglobular and rapidly enlarging chambers biserially arranged but slightly twisted; sutures distinct, depressed, nearly straight and slightly oblique; wall calcareous, finely perforate, surface smooth to finely spinose especially in the terminal portion of the test; aperture a broad low arch with a bordering necklike extension of the chamber, commonly forming a more strongly developed flap at one side, so that the aperture appears to be directed toward one of the flat sides of the test instead of toward its edge.

Remarks.—This species shows considerable variation in the degree of flaring of the test and in the development of the apertural lip. Some specimens may show a nearly symmetrical lip, others show a less well preserved lip so that it appears to consist of lateral flanges and in some slightly twisted tests the aperture may appear to be directed to one side, with a stronger development of the lip at one side than on the other. All gradations may be found, proving these to be merely individual variations.

Types and occurrence.—Holotype (Cushman Coll. no. 35715) from the Midway group, on U. S. Highway 80, south of Sucarnochee Creek, ½ mile southwest of Livingston, Sumter County, Ala. The writers have also observed this species in Midway strata of Texas and Alabama, the Brightseat formation of Maryland, and in the Hornerstown formation of New Jersey.

PALEONTOLOGY.—Galaxaura (*calcareous algae*) *and similar fossil genera*.

Graham F. Elliott, Iraq Petroleum Co., Ltd. (Communicated by Alfred R. Loeblich, Jr.).

(Received August 22, 1956)

In northern Iraq parts of the Lower Cretaceous succession are characterized by the occurrence of frequent but fragmentary calcareous algae (Elliott, 1955b). At a level dated as Barremian-Aptian the foraminifer *Orbitolina* is accompanied by *Munieria baconica* Deecke and a second fragmentary alga which during routine studies was known by a code number, for while it was recognizable, a reconstruction was not possible. Exceptional material later revealed that these fragments are of a species surprisingly similar to forms from the Permian of the same area and elsewhere. This new species is now described and its significance discussed. I am indebted to the Iraq Petroleum Co., Ltd., London, for permission to publish this note.

Genus **Permocalculus** Elliott, 1955

Permocalculus inopinatus, n. sp.

Description.—Thallus fingerlike, somewhat irregular, circular in cross section, up to 5 mm long and 1.75 mm in transverse diameter; calcification varying between different individuals from a thin irregular peripheral development to a nearly solid thallus; sporangia ill-defined, subcortical in position; pores with diameter of 0.020 mm at the outer edge of the calcification where they are clearly visible, only occasionally seen extending inwards, when they are fine and twisted, widening at the surface.

Syntypes.—The specimens illustrated in Figs. 1A, B, from the Aptian limestone of Ru Kuchuk, Chama, Mosul Liwa, N. Iraq, Geol. Coll. Iraq Petroleum Co., Ltd., London, reg. nos. DM. 1286, 1284.

Other material.—Numerous random sections, mostly fragmentary, from the Barremian-Aptian limestones of Ru Kuchuk and Jabal Gara, Mosul Liwa; Sarmord, Sulemania Liwa; Koi Sanjak, Erbil Liwa; all in northern Iraq. Also from a similar horizon at Wady Hajar, Hadhramaut, southern Arabia.

This species bears a surprising resemblance to species of *Permocalculus* from the Permian of the same area (Elliott, 1955a) and elsewhere, notably *P. solidus* (Pia) and *P. digitatus* Elliott. It is evidently the calcified thallus of a very similar plant, though it can readily be distinguished by the very different associated algal and other species.

The Permian *Gymnocodium*, after several changes in classification, was compared by Pia to the Recent *Galaxaura* and placed with it in the Chaetangiaceae. The writer (Elliott, 1955a) confirmed this resemblance after an examination of the calcareous micro-structure of the Recent *Galaxaura fastigiata* Decaisne and the Permian *Gymnocodium bellerophontis* (Rothpletz), in which the calcification is subdermal only, and separated off various Permian species, differing in form and calcification, as *Permocalculus*. A similar comparison could have been made between the Recent *Galaxaura glabriuscula* Kjellmann and *Permocalculus solidus* (Pia): in the Recent species there is marked calcification, particularly of the stem, which is not well differentiated from the other portions of the thallus.

In view of the close general similarities between *Galaxaura* and the fossil forms the additional evidence available from the former should be considered in classifying the latter; the recent study of Svedelius (1953) is of particular interest since this writer, unlike many botanists, attaches some degree of taxonomic importance to calcification. *Galaxaura* is represented by sexual and nonsexual generations; the plants of the two are different, and the former is itself represented by male and female plants, with differently sized cavities for reproductive structures. In spite of the frequent association of plants of two generations, and close examination for structural peculiarities held in common, however, Svedelius concludes that only by experimental spore-culture can the plants be conclusively paired as representing different generations of the same species.

If this difficulty arises with living plants, it seems impossible with the fossils, where the calcification alone remains, to classify them on other than a strictly morphological basis, as was done by the writer in separating *Permocalculus* from *Gymnocodium*, placed together in the Gymnocodiaceae as a comparable family to the

Chaetangiaceae. So long as the former was represented by Permian species only, the distinction was clear-cut and suggested that similar algae had twice independently achieved calcification. The known Cretaceous forms are therefore of especial interest.

Corallinites galaxaura Massalongo, from the Italian Lower Cretaceous, is known only from this writer's early account and figures (1856) which show a small segmented alga, and while possibly a *Galaxaura* (see also Massalongo, 1859) nothing more can be said of it.

Permocalculus inopinatus, described above from the Lower Cretaceous of the Middle East, is extremely similar to certain Permian species. *Gymnocodium nummuliticum* Pfender was described from the Egyptian Eocene and recorded also from the Upper Cretaceous of France and Spain (Pfender, 1940). This alga was described as very similar to the Permian *G. bellerophontis* (Rothpletz): the figures of Cuvillier (1930) quoted by Pfender are too small to be useful for a detailed study, and the present writer (1955a), without actual specimens for examination, did not consider them further. In material from Wady Hajar, Hadhramaut, southern Arabia, however, in a Lower Cretaceous *Orbitolina*-limestone of probable Barremian age, abundant debris of *Permocalculus inopinatus* was accompanied by at least one section similar to the Permian *Gymnocodium bellerophontis*, just as described by Pfender.

It would seem, therefore, that algae ancestral to the present-day Chaetangiaceae have existed since the Permian, though represented in varying abundance at different horizons. Their classification, in view of the difficulties attaching to that of the living plants, is best made, in the present state of knowledge, on a strictly morphological basis.

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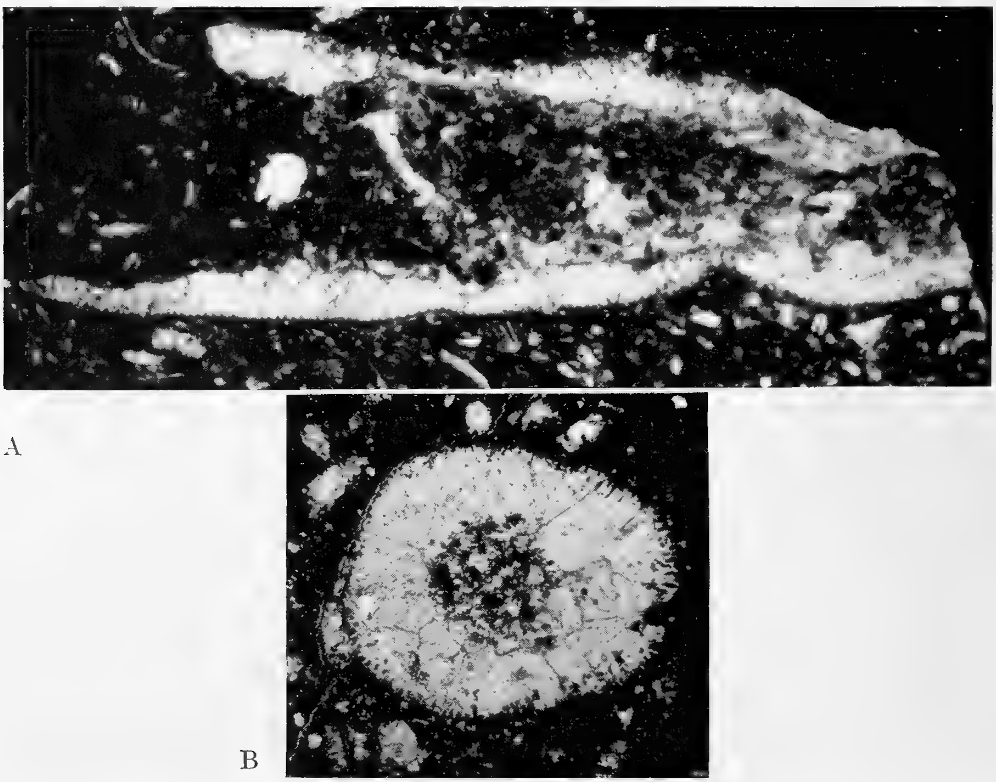

A

B

FIG. 1.—*Permocalculus inopinatus*, n sp.: A, Longitudinal section; B, transverse section × 30: syntypes. Lower Cretaceous (Aptian); Ru Kuchuk, Chama, Mosul Liwa, Iraq.

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H. M. S. "LOO"

The insigne of England's Tudor and Stuart kings, the crowned rose, has provided a clue that enabled a Smithsonian historian to reconstruct a two-century-old tragedy of the Spanish Main—the shipwreck of a British man-of-war and the desperate plight of 280 sailors on a desert island beset by hostile savages.

Off the central Florida keys, about 35 miles southwest of the town of Marathon, is a submerged reef—marked "Looe reef" on maritime charts. Near it the sea bottom is strewn with metal objects, long since covered with a sand crust that makes them the same color as the bottom and nearly indistinguishable. They obviously are the remains of some shipwreck. The wreck was first explored by a party consisting of Bill Thompson, of Marathon, Fla.; Dr. and Mrs. George Crile, Jr., of Cleveland, Ohio; Mr. and Mrs. E. A. Link, of Binghamton, N. Y.; Mr. and Mrs. James Rand, of Cleveland, Ohio; Mr. and Mrs. John Shaheen, of New York City; and Arthur McKee, of Homestead, Fla. The party was accompanied by Mendel L. Peterson, Smithsonian Institution curator of naval history. Largely through Mr. Peterson's researches the ship now has been identified and its complete story recovered. It was H. M. S. *Loo*, a frigate of 40 to 44 guns, under Capt. Ashby Utting, lost off the keys after running aground in the midwinter of 1744.

The metal objects recovered went part of the way in reconstructing the story. They were cannonballs, nails, fragments of rum and brandy bottles, the knob of a walking stick, some fragments of table plates decorated with a blue flower design, a 2,000-pound cannon barrel, and various 18th-century European coins. Cast into the barrel was the "crowned rose." It was an insigne used by both the Stuart and Tudor kings. As its use was discontinued after Queen Anne, the date of the shipwreck must have been before, or shortly after, her death. The normal life of an iron barrel on shipboard, it was ascertained, was probably not more than 40 years. If it is assumed that the cannon had been put in service in the last year of Anne's reign, 1714, the wreck could not have been later than 1754. Other evidence indicated that it could not have been earlier than the start of her reign.

Thus Peterson got the clue by which he was able to search records of the British Admiralty over a specific period, and bit by bit—from orders, letters, payrolls, and other papers—emerged the story of the wreck of the *Loo*. Looe is a town in Cornwall from which the ship took its name. How the Florida reef happened to have that name nobody knew. Here in brief is the story of the frigate as traced from the clue of the crowned rose, which has recently been published by the Smithsonian Institution where many of the articles recovered from the wreck now are being studied:

The *Loo* had sailed from Cuba with a small prize ship. During the night she ran close to the reef, while off her assumed course, and "three or four severe seas crushed the ship against the reef and she began sinking rapidly. The reef was then above water, a small desert island. Captain Utting, however, was able to land safely all his own crew and that of the captured prize ship.

"The desperate situation of the group was evident to all. "Here were 280 men stranded on a small sandy islet just off a hostile coast swarming with the savage Caloosa Indians who murdered Englishmen on sight. To add to the insecurity was the evident fact that in a blow of any force the whole islet would be swept by waves. At night Utting posted watches, each consisting of 25 marines and 25 sailors at the water's edge as 'centenells' to prevent a surprise night attack. Meanwhile the men, frightened and confused, became very rebellious and mutinous, dividing into parties and claiming that the officers no longer had any authority over them. They clamored to leave the island immediately. Utting took no notice of them, but, with the few men who would work, continued efforts to recover water and other provisions from the wreck."

Two days later the captain was able to get off all the men in small boats and eventually steered northward toward the harbor of Port Royal, S. C. This was a direction in which he did not want to go but proceeded "rather than all be drowned." But everybody came through alive. Once his crew were safe Utting's first chore was to find a colonial justice of the peace and make depositions in connection with a court martial for loss of his ship, which he knew was inevitable. From the Admiralty records Peterson obtained a full account of this court martial, at which the captain was acquitted of all charges.

BACTERIOLOGY.—*Quantitative studies of differential staining reactions, III: A quantitative acid-fast stain*[1]. A. F. WOODHOUR, Catholic University of America. (Communicated by E. R. Kennedy).

Bacteria in the genus *Mycobacterium* are resistant to staining with basic dyes, but once stained the cells are resistant to decolorization with acid-alcohol. This procedure is known as the acid-fast reaction, and possession of the acid-fast property is the chief characteristic that differentiates this genus from other Schizomycetes.

Attempts have been made to associate the virulence of mycobacteria with some consistent aspect of the organisms. Middlebrooke, Dubos, and Pierce (1947) found that virulent tubercle bacilli form microscopically demonstrable serpentine cords which enable the organisms to spread more readily on the surface of liquid and solid media. Avirulent forms do not form such cords. These investigators also reported that the virulent bacilli are strongly acid-fast, whereas the avirulent forms are much less acid-fast. It should be possible, in the light of this information, to associate virulence with a quantitative determination of acid-fastness.

Until the present time no quantitative method has been described to estimate the degree of acid-fastness among species or strains of *Mycobacterium*. Kennedy and Barbaro (1953) reported an accurate quantitative method for determining the adsorption of crystal violet by bacteria based on micro-Kjeldahl analyses of bacterial cells and stain reagents. The present report describes a modification of this procedure as applied to the acid-fast reaction and presents evidence for the existence of degrees of acid-fastness among the mycobacteria.

MATERIALS AND METHODS

The crystal violet used throughout the investigation has been described previously (Kennedy and Barbaro, 1953).

Basic fuchsin was obtained from the National Aniline & Chemical Co., Inc., New York, N. Y. (total dye content, 95 percent, Certification no. NF 57, C. I. no. 677).

Modified Ziehl-Neelsen carbol fuchsin was prepared by dissolving 3.15 g of basic fuchsin in 10 ml of 95 percent ethyl alcohol; a solution composed of 2 g of phenol in 95 ml of deionized water was added to the alcoholic dye solution.

The crystal violet solution, decolorizing agent (3 percent hydrochloric acid-alcohol) and M/15 phosphate buffer were stored at 5 C and maintained as close as possible to that temperature throughout the procedure. The modified Ziehl-Neelsen carbol fuchsin was stored at room temperature to avoid excessive precipitation of carbolic acid.

The organisms were obtained from cultures maintained in this laboratory and the American Type Culture Collection and maintained at room temperature. The acid-fast organisms used in the study were:

	Strain No.
Mycobacterium tuberculosis var. *hominis* ATCC no. 9360	H37Rv
Mycobacterium tuberculosis var. *hominis* ATCC no. 9431	H37Ra
Mycobacterium tuberculosis var. *bovis* ATCC no. 9834	549

The non-acid-fast organism was:

Corynebacterium xerose	513

The tubercle bacilli were cultivated at 37 C for 3 weeks on Dubos broth base to which "Dubos medium albumin" and 1.2 percent agar had been added. All other organisms were cultivated at 37 C for 24 to 72 hours on a modified tryptose agar medium.

The preparation of cell suspensions and micro-Kjeldahl procedure have been described previously (Kennedy and Barbaro, 1953).

EXPERIMENTAL PROCEDURE AND RESULTS

The procedure for a typical quantitative acid-fast reaction was as follows: Organisms

[1] This work was supported in part by funds received from the American Association for the Advancement of Science on the recommendation of the Washington Academy of Sciences.

Table 1.—Quantitative Acid-fast Reaction as Determined by Micro-Kjeldahl Analyses of Crystal Violet and Bacteria

Species	Analyses on supernatants			Analyses on bacteria			Per mg bacterial N	
	Original dye N	Dye N after staining (unadsorbed)	Dye N adsorbed	Acid-fast stained bacteria	Unstained bacterial N	Dye N retained	Dye N adsorbed	Dye N retained
	mg	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*
Myco. tuberculosis var. *hominis* H37Rv	0.40	0.22	0.18	0.73	0.69	0.04	0.26	0.06
Myco. tuberculosis var. *hominis* H37Ra	0.40	0.10	0.30	1.12	1.10	0.02	0.27	0.02
Myco. tuberculosis var. *bovis*	0.37	0.03	0.34	1.46	1.39	0.07	0.25	0.05
Myco. phlei	0.42	0.04	0.38	1.73	1.69	0.04	0.23	0.03
C. xerose	0.41	0.06	0.35	2.21	2.21	0.00	0.11	0.00

to be tested were harvested in 0.85 percent saline solution, heat-killed at 99 C for 30 minutes, and washed until the supernatant fluid was nitrogen free as determined by micro-Kjeldahl analyses. The washed cell suspension was diluted to contain the desired concentration of bacteria per milliliter. One ml of the uniformly mixed bacterial suspension was added in triplicate to thick-walled centrifuge tubes and centrifuged in the cold (0–5 C) at approximately 8,000 rpm (rcf 6,000) for 30 minutes. The supernatant fluid was discarded, and 2 ml of suitably diluted crystal violet stock solution were added to the packed cells. After thorough mixing, the tubes were stoppered and kept at room temperature overnight (approximately 18 hours). The next day the stoppers were removed and the tubes centrifuged in the cold for 30 minutes. The supernatant crystal violet solution was transferred to a Kjeldahl flask, and the packed cells were washed with 2 ml of buffer solution at pH 7.1 and centrifuged again in the cold. The buffer washings were transferred to the Kjeldahl flask and one ml of 3 percent hydrochloric acid-alcohol was added to the packed cells. The cells were mixed thoroughly and immediately centrifuged in the cold for 5 minutes. The supernatant acid-alcohol and subsequent buffer wash were placed in a second Kjeldahl flask for analysis. The packed cells were suspended in buffer solution and transferred quantitatively to a third Kjeldahl flask for analysis.

Unstained bacterial suspensions and dye solutions were added directly to Kjeldahl flasks in triplicate and analyzed. These values were used as control determinations.

Table 1 contains representative data obtained when this procedure was applied to acid-fast and non-acid-fast organisms. In all cases each figure indicates the average of triplicate determinations. The method is such that each of the triplicates agrees within 0.02 mg of nitrogen. To simplify the comparison of results, the values in the last two columns have been calculated on the basis of one mg of bacterial nitrogen. The term *adsorption* is used to describe the dye originally taken up by the bacterial cells; the term *retention* means the amount of dye which remains in the cells after decolorization. The adsorption values are similar among all acid-fast organisms tested but the retention values differ. The difference in retention indicates degrees of acid-fastness.

One ml of modified Ziehl-Neelsen carbol fuchsin was employed in place of crystal violet in the above procedure under the same conditions. Table 2 contains representative data obtained with this procedure. One of the most significant differences between this modification and the crystal violet procedure is the generally higher adsorption values obtained with carbol fuchsin, though the retention values are similar. The individual retention values are significant: the two supposedly most acid-fast organisms of the group retain the most dye while the least acid-fast organisms retain appreciably less dye.

DISCUSSION

The application of a quantitative technique to the acid-fast reaction is dependent to a great extent on the preparation of homogeneous bacterial suspensions and adequate control of the decolorization procedure. The difficulty of preparing homogeneous suspensions of mycobacteria can be overcome by the use of Tween 80-albumin medium which has been recommended for the cultivation of tubercle bacilli. The formation of cords in virulent species is inhibited on this medium (Middlebrooke, Dubos, Pierce, 1947). Numerous thorough mixings and centrifugations of the cells with subsequent double filtration through cotton results in homogeneous suspensions. This is substantiated by analyses of triplicate samples of unstained organisms. The results agree within the limits of error of the micro-Kjeldahl method ± 0.02 mg nitrogen. The utilization of low temperature centrifugation during the decolorization process is believed to slow the decolorization process sufficiently to allow complete removal of measureable dye from non-acid-fast organisms without over decolorization of the weakly acid-fast *Myco. phlei.*

The use of crystal violet in the procedure described here is supported by the work of Benians (1912–1913) who found that, when crystal violet was employed without a mordant in the acid-fast reaction, acid-fast organisms retain dye after acid-alcohol decolorization while non-acid-fast organisms are completely decolorized. In the course of the present work, crystal violet was found much easier to use than carbol fuchsin. When triplicate samples of the respective dyes were subjected to analyses, crystal violet samples always agreed within the limits of error of the procedure while carbol fuchsin replicates showed marked discrepancies on many occasions. In addition, carbol fuchsin takes much longer to digest in Kjeldahl analysis than does crystal violet and therefore lengthens the complete procedure. The results in the tables, however, represent experiments in which triplicate dye samples agreed within the limits of error of the method.

There appear to be many variables that influence the values obtained, such as composition of media, dye concentration, staining time, temperature of staining and decolorizing procedures. These factors undoubtedly influence the acid-fast reaction when performed on glass slides. The values found (tables 1 and 2) are relative rather than absolute but it should be remembered that they are the result of triplicate analyses and agree within 0.02 mg nitrogen. The reliability of these values is further emphasized by the fact that analyses were made of the supernatant fluids as well as stained cells and it is possible to account for all dye, adsorbed and unadsorbed, used throughout the procedure.

In the interpretation of quantitative acid-fast values consideration must be given to the physiological condition of the cells used. Dubos and Davis (1946) pointed out the heterogeneity of fully grown cultures of tubercle bacilli. The cells in a given culture vary greatly in age and therefore, physiological state. In addition, when organisms

TABLE 2.—QUANTITATIVE ACID-FAST REACTION AS DETERMINED BY MICRO-KJELDAHL ANALYSES OF CARBOL FUCHSIN AND BACTERIA

SPECIES	ANALYSES ON SUPERNATANTS			ANALYSES ON BACTERIA			PER MG BACTERIAL N	
	Original dye N	Dye N after staining (unadsorbed)	Dye N adsorbed	Acid-fast stained bacteria	Unstained bacterial N	Dye N retained	Dye N adsorbed	Dye N retained
	mg	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*	*mg*
Myco. tuberculosis var. *hominis* H37Rv	0.58	0.24	0.34	1.04	0.97	0.07	0.35	0.07
Myco. tuberculosis var. *hominis* H37Ra	0.61	0.27	0.34	0.91	0.90	0.01	0.37	0.01
Myco. tuberculosis var. *bovis*	0.60	0.13	0.47	1.50	1.43	0.07	0.33	0.05
Myco. phlei	0.61	0.18	0.43	1.72	1.69	0.03	0.25	0.02

grow in clumps the environmental conditions of cells at the periphery are different from those of cells at the center. These conditions might well reflect differences in structure and metabolism. Since conditions of cultivation are kept constant for all organisms it seems justifiable to assume that these values are correct when applied to a culture as a whole. Possibly the values would be higher if only young organisms were used or considerably lower if only old organisms were used. Since, however, a mixture of both were employed the values indicate an average acid-fast value. The conditions are the same for all species to which the procedure has been applied.

With the classic acid-fast test performed on glass slides, visual observation does not necessitate the presence of abundant amounts of dye within the cells. The quantitative procedure, however, demands the presence of significant amounts of dye. The micro-Kjeldahl method measures 0.02 mg of nitrogen but when small amounts of organisms were used, even though the cells were visibly stained, the retained dye nitrogen could not be measured. This can be overcome by increasing the number of organisms so more adsorbed dye can be measured and decreasing the decolorization time to the extent that non-acid-fast organisms give no retention values, though they are visibly stained. This procedure indicated the minute quantity of dye retained by acid-fast organisms when stained by the classic method on glass slides.

The amount of dye retained per mg of bacterial nitrogen is significantly different among species of mycobacteria. The conclusion that degrees of acid-fastness exist among the mycobacteria agrees with reports of other investigators (Lamanna and Mallette, 1953; Bergey *et al.*, 1948). These workers based their conclusions on qualitative interpretations utilizing the classic Ziehl-Neelsen technique of staining. The data presented in this report indicate the existence of quantitative degrees of acid-fastness among mycobacteria whether stained with carbol fuchsin or crystal violet when the results are calculated as retained dye per unit of bacterial nitrogen.

The method which has been reported offers the first quantitative experimental approach to basic studies on the mechanism of the acid-fast reaction and to studies of the effects of environment, staining time, temperature of staining, dye concentration, and decolorizing agents.

SUMMARY

A quantitative acid-fast reaction based on micro-Kjeldahl analyses of reagents and of cells decolorized at low temperature is described.

Quantitative evidence is presented to show that degrees of acid-fastness exist among mycobacteria.

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Though the mills of God grind slowly, yet they grind exceedingly small.—Longfellow.

ZOOLOGY.—*North American harpacticoid copepods: 3*, Paracamptus reductus, *n. sp., from Alaska.*

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(Received July 30, 1956)

The genus *Paracamptus* is among the few genera of fresh-water Canthocamptidae occurring in Europe and Asia that has not been reported from North America. It is of interest therefore to record its occurrence on this continent, as represented by a new species found in Alaskan collections. The harpacticoid copepods listed as occurring with the new *Paracamptus* also represent new records for North America. Reference has been made (M. S. Wilson, 1956) to their discovery in Alaska, but these are the first locality records to be published. The genus *Maraenobiotus* is likewise a Eurasian genus of the Canthocamptidae not before known from North America.

I am indebted to O. A. Mathisen, Fisheries Research Institute, University of Washington, and to Kenneth Andress, Spenard, Alaska, for the collections containing this new species.

Paracamptus reductus, n. sp.

Figs. 1–16

Specimens examined.—Type lot: 9 ♀ (2 ovigerous), 4 ♂. Margin of Lake Tikchik, Bristol Bay area of southwestern Alaska (about lat. 60°N., long. 159°W.); August 19, 1954; O. A. Mathisen. Occurring with *Moraria duthiei* T. and A. Scott and *Maraenobiotus insignipes* (Lilljeborg). Holotype ♀, U. S. National Museum no. 99416; allotype ♂, no. 99417.

1 ♀ (ovigerous). Margin of Paxson Lake, Richardson Highway, Alaska, (about lat. 63°N., long. 145°W.); June 28, 1951; K. Andress. Occurring with *Moraria duthiei* and *M. mrazeki* T. Scott.

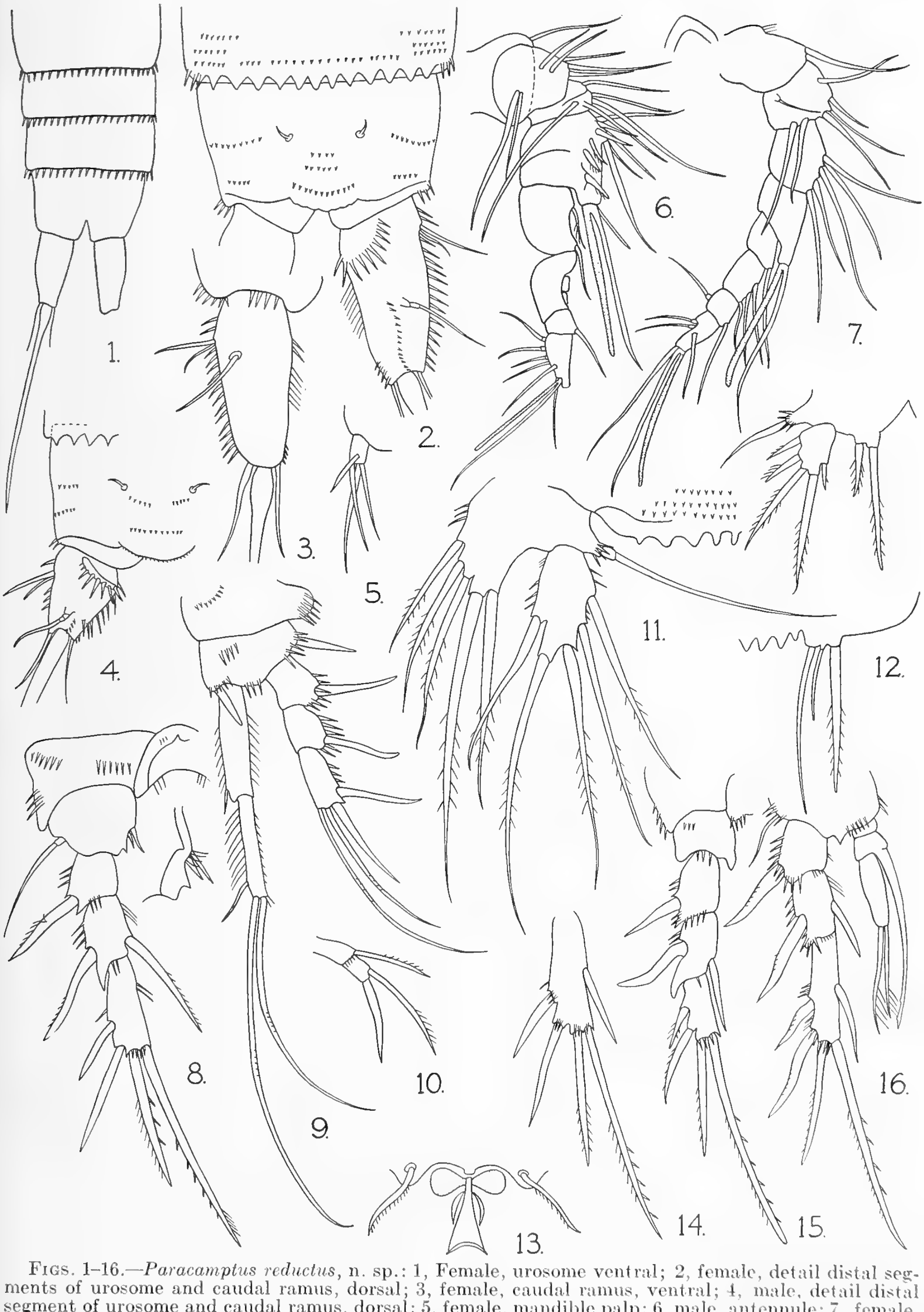
Diagnosis.—Caudal rami of female, length more than twice width; shorter in male; both sexes with curved crest of spinules near base of inner dorsal side and longitudinal crest of spinules posterior to insertion of dorsal seta. Leg 1 with three setae on endopod segment 2, both apical setae much longer than endopod and modified like those of exopod. Endopods lacking on legs 2–4 of female and on legs 2 and 4 of male; that of leg 3 normally developed in male, with two apical setae. Leg 5, segment 2 of both sexes, middle seta of similar stoutness and armature to other setae.

Description.—Length, dorsal midline, ♀ Tikchik Lake, 0.55–0.6 mm, Paxson Lake, 0.7 mm; ♂, 0.465–0.47 mm.

FEMALE: Posterior edge of all body segments, except the last, coarsely serrate on dorsal side (Fig. 2); surface covered by broken rows of minute spinules (partially indicated in Fig. 2). Ventrally, urosome segments not serrate but each with single unbroken row of spines (Fig. 1). Last segment with a few spines ventrally at bases of rami and a lateral group. Margin of anal operculum wavy or minutely spinulose.

Caudal ramus (Figs. 2, 3) constricted distally, length more than twice its greatest width (2.3–2.45 times); longer than outer margin of last body segment (about 1.4 times). Lateral setae placed as usual, the proximal on outer margin near base and accompanied by shorter seta; distal seta placed a little distad on ventral surface. Dorsal seta on a twice segmented base, placed just distad to middle of ramus. Entire outer margin including that above proximal seta, armed with row of slender spinules. Arc of somewhat larger, graduated spinules forming transverse crest on inner proximal portion of dorsal surface. Longitudinal row of very short spinules ranging from behind point of insertion of dorsal seta to apex of ramus. Inner margin with medial group of fine hairs and distal group of minute spinules. Caudal setae (Fig. 1) as usual for *Paracamptus*, outer and inner setae of subequal size, length less than that of ramus; middle seta well developed, base enlarged, unjointed; length less than that of urosome (equaling a little more than segments 4 and 5 plus ramus) and from 2.2 to 2.9 times length of ramus.

Antennule (Fig. 7) 8-segmented; without plumose setae; aesthete of segment 4 reaching to end of antennule; outer setae of two apical segments on segmented bases. Exopod of antenna (Fig. 10) 2-segmented; first segment with plumose



FIGS. 1–16.—*Paracamptus reductus*, n. sp.: 1, Female, urosome ventral; 2, female, detail distal segments of urosome and caudal ramus, dorsal; 3, female, caudal ramus, ventral; 4, male, detail distal segment of urosome and caudal ramus, dorsal; 5, female, mandible palp; 6, male, antennule; 7, female, antennule and rostrum; 8, female, leg 4, with detail inner distal edge of basipod 2; 9, female, leg 1; 10, female, exopod of antenna; 11, female, leg 5; 12, male, legs 5 and 6; 13, female, detail of genital area; 14, female, leg 2, exopod segment 3; 15, male, leg 4; 16, male, leg 3.

seta; second with subapical plumose seta and very stout, unornamented apical spine. Mandible palp (Fig. 5) 1-segmented, with one subapical and three apical setae.

Leg 1 (Fig. 9) with 3-segmented exopod and 2-segmented endopod; exopod shorter than endopod, reaching to about proximal third of apical endopod segment. Endopod segment 1 wider and a little longer than segment 2, with short inner seta. Segment 2 narrowed, with short inner seta distally and two long, curved apical setae of the modified type found on apical exopod segment; inner seta longer than outer and both longer than endopod; relative length of outer seta, inner seta and endopod, 22:30:17.

Legs 2–4 with 3-segmented exopods. Exopod segment 2 always with inner seta. Exopod segment 3 with two outer and two terminal spines of which the inner is the longer; inner spiniform seta on legs 2 and 3 (Fig. 14), absent on leg 4. Endopods lacking, though usually minute setae present in usual position of endopod (Fig. 8).

Leg 5 (Fig. 11). Distal segment 2, length about 2 times its width; all five setae similar to one another, sparsely plumose; seta 4 the longest, seta 5 the shortest; relative length of setae to one another (from outer edge), 19:21:22:25:16. Basal segment, outer portion of inner expansion bearing the first two setae produced beyond the rest of segment, reaching to about middle of segment 2; relative length of setae to one another, 19:27:15:13:10.

MALE: Habitus as in female. Caudal ramus (Fig. 4) differing from female in being shorter than outer margin of last body segment (about 14:20). Armature similar; spinal arc on proximal dorsal face accompanied by distinct ridgelike sclerotization. Dorsal seta placed at about distal third; distad to it a short, longitudinal row of 3–4 spines.

Antennule (Fig. 6) 8-segmented, third and fourth segments imperfectly separated into additional segments. Fourth segment dilated and bearing short, stout setae. Three segments beyond geniculation, apical segment shorter than two preceding segments, apex constricted and produced beyond insertion of terminal setae; proximal, lateral setae with segmented bases as in female.

Leg 1 as in female. Legs 2 and 4 lacking endopods (no minute setae found as in female). Leg 3 (Fig. 16) with 3-segmented endopod reaching to end of exopod 2; its basal segment without inner seta; apophysis well developed, reaching to end of exopod, its total length greater than that of endopod; third segment with two subequal, apical setae also reaching to near end of exopod, their length subequal to that of endopod.

Leg 4 (Fig. 15), exopod with same setation as in female but somewhat modified. Outer distal corner of segment 2 more enlarged and outer spine much more recurved than in female. Exopod segment 3 reduced in size, its length subequal to that of exopod 2 rather than longer as in female.

Leg 5 (Fig. 12). Distal segment 2 small, length about 1.5 times the width, with five setae; four outer setae of different lengths but of similar stoutness, all plumose; innermost seta reduced, shorter than segment; relative length of setae to one another (from outer to inner), 5:7:11:16:4. Inner basal portions of leg not divided, with two spiniform setae borne on slight production of segment, inner seta subequal in length to longest (fourth) seta of segment 2, and a little more than twice length of outer (17:7). Leg 6 (Fig. 12) with three setae, the innermost stout and spiniform, subequal to slender outer seta; both outer and innermost setae a little longer than longest seta (second basal) of leg 5.

Discussion.—Only two species of *Paracamptus* are known: *P. schmeili* (Mrazek) from Europe and *P. baikalensis* Borutzky from Lake Baikal in Asia. Several varieties have been named for *schmeili* but Lang (1948), on the basis of the extreme variability found in specimens he studied from Sweden, considers that none can be recognized as subspecies.

P. baikalensis, known only from the female, is separable from *schmeili* on the basis of the much shorter caudal ramus (wider than long) and the lack of reduction and modification of the middle seta of the second segment of the fifth leg. The setae of the fifth leg of *schmeili* are reportedly variable, but according to Lang, the third or middle seta of the second segment is always finer than the others, nonplumose, usually shorter than the outer setae, and always shorter than the inner setae. This seta in the new Alaskan species *reductus* is not modified or reduced, being plumose and of similar stoutness to the other setae in both sexes. The occurrence of this character in a species so distinct as *reductus* gives strength to its importance as a specific differentiation between *baikalensis* and *schmeili*, a point which Lang questioned.

In comparing *reductus* with the other two known species, the most obvious difference is the lack of the endopods of legs 2–4, an unusual character in free-living copepods and not previously known in the Canthocamptidae. Such a lack has been recorded in the Harpacticoida for two other genera, *Paranannopus* (family Cletodidae) and *Leptopsyllus* (family Parameso-chridae). The endopods of these legs in *Paracamptus* are reduced in segmentation, size and armature, but the forms that have been described have shown no indication of intermediate conditions leading to the complete loss of the endopod. If one were dealing with only a single specimen, a single sex, or a collection from a single lake, it might be suspected that an anomalous condition exists. But all the specimens examined lack the endopods, and the species is known from two widely separated lakes of different drainage systems. Possibly the strongest reason for not regarding this condition as anomalous is the fact that the endopods are lacking not only in the female, but also on legs 2 and 4 of the male, although the modified copulatory endopod of the third leg is normally and strongly developed. Additional evidence that the complete loss of the endopod is normal for this species, is found in the second basal segment, which is likewise reduced. This is shown clearly in figure 8. The inner portion of the basal segment is slanted abruptly upwards just beyond the spinous point which is present between the exopod and endopod in all *Paracamptus*. That the minute setae present in the female may be regarded as remnants of the endopod is suggested by their position just beyond this spinous point where the endopod would normally be attached.

Even if the endopods were normally developed, *P. reductus* has other characters which would separate it from *baikalensis* or from any of the forms of *schmeili*. The caudal ramus is shaped much like that of typical *schmeili*, but the armature apparently differs in part. In *reductus*, there is a basal crest of strong spines instead of hairs. The longitudinal row of spinules running from the base of the dorsal seta to the apex of the ramus in both sexes of *reductus* has not been shown in any figures of *schmeili*. The great length of the outer apical seta of the endopod of the first leg may be peculiar to *reductus*; the reduced inner seta present in *reductus* is usually absent in *schmeili*. The fifth legs of both sexes differ from *schmeili* in that the third seta of the second segment is similar to the other setae. The basal portion of this leg in the female of *reductus* differs from both *schmeili* and *baikalensis* in the prominent production of the outer portion bearing the first two setae. The endopod of leg 3 of the male has a single apical seta in *schmeili* and the presence of two apical setae in *reductus* appears to constitute a further distinction of the new species.

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GRANTS-IN-AID

The Committee on Grants-in-Aid for Research wishes to remind Academy members that the Academy has a few hundred dollars available to aid those engaged in research. The sum is not large but is adequate to supply special equipment or supplies needed in research. The funds are advanced to the Academy by the AAAS and are available to high-school students, college students at the undergraduate or graduate level, and to instructors. Requests should be addressed to either Dr. H. Specht, of the National Institutes of Health, or to the undersigned.

Walter J. Hamer
Chairman, Committee on
Grants-in-Aid for Research

MAMMALOGY.—*Little-known reference to name of a harbor seal.* VICTOR B. SCHEFFER, U. S. Fish and Wildlife Service. (Communicated by Herbert Friedmann.)

(Received September 12, 1956)

About 1950, we received from its author a reprint of an article in Japanese, as follows: INUKAI, TETSUO. Hair seals (azarashi) in our northern waters [i.e., Japanese waters]. Shokubutsu oyobi Dobutsu [Botany and Zoology], Yokando, Tokyo, **10** (10): 927–932, text figs. 1–5 [fig. 1 in 2 parts], 1 October; no. 11, p. 1025–1030, text figs. 6–7, 1 November. 1942. [In the reprint, no. 10, is part 1, p. 37–42; no. 11 is part 2, p. 41–46.]

Among materials brought back by Ford Wilke, U. S. Fish and Wildlife Service, from the National Resources Section, General Headquarters, Supreme Commander for Allied Powers, Tokyo, about 1950, is a translation of Inukai's article, translator's name not shown. We quote excerpts, as follows:

"I think these four species [ribbon seal, bearded seal, ringed seal, and harbor seal] are enough for the hair seal classification [to date] . . . In addition I tell you that another species 'zenigata-azarashi' is recognizable besides the above four" (p. 928).

"This species appears black as a whole and people call it 'Kuro'—black. It has spots all over the body, white ones about 3 cm. long and 1 cm. wide which have coin-shaped black spots inside them. These coin-shaped spots look like the spots of the 'fuiri-azarashi' [quite certainly the ringed seal, *Phoca hispida*], clear on the back and dim on the belly (fig. 4). The body size is almost the same as 'gomafu-azarashi' [quite certainly the harbor seal, *Phoca vitulina*] but many of them are rather small. They live mostly in the southern Kuriles and their distribution is limited to a small area on the Pacific coast. Their western limit is Erimo Zaki [southeastern Hokkaido], the eastern limit is northern Kuriles. Their skulls resemble 'gomafu' and they live with them except during the breeding season. I think they are a variation of the 'gomafu'. Their actions are faster than 'gomafu'; their legs are larger; they run away very quickly. I suggest *Phoca uochotensis* [read *ochotensis*; certainly a typesetter's error, since the name is spelled correctly elsewhere in the paper] var. *kurilensis* for this species. Occasionally, skins that appear intermediate between those are found in the southern Kuriles (fig. 5)." (This paragraph, including figs. 4 and 5, on p. 930.)

Fig. 4 represents the flat skin of a male, locality not specified. In our opinion, the pattern is that of a dark harbor seal, *P. vitulina*. Fig. 5 represents the flat skin of a male, apparently a medium-dark harbor seal. No measurements of body or skull for "zenigata" are given. No specimens were reported saved.

Farther along in his paper (pp. 930–1026) Inukai gives certain biological data for "zenigata." In a commercial catch of seals from the southern Kuriles from early July to early September, there were 139 harbor seals, 42 ringed seals, and 21 "zenigata". The copulating season for "zenigata" is said to be in mid-June, a little later than for the habor seals. This information, if true, would be extremely difficult to obtain. It indicates, however, that "zenigata" are adults and that the name is not a collective one for subadults. Pups are born with yellowish-white, long, downy hair—characteristic both of ringed and harbor seals. Mother seals carrying young on their backs are seen around Erimo Zaki in May—an observation which might be made both of ringed and harbor seals. " 'Zenigata' . . . seems to have the same food habits as 'gomafu' " . We take this to mean that "zenigata" feeds, like the harbor seal, on fish, squid, octopus, and larger shellfish, rather than like the ringed seal on macroplankton.

We call attention to the name *P. kurilensis* since it does not appear in the Zoological Record or in Ellerman and Morrison-Scott's "Check List of Palaearctic and Indian Mammals 1758 to 1946." Pending further study, we suggest that *P. kurilensis* be regarded as one of the approximately ten synonyms of *Phoca vitulina largha* Pallsa, 1811.

ENTOMOLOGY.—*A review of the psocids, or book-lice and bark-lice, of Texas (Psocoptera).*[1] Edward L. Mockford, University of Illinois, and Ashley B. Gurney, U. S. Department of Agriculture.

(Received August 8, 1956)

The psocids (Psocoptera) are one of the minor orders of insects, with only about 145 species recorded from the United States. Their obscure habits, small size, and limited importance are probably responsible for their nearly complete neglect by all but a very few entomologists, and it is probable that intensive study will double the number of known Nearctic species. This paper is designed to lay a foundation for future work on the psocids of Texas.

The principal specimens on which this report is based were secured by the junior author in 1951, when he visited Texas in company with O. L. Cartwright and, between September 18 and October 8, collected insects at about 55 localities in the eastern, central, and southern parts of the State. In addition to reporting on this collection, we have included information on other available Texas material, and previous records in the literature are also summarized.

It should be realized that the 1951 trip was only a beginning of a survey of the psocid fauna of the State as a whole, since it covered less than a third of Texas in a very hurried manner at one season of the year, and the beating of foliage was the chief collecting method utilized. The biotic provinces and physiographic regions of Texas are quite varied, and future collecting probably will disclose many additional species. Several publications on Texas natural areas may be helpful to future students. Blair (1950) described six principal biotic provinces, these representing some modifications of Dice's (1943) results and a considerable advance over Bailey's (1905) grouping, which consisted of traditional life zones based largely on temperature. Taylor (1945) and Russell (1945) have contributed other general works dealing with factors that influence the distribution of animals of Texas.

The largest number of specimens taken in 1951 were beaten from foliage into a black umbrella, picked from the umbrella with a camel-hair brush dipped in alcohol, and placed in 70-percent alcohol. Others were found under bark, and a few were attracted to lights at night. Sifting ground litter and examining the outer surface of tree trunks were methods little utilized, though usually these are helpful and should be used in future psocid collecting. In general, psocids did not appear abundant until the Rio Grande Valley from Mission eastward was reached, and the very dry conditions over most of the State in 1951 may have been partly responsible for their scarcity. From Mission to Brownsville and along the east coast, palm trees, especially *Washingtonia filifera* Wendl. (introduced, probably from California), harbored many psocids. The dead fronds of untrimmed *Washingtonia* trees were excellent psocid habitats, especially the lower surfaces of the more apical portions.

Special mention should be made of the stands of the sabal or palmetto, *Sabal texana* Becc., near Brownsville. Originally there were extensive groves of the sabal on the delta about the mouth of the Rio Grande. Now, except for scattered remnants throughout the delta and extending as far north of Brownsville as Olmito, and about 80 miles west from the Gulf, native stands are largely restricted to the Southmost and Rabb "bends" of the Rio Grande, located about 6 to 12 miles southeast of downtown Brownsville. Several very profitable visits were made in 1951 to that portion of the Rabb Grove, which is owned by Mrs. R. M. McCormick, about 7 miles east-southeast of Brownsville. A full account of the sabal, with special reference to the groves at Southmost, is that of Davis (1942); an earlier review is by Small (1927), and

[1] Field work by the junior author was supported in part by a grant from the Penrose Fund of the American Philosophical Society.

Bailey (1944) has revised the group. This area south and southeast of Brownsville is the most nearly tropical portion of Texas, though there is a fairly severe frost about every 6 to 10 years, and light frosts are not rare. Although several plants and animals of the area are essentially tropical species, the area can not be considered part of the true Tropical Zone. A valuable summary of the plants and zonal affinities is by Clover (1937). The commercial growing of bananas and other tropical fruits is impossible in view of the occasional killing frosts. One of the most severe freezes, with temperatures below 19° F., occurred in early 1951, and is reviewed by Gunter and Hildebrand (1951). Goldman (1951, pp. 259–267) described Matamoros and nearby areas of northern Tamaulipas as Lower Austral, though invaded by some Arid Upper Tropical Subzone elements. Students of broad distributional problems may be assisted by Galtsoff, et al. (1954).

The pioneer worker on Texas psocids was Frank Aaron (1862–1947), of Philadelphia, Pa., whose life was reviewed by Calvert (1947). Aaron made a hunting trip on the plains of southwestern Texas when 16 years old. He collected Texas insects extensively in 1884, and it was probably then that he collected the five psocids he described in 1886. He discussed (1884) collecting insects, evidently mostly Lepidoptera, in the vicinity of Corpus Christi, visiting "heavy bottom lands," the coastal area, and "many broad pastures." He also made a wagon trip, for collecting purposes, of over 100 miles along the coast north of Corpus Christi. While we have not seen all the type series of his species, which are preserved in the Academy of Natural Sciences of Philadelphia, several specimens have been examined and found to bear no collecting data except a simple label, "Tex." Many natural habitats visited by Aaron probably have been greatly altered by agricultural and industrial developments; Cook (1908) has dealt with such changes in Texas.

Nathan Banks (1868–1953), for many years the only American student of psocids, described five psocids from Texas, and others described by him doubtless will be found in the State eventually, in addition to some here recorded for the first time. P. J. Chapman (1930), in what was the first thoroughly modern important systematic work on Nearctic psocids, contributed very few Texas records additional to citing the Aaron and Banks types. Neither Chapman himself, nor C. R. Crosby and S. C. Bishop, who elsewhere in the United States were extensive collectors of material studied by Chapman, are mentioned as the collectors of any Texas psocids.

The beginning student of psocids is advised to consult such general works as Badonnel (1943, 1951) and Borrow and DeLong (1954). For identification of material Chapman's paper (1930) is quite basic for the genera he treated, and there is a growing list of recent revisionary works. The classification of families and higher groups in this paper follows that used by Badonnel (1951).

Faunal affinities: Of the 47 species mentioned in this paper, 15 are generally distributed throughout the eastern half of the United States. These are as follows: *Echmepteryx hageni*, *Trogium pulsatorium*, *Psyllipsocus ramburii*, *Lachesilla forcepeta*, *L. major*, *L. nubilis*, *L. pedicularia*, *Ectopsocopsis pumilis*, *Peripsocus madidus*, *Psocus pollutus*, *P. bisignatus*, *Trichadenotecnum unum*, *Cerastipsocus venosus*, *Metylophorus purus*, and *Blaste quieta*. Of these, three are commonly spread by commerce and are found on both sides of the Atlantic. *Trogium pulsatorium* was with little doubt introduced into Texas by commerce since it is exclusively domestic in North America. *Lachesilla pedicularia* may be native to both Europe and North America, since it occurs commonly in both domestic and outdoor habitats in both continents. *Psyllipsocus ramburii* was probably introduced from Europe into domestic situations in North America, but it may be native to caves in Texas. It has not been recorded from as far south as Texas in dwellings, and the Texas specimens differ slightly in appearance from northern domestic material. Badonnel (1955) has recorded it from a cave in Angola.

Two species were probably introduced into Texas by commerce but are scarce in

North America generally. These are *Ectopsocus richardsi* and *Lepinotus reticulatus*. *E. richardsi* is not recorded in the North American literature; both the Texas specimens and material taken in Florida by the senior author were from domestic habitats. It has also been found in large numbers in a Boston (Mass.) warehouse. *L. reticulatus* has been recorded from only two other North American localities (Gurney, 1949).

Cerobasis guestfalica, taken at one Texas locality, is probably native to North America as well as Europe. It is generally distributed throughout the western States (Colorado, Utah, California, Washington, Arizona) and has been found at one Florida locality (unpublished records of senior author).

Twelve Texas species show a definite tropical affinity. These include the species of *Rhyopsocus*, *Tapinella*, and *Archipsocus*, *Pseudocaecilius citricola*, *Pseudoseopsis hellmani* *Psocathropos* sp., and *Psyllipsocus oculatus*. The first five genera of this list are largely tropical and reach their northern limit around the Gulf of Mexico and up the southeastern Atlantic Coast. *Tapinella* has not previously been recorded in the North American literature. *Psyllipsocus oculatus* was previously of uncertain locality as the holotype was found on plants from Mexico at a quarantine station at Laredo, Tex.

The family Amphientomidae, represented in Texas by *Pseudoseopsis hellmani*, n. sp., has not previously been recorded from the United States. It is well represented in tropical South America, Africa, and India. The genus *Pseudoseopsis* contains only one other species, *P. vilhenai* Badonnel from Angola. The generic assignment of the Texas species is tentative, and collection of additional material may show that a new genus is desirable for it.

Acknowledgments: The 1951 trip of the junior author was greatly aided by a grant from the Penrose Fund of the American Philosophical Society. He is also grateful for cooperation and courtesies received during the trip from the following entomologists at the places mentioned: O. P. Breland (Austin); L. J. Bottimer, C. L. Smith (Kerrville); J. B. R. Leary (Laredo); Paul C. Avery (Mission); F. A. Allen, R. A. Alexander, O. D. Deputy, R. B. Lattimore, C. H. Wallis, A. L. Williamson (Brownsville). Laboratory facilities and/or assistance in reaching collecting localities at Kerrville, Laredo, Mission, and Brownsville were generously provided by workers of the U. S. Department of Agriculture. Dr. B. C. Tharp, of the University of Texas, and Mrs. L. Irby Davis, of Harlingen, Tex., have since been of much assistance concerning the distribution of *Sabal texana*.

Suborder TROGIOMORPHA Roesler

Group ATROPETAE Pearman

Family LEPIDOPSOCIDAE Enderlein

Echmepteryx hageni (Packard)

Amphientomum hageni Packard, 1870, p. 405; *Echmepteryx agilis* Aaron, 1886, p. 17; *Echmepteryx hageni* (Parkard) Enderlein, 1906, p. 320; *id.*, Mockford 1955, p. 438.

Ten miles west of Orange, Oct. 8, 1951, beating oaks, 1 ♀, A. B. Gurney.

Family TROGIIDAE Enderlein

Lepinotus reticulatus Enderlein

Lepinotus reticulatus Enderlein, 1905, p. 31; *id.*, Gurney, 1949, p. 63.

Kerrville, Sept. 21, 1951, in floor litter of chicken house, 1 ♀, A. B. Gurney.

Trogium pulsatorium (Linnaeus)

Termes pulsatorius Linnaeus, 1758, p. 610. Synonymy discussed by Gurney, 1939.

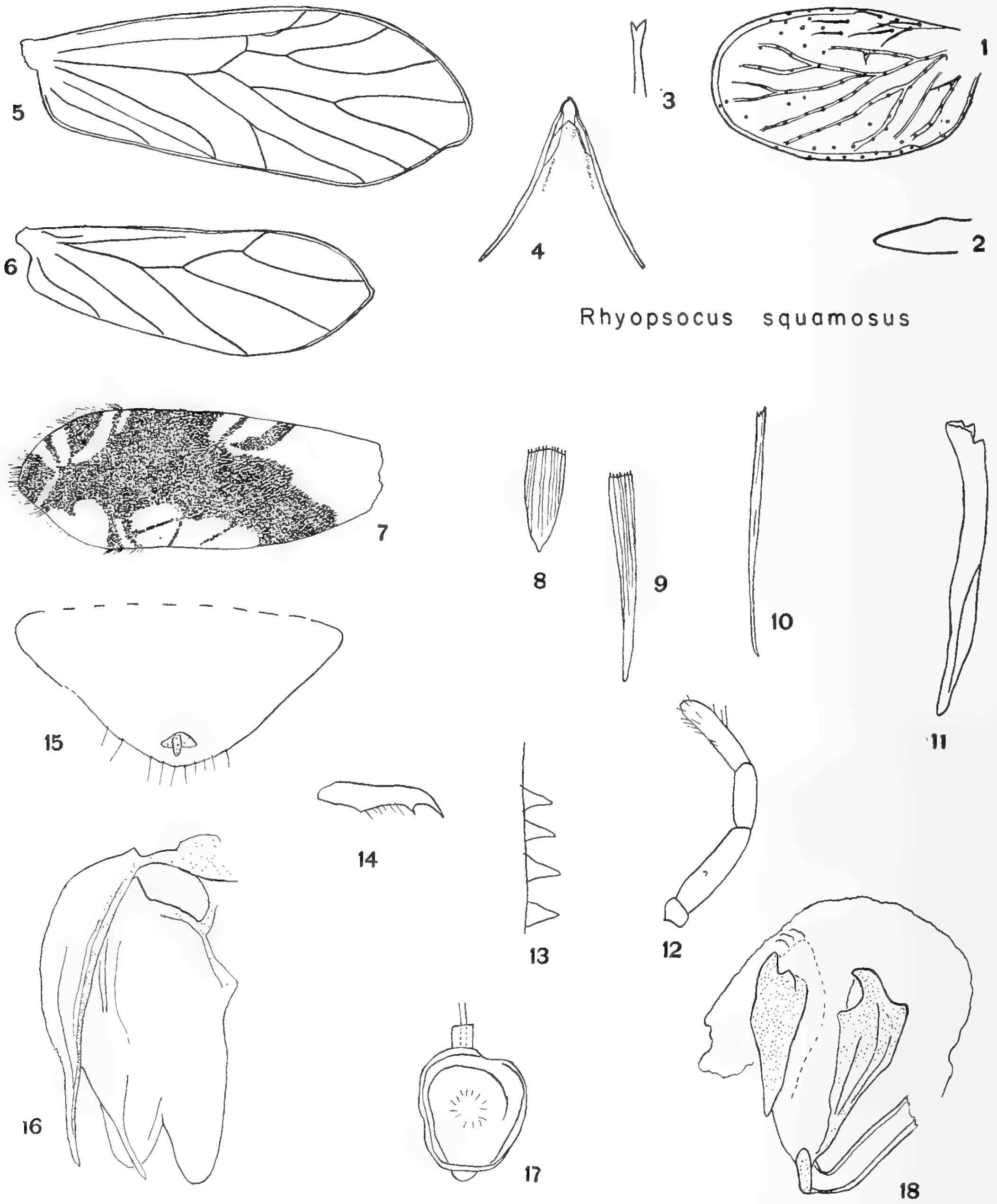
Corpus Christi, Aug. 1945, from house, 9 ♀, 4 nymphs, F. R. DuChanois.

Cerobasis guestfalica (Kolbe)

Hyperetes guestfalicus Kolbe, 1880, p. 132 (original description examined).

The spelling of *guestfalica* agrees with the feminine gender of *Cerobasis*, unlike *lapidarius* as given by Badonnel (1955, p. 32). The combination *C. muraria* used by Kolbe (1882, p. 212) also agrees. *Cerobasis* is comparable in gender to *Goniobasis* (shown as feminine by Brown, 1954, p. 124). Generic synonymy has been discussed by Gurney (1949) and given earlier by Roesler (1944, p. 131).

Kerrville State Park, Sept. 20, 1951, 7 ♀, 3 nymphs; Kerrville: U. S. Dept. of Agriculture



FIGS. 1–4.—*Rhyopsocus squamosus*, n. sp., male: 1, Front wing; 2, hind wing; 3, tip of lacinia; 4, parameres. FIGS. 5–18.—*Pseudoseopsis hellmani*, n. sp., female: 5, Front wing; 6, hind wing; 7, front wing, showing pattern of scales; 8, 9, scales of wing membrane; 10, scale from margin of wing; 11, lacinia; 12, maxillary palpus; 13, spines of row on front femur; 14, tarsal claw; 15, subgenital plate; 16, gonapophyses; 17, plate of opening of spermathecal duct; 18, sclerotization beside spermatheca.

Laboratory, Sept. 21, 1951, beating cedars, 5 ♀, 3 nymphs. Both collections by A. B. Gurney.

Family PSOQUILLIDAE Pearman

Rhyopsocus bentonae Sommerman

Rhyopsocus bentonae Sommerman, 1956, p. 146.

Corpus Christi, Oct. 6, 1951, beating palms, 1 ♂, 1 ♀, A. B. Gurney.

Rhyopsocus phillipsae Sommerman

Rhyopsocus phillipsae Sommerman, 1956, p. 146.

Ten miles west of Orange, Oct. 8, 1951, beating oaks, 1 ♂, A. B. Gurney.

Rhyopsocus squamosus, n. sp.

Figs. 1–4

Diagnosis.—Differs from *R. speciophilus disparilis* (Pearman), and presumably *R. s. speciophilus* (Enderlein), in smaller size (body length of that species 1.4 mm) and relatively shorter wings. Differs from *R. afer* (Badonnel) in paler color of head and thorax, relatively shorter wings, and in details of male genitalia. Differs from *R. bentonae* Sommerman in microptery and in details of male genitalia. Differs from *R. phillipsae* Sommerman in lack of abdominal tergal lobes of male, genitalic details, and shorter wings.

Holotype ♂.—Measurements: Total body length 1.17 mm; forewing length 0.37 mm; hind tibia length 0.20 mm; hind tarsus: T_1 0.13 mm, T_2 0.04 mm, T_3 0.04 mm.

Morphology.—Brachypterous; forewings extending to about half length of abdomen and showing very faint venation (Fig. 1). Hindwings (Fig. 2) slightly longer than metathorax. IO/D = 1.62; PO/D[2] = 0.50. Anteroposterior diameter of eye 0.173 mm. Epicranial and frontal sutures present. Ocelli absent. Lacinia (Fig. 3) of usual type for the genus. Terminal segment of maxillary palpus clavate. Thoracic nota of the short-winged type with no prominent lobes. All tibiae with three terminal spurs. Hypandrium unmodified. Parameres (Fig. 4) long, slender, diverging anteriorly. Sclerites of the penis canal complex, lacking denticles. Paraprocts each with a strong spine near inner margin and several cilia apparently lacking basal rosettes.

Color (from paratype in alcohol).—Eyes black; three brown pigment spots in ocellar positions; a few other tiny brown spots in front, otherwise head, body, and appendages pale straw-colored.

Type locality.—Texas, Olmito Resaca, near Brownsville, holotype ♂, 1 paratype, ♂, 1 nymph, Oct. 4, 1951, on vegetation, A. B. Gurney.

Types in U. S. National Museum, no. 62261.

Discussion.—This species is considered a brachypterous *Rhyopsocus* because its hind wings and lack of ocelli exclude it from the genera *Eosilla* Rib. and *Empheriella* Enderlein, and its *Rhyopsocus*-type lacinia exclude it from *Balliella* Badonnel. We consider *Deipnopsocus* Enderlein and *Rhyopsocopsis* Pearman (new synonymy) synonyms of *Rhyopsocus* Hagen. *Deipnopsocus* has already been placed in synonymy by Badonnel (1949, p. 29).

Rhyopsocus texanus (Banks)

Deipnopsocus texanus Banks, 1930, p. 223.

Type locality, Brownsville. This species cannot be recognized from the original description. It is discussed by Sommerman (1956). The type is in the Museum of Comparative Zoology, Cambridge, Mass.

Group PSOCATROPETAE Pearman

Family PSYLLIPSOCIDAE Enderlein

Psyllipsocus ramburii Selys-Longchamps

Psyllipsocus ramburii Selys-Longchamps, 1872, p. 146. Synonymy listed by Gurney, 1943.

Sonora, Wyatt Cave, July 23, 1926, 1 ♀; Hayes County: San Marcos, Sept. 15, 1953, under rocks in entrance to Ezel's Cave, 5 ♀, 2 nymphs, E. L. Mockford.

Psyllipsocus oculatus Gurney

Figs. 52–53

Psyllipsocus oculatus Gurney 1943, p. 214.

The female of this species, previously undescribed, is similar to the male in size and color. The gonapophyses (Fig. 53) differ from those of the other American species in possessing a rudimentary internal valve.

[2] It is not clear from Badonnel's explanation of PO (Badonnel, 1955, p. 18) exactly what is meant. As stated, it is a simple linear measurement which should be expressed in units and which would not show the prominence of the eye. In the text of Badonnel's paper, no units accompany the figures. Figures of comparable size, and which do express the prominence of the eye fairly satisfactorily are obtained by dividing the transverse diameter by the anteroposterior diameter (both measurements taken in dorsal view of the head.) Our figures for PO/D were obtained in this manner.

Mission, Sept. 30, 1951, beating palms, 1 ♂, 1 ♀, A. B. Gurney.

Psocathropos sp.

This species was discussed by Gurney (1949) as *P. lachlani* Ribaga, but until more information is available it may be best to avoid applying that specific name to our United States population. We are using Ribaga's original spelling of the generic name.

Houston, in house, July 26, 1941, M. Cockrell, 3 ♂, 2 ♀, 2 nymphs; Brownsville, on loose paper in laboratory, Oct. 3, 1951, A. B. Gurney, 1 ♀; Brownsville, in house, Oct. 31, 1951, F. A. Allen, 3 ♂, 1 ♀, 2 nymphs.

Suborder Troctomorpha Roesler

Group Amphientometae Pearman

Family Amphientomidae Enderlein

Pseudoseopsis hellmani, n. sp.

Figs. 5–18

Diagnosis.—Differs from the African species *P. vilhenai* Badonnel in presence of ocelli and in shape of the gonapophyses of segment 9.

Holotype ♀.—Measurements: Total body length 2.83 mm; forewing length 2.73 mm; hindwing length 2.23 mm; hind tibia length 1.07 mm; hind tarsus: T_1 0.67 mm, T_2 0.107 mm, T_3 0.107 mm.

Morphology (from holotype and paratypes).—Eyes bare, their posterior margins coinciding with the straight posterior margin of the vertex viewed from above. Three distinct ocelli located far apart, the laterals immediately beyond and below ends of frontal sutures and near compound eyes. Antennae of 12 segments, the basal flagellar segments quite long. Numerous indistinct striae on all flagellar segments, very close together toward the tip. Maxillary palpi covered with tiny hairs, interspersed with larger hairs arranged roughly in rows encircling the segments. Second segment showing three papillae (sensillae?) on one palpus of a paratype, only one on the other palpus; third segment somewhat shorter than second and fourth. Lacinia as in Fig. 11, slightly curved near tip. Forewing (Fig. 5) with a slightly extended apex, the extended portion actually rounded. Distal portion of Sc distinct. Scales of membrane mostly short and wide with the apex truncate (Fig. 8), but some quite slender (Fig. 9). Marginal scales slender; some extremely slender with the apex slightly emarginate (Fig. 10). Hind wing with acute apex; vein R_1 nearly reaching wing margin; vein Ax strongly curved. Scales mostly slender; some marginal scales extremely long and slender with emarginate apices.

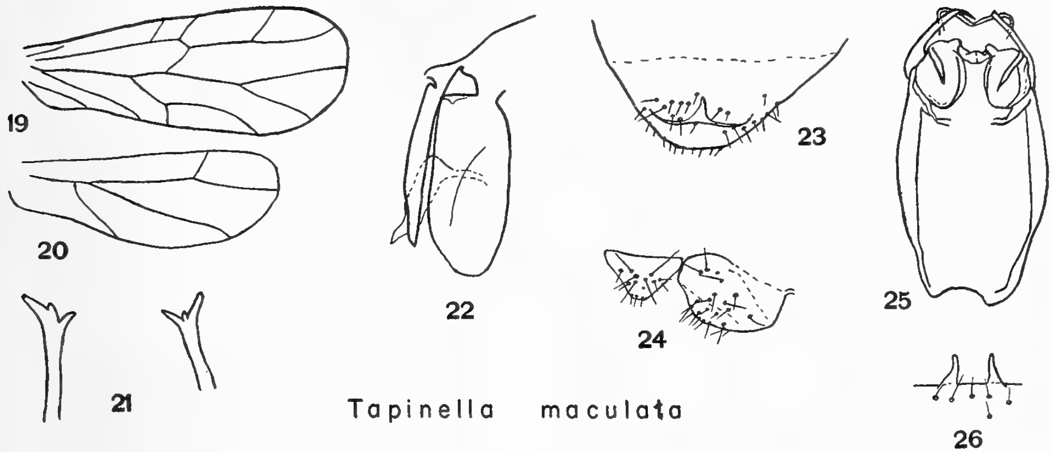
Anterior femur with a row of 25 spines (Fig. 13) with wide bases, not articulated. Other spination of legs summarized in Table 1. Twenty-two ctenidiobothria on T_1 of hind leg. A small comb running to the claw at apex of T_3 of each leg. Claw with single preapical tooth and a row of tiny hairs ventrally (Fig. 14).

Genitalia and terminalia.—Subgenital plate (Fig. 15) with a sclerotized process. Gonapophyses (Fig. 16): ventral valve long, slender, acuminate apically with a sclerotized inner edge; dorsal valve acuminate apically; lobes of external valve rounded apically. Sclerite of spermathecal opening (Fig. 17) and sclerite beside spermatheca (Fig. 18) as illustrated. Epiproct and paraprocts covered with long, slender hairs; paraprocts each with a field of hairs with basal rosettes.

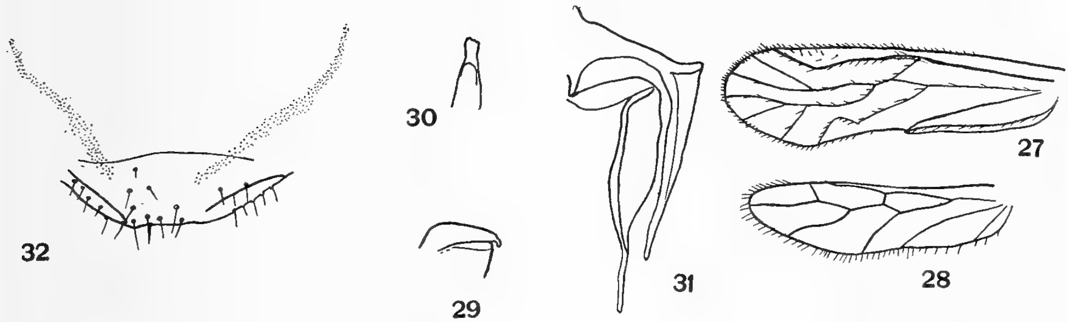
Scale color pattern (from dry specimens).—Head except eyes covered with slender, curved pale-gray scales. Mesonotum covered with short, wide white scales. Femora covered with dirty-gray and brown scales; fore and middle tibiae

Table 1.—Spination of Legs in Pseudoseopsis hellmani

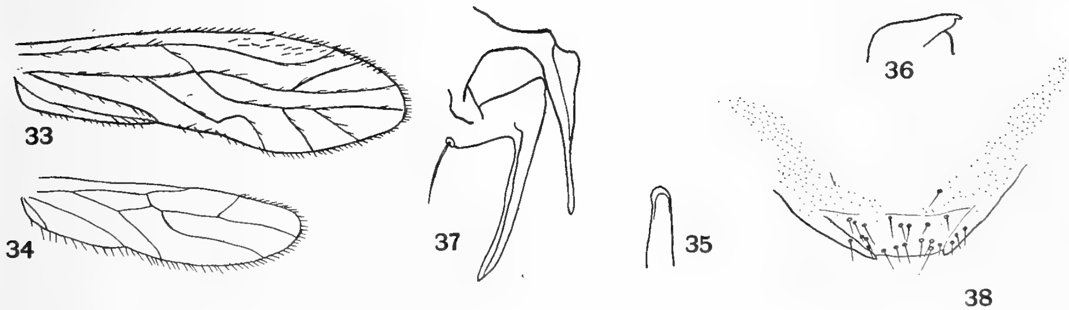
Region of leg	Number of spines on—		
	Prothoracic leg	Mesothoracic leg	Metathoracic leg
Femur apex	None	1 lateral 1 curved, external	1 lateral 1 curved, external
Body of tibia	None	1, 1/3 distance from base 1 near apex	External—1, 1/8 from base 1, 2/8 from base 2, 3/8 from base 2, 4/8 from base Lateral 1, 6/8 from base Internal 1, 5/8 from base 2, 6/8 from base 2, 7/8 from base
Tibia apex	1	5	6
First tarsal segment	3 near apex, ventral 2 apical, ventral	3 near apex, ventral 2 apical, ventral	3 near apex, ventral 2 apical, ventral
Second tarsal segment	1 apical, ventral	2 apical, ventral	1 apical, ventral
Third tarsal segment	None	None	None



Tapinella maculata



Caecilius palmarum



Caecilius caloclypeus

FIGS. 19–24.—*Tapinella maculata*, n. sp., female; 25–26, same, male: 19, Front wing; 20, hind wing; 21, tips of laciniae; 22, gonapophyses; 23, subgenital plate; 24, epiproct and paraproct; 25, phallic frame; 26, posterior margin of 9th abdominal tergite. FIGS. 27–32.—*Caecilius palmarum*, n. sp., female: 27, Front wing; 28, hind wing; 29, tip of mandible; 30, tip of lacinia; 31, gonapophyses; 32, subgenital plate. FIGS. 33–38.—*Caecilius caloclypeus*, n. sp., female: 33, Front wing; 34, hind wing; 35, tip of lacinia; 36, tip of mandible; 37, gonapophyses; 38, subgenital plate.

covered with brown scales except for an apical band of white scales on each. Hind tibia with a basal, medial, and apical band of white scales, the remainder covered with brown scales. Tarsi: each T_1 with an apical band of dirty white scales, the remainders covered with brown scales. Forewings marked with a complex pattern of gray and white scales (Fig. 7); in areas of white scales adjacent to the wing margin, the long marginal scales are white. Hind wings not visible on the dry specimens. Scales very sparse on abdomen.

Type locality.—Texas, Ezel's Cave (near San Marcos, Hayes County), holotype ♀, 4 ♀ paratypes and 2 nymphs, Sept. 15, 1953, on limestone outcrop at mouth of cave, R. E. Hellman and E. L. Mockford.

Holotype and one *paratype* in U. S. National Museum, no. 63276; remaining paratypes in E. L. Mockford Collection.

Discussion.—We have chosen the following characters as important for generic diagnosis in the Amphientomidae: (1) Shape of forewing apex, (2) nature of spines in row on femur I (they may be numerous, wide, and unarticulated, or few, slender, and articulated), (3) number of preapical teeth on tarsal claws, (4) curvature of lacinia, (5) shape of scale apices and pattern of striation on scales, and (6) presence or absence, and size and number of sensory cones on second segment of maxillary palpi. The Texas species agrees with the genotype of *Pseudoseopsis* in four of these characters, whereas it agrees with no other closely related genus in more than three. It is also very similar to *P. vilhenai* in general shape of the wings.

This species is named for Robert E. Hellman, of New York City, a herpetologist and former classmate of the senior author at the University of Florida. His companionship and aid on many field trips, including the one on which the type series of this species was taken, are gratefully acknowledged.

Group Nanopsocetae Pearman

Family Liposcelidae Enderlein

Genus **Liposcelis** Motschulsky

Dr. Kathryn M. Sommerman has very kindly examined our material in this genus and informs us (in litt.) that it contains five species, three of which are described as new in a paper which she has in press.

Family Pachytroctidae Enderlein

Tapinella maculata, n. sp.

Figs. 19–24

Diagnosis.—Differs from *T. formosana* Enderlein and *Psylloneura williamsi* Banks (probably a *Tapinella*) in color, these species being pale yellow-brown, unmarked. Differs from *T. castanea* Pearman, *T. africana* Badonnel, *T. squamosa* Badonnel, and *T. curvata* Badonnel also in color, these species being largely dark brown.

Holotype ♀.—Macropterous. Measurements: Total body length 1.60 mm; forewing length 1.40 mm; hindwing length 1.07 mm; hind tibia length 0.53 mm; hind tarsus: T_1 0.24 mm, T_2 0.05 mm, T_3 0.07 mm.

Morphology.—Compound eyes not exceeding posterior margin of head. Epicranial and frontal sutures distinct. Ocellar triangle slightly nearer clypeus than posterior margin of head. Suture between clypeus and front straight when viewed from above. Mouthparts of usual type for the group. Lacinia slender, tridentate at apex (Fig. 21). Maxillary palpi lacking specialized sensory spines. Antennae of 15 segments which are secondarily ringed from the distal half of F_5 outward to the tip. Wings unmarked. Venation of usual form for the genus; closed cell absent in hind wing. Abdomen completely membranous, including genitalia. Gonapophyses as in Fig. 22, closely associated with an appendage from the paraproct, shown under the external valve in the figure. Subgenital plate bearing T-shaped sclerite with arms long and curved.

Color (in alcohol).— Ground color cream, eyes black. A pale red-brown band from each compound eye through base of antenna to about midpoint of clypeus, the two bands meeting there. An irregular dark red-brown band on each side of thorax just above coxal insertions. Abdomen marked with six series of red-brown spots from segments 1 through 8 (one spot in each series per segment): two dorsal series of rather pale spots wider than long, a paired dorso-lateral series of dark U-shaped spots with open ends of U-s directed posteriorly, and a paired ventro-lateral series of spots longer than wide.

Allotype ♂.—Apterous. Measurements: Total body length, 1.13 mm; hind tibia length 0.40 mm; hind tarsus: T_1 0.13 mm, T_2 0.05 mm, T_3 0.07 mm. Differs from holotype in smaller size, aptery and associated characters of absence of ocelli and flat notal lobes, and absence of frontal sutures. Genitalia as in Fig. 25.

Variation.—Some female paratypes are apterous, lack ocelli, and lack all trace of subdivisions of the pterothoracic tergites (in macropterous forms each pterothoracic tergite is composed of a trilobed scutum and separate scutellum); these have only a trace of frontal sutures. Among alate females much variation exists in details of venation; it is seldom bilaterally symmetrical. Variations observed are: (1) A closed cell in hind wing at point of first branching of the main vein, (2) radial branch in hindwing disconnected from main vein, (3) a closed cell in forewing formed by presence of two R-M crossveins, (4) R_s in forewing 3-branched, (5) Cu_{1b} in forewing set at angle of Cu stem, (6) R + M in forewing joined at a point.

Type locality.—Texas, Mission, holotype ♀, allotype ♂, 2♂ paratypes, 7 alate ♀ paratypes, 20 apterous ♀ paratypes, and 5 nymphs, Sept. 30, 1951, on palm leaves, A. B. Gurney. Other paratypes—Texas, Palm Grove near Brownsville, 5 apterous ♀, 1 nymph (not paratype), Oct. 2 and 3, 1951, beating palm leaves; Olmito Resaca, 1 apterous ♀, 1 nymph (not paratype), Oct. 4, 1951, beating vegetation; all collected by A. B. Gurney.

Types in U. S. National Museum, no. 62264.

Tapinella sp.

A single female taken at Weslaco on dead palm leaves, Oct. 1, 1951, differs from *T. maculata* in its uniform straw-brown color (slightly darker on head and terminal abdominal segments). It is probably a new species since the arms of the T-shaped sclerite are longer than in *T. maculata*.

Suborder PSOCOMORPHA Weber

Group CAECILIETAE Pearman

Family CAECILIIDAE Enderlein

Caecilius palmarum, n. sp.

Figs. 27–32

Diagnosis.—A pale yellow species, differing from the other North American species with that coloration (*C. aurantiacus* (Hagen), *C. manteri* Sommerman, *C. sommermanae* Mockford) in being marked with a brown band longitudinally through the vertex, front, and clypeus. Head and wings narrower than in these other species.

Holotype ♀.—Measurements: Total body length 2.67 mm; forewing length 2.57 mm; hindwing length 1.87 mm; hind tibia length 0.90 mm; hind tarsus: T_1 0.267 mm, T_2 0.107 mm.

Morphology.—IO/D = 1.28. Lacinia with a slender, blunt tip (Fig. 30). Tip of mandible bearing a hooked tooth. Wing venation and ciliation normal for the genus. A long fusion of R_s and M in both fore and hind wings. Gonapophyses (Fig. 31) straight with slender tips. Subgenital plate (Fig. 32) with sclerotized area in the form of a pair of slender, converging bands visible after staining.

Color (in alcohol).—Eyes black. Antennae, anal veins, and veins of apical one-third of forewing straw colored. Rest of body pale yellow except for a pale brown band from immediately anterior to occiput on vertex to lower border of clypeus, and pale brown lateral areas on thoracic tergal lobes.

Type locality.—Texas, Olmito Resaca, 9 miles north of Brownsville, holotype ♀, 50 ♀ paratypes, and 57 nymphs, Oct. 4, 1951, beating palms and palmettoes, A. B. Gurney. Other paratypes (not including nymphs), Palm Grove near Brownsville, 14 ♀, numerous nymphs, October 1 and 3, 1951, beating dead leaves, Gurney & Allen; western outskirts of Corpus Christi, 70 ♀, 24 nymphs, Oct. 6, 1951, beating palm leaves, A. B. Gurney.

Types in U. S. National Museum, no. 63237.

Caecilius calocylpeus, n. sp.

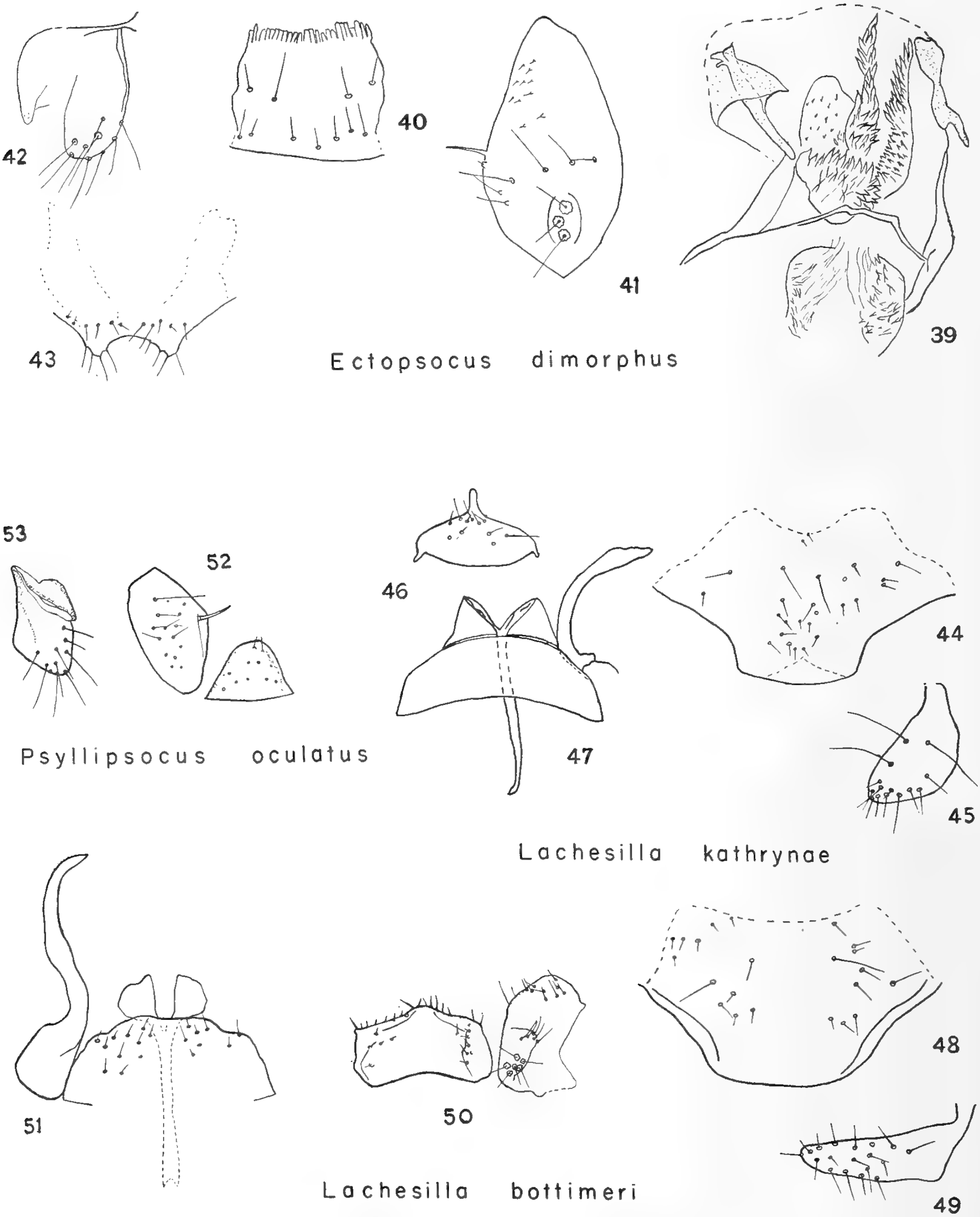
Figs. 33–38

Diagnosis.—A pale-yellow species, differing from the other North American species with that coloration in that the only conspicuous body marks are several pairs of clypeal striations.

Holotype ♀.—Measurements: Total body length 2.93 mm; forewing length 2.87 mm; hindwing length 2.13 mm; hind tibia length 1.07 mm; hind tarsus: T_1 0.267 mm; T_2 0.107 mm.

Morphology.—IO/D = 1.57. Lacinia rounded at tip. Tip of mandible bearing a straight tooth. Wing venation and ciliation normal for the genus. A short fusion of both R_s and M in both fore and hind wings. Gonapophyses (Fig. 37) a pair of curved blades; valve of 9th bearing a stout basal seta. Subgenital plate (Fig. 38) with sclerotized area as a pair of converging bands, wider than in *C. palmarum*, visible after staining.

Color (in alcohol).—Eyes black. Antennae, fore tibiae and tarsi, and veins in apical half of forewing straw colored. Rest of body pale yellow except for seven pairs of purplish brown striae on clypeus and a faint purplish brown band on each



Figs. 39–40.—*Ectopsocus dimorphus*, n. sp., male; 41–43, same, female: 39, Apex of phallic frame (somewhat distorted) and penis sclerotizations; 40, ninth abdominal tergite with comb; 41, paraproct; 42, gonapophyses; 43, subgenital plate. Figs. 44–45.—*Lachesilla kathrynae*, n. sp., female; 46–47, same, male: 44, Subgenital plate; 45, gonapophysis; 46, epiproct; 47, hypandrium and parameres. Figs. 48–49.—*Lachesilla bottimeri*, n. sp., female; 50–51, same, male: 48, Subgenital plate; 49, gonapophysis; 50, epiproct and paraproct; 51, hypandrium and parameres. Figs. 52–53.—*Psyllipsocus oculatus* Gurney, female: 52, paraproct and epiproct; 53, gonapophyses. (All drawings by the senior author.)

side running the length of the lateral prothoracic sclerites.

Type locality.—Texas, Palm Grove near Brownsville, holotype ♀ and 2 nymphs, Oct. 1, 1951, beating palms. Paratypes—Mission, 1 ♀, Sept. 30, 1951, beating palmate palms; Olmito Resaca near Brownsville, 1 ♀, Oct. 4, 1951, beating palms and palmettoes. All collected by A. B. Gurney.

Types in U. S. National Museum, no. 63238.

Group Homilopsocidea Pearman

Family Peripsocidae Pearman

Peripsocus madidus (Hagen)

Psocus madidus Hagen, 1861, p. 12. Synonymy presented by Chapman, 1930.

Bexar County, May 5, 1938, swept from peach, 4 ♂, 14 ♀, 1 nymph.

Ectopsocus richardsi (Pearman)

Chaetopsocus richardsi Pearman, 1929, p. 105; *Ectopsocus richardsi* Pearman, 1942, p. 290.

Houston, April 15, 1948, in stored rice, 3 ♂, 2 ♀, R. T. Cotton; Beaumont, July 18, 1936, cracks in floor in rice mill, 1 ♂, 1 ♀, A. L. Balzer.

Ectopsocus dimorphus, n. sp.

Figs. 39–43

Diagnosis.—Very similar to *E. pearmani* Ball of Belgian Congo, differing chiefly in shape of subgenital plate, the apical lobes being further apart in the present species; also differing slightly in several measurements. Males micropterous (nearly apterous); females dimorphic: macropterous and micropterous.

Holotype ♀.—Macropterous. Measurements: Total body length 1.43 mm; forewing length 1.40 mm; hindwing length 1.17 mm; hind tibia length 0.50 mm; hind tarsus: T_1 0.187 mm, T_2 0.080 mm.

Morphology.—Epicranial and frontal sutures distinct. Eyes small but prominent. IO/D = 2.9; PO/D = 0.65; anteroposterior diameter of eye 0.133 mm. Vertex, front, and postclypeus covered with curved setae. Antenna somewhat shorter than forewing. Ratio of f_1 to Sc + P = 1.8; ratio of f_1 to $f_2 + f_3$ = 0.76. Eight ctenidiobothria on first segment of hind tarsus; none on that of middle tarsus. Stigma sack of normal length, rounded apically. In forewing R_s meets M for a short distance, or the two are connected by a short cross-vein. Hairs on wings restricted to stem of R, stem of M + Cu, and Ax in forewing; these hairs few and short. Gonapophyses (Fig. 42): internal valve very minute; ventral valve with spinulose apex; external valve a thumblike flap, mostly sclerotized, bearing 10 setae distally. Subgenital plate (Fig. 43) bilobed apically, each lobe with several marginal setae. Paraprocts (Fig. 41) bearing four trichobothria and a median row of five setae; duplex spine of inner margin very minute.

Color (in alcohol).—Eyes black. Body and appendages generally tawny brown. Membranous portion of abdomen pale, ringed with brown (subcuticular pigment). Wings unmarked, slightly tawny.

Allotype ♂.—Micropterous. Measurements: Total body length 1.27 mm; hind tibia length 0.467 mm; hind tarsus: T_1 0.147 mm, T_2 0.080 mm. Differs from holotype in much smaller size and microptery; wings represented by two pairs of small fleshy lobes, each bearing a few bristles. IO/D = 2.2. PO/D = 0.6, anteroposterior diameter of eye 0.133 mm. Ocelli absent. Thoracic tergites of micropterous type, with large prothoracic tergite and pterothoracic tergites not divided into lobes. Similar in color to holotype, but abdominal rings more distinct. Each abdominal tergite bearing a distinct row of bristles. Tergite 9 adorned with a comb of teeth (Fig. 40). Penis and parameres (Fig. 39) with external parameres rather far apart so that aedeagal arch is wide. Sclerotizations of penis consisting of a pair of rods spinose apically, a hook on each side externally (not symmetrical), and other small sclerites of the canal.

Variation.—Micropterous females occur with wing pads not reaching the abdomen. These have typical undivided thoracic tergites of the short-winged type, and ocelli represented by three small subcuticular pigment spots. Setae of the vertex, front, and postclypeus are somewhat shorter than in the macropterous forms.

Type locality.—Texas, Brownwood (Brown County), holotype ♀ and a large number of macropterous paratype ♀♀ May 14, 1939, from peach, L. S. Jones. Allotype ♂, Texas, Tyler, Nov. 24, 1939, on cover crop in peach orchard, associated with 4 micropterous ♀ paratypes and 2 nymphs, L. D. Christensen. Other paratypes—Texas, Brownwood (Brown County), 1 macropterous ♀, March 26–27, 1939, from peach, L. S. Jones; Bangs (Brown County), 4 macropterous ♀, June 8, 1938, sweeping peach and cover crops, Christensen et al.; Brown County, 1 micropterous ♀, 2 macropterous ♀, July 14, 1937, peach orchard, Turner & Anderson; Bexar County, 11 macropterous ♀, May 5, 1938, on peach, W. R. Turner; same locality, 1 macropterous ♀, 6 micropterous ♀, Nov. 23, 1938, on soil under grass and leaves in peach orchard, W. F. Turner; Dallas, 1 macropterous ♀, May 25, 1939, on cane, W. G. Bruce; El Paso County, 7 micropterous ♀, July 22, 1937, on soil in peach orchard, Turner & Anderson. New Mexico, Albuquerque, 8 micropterous ♀, 1 ♂, 1 nymph, March 3, 1938, from soil, L. D. Christensen; same locality, 2 micropterous ♀, December 9, 1939, from soil, L. D. Christensen. California, Cherry Valley, 3 macropterous ♀, May 7, 1937, on peach and in soil, Christensen & Jones; Hemet, 1 ♂, 1 micropterous ♀, Jan. 13, 1938, in soil, Christensen et al.; Los Angeles County, Ranger Station at west fork of San Gabriel River near Mount Wilson, elevation 3,200 feet, 1 ♂, 1 micropterous ♀, Sept. 9, 1953, in ground litter under California Live Oak, E. L. Mockford; Georgia, Decatur County, Woodruff Dam site near Florida line, 1 ♂, 1 micropterous ♀, June 2, 1953, in ground litter on hillside in newly cleared field, E. L. Mockford.

Holotype, *allotype*, and most of *paratypes* in U. S. National Museum, no. 63239.

Ectopsocopsis pumilis (Banks)

Peripsocus pumilis Banks, 1920, p. 313; *Ectopsocus pumilis* (Banks), Chapman, 1930, p. 380.

Beaumont, Oct. 8, 1951, beating palms, and in rice straw near rice experiment station, 4 ♂, 9 ♀; western outskirts of Corpus Christi, Oct. 6, 1951, beating palms, 3 ♀, 1 nymph; 9 miles north of Brownsville, Oct. 4, 1951, beating palms and palmettoes, 1 ♀, 2 nymphs. All collected by A. B. Gurney.

The genus *Ectopsocopsis* has recently been described by Badonnel (1955, pp. 185, 193).

Family Pseudocaeciliidae Pearman

Pseudocaecilius citricola (Ashmead), n. comb.

Psocus citricola Ashmead, 1879, p. 228; *Caecilius pretiosus* Banks, 1920, p. 311 (new synonymy); *Pseudocaecilius wolcotti* Banks, 1924, p. 423 (new synonymy); *Pseudocaecilius pretiosus* (Banks), Chapman, 1930, p. 332.

San Antonio, 3 ♀ (holotype and paratypes of *C. pretiosus* Banks).

Four specimens on paper points were found in the U.S. National Museum which apparently are cotypes of *Psocus citricola* Ashmead. Each bears a printed label "Jacksonville, Fla." and a handwritten label "*Psocus citricola* Ashm." The writing on the latter labels has been identified as that of Ashmead by A. B. Gahan, long a Hymenoptera specialist at the National Museum. Ashmead lived in Jacksonville when he published the description of this species, and most of his collecting was done locally. From the dry specimens it can be seen that all are the same species, a *Pseudocaecilius*. One, here selected as lectotype (U.S.-N.M. type no. 63247), has been soaked from its point in KOH solution and mounted on a slide for critical comparison with paratypes of *pretiosus* and *wolcotti* borrowed from the M.C.Z. Since no differences of specific magnitude have been noted in wing markings, venation, ciliation, measurements of head, wings, and hind legs, and number of ctenidiobothria on posterior T_1 (genitalia can not be compared as none of the *citricola* specimens have abdomens), we regard the latter two forms as synonyms of *citricola*.

Family Lachesillidae Badonnel

Lachesilla forcepeta Chapman

Lachesilla forcepeta Chapman, 1930, p. 348.

Kerrville State Park, Sept. 20, 1951, beaten from cedar, 1 ♀, 2 nymphs, A. B. Gurney.

Lachesilla major Chapman

Lachesilla forcepeta var. *major* Chapman, 1930, p. 349; *Lachesilla major* Chapman, Sommerman, 1946, p. 645.

Ten miles west of Orange, Oct. 8, 1951, beating live oak and other oaks, A. B. Gurney.

Lachesilla nubilis (Aaron)

Caecilius nubilis Aaron, 1886, p. 13; *Lachesilla nubilis* (Aaron), Chapman, 1930, p. 351.

Kerrville, Sept. 21, 1951, at light in laboratory, 1 ♂, A. B. Gurney; Dilly, Frio State Park, Sept. 24, 1951, 1 ♂, A. B. Gurney; Dallas, Apr. 5, 1905, in dry cotton bolls, 2 ♂, 3 ♀, 9 nymphs. Type locality "Southern Texas" (Aaron). See records in Sommerman, 1946, p. 648.

Lachesilla pedicularia (Linnaeus)

Hemerobius pedicularia Linnaeus, 1758, p. 551. Synonymy presented by Enderlein, 1919, p. 16.

Dallas, April 15, 1908, 1 ♂, 1 ♀. F. C. Bishopp.

Lachesilla penta Sommerman

Lachesilla penta Sommerman, 1946, p. 652.

Corpus Christi State Park, Oct. 6, 1951, beating mesquite and other vegetation, 2 ♀, 2 nymphs. Type locality, Brownsville, May 2, 1904, 1 ♂, 1 ♀, H. S. Barber.

Lachesilla rena Sommerman

Lachesilla rena Sommerman, 1946, p. 653.

A male paratype was recorded from Brownwood, Tex., by Sommerman.

Lachesilla kathrynae, n. sp.

Figs. 44–47

Diagnosis.—A member of the species group including *L. anna* Sommerman, *L. chapmani* Sommerman, *L. forcepeta* Chapman, *L. contraforcepeta* Chapman, and *L. major* Chapman. Very similar to *L. chapmani*, differing in details of the genitalia in both sexes.

Holotype ♂.—Measurements: Total body length 1.33 mm; forewing length 1.53 mm; hindwing length 1.17 mm; hind tibia length 0.63 mm; hind tarsus: T_1 0.267 mm, T_2 0.080 mm.

Morphology.—Genitalia (Figs. 46, 47) with several characters typical of the species group—hypandrium of a large basal and small apical sclerite, the apical sclerite with a deep v-shaped cleft in its posterior margin. Parameres fused basally into a rod, but this rod curved rather than straight as in closely related species; parameres diverging apically, the two arms joined to the hypandrium along its cleft. Claspers curved out, stouter than in *L. chapmani*, and bulging near their apices. Paraprocts each with a ridge arising near sense tubercles and running to inner margins. Epiproct bearing a conspicuous apical tubercle as in *L. chapmani*.

Color (in alcohol).—Eyes black; antennae, wing veins, and dotted areas on vertex straw-colored. Body colorless except for red brown pigment distributed as follows: on cervical sclerites, on mesepimeral sutures, inner surfaces of coxae; two rows on each side of abdominal tergites 2 through 5, the dorsal rows continuing as weak spots to tergite 7.

Allotype ♀.—Measurements: Total body length 1.70 mm; forewing length 1.93 mm; hindwing length 1.37 mm; hind tibia length 0.73 mm; hind tarsus: T_1 0.280 mm, T_2 0.093 mm.

Morphology.—Gonapophyses (Fig. 45) a simple pair of flaps, narrowed near base and expanded preapically. Subgenital plate (Fig. 44) with an extended apical region; a more heavily sclerotized area (detectable by staining with acid fuchsin) outlined in dashed lines on the figure. Lacking a colored ventral interior plate.

Color (in alcohol).—Similar to holotype but abdominal red-brown spots present only on tergites 2 through 4.

Variation.—Some ♂ paratypes show the red-brown abdominal marks only on tergites 2 through 4, while some ♀ paratypes show them only on tergites 2 and 3.

Type locality.—Texas, Palm Grove near Brownsville, holotype ♂, allotype ♀, 5 ♂, and 17 ♀ paratypes, Oct. 3, 1951, beating dead palm leaves. Other paratypes: type locality, 5 ♂, 1 ♀, Oct. 1, 1951, beating palms; Mission, 2 ♂, 3 ♀, 1 nymph (not paratype), Sept. 30, 1951, beating palm leaves; Olmito Resaca near Brownsville, 1 ♀, Oct. 4, 1951, beating palms and palmettoes. All collected by A. B. Gurney.

Types in U. S. National Museum, no. 63240.

We are glad to dedicate this species to Dr. Kathryn M. Sommerman, in recognition of her many scholarly and highly basic studies of Nearctic psocids.

Lachesilla bottimeri, n. sp.

Figs. 48–51

Diagnosis.—A member of the same species group as *L. kathrynae*, differing from all other members in possession of very long, incurved claspers in the male (Fig. 51) and in other genitalic details in both sexes.

Holotype ♂.—Measurements: Total body length 1.40 mm, forewing length 1.67 mm; hindwing length 1.27 mm; hind tibia length 0.70 mm; hind tarsus: T_1 0.213 mm, T_2 0.093 mm.

Morphology.—Genitalia with usual characters typical of the species group. Cleft in apical sclerite of hypandrium U-shaped. Rod formed by fused parameres straight; parameres diverging apically and joined to hypandrium along U-shaped cleft. Claspers long (exceeding tip of abdomen) and slender, curving in at their tips; tips sharply pointed.

Color (in alcohol).—Eyes black; antennae and thorax above tan; dotted areas of vertex, thorax below, legs, and genitalia pale straw-colored. Wing membranes clear, the veins brown. Remainder of head and abdomen unpigmented except for dark red-brown marks (also on thorax) distributed as follows: a line over each antennal insertion, the two joined by a pale brown line across front; the two lines above antennae each joined to a band starting posterior to antenna and continuing to abdominal segment 7, widest on abdomen.

Allotype ♀.—Measurements: Total body length 1.67 mm; forewing length 1.73 mm; hindwing length 1.33 mm; hind tibia length 0.73 mm; hind tarsus: T_1 0.200 mm; T_2 0.080 mm.

Morphology.—Gonapophyses (Fig. 49) a pair of rather elongate flaps, narrow at base and directed mesally near base. Subgenital plate (Fig. 48) with a very weakly delineated extended apical region; a more heavily sclerotized area (detectable by staining with acid fuchsin) outlined proximally in dashed lines and extending distally to the apex. A colored ventral interior plate absent.

Color same as in holotype.

Variation.—On one paratype ♀ the red-brown lateral bands do not extend beyond the 4th abdominal segment.

Type locality.—Texas, Palm Grove near Brownsville, holotype ♂, allotype ♀, 8 ♀ paratypes and 6 nymphs, Oct. 1, 1951, beating palms. Other paratypes (not including nymphs)—type locality, 14 ♂, 30 ♀, 26 nymphs, Oct. 2 and 3, 1951, beating dead palm leaves; near Brownsville, 1 ♀, Oct. 4, 1951. All collected by A. B. Gurney.

Types in U. S. National Museum, no. 63241.

It is a pleasure to name this species in honor of L. J. Bottimer, of Kerrville, Tex., a devoted collector and a specialist in the Bruchidae, who assisted the junior author in many ways while at Kerrville and during a week-end trip to Uvalde and Garner State Park.

Family Archipsocidae Pearman

Archipsocus floridanus Mockford

Archipsocus floridanus Mockford, 1953, p. 116.

Palm Grove near Brownsville, Oct. 3, 1951, 2 ♂, 12 macropterous ♀, 9 micropterous ♀, 16 nymphs, from webs on tree, A. B. Gurney.

Archipsocus nomas Gurney

Archipsocus nomas Gurney, 1939, p. 502.

Palm Grove near Brownsville, Oct. 2 and 3, 1951, webs on tree, 2 ♂, 3 macropterous ♀, 8 micropterous ♀, 6 nymphs, A. B. Gurney; Brownsville, Apr. 20, 1953, webs on ebony limb, 32 brachypterous ♀, 5 nymphs (some macropterous).

Group Psocetae Pearman

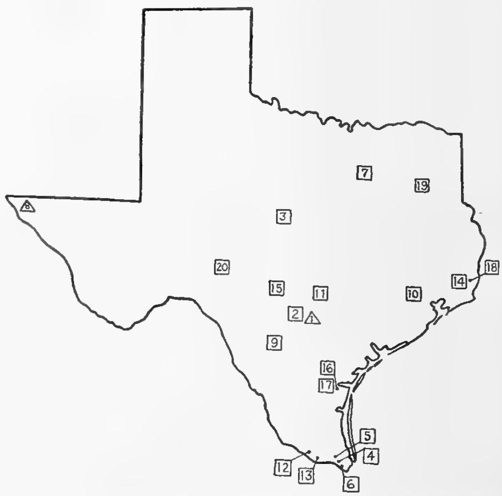
Family Myopsocidae Enderlein

Lichenomima sp.

Brownsville, Feb. 29, 1952, 1 ♀, D. L. Bauer.

Family Psocidae Stephens

Dr. Sommerman is currently preparing a revision of this family for North America and will include distribution records from Texas in her paper. The following species have been recorded from Texas: *Psocus pollutus* Walsh, *P. bisignatus* Banks, *P. campestris* Aaron, *P. persimilis* Banks, *P. submarginatus* Aaron, *P. texanus* Aaron, *Trichadenotecnum unum* Sommerman, *Cerastipsocus venosus* (Burmeister), *Metylophorus purus* (Walsh), and *Blaste quieta* (Hagen).



Map 1.—Outline map of Texas, showing location of localities mentioned. Squares represent definite localities, triangles county records only.

ALPHABETICAL LIST OF COUNTIES IN WHICH LOCALITIES MENTIONED IN THIS PAPER ARE LOCATED

Numbers on map correspond to those of the list.

1. Bexar—County record only.
2. Bexar—San Antonio.
3. Brown—Bangs; Brownwood (about 8 miles east of Bangs).

4. Cameron—Brownsville.
5. Cameron—Olmito Resaca.
6. Cameron—Palm grove.
7. Dallas—Dallas.
8. El Paso—County record only.
9. Frio—Dilly (Frio State Park).
10. Harris—Houston.
11. Hayes—San Marcos (Ezel's Cave).
12. Hidalgo—Mission.
13. Hidalgo—Weslaco.
14. Jefferson—Beaumont.
15. Kerr—Kerrville; Kerrville State Park.
16. Nueces—Corpus Christi.
17. Nueces—Corpus Christi State Park.
18. Orange—10 miles west of Orange.
19. Smith—Tyler.
20. Sutton—Sonora (Wyatt Cave).

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BARRO COLORADO BIRDDOM

On Barro Colorado Island, the Smithsonian Institution's tropical preserve in Gatun Lake, Panama Canal Zone, there is a "bird that roars like a lion." The roar, sometimes mistaken for the call of a howler monkey, is the male courtship song of the turkeylike curassow. The female usually is silent.

Weirdest of the feathered creatures of the preserve is the fruit-eating hawk known as "burja," the witch—a bird about the size of a raven. It has a coal-black back, a white belly, red feet, and a greenish-yellow bill which sometimes is slightly blue at the tip. The name, however, is due less to its weird appearance than to the almost continual "scolding" at other birds or at any intruder into its retreat.

What may appear like fashions in birddom is illustrated by the curious behavior of another Barro Colorado denizen, the motmot, a lovely grayish-green bird with a chestnut-colored head and neck. These have tails that look like tennis rackets. They are fashioned by the birds themselves which pluck off about an inch of the feather vane below the ends of the two outermost feathers. The bird swings this tail from side to side like a pendulum.

A fierce little fighter is the violet-throated hummingbird, one of the most colorful feathered creatures found on the island. This bird, *Anthracothorax violaceicollis*, sometimes builds its solitary nest in the most exposed part of a tree, with no leaf within 25 feet or more. Then it demands dominion over the whole tree and does not hesitate to attack other birds many times its size. It attacks fearlessly, for example, the giant oriole, or oropendula, which is the size of a North American crow. The oriole is described as "helpless as a dirigible before a pursuit plane." When not fighting, the mother hummingbird sits on the nest nearly all the time, protecting eggs and young from sun and rain. The male seldom is seen. There is some reason to believe that his mate drives him away as soon as the eggs are laid. Although generally resentful of the large orioles in the same tree, sometimes it cooperates with them. A species of cowbird has a habit of laying its eggs in the oropendula nests. The hummingbird does not hesitate to drive it away, although its own nest is entirely safe.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1414th meeting, October 7, 1955

Theodore Litovitz, of the Catholic University of America, spoke on *Ultrasonics and the liquid state*. By ultrasonics is meant mechanical vibrations at frequencies from 20 kilocycles up to the present practical limit of 500 megacycles per second or more. These vibrations can cause changes of three kinds in the matter through which they pass: a volume change caused by pressure, a temperature change caused by adiabatic compression, and a change in shape caused by shear forces. In some or all of these the strain may lag the stress, with a relaxation time characteristic of the particular mechanism involved. The velocity of propagation and the absorption are both functions of the frequency that differ from those calculated from classical laws. As the frequency increases, the shear viscosity, for example, may "relax out" and the absorption due to it disappear. In shear the stress from the ultrasonic vibration biases the lattice, and the molecules jump to a new position, at a rate measured by the diffusion time. At high frequencies there is not time for them to jump and the lattice appears rigid.

At low frequencies, and in all liquids except the monatomic ones, the effective viscosity is higher than the classical amount. In explanation, a volume viscosity is postulated which relaxes as the frequency rises. For non-associated liquids, a thermal relaxation is postulated, but it does not do for associated liquids with high dipole moments. In them the volume viscosity has the same temperature dependence as does the shear viscosity.

In water the extra energy loss is not caused by thermal relaxation, because it has been shown that in water at 4° (where there is no adiabatic heating on compression because $\partial v/\partial t = 0$) the absorption is the same as at 20°, where $\partial v/\partial t$ is not zero. The phenomenon seems to be a "structural relaxation," i.e., when the water is compressed, flow occurs in the direction of closer packing, and the loss comes directly from the lagging volume change, not from a temperature change. If there is a lag in the flow, there is absorption.

In both shear and volume viscosity in water, bonds are broken with the same activation energy. Hall showed that water is a mixture of two packings: "ice" and "close." Compression upsets the equilibrium between them and one can then calculate the compressional viscosity on this assumption, and the temperature dependence agrees well with calculation.

Comparing dielectric relaxation with ultrasonic, we find there is also relaxation and absorption in dielectrics, but it is traceable here to a rotation as compared to translation under ultrasonic stress. The dielectric relaxation time has the same temperature dependence as the compressional viscosity, hence they have the same activation energy. But the actual times may not be the same. In glycerol, however, the acoustic and dielectric relaxation times are in fact the same, while in nearly all other liquids the rotational jump can take 1,000 times longer than the displacement.

The velocity in fluid is, of course, related to the adiabatic compressibility. The compression of a liquid is in two parts: (1) Change the lattice spacing, (2) change in the arrangement. Liquids are more compressible than solids because their structure can change. At high frequencies, therefore, one might expect a liquid to become solid-like. 25% of the total β (compressibility) in liquids comes from the change in structure, and the velocity increases as the frequency rises above the relaxation time of the structural change.

On cooling arachlor, this viscous liquid behaves more and more like a solid as its viscosity rises, but the temperature dependence is still almost big as a liquid. Such behavior is appropriate to a glass. In a liquid the number of holes decreases with the temperature, which is not true for crystalline solid. Arachlor and glycerol show a low temperature dependence after they become glassy. β_0 approaches β_∞ as T goes down. The liquid thus becomes a solid without crystallization.

Mr. Shapiro gave, as an informal communication, a report on the Cosmic Ray Conference at Guanajuato in Mexico, at which for the first time in many years Soviet members were in attendance.

The tribute was paid at that conference to our past president Mr. Forbush for his extensive and valuable work.

Mr. Potter gave an informal communication calling attention to certain heresies in genetics, to the latest biological theories of Mr. Gamow, and to the "hope that springs eternal in the mechanistic breast." (*Secretary's abstract.*)

1415TH MEETING, OCTOBER 21, 1955

ROBERT J. MAURER, of the University of Illinois, spoke on *Photoeffects and excitons in alkali halides.* The "exciton" is a lonely concept, or particle if you prefer, in solid state physics; a rare and little understood thing that deserves to be more widely used. Consider the excited atom: after 10^{-8} seconds, or eight seconds, or even hours, it may descend to the ground state, but if it meantime suffers a collision it can pass on its energy to whatever it strikes. In a condensed system—a solid—this passing on occurs very rapidly and continues until the energy reaches some impurity, or imperfection, or the surface, where it may produce a photoelectron, or release radiation. In the Bloch approximation the energy levels are reduced to a single system, and an electron moves in the total potential field, but this approximation is defective because it provides no excited states. The concept of excitons does so. In diamond, for example, electrons in the valence band are lifted to the conduction band by absorbing a quantum, and the electron and the hole from whence it came then migrate freely—effectively an infinite distance apart. Now, just at the absorption edge we should have an optical absorption band structure, corresponding to electrons lifted up to the conduction band but not fully away from the neighborhood of the hole from whence they came. The hole and the electron then move together through the solid as a neutral particle, possessing energy. One should thus have "exciton bands," just below the conduction band in energy and just below the absorption edge in frequency.

Of the possible ways to demonstrate this mechanism, only the photoelectric effect and photoconduction are thus far amenable to experiment, and substances that will be suitable are hard to find. In AgCl for example the exciton bands lie so close to the ionization levels that even the thermal energy kT pushes the excitons on up into full ionization.

The speaker discussed Apker and Taft's photoelectric experiments in some detail: experiments with alkali halides containing a goodly number (10^{19}/cc) of F centers, i.e., either extra alkali atoms, or missing halogens whose places are filled by electrons. A pure crystal does not show photo current. The yield curves show a plateau (plotting current against electron volts) from 2 to 5 volts and strong peak at 5.6, which comes from the fundamental absorption spectrum. Apker and Taft suggest that the absorbed quantum becomes an exciton and moves about until it meets an F center from which it expels an electron.

In Maurer's work crystals with known concentrations of F centers were exposed to quanta in the tail of the absorption spectrum and the photoconductive current was measured. A difficult experiment, since the currents are down in the ratio of the mean free path in the gas to the distance apart of the atoms in the solid. One can determine the lifetime of the exciton as a function of the F center concentration, since the *mfp* is inversely proportional to the F center concentration and the velocity of the exciton is about 10^7 cm/sec. Below 10^{15} centers per cc impurities compete too heavily, and the current is small because few excitors are produced and the interfering effects are many. Above 2×10^{17} the currents fall again because the F centers destroy the excitons before they can go very far. The lifetime turns out to be of the order of 10^{-9} seconds.

Curves of current against energy, and against concentration were displayed, and a number of yet little understood points were discussed. These experiments are considered, however, to be a direct approach to the problem of the existence of the exciton, and the results are interpreted in terms of them. (*Secretary's abstract.*)

1416TH MEETING, NOVEMBER 4, 1955

ROBERT JASTROW, of the Naval Research Laboratory, spoke on *The structure of the atomic nucleus.* That the nucleus has a structure has been known for fully 25 years, but only in the last 5–8 years have we accumulated enough facts to develop an acceptable theory of its behavior. We are not yet in the state where our knowledge of the internucleon forces is such that a complete structural theory is merely an exercise in mathematics, but are rapidly approaching the reverse state, where we should soon be able to calculate the forces from the facts.

A nucleus consists of neutrons and protons, with an excess of neutrons, packed into an approximate sphere at a uniform density of 10^{38} nucleons per cc, or 400,000 tons per cubic millimeter. The average inter-nucleon distance is 2×10^{-13} cm, and attractive forces bind them into a potential well about 40 Mev deep, with kinetic energies up to 30 Mev.

Two different models suggest themselves. First, the classical liquid drop, with long range attraction and short range repulsion, and a mean free path of the order of the "cell-width." The mean spacing is about equal to the range of the repulsive force. Second, the electrostatic action between particles; weak compared to the central force.

Which fits the nucleus? To find out, the nucleus has been probed with beams of particles of various energies, and the scattering laws have been investigated, remembering that the de Broglie wave length for 350 Mev particles is of the same order as the size of the nucleus and that quantum, not classical, laws apply. At lower energies the cross-section increases rapidly, as $1/E$, and the mean free path of the entering particle is much less than r, the nuclear radius. Consequently the nucleus is opaque, and it displays a cross section of $2\pi r^2$. (The 2 comes half from absorption, half from shadow scattering). The approximate expression for the cross-section becomes: $\sigma = f(A, E)$ where R varies as A and as $1/E^{1/2}$. The variation of σ with A and E should therefore be uniform, monotonic, and slow: in a word, "dull". Experimentally, though, there are hills and valleys in a three dimensional plot of sigma against A and E: The most conspicuous example of which is "Mount Barschall", appearing at high energies in the intermediate masses. To account for this we must postulate a transparent nucleus, showing diffraction effects and phase changes in the particle wave-functions as they pass through it. If the phase change is 180° the scattering is a maximum. "Monte Carlo" Calculations, using this postulate, yield sigma-surfaces that agree reasonably well with experiment.

On the other hand, the existence of a shell structure can be demonstrated by showing how the nuclear quadrupole moments vary with A, the atomic weight. Repeated large changes in the sign and magnitude of the nuclear quadrupole moment occur at the so-called "magic numbers": 2, 8, 28, 50, 82, 126. The largest nuclear quadrupole moment known is shown by Lutecium 128, corresponding to an elliptical eccentricity of 25 per cent. One consequence of a quadrupole moment was shown by comparing the scattering of protons from gold with that from tantalum. Gold has zero moment and shows strong diffraction maxima and minima in a plot of scattering against angle. Tantalum has a large moment and shows only small inflections. In tantalum the random orientation of the ellipticity smears out the diffraction structure.

The nucleus remains something of a paradox: having a long mean free path for particles entering it, but acting on them with very strong forces. (*Secretary's abstract.*)

1417TH MEETING, NOVEMBER 18, 1955

WILLARD H. BENNETT, of the Naval Research Laboratory, spoke on *Solar protons and aurorae.* The talk outlined recent results in formulating the theory of aurorae, or "northern lights." Two forms have been observed: the "quiet arc," seen as a general glow, and the other more spectacular form seen as rays and brightly colored draperies. The earliest attempt at a rational theory was Birkeland's in 1896, who postulated that the sun projected particles that were deflected by the earth's magnetic field as they entered it. On this basis Carl Störmer calculated the orbits of the beam. The theory was not generally accepted because it was believed that the charged particles of which the beam was composed would repel each other and not remain concentrated in the narrow beams needed to produce the sharply localized effects. More recently Martyn theorized that the protons and electrons are projected from Sun's surface simultaneously in the form of jets and streams which sweep across the earth's atmosphere. The electrons are deflected while the protons reach the earth. A particle of 1 BEV may penetrate to 19 kilometers from the surface, while a 100 KEV particle may reach only 100 Km. The difference between the northern and the southern auroral zones is accounted for by the fact that the earth's magnetic axis does not pass through the center of the earth. The change in the relative inclination of the axis with the seasons accounts for the seasonal nature of the phenomenon.

A gas tube, called the "Störmertron," has been devised to simulate the aurorae in the laboratory. A stream of electrons from a gun passes through mercury vapor at a very low pressure in a glass envelope. In the center of the tube is a simulated earth, containing a small magnet. The direction of the beam and the orientation of the "earth" are continuously variable, and the luminous beam twists and turns through fantastic convolutions as the initial direction is swung back and forth across the earth. Fluorescent material on the earth shows by bright patches whenever the beam actually strikes it. The phenomena were most strikingly shown by motion pictures of the tube in operation. Sometimes the beams are actually twisted in a tight helix in a captive orbit and produce a bright halo around the earth, which simulates the general glow. The path sometimes takes the form of a series of rose-petal curves striping northern and southern hemispheres alternately. This behavior accounts for aurorae observed in Fairbanks Alaska (for example) followed minutes later by a similar display off South Africa, and still later by one in Norway. In the actual aurorae, the 2½ Mev protons produce electrons of 10 to 15 volts, which luminesce upon returning to the ground state.

In discussion, McNish emphasized the difficulties encountered in formulating an adequate theory and in convincing the skeptics. Answering Mr. Mohler, the speaker confirmed the observation of maximal phenomena at about 9 p.m. local time. (*Secretary's abstract.*)

1418th meeting, december 2, 1955

Maurice M. Shapiro, of the Naval Research Laboratory, gave a paper on *Megalomorphs*, a term invented by J. R. Oppenheimer to describe the larger cosmic ray fragments known variously as Heavy Mesons, Hyperons, and Heavy Fragments.

The lighter particles found in cosmic rays and produced by the Bevatron were first described and listed, with slides showing their weights, half lives, charges, and relevant genetic relationships. Among them are π^+, π°, π^-; μ^+, μ^-, and the k mesons that seem to be the source of internucleon forces. There are also the τ, θ, and k mesons with lives of the order of 10^{-8} seconds, which though short, are much too long to be understood on any simple theoretical basis. As an example of the complexity of the phenomena, a complete event was shown on a slide, consisting of five generations of particles forming an "energetic star". The steps in the sequence are: primary particle, a burst of 8 to 10 protons, a tau meson, 3 pi mesons, mu mesons, and finally some common or garden-variety electrons. The pi mesons can produce "neutron stars," and one in three do so.

The speaker then turned to particles heavier than protons or neutrons; the Y, K, and L classes of Hyperons. Given as examples of these were Λ^0, Σ^+, Σ^-, and Ξ particles. These are all "excited nucleons", and the emission of pi mesons by them is quite analogous to the emission of light by excited atoms. As a specific example, the Λ^0 particle weighs 2181 electron masses, has a mean life of 3.7×10^{-10} secs, and breaks up into a proton and a pi minus meson with a reaction energy, Q, of 36.9 Mev. The Σ and Ξ are similar.

The Hyperfragment is another class of particle with various weights and energies. A tritium fragment, for example, in the right state of excitation will break up into a ${}_2He^3$ atom and a pi minus meson. In other words, the fragment had part of its structure replaced by a hyperon. These reactions have definite components, products, reaction energies and half lives.

The beginning of an understanding of this maze of reactions involving these transient entities is coming about through the introduction of a sort of quantum number with unique selection rules. This number is called the "strangeness", and is as characteristic of any given particle—at least as presently conceived—as is its charge or half life. "Strangeness" must be conserved in a "strong interaction"; spontaneous decay is a "weak reaction", and the decay of many of these particles is much slower than would be expected because there is a change in "strangeness" between components and products.

After a discussion, in which Messrs Wood, Page, Maxwell, Tuckerman, Mohler and others took part, the speaker was asked to report on the recent discovery of the "anti-proton" at Berkley, where he had been visiting. (*Secretary's Abstract.*)

Facts are the body of science, and the idea of those facts is its spirit.—S. Brown.

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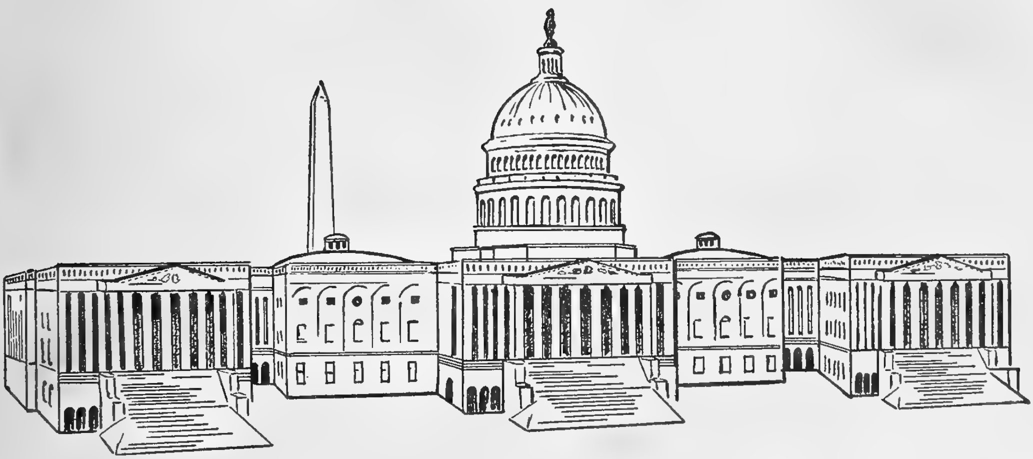

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MATHEMATICS.—*Commuting bilinear transformations and matrices.*[1] OLGA TAUSSKY and JOHN TODD, National Bureau of Standards.

(Received October 29, 1956)

We present in paragraphs 1–4 an alternative approach to a theorem of K. Goldberg [*1*] and in paragraphs 5 and 6 a generalization of that theorem. The two sections of this paper are essentially independent.

1. Denote by Γ the group of bilinear transformations of the form

$$(1) \qquad w\colon w = \frac{az + b}{cz + d},$$

where a, b, c, d are rational integers and $ad - bc = 1$.

We shall establish:

Theorem 1. A necessary and sufficient condition for two transformations of Γ to commute is that each is an iterate of the same transformation of Γ.

Only the necessity of the conditions requires detailed proof.

2. We begin with the following well-known result, of which we sketch a proof (see, e.g., Forsyth [*2*, p. 719]):

Lemma 1. In order that two transformations of Γ should commute, it is necessary and sufficient that their fixed points should coincide.

Proof. Let

$$(2) \qquad W\colon W = \frac{Az + B}{Cz + D}$$

be another transformation of Γ. In order that $w(W) \equiv W(w)$ we must have

$$(3) \qquad \begin{aligned} Aa + Bc &= aA + bC \\ Ab + Bd &= aB + bD \\ Cb + Dd &= bC + dD \\ Ca + Dc &= cA + dC \end{aligned}$$

and conversely. These relations are equivalent to the fact that the following equations, which give the fixed points of the transformations w, W,

$$(4) \qquad cz^2 + (d - a)z - b = 0$$

$$(5) \qquad Cz^2 + (D - A)z - B = 0,$$

have the same roots. To see this observe that the upper pair of (3) gives $bC = Bc$ and the lower pair gives $b(A - D) = B(a - d)$ and $c(A - D) = C(a - d)$, and so, in general,

$$\frac{c}{C} = \frac{d - a}{D - A} = \frac{b}{B}.$$

Exceptional cases, when b, c, B, C vanish or $a = d$, $A = D$ can be discussed easily.

It is easy to see that the condition presented in the lemma can be expressed in matrix language as follows: *The corresponding matrices* $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$, $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$ *should have common characteristic vectors.*

3. We require the following classical result about the units of quadratic fields:

Lemma 2. All units in a real quadratic field are of the form $\pm \epsilon^m$ where m is an integer (positive or negative or zero) and ϵ ($\neq \pm 1$) is the fundamental unit. All units in complex quadratic fields are roots of unity: ± 1 in general, ± 1, $\pm i$ in the field $R(\sqrt{-1})$ and ± 1, $\pm\frac{1}{2}(1 \pm \sqrt{-3})$ in the case of $R(\sqrt{-3})$.

Proofs of this are available, e.g., in Hecke [*3*] or in Reid [*4*, chapter 13]. The problem

[1] The preparation of this paper was supported in part by the Office of Naval Research.

of determining the unit in $R(\sqrt{n})$, where $n > 0$, is essentially that of solving a Pell's equation.

4. *Proof of Theorem 1.* We use the canonical forms for transformations with fixed points α, β (see, e.g., Forsyth [2, p. 620]).

If α, β are finite and distinct, then

$$\frac{w-\alpha}{w-\beta} = k\frac{z-\alpha}{z-\beta} \tag{6}$$

where the "multiplier" k is given by

$$k = \frac{a+d-\sqrt{\{(a-d)^2+4bc\}}}{a+d+\sqrt{\{(a+d)^2+4bc\}}}$$

and

$$\frac{w-\alpha}{w-\beta} = K\frac{z-\alpha}{z-\beta},$$

$$K = \frac{A+D-\sqrt{\{(A-D)^2+4BC\}}}{A+D+\sqrt{\{(A+D)^2+4BC\}}}.$$

It is clear that two transformations of type (6) are compounded by multiplying the multipliers. What we have to show, therefore, is that k, K are integral powers of the same κ and that the transformation with multiplier κ belongs to Γ.

Consider the quadratic field f generated by the characteristic roots λ, μ of the matrix $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$. Since the matrix is unimodular these roots are units, and therefore of the form $\pm\epsilon^n$, where n is an integer and ϵ is the fundamental unit in case f is real, or the primitive root of unity in f, if f is complex. Hence

$$k = \frac{\lambda}{\mu} = \frac{\lambda\mu}{\mu^2} = \frac{1}{\mu^2}$$

and is therefore an integral power of ϵ, with *positive* sign.

Exactly the same holds for K in F, the field generated by the characteristic roots of $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$. However, in view of the equivalence of (4) and (5), the fields f, F are the same.

Hence we have $k = \kappa^m$, $K = \kappa^M$ for certain integers m, M. Let d be the greatest common divisor of m, M. Consider the transformation

$$Z: \frac{z-\alpha}{z-\beta} = \epsilon^d\frac{z-\alpha}{z-\beta}. \tag{10}$$

It is clear that w and W are iterates of Z, in fact

$$w = Z^{(m/d)}, \qquad W = Z^{(M/d)}$$

To show that $Z \epsilon \Gamma$ we use the fact that there are integers m_1, M_1, such that

$$m\, m_1 + M\, M_1 = d,$$

and this implies that $w^{m_1}W^{M_1} = Z$ and, Γ being a group, we have $Z \epsilon \Gamma$.

If α is finite, β infinite the corresponding forms are

$$\begin{aligned} w-\alpha &= k(z-\alpha), \\ k &= d/a, \quad \alpha = b/(d-a), \\ W-\alpha &= K(z-\alpha), \\ K &= D/A, \quad \alpha = B/(D-A), \end{aligned}$$

and the discussion is similar.

In the case when $\alpha = \beta$ the canonical forms for the transformation are

$$\begin{aligned} (w-\alpha)^{-1} &= (z-\alpha)^{-1} + c, \\ (W-\alpha)^{-1} &= (z-\alpha)^{-1} + C, \end{aligned}$$

and c, C being integers, the necessity of the condition of Theorem 1 is almost obvious.

5. Let A and B be 2×2 matrices whose elements are integers in a complex quadratic field F and whose determinants are units in F.

Theorem 2. Assume

(1) *that neither A nor B is similar to a matrix of the form* $\zeta\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$ *where ζ is a root of unity in* F *and*

(2) *that the characteristic roots of A and B do not lie in the field of the* 8th *or* 12th *root of unity.*

Under these assumptions A and B commute if and only if (apart from a unit in F*) they are powers of the same matrix in* F.

Proof. Only the necessity needs to be proved. It is sufficient to show that a matrix K exists such that $A = e_1 K^m$, $B = e_2 K^n$, where e_1, e_2 are units in F and m, n are rational integers. It then follows as in [1] that K can be chosen in F. The following two cases are possible:

(I) A has its characteristic roots not in F,

(II) A has its characteristic roots in F.

In case (I) the characteristic polynomial of A is irreducible with respect to F. Hence a nonsingular matrix U exists such that

$$U^{-1}AU = \begin{pmatrix} \alpha_1 & 0 \\ 0 & \alpha_2 \end{pmatrix}$$

The numbers α_1, α_2 lie in a field Φ which is relatively quadratic with respect to F and α_1, α_2 are relative conjugate. The field Φ being complex with all its conjugates and biquadratic has one fundamental unit ϵ (see [3]). Hence, unless Φ is the field of the 8th or 12th root of unity, every unit in Φ is a power of ϵ, multiplied by a root of unity in F. If we then assume that Φ is not one of these cyclotomic fields we have

$$\alpha_1 = e_1 \epsilon^m, \qquad \alpha_2 = e_1 \bar{\epsilon}^m$$

where e_1 is a root of unity in F and $\bar{\epsilon}$ is the relatively conjugate number of ϵ, hence $\bar{\epsilon}$ is in Φ. Hence the coefficients of the matrix U can be chosen in Φ. Since $U^{-1}BU$ commutes with UAU it must be diagonal too. Hence the characteristic roots of B lie in Φ too and are of the form

$$\beta_1 = e_2 \epsilon^n, \qquad \beta_2 = e_2 \bar{\epsilon}^n,$$

e_2 a root of unity in F. Hence

$$U^{-1}AU = e_1 \begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}^m,$$

$$U^{-1}BU = e_2 \begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}^n,$$

and

$$A = e_1 \left[U \begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix} U^{-1} \right]^m,$$

$$B = e_2 \left[U \begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix} U^{-1} \right]^n$$

Put $U\begin{pmatrix} \epsilon & 0 \\ 0 & \bar{\epsilon} \end{pmatrix}U^{-1} = K$ and case (I) is completed.

(II) We may assume the characteristic roots to be different. Let ζ be the root of unity of highest period in F. Then A or B must both be similar to matrices of the form

$$U^{-1}AU = \zeta^{a_1} \begin{pmatrix} 1 & 0 \\ 0 & \zeta^{a_2} \end{pmatrix},$$

$$U^{-1}BU = \zeta^{b_1} \begin{pmatrix} 1 & 0 \\ 0 & \zeta^{b_2} \end{pmatrix}$$

Hence K can be taken as $\begin{pmatrix} 1 & 0 \\ 0 & \zeta \end{pmatrix}$.

6. The exceptional cases (1) and (2) in Theorem 2 are genuine.

(1) Any two matrices of the form

$$\begin{pmatrix} 1 & \alpha \\ 0 & 1 \end{pmatrix}, \qquad \begin{pmatrix} 1 & \beta \\ 0 & 1 \end{pmatrix}$$

commute when α, β are any integers in F. However, α, β are in general, not commensurable.

(2) In the case of the field of the eighth roots of unity we observe that the matrices

$$\begin{pmatrix} 0 & 1 \\ i & 0 \end{pmatrix}, \qquad \begin{pmatrix} 1 & 1-i \\ 1+i & 1 \end{pmatrix},$$

commute. The first has eighth roots of unity as characteristic roots and generates a cyclic group of order 8, while the second has as characteristic roots the units $1 \pm \sqrt{2}$ and generates an infinite cyclic group. It follows that there is no matrix of which these are integral powers. Moreover, it can be shown that any pair of commuting matrices in this case is similar to products of powers of these two.

Similar results hold in the case of the twelfth root of unity. Corresponding examples are

$$\begin{pmatrix} 0 & 1 \\ 1 & -i \end{pmatrix}, \qquad \begin{pmatrix} 2+i & 2 \\ 2 & 2-i \end{pmatrix}.$$

They commute and have as characteristic roots twelfth roots of unity, and the units $2 \pm \sqrt{3}$.

7. *Generalizations.* There are several possible directions in which the results of this paper can be generalized; some of these have been investigated by E. C. Dade [5].

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BOTANY.—*New grasses from Mexico.* ERNEST R. SOHNS, U. S. National Museum. (Communicated by Agnes Chase.)

(Received July 27, 1956)

In the course of routine identification of miscellaneous collections of grasses from Mexico, six new taxa were discovered and the original descriptions of two species required emendation. The new entities and emendations are presented in this paper.

Panicum clivum Sohns, sp. nov.

Figs. 1–8

Gramen perenne; culmi 20–50 cm alti, decumbentes, graciles; vaginae internodiis breviores, inferiores striatae, papilloso-pilosae, superiores marginibus papilloso-pilosis; ligula circiter 1 mm longa; laminae 2–8.5 cm longae, 3–12 mm latae, omnes pubescentes, margines papilloso-pilosis; panicula 5–8 cm longa, 2–8 cm lata, ramis brevibus, inferiores 4.5 cm longi; spiculae 2.3–2.7 mm longae; gluma prima 0.5–0.9 mm longa, lata, rotundata, enervis; gluma secunda et lemma sterile subaequans; lemma fertile circiter 2–2.2 mm longum, 7-nervis; lemma sterile vacuum; lemma fertile 2.1–2.4 mm longum, 1.0–1.1 mm latum, glabrum, 5-nervis; palea lemma sterile aequans; staminia 3, antherae 0.4 mm longae; lodiculae 2, membranaceae, 0.2 mm longae; caryopsis circiter 1.5 mm longa, 1 mm lata.

Perennial; culms decumbent at first and/or second nodes, but not rooting, 20–50 cm tall, glabrous; sheaths shorter than the internodes, the lower loose, striate, papillose-pilose, upper sheaths papillose-pilose on the margin and sparingly pilose between the nerves, a dense ring of hairs on the collar across the back; ligule a fringe of hairs about 1 mm long; blades to 8.5 cm long, 3 to 12 mm or more wide, sometimes cordate-clasping, pubescent on both surfaces, papillose-pilose on the margins, especially near the base; inflorescence a narrow exserted panicle, 5–8 cm long, 2–8 cm wide, panicle branches mostly short, the lower sometimes 4.5 cm long, the axes and branches glabrous; spikelets 2.3–2.7 mm long, averaging 2.47 mm (measurements on 60 spikelets); first glume 0.5–0.9 mm long, broad, rounded, clasping base of spikelet, nerveless or sometimes with a faint median nerve; second glume and sterile lemma about 0.1 mm shorter than the fertile lemma; both 7-nerved, very sparingly short-pilose with scattered hairs; sterile lemma with a membranous palea about 1 mm long; fertile lemma 2.1–2.4 mm long, about 1–1.1 mm wide, smooth and shining, 5-nerved, the nerves visible as faint white lines; palea as long as the lemma; stamens 3, anthers 0.4 mm long; lodicules 2, membranous, spatulate, 0.2 mm long; caryopsis about 1.5 mm long and 1 mm wide.

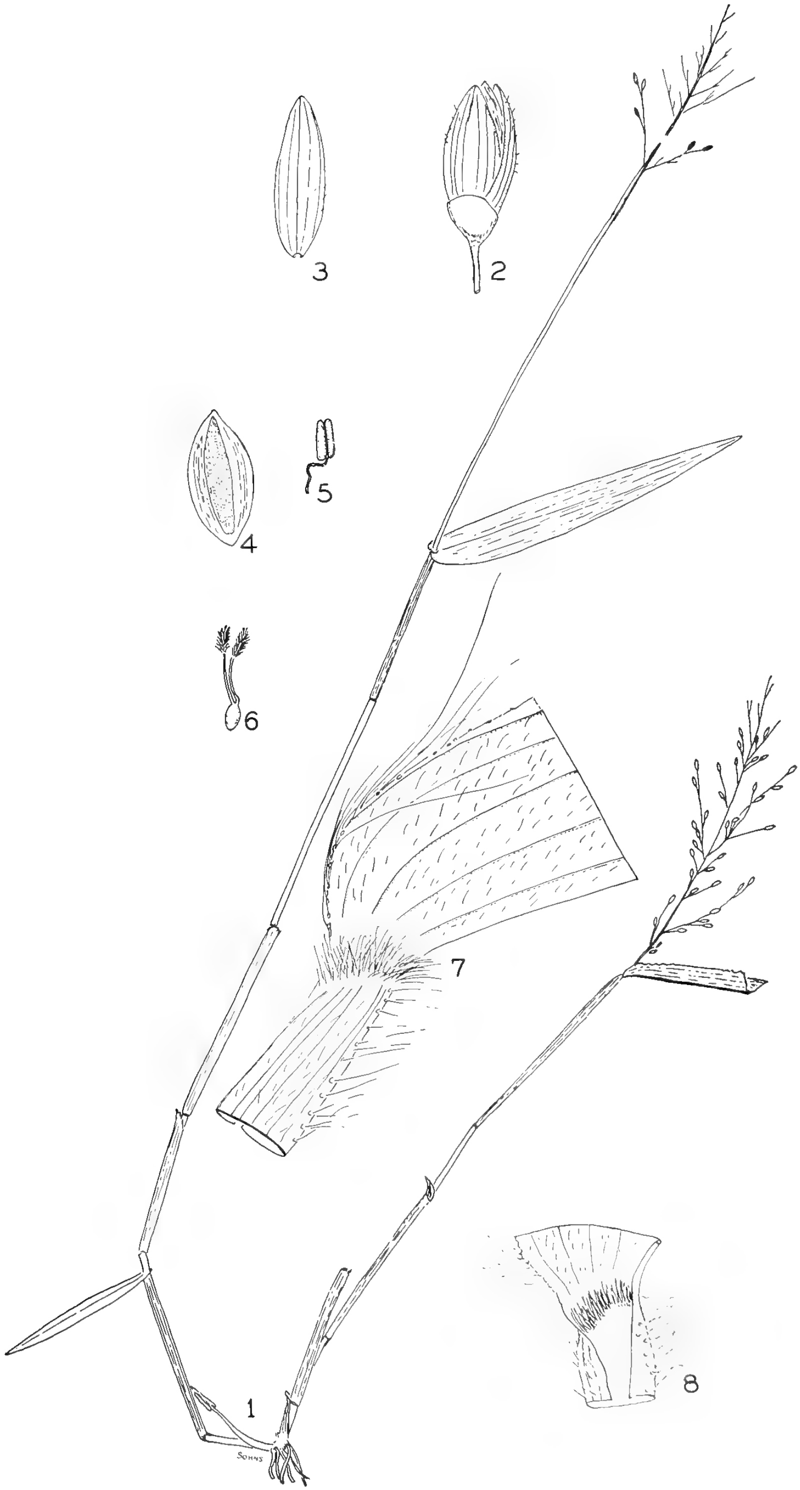
Type in the U. S. National Herbarium, no. 2041588, collected "on mossy limestone boulder; ravine slopes above Tepeoco, 3.5 miles from Zacualtipan on road to Tianguistengo," State of Hidalgo, altitude 2,100 meters, March 20, 1947, by H. E. Moore, Jr. (no. 2371). Additional specimens examined: HIDALGO: Palo Hueco, *Moore* 2694. MÉXICO: Cañado de Nanchititla, *Matuda* 30818.

This species belongs in the subgenus *Dichanthelium*, section *Commutata*, and is related to *P. albomaculatum*, *P. hintonii*, and *P. joorii*. A key to the species of this section follows the discussion of *P. albomaculatum*. The distribution of the species in this section is shown in Fig. 9.

In the course of examining collections of *P. albomaculatum* Scribn. (U. S. Dept. Agr. Div. Agrost. Circ. **19:** 2. 1900) in the U. S. National Herbarium, including the type and the original description, it became apparent that the original description required emendation.

In his description Scribner stated that the spikelets are "2.5 mm long; . . . " Spikelets on the type specimen measured 2.5 to 3.0 mm in length (the average of 25 spikelets: 2.7 mm). No measurements were given for the length of the panicle which is found to vary from 12 to 18 cm. The branches of the panicle are relatively stiff and somewhat ascending. The blades are described as "scabrous on the nerves below, glabrous above, . . ." Seven collections of *P. albomaculatum* have sheaths and blades which are papillose-pilose in varying degrees of density. The spikelets of these pubescent specimens are in the same size range as the sparingly pubescent spikelets of the type. The average length of 100 spikelets is 2.66 mm.

The new species may be separated from other species in this section by the following key.



Figs. 1–8.—*Panicum clivum* Sohns, sp. nov.: 1, Plant, × ½; 2, spikelet; 3, sterile lemma; 4, fertile lemma (palea visible); 5, stamen; 6, ovary; 7, junction of blade and sheath; 8, view of ligule. Figs. 2–6 and 8, × 8; fig. 7, × 16. Drawn from the type specimen.

Blades asymmetrical and falcate; culms decumbent; first glume about one-third as long as the spikelet . . . . *P. joorii*
Blades symmetrical, nearly linear.
Spikelets glabrous, 2.2–2.4 mm. long . . *P. hintonii*
Spikelets pubescent.
Spikelets 2.5–3 mm long (averaging 2.7 mm); plants erect; panicles open, many-flowered, 12 to 18 cm long . . . . *P. albomaculatum*
Spikelets 2.3–2.7 mm long (averaging 2.4 mm); plants decumbent-straggling; panicles small, 5 to 8 cm long . . . . *P. clivum*

Panicum crateriferum Sohns, sp. nov.

Figs. 10–22

Gramen perenne; culmi basi repentes, e nodis radicantes, dein erecti, usque ad 35 cm alti, graciles, nodi pubescenti; vaginae internodiis breviores, striatae, ad os dense pubescentis; ligula circiter 0.5 mm longa; laminae lanceolatae, 2–5 cm longae, 5–12 mm latae, subtus glabrae, supra sparsim hirsutis tuberculatis adspersae; racemi 6, usque ad 2 cm longi; spiculae geminae, inferiores plerumque reductae, superiores 2.3–3 mm longae. Spicula superna: gluma prima 1.7 mm longa, valide 3-nervis, versus summam papilloso-pilosa, margine hyalina; gluma secunda 2.5 mm longa, 5-nervis, papilloso-pilosa; lemma sterile (interdum cum flore masculo) 2.7 mm longum, parce papillose-pilosum, margines dense papilloso-pilosis, cum glandulis duobus; palea membranacea; lemma fertile oblongo-ovatum, circiter 1.6 mm longum, glabrum; staminia 3, antherae 0.9 mm longae.

Perennial, with wiry, creeping culms producing upright culms at the nodes; culms slender, up to 35 cm tall, nodes pubescent, internodes glabrous or sparingly pubescent near the summit; sheaths shorter than the internodes, striate, glandular-spotted, densely pubescent at the summit across the back; ligule a ciliate rim about 0.5 mm long; blades lanceolate, 2 to 5 cm long, 5 to 12 mm wide, asymmetrical at base, junction of blade and sheath scarcely petiolate, lower surface of blade glandular spotted, glabrous, upper surface sparsely papillose-hirsute, midrib prominent; inflorescence usually consisting of six racemes, averaging 2 cm in length, each bearing 4 to 10 paired spikelets, the lower spikelet usually reduced, a few papillose hairs at the base of the raceme, the axis papillose-pilose; rachis terminated by a single spikelet; upper spikelet of the paired spikelets from 2.3 to 3 mm long (average length of 46 spikelets: 2.68 mm). Reduced lower spikelet of pair: first glume with a pronounced, clasping hyaline margin, 3-nerved, papillose-hirsute over the back; second glume 5-nerved, papillose-hirsute over the back; upper spikelet of the pair (averaging 2.6 mm in length): first glume 1.7 mm long, strongly 3-nerved, papillose-pilose on the back near the tip, margins hyaline; second glume 2.5 mm long, 5-nerved, papillose-pilose over the back; sterile lemma 2.7 mm, 5-nerved (often a faint vascular bundle may be seen on the margin on each side of the lemma), sparingly papillose-pilose over the back, but more densely so along the margins, with two gland-like structures, one on each side of the keel about 1 mm from the tip; palea very thin, enclosing three rudimentary stamens; fertile lemma oblong-oval, about 1.6 mm long, smooth; stamens 3, anthers about 0.9 mm long.

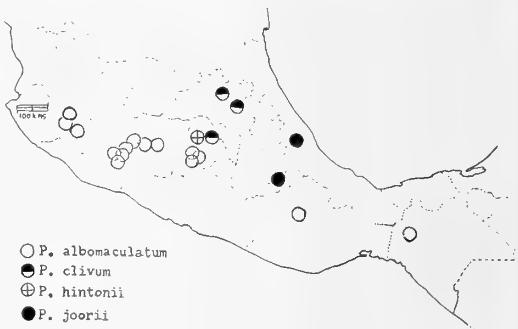


Fig. 9.—Map of portion of Mexico showing distribution of species of *Panicum* in the section *Commutata*, subgenus *Dichanthelium*.

Type in the U. S. National Herbarium, no. 1983658, on "steep grassy slopes and narrow ravine with open pine woods and scattered oaks on granitic soil at km 339–40 between Acahinzotla and Agua de Obispo, on highway to Acapulco, alt. ca. 3000'" State of Guerrero, October 1, 1949, by H. E. Moore, Jr. (no. 5148). Other specimens examined: Guerrero: Montes de Oca, *Hinton* 10801; Galeana, *Hinton* 14646, 14725.

This species belongs in the section *Stolonifera*, subgenus *Eu-Panicum* and is related to *P. biglandulare* and *P. pulchellum*.

Panicum biglandulare Scribner and Smith, emended

Figs. 24–31

Perennial, culms prostrate or ascending, producing branches from the nodes, 40 cm to more

FIGS. 10–22.—*Panicum crateriferum* Sohns, sp. nov.: 10, plant × ½; 11, node; 12, paired spikelets; 13, sterile lemma and fertile lemma; 14, palea of sterile lemma; 15, first glume of lower spikelet; 16, second glume of lower spikelet; 17, sterile lemma of lower spikelet; 18, fertile lemma of lower spikelet; 19, sterile lemma of upper spikelet; 20, fertile lemma of upper spikelet; 21, pistil and 22, anther. Figs. 11–14, × 8; all others × 16.

than 1 meter tall; nodes swollen and glabrous; sheaths shorter than the internodes, striate, sparingly pilose, the overlapping half of the sheath densely papillose-pilose, the pilose margins alternating with each node from base to tip; ligule a membranous rim, finely ciliate at the summit, usually less than 0.5 mm long; blades with a petiole about 1 mm long, a line of hairs across the back at the collar, lanceolate, acuminate, 3 to 9 cm long, 0.9 to 22 mm wide, the base asymmetrical, from sparingly to densely papillose-pilose on both surfaces, margins antrorsely scabrous; inflorescence exserted, composed of usually six to ten somewhat distant racemes, 0.6–2.5 cm long; spikelets borne on one side of the rachis, usually paired, the lower sometimes undeveloped, 2.5 to 4 mm long (average length of 147 spikelets: 3.33 mm); first glume 1.3–1.8 mm, 3-nerved, ovate, papillose-pilose over the back and near the tip; second glume 1.3–3.2 mm long, 5-nerved, sparingly papillose-pilose over the back and on the margins; sterile lemma 2.5 to 4 mm long, 7-nerved (marginal nerves sometimes scarcely visible), minutely scaberulous and sparsely papillose-pilose over the back and on the margins, provided with two raised, gland-like structures about 1 mm from the tip, one on each side of the median nerve; fertile lemma smooth, shining, 2–2.5 mm long; anthers 3, well developed, 1–1.3 mm long.

According to Scribner and Smith's original description the margins of the sheaths "are clothed with glands bearing branching hairs; . . . " The margins of the sheaths are only papillose-pilose. The spikelets are also described as "almost sessile, 2 lines long [4 mm]; . . . " The average length of the spikelet in the type specimen is 3.70 mm (measurements on 24 spikelets). The spikelets varied in length from 3 to 4 mm. The specimen collected by Santos (No. 3437) in Oaxaca has smaller spikelets, on the average, than those specimens collected in Chiapas and Guatemala. The spikelets of this collection range in size from 2.5 to 3 mm, the average length of 21 spikelets, 2.6 mm. The specimen is referred to *P. biglandulare*; its small stature and small spikelets are probably responses to edaphic conditions.

The distribution of *P. pulchellum*, *P. biglandulare* and *P. crateriferum* is shown on the map (Fig. 23).

Specimens examined: MÉXICO: CHIAPAS: near Piñabete, *Nelson* 3781 (type); Mount Pasitar, *Matuda* 316; Montecristo, *Matuda* 2006; Monte Bello, *Carlson* 2330. OAXACA: Santa María de Lovani, San Juan de Petlapa, *Santos* 3437.

GUATEMALA: Cobán, *von Türckheim* 1342, 1956; hills between Cobán and Tres Cruces, *Standley* 90263.

Species of the section *Stolonifera*, subgenus *Eu-Panicum* may be separated by the following key:

Nodes glabrous; blades sparingly to densely long papillose-pilose on both surfaces; spikelets 3–4 mm long . . . . *P. biglandulare*
Nodes pubescent
- Spikelets not over 2 mm long; blades short, ovate-lanceolate, usually not over 4 cm long *P. pulchellum*
- Spikelets 2.3–3.0 mm long; blades lanceolate, pale green, sparsely pilose on both surfaces *P. crateriferum*

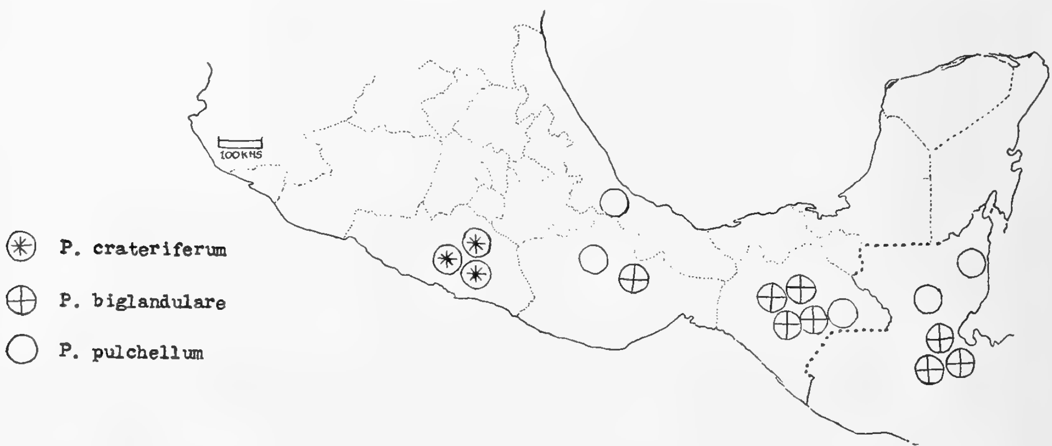
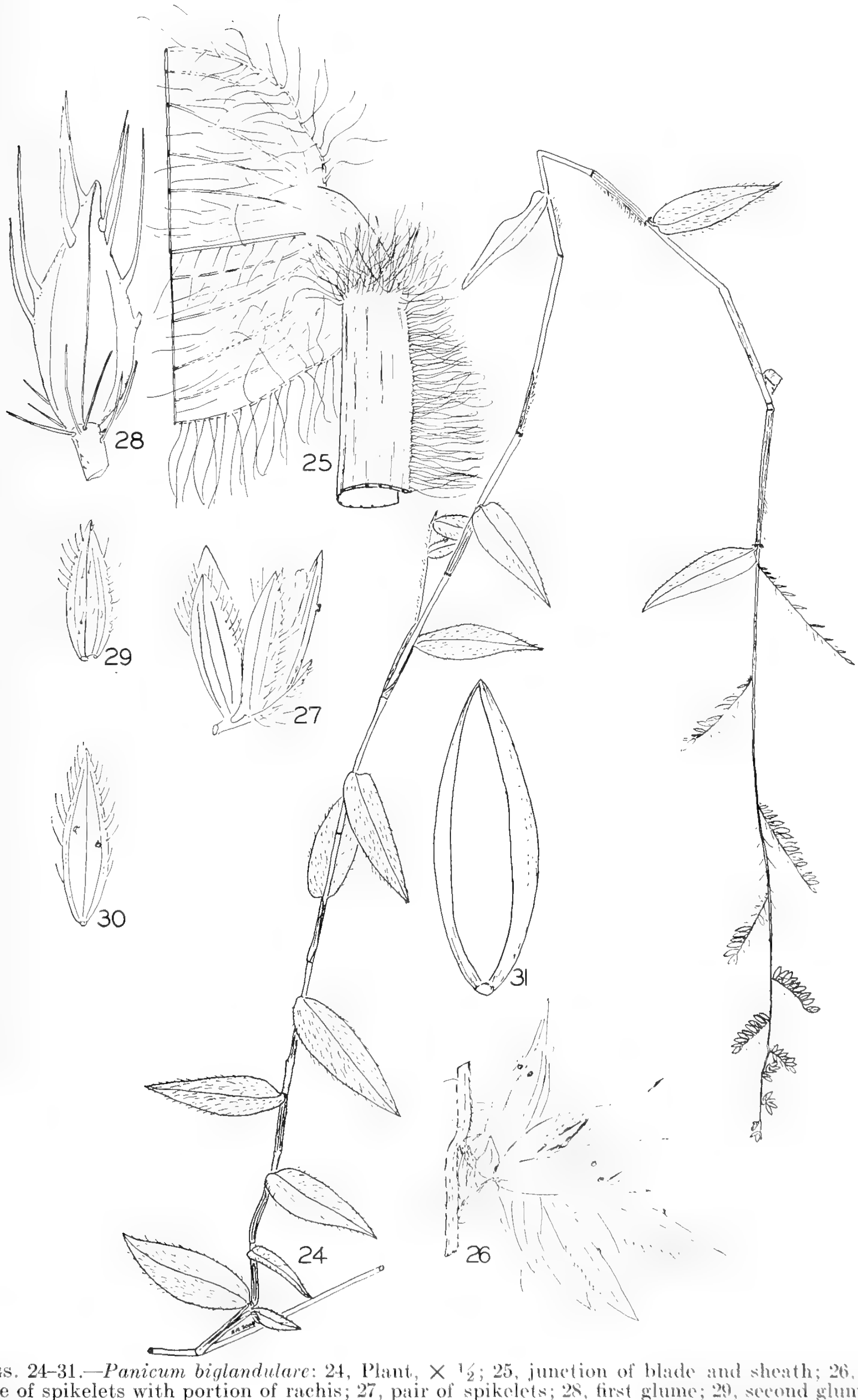


FIG. 23.—Map showing distribution of species of *Panicum* in the section *Stolonifera*, subgenus *Eu-Panicum*.



FIGS. 24–31.—*Panicum biglandulare*: 24, Plant, × ½; 25, junction of blade and sheath; 26, short raceme of spikelets with portion of rachis; 27, pair of spikelets; 28, first glume; 29, second glume; 30, sterile lemma; 31, fertile lemma. All figs. × 8, except 28 and 31, × 16. Drawn from *Türckheim* 1342.

Muhlenbergia matudae Sohns, sp. nov.

Figs. 32–38

Gramen perenne; culmi erecti, 20–50 cm alti, graciles, ad nodos hispidis, vaginae inferiores papyraceae, superiores internodiis breviores, glabrae; ligula truncata, circiter 1 mm longa; laminae 4–10 cm longae, 0.8–1.5 mm latae, utrinque scabrae, margine scabrae; panicula exserta, patula, pauciflora; usque ad 15 cm longa; spiculae 3.5–6.3 mm longae; gluma prima 1.5–2.1 mm longa, 1-nervis, carina scaberula, arista circiter 0.5 mm longa; lemma 2.6–3.8 mm longum, 3-nervis, callo pilis brevis, ad margines parce pilis, carinis parce scabris versus summam, arista 0.9–2.6 mm longa, scabra; palea lemma aequans, bicarina, glabra; staminia 3, antherae 1.5 mm longae; lodiculae 0.

Perennial; loosely tufted, culms 20–50 cm tall, slender, erect, hispid below the nodes; sheaths of basal blades papery and straw-colored, glabrous, upper sheaths shorter than the internodes, glabrous; ligule a truncate membranous rim about 1 mm long; blades mostly basal, 4–10 cm long, 0.8 to 1.5 mm wide, scabrous on both surfaces and on the margins, loosely involute when dry, tips slightly flexuous; inflorescence an exserted, loose, open, few-flowered panicle, up to 15 cm long, the spikelets borne singly at the ends of the slender branches; spikelets 3.5–6.3 mm long (including the awn), the lowermost spikelets about 3.5–3.8 mm long, the terminal spikelet of each first-order branch largest, from 3.9–6.3 mm (average length 4.9 mm) long; first glume 1.5–2.1 mm long, 1-nerved, slightly scaberulous on the keel toward the awn-pointed tip; second glume 1.9–2.8 mm long, 1-nerved, scaberulous on the keel toward the abruptly awn-pointed tip, the awn about 0.5 mm long; lemma 2.6–3.8 mm long, 3-nerved, the lateral nerves sometimes obscure, a few short hairs on the callus and on the margins, sparingly scabrous on the keel toward the tip, awn 0.9–2.6 mm long, antrorsely scabrous; floret readily deciduous, leaving the glumes at the end of the branchlet; palea as long as the lemma, 2-keeled, glabrous; stamens 3, anthers 1.5 mm long; styles 2, free to top of ovary; stigmata plumose; lodicules 0.

Type in the U. S. National Herbarium, no. 2079186, collected "en ladera húmeda, orilla de bosque mixto de pinos y oyamel, Lago de Zempoala, Edo. de Morelos" altitude 3,000 meters, October 7, 1951, by Dr. E. Matuda (no. 25601).

This species is named in honor of Dr. Eizi Matuda, good friend and excellent collector of Mexican plants.

This species is related to *M. arizonica* and *M. arenicola*. It may be separated from these species by the following key:

Blades flat or only loosely involute, ligules 1–2 mm long.
- Glumes subequal, the first 1.5–2.1 mm, the second 1.9–2.8 mm long, awn-pointed, the second glume with an awn about 0.5 mm long; panicle branches long, few-flowered ... *M. matudae*
- Glumes equal, about 1 mm long; panicle branches short, many-flowered ... *M. arizonica*

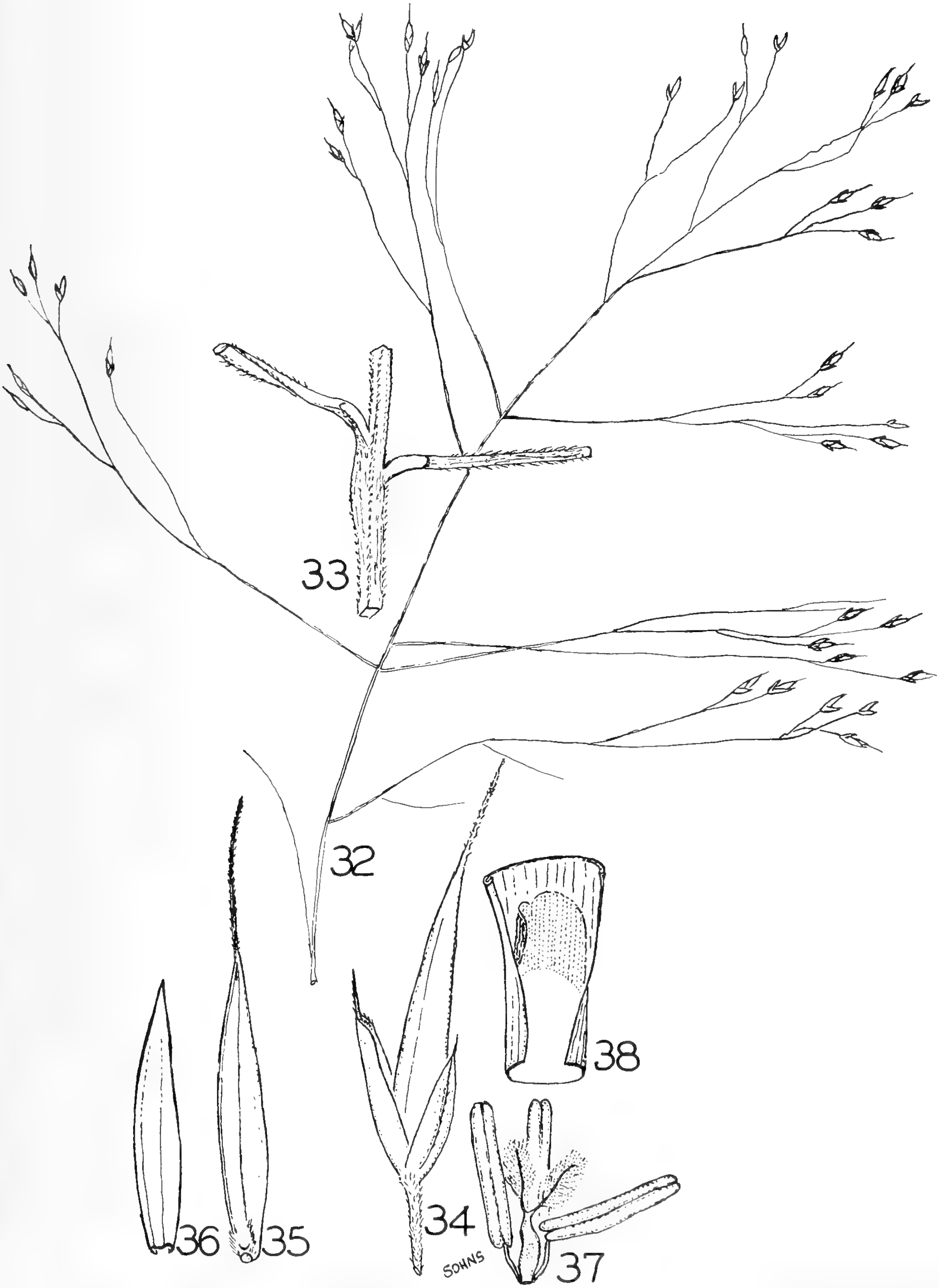
Blades involute; ligule 2.5–3 mm long, firm; glumes 2.3–2.5 mm long; lemma about 3 mm long, scaberulous at tip; panicle branches short, many-flowered ... *M. arenicola*

Calamagrostis mcvaughei Sohns, sp. nov.

Figs. 39–46

Gramen perenne; rhizomate; culmi 50–100 cm alti, graciles, glabri; vaginae internodiis longiores, arctae, scaberulae, ad os parce pilosis; ligula rotundata, membranacea, 1–1.2 mm longa; laminae 10–30 cm longae, subtus scabrae, supra valide nervis prominulis percursae, in collo parce strigosis; panicula densiflora, laxa, pyramidata, ramis gracilibus, verticillatis, flexuosis; spiculae 4–5 mm longae; gluma prima 3.4–4.2 mm longa, 1-nervis, carina scaberula ad summam; gluma secunda 4–5 mm longa, ceteroqui primam similis; lemma 3.4–4.1 mm longum, 5-nervis, scaberulum, 2- (interdum 4-) denticulata, dorso medium aristatum, 6–8 mm longa, geniculata; callo pilis copiosis, lemmam dimidio breviore; palea membranacea, lemmam subaequans; staminia 3, antherae circiter 2 mm longae; lodiculae 2; rachilla producta.

Perennial, rhizomatous, tufted; culms 50–100 cm tall, slender, erect, glabrous; sheaths overlapping at base, straw-colored, scaberulous and slightly pilose, especially toward the collar; ligule a rounded membranous rim 1.0–1.2 mm long; blades 10 to 30 cm or more long, convolute when dry, scabrous on the lower surface, strongly ribbed on the upper surface and pilose on the nerves; collar sparsely strigose on the margins at the junction of the blade and sheath; panicle many-flowered, open, pyramidal, the branches slender, flexuous, verticillate, the lower branches



FIGS. 32–38.—*Muhlenbergia matudae* Sohns, sp. nov.: 32, Panicle, natural size; 33, panicle branches; 34, spikelet; 35, lemma; 36, palea; 37, essential organs; 38, ligule. All figures, except 32, × 16. Drawn from type specimen.

Figs. 39–46.—*Calamagrostis mcvaughei* Sohns, sp. nov.: 39, Plant, × ½; 40, spikelet; 41, floret; 42, anther; 43, lodicule; 44, cross section of blade; 45, external view of collar at junction of sheath and blade; 46, inside view of ligule, one-half of blade, sheath and ligule removed. Figs. 42 and 44, × 16, all others, × 8. Drawn from the type specimen.

bearing spikelets at the tips, the branches antrorsely scaberulous, glabrous in the axils; spikelets spreading in anthesis, pale-green to reddish-purple, 4–5 mm long (average length of 15 spikelets: 4.4 mm); first glume 3.4–4.2 mm long, 1-nerved, scaberulous on the keel toward the tip; second glume 4–5 mm long, 1-nerved, scaberulous on the keel toward the tip; lemma with an awn 6–8 mm long, inserted about the middle, one (or indistinctly twice) geniculate, exserted, antrorsely scaberulous, the lemma 3.4–5.1 mm long, 5-nerved, scaberulous on the back and scabrous on the keel toward the tip, apex with 2 (sometimes 5) setaceous teeth, callus hairs abundant, about half as long as the lemma; palea membranous, thin, about as long as the lemma; stamens 3, anthers about 2 mm long; lodicules 2, slightly swollen at the base, terminal half thin and flattened; rachilla prolonged, pilose, the hairs extending to the tip of the second glume.

Type in the U. S. National Herbarium, no. 2118496, collected in "Sierra de Manantlan (15–20 miles southeast of Autlan), near Aserradero El Cuartón, elevation 2500 m; steep slopes near summits, in pine-oak-fir forests," in the State of Jalisco, November 2, 1952, by Rogers McVaugh (No. 13853). Additional specimen examined: JALISCO: northeastern slopes of the Nevado de Colima, below Cañoa de Leoncito, *McVaugh* 13468.

This taxon is related to *C. tolucensis* and is named in honor of Dr. Rogers McVaugh, of the University of Michigan.

Calamagrostis valida Sohns, sp. nov.

Figs. 47–55

Gramen perenne; caespitose, culmi usque ad 65 cm alti; vaginae inferiores efoliatae, superiores internodiis longiores, scaberulis; ligula membranacea, 2.5–3 mm longa; laminae 8–20 cm longae, usque ad 8 mm latae, supra pilosis, subtus glaberrimis; panicula densiflora, 15–25 cm longa, ramis verticillatis; spiculae 5–6 mm longae, in callo pilis copiosis, usque ad 4 mm longis; gluma prima circiter 4 mm longa, 1-nervis, carina scaberula, ceteroqui glaberrima; gluma secunda usque ad 5.5 mm longa, 3-nervis, glaberrima; lemma circiter 4.5 mm longum, 5-nervis, 2-denticulata, arista usque ad 6 mm longa, dorso medium aristatum, columna laxe torta, exserta, leviter geniculata; palea 3.8–5 mm longa, bicarinata, bifida, membranacea; staminia 3, antherae 3.5–4 mm longae; lodiculae 2, 0.5–0.8 mm longae; rachilla producta, 1.8–2 mm longa, longe-pilosi.

Perennial; caespitose, culms up to 65 cm tall; basal sheaths bladeless, glabrous, upper sheaths scaberulous, longer than the internodes, pale pinkish-purple, hirtellous across the back at the collar; ligule firm, membranaceous, 2.5–3 mm long, blades 8–20 cm long, up to 8 mm wide, the margins slightly convolute when dry, upper surface pilose, lower surface glabrous, the tip long-attenuate; terminal blades sometimes overtopping the inflorescence; inflorescence 15–25 cm long, dense, branches fascicled, 1.5–2 cm distant in the center of the inflorescence, alternately arranged, branches probably spreading in anthesis, slightly purplish, included at the base; spikelets 5–6 mm long; callus hairs copious, up to 2.4 mm long; first glume about 4 mm long, 1-nerved, scaberulous on the keel, otherwise glabrous; second glume up to 5.5 mm long, 3-nerved, glabrous; lemma about 4.5 mm long, 5-nerved, with 2 setaceous teeth, awned from the back, the awn up to 6 mm long, loosely twisted, exserted, slightly geniculate; palea 3.8 mm long, 2-keeled, membranaceous; stamens 3, anthers 3.8–4 mm long; lodicules 2, 0.5–0.8 mm long; rachilla joint 1.8–2 mm long, long-pilose.

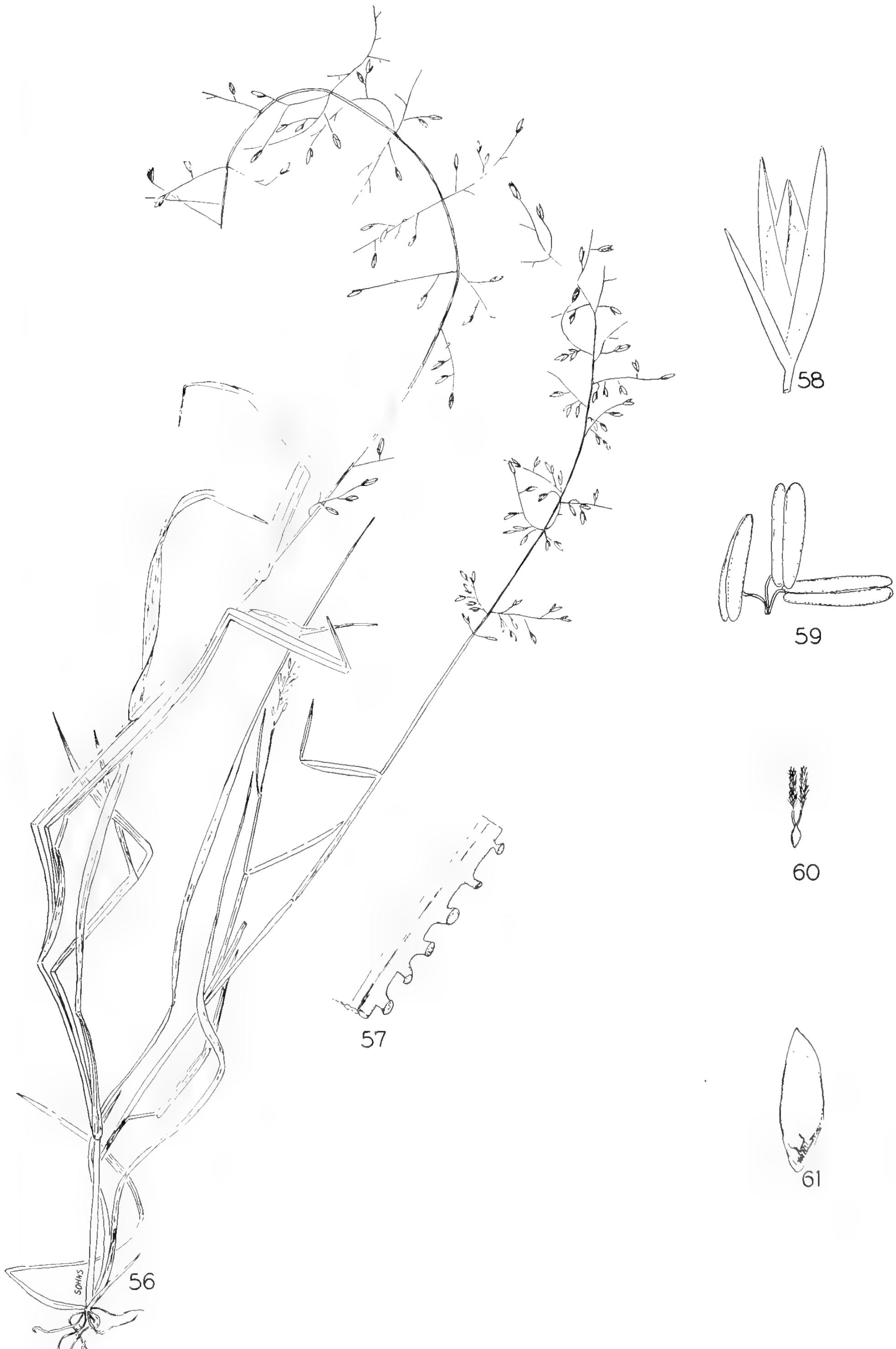
Type in the U. S. National Herbarium, no. 2118491, collected on the northeastern slopes of the Nevado de Colima, below Cañoa de Leoncito; steep cut-over mountainsides in fir zone at head of Barranca de la Rosa, elevation ca. 2800 m, October 10, 1952, by Rogers McVaugh (no. 13410).

Sporobolus viscidus Sohns, sp. nov.

Figs. 56–61

Gramen annuum; culmi usque ad 50 cm alti, graciles, infra nodos crateriformi-tuberculati; vaginae internodiis breviores, glabrae, carinis tuberculatae, nervi culmorum sparse tuberculatae; ligula ciliolata, 0.5 mm longa; laminae 4–20 cm longae, usque ad 6 mm lata, tenuis, plana, supra glabra, subtus scaberula, margines tuberculatis et scaberrimis; panicula 15 cm vel longior, rachis tuberculata, glabra, viscida; ramis brevibus, rigidis, sparse ramosis, viscidis; spiculae 3.5–4 mm longae, pallido-purpurea; gluma prima 1.9–3 mm longa, enerve; gluma secunda 2.5–4 mm longa, 1-nervis; lemma usque ad 4 mm longum, 1-nerve; palea lemma aequans vel longior, valide bicarina; staminia 3, antherae

FIGS. 47–55.—*Calamagrostis valida* Sohns, sp. nov.: 47, Plant, × ½; 48, spikelet; 49, floret; 50, anther; 51, lodicule; 52, node on the axis of the raceme; 53, ligule, median adaxial view; 54, collar at junction of the blade and sheath; 55, cross-section of blade. Figs. 48–50, 52–55, × 8; 51, × 20. Drawn from the type specimen.



FIGS. 56–61.—*Sporobolus viscidus* Sohns, sp. nov.: 56, Plant, × ½; 57, margin of blade; 58, spikelet; 59, stamens; 60, ovary; 61, caryopsis (pericarp free at tip and base). All figures, except 56, × 8. Drawn from the type specimen.

1.8–2.2 mm longae; lodiculae 2, 0.2 mm longae; caryopsis circiter 3 mm longa, 1 mm lata.

Annual; culms up to 50 cm tall, slender, tuberculate-crateriform below the nodes; sheaths shorter than the internodes, glabrous, a line of glands on the keel, sparsely glandular on the lateral nerves; ligule a fringe of hairs, 0.5 mm long; blades 4–20 cm long, up to 6 mm wide, thin, flat, glabrous above, scaberulous below, margins near the base glandular, otherwise short-ciliate, the margins of the tip slightly inrolled; panicle 15 cm or more long, rachis tuberculate-glandular, the branches short, stiff, viscid; spikelets 3.5–4 mm long, pale-purplish; first glume 1.9–3 mm long, nerveless; second glume 2.5–4 mm long, 1-nerved; lemma up to 4 mm long, 1-nerved; palea firm, as long as or longer than the lemma, strongly 2-keeled, splitting when mature; stamens 3, anthers 1.8–2.2 mm long; lodicules 2, 0.2 mm long; caryopsis about 3 mm long and 1 mm wide.

Type in the U. S. National Herbarium, no. 2181966, collected "en matorral seco, 550 m. de altitud, La Junta, cerca de Tingambato, Diciembre 20, 1953," Estado de Mexico, by Dr. E. Matuda (no. 29813).

This taxon is related to *S. hintonii* Hartley, but it may be distinguished from that species by the narrow, short-branched, viscid panicle and the larger spikelets.

LEATHER RESEARCH AT NBS

In many respects leather is a unique material, possessing a number of desirable physical properties, such as tearing strength, flexibility, and porosity, that make it particularly well suited to use in shoes, gloves, and other articles of clothing. For specific applications, these properties can be controlled to a considerable extent by proper selection of skins, tanning agents, and finishing processes. A knowledge of the structure of collagen, the basic leather forming protein of hides, as well as an understanding of the mechanism of tanning, is thus of direct importance to tanners, shoe manufacturers, and other industrial users of leather.

To provide basic information of this kind for Government and industry, the National Bureau of Standards has, over the past 40 years, carried on an extensive program of research and development in the field of leather.[1] This program, now under the direction of Dr. J. R. Kanagy, has included fundamental studies of collagen, development of concepts for the mechanism of tanning, and measurement of the physical and chemical properties of collagen and leather. Much of the information thus obtained has been applied to the improvement of leather products and the development of standard methods for their evaluation.

[1] For further details and a bibliography of NBS publications in the leather field see, *Leather research and technology at the National Bureau of Standards*, by Everett L. Wallace, NBS Circ. 560. 1955. Available from the Superintendent of Documents, U. S. Government Printing Office, 15 cents.

FUNDAMENTAL PHYSICOCHEMICAL STUDIES

Because of the complex nature of collagen, a large proportion of the Bureau's leather investigations have combined both physical and chemical studies. An example is a series of investigations of the interactions of leather and collagen with water in various forms. Leather excels in its ability to transfer water vapor from a region of high humidity to one of lower humidity. Because of the relation of this property to shoe comfort and the removal of perspiration from shoes, water-vapor transfer through leather has been extensively studied at NBS.[2] The strong adsorptive capacity of leather and collagen for water and water vapor also has an important effect on the properties of leather. This has led to a series of studies on water adsorption and its variation with temperature, tannage, and other factors. These studies are being extended to include heats of wetting of leather and other fibrous polymers.

The physical constants of leather fibers are perhaps of less immediate practical importance. Nevertheless, they are of great value in understanding the complex nature of collagen and the processes involved in converting collagen to leather. In general, studies of fiber constants are made under varying conditions of tannage, moisture content, temperature, composition, and other factors, so that extensive data result.

[2] *Water vapor permeability of leather*, NBS Technical News Bull. 34: 163. Nov. 1950.

To learn more about the thermodynamic properties of leather, data have been obtained on its density, compressibility, expansivity, and specific heat. In the course of this work, investigators encountered interesting phenomena which are being explored further. For example, the expansivity measurements led to studies of shrinkage rates, with resulting data on heats and entropies of activation. Likewise, compressibility measurements at the high pressures required for solid materials led to similar studies on synthetic polymers. Data on specific heats are now being accumulated in connection with basic studies on interactions of moisture and leather.

BASIC CHEMISTRY OF COLLAGEN

Skin collagen, being a natural fibrous protein, is a highly complex polymer that occludes extraneous materials, such as fats, salts, and other proteins. Thus, fundamental chemical studies of collagen first required investigation of methods for removing extraneous materials so that a chemically reproducible purified collagen might be prepared.

The chemistry of the purified collagen that was finally obtained has been intensively studied, providing data that should be of great value in determining its structure and the mechanism of tanning. Besides studying relatively simple chemical reactions, such as esterification, deamination, and various tanning procedures, the Bureau has determined the combining weights and the reactive basic groups. It has also studied the amino acid structure and the amide nitrogen content of collagen.

Recently, a rapid chromatographic method was developed for determining the amino acid content of collagen.[3] This quantitative technique can be applied not only to collagen itself but also to its derivatives and degradation products. In contrast to other methods currently employed, it enables the analyst to follow with a high degree of detail the reactions and changes in which collagen may be involved. It is thus expected to provide a useful tool that will aid in further understanding the structure of collagen and the properties of leather.

PHYSICAL PROPERTIES

The behavior of leather in service is largely determined by the physical properties of the leather matrix. Mechanical properties that have been investigated extensively include tensile strength, stretch, tearing strength, stiffness, bursting strength, rigidity, and flexural resistance. Investigations of thermal properties have involved shrinkage temperature, area stability, and thermal conductivity. Other studies have dealt with electrical resistance, dielectric constant, and structural properties such as pore-size distribution in the fibers and leather.

Recently, fundamental information regarding the structure of leather and collagen fibers was obtained from studies of pores in leather.[4] Pressure porosimeter and electron microscope studies revealed the presence of large numbers of extremely small pores—less than a millionth of an inch in radius—in both leather and collagen. Quantitative information was obtained on pore-size distribution within the individual collagen fibrils. These data should aid the leather technologist in understanding the swelling and shrinkage accompanying water-leather interactions. They are also expected to shed additional light on the ability of leather to transmit or absorb water vapor, tannins, or impregnants. The permeability of leather to water vapor, which makes it so well suited to use in footwear, is undoubtedly related to the presence of pores.

LEATHER TECHNOLOGY

In 1924, a survey by the U. S. Department of Commerce stated that 40 percent of the vegetable tanning materials consumed in the United States in 1922 were imported. It also pointed out that 99 percent of the chrome ore used in the United States at that time came from abroad. In view of the obvious importance of a substitute tanning material to the national economy, the Bureau initiated research on synthetic tanning agents.

Representative syntans of various types were prepared and were evaluated by tanning tests. The published results helped lay the foundation for the development of present-day satisfactory syntans by industry. An investigation of the tanning properties of sulfite cellulose, a by-product of the paper industry, demonstrated that this material could be used in conjunction with vegetable tanning extracts. Later, during World

[3] *A rapid quantitative analysis of collagen*, NBS Technical News Bull. 40: 65. May 1956.

[4] *Micropores in leather*, NBS Technical News Bull. 39: 68. May 1955.

War II, it was shown that iron could be substituted for chromium during an emergency.

During World War II military and civilian shoe requirements were so great that the tanning industry had difficulty in expanding operations sufficiently to meet the increased demand. Of chief concern were the acute shortages of hides and tannins. Recognizing the need for conservation, the Army Quartermaster Corps sponsored research at the Bureau to improve the stability and serviceability of leather and to develop test methods for military items. The Bureau investigated several oil and wax treatments, which were adopted by the Armed Forces to increase the wear resistance of sole leather.

After the war, research directed toward improving the serviceability of leather was continued. This work aimed not only to increase the wear resistance of sole leather but to improve low-grade hide areas so that more first-quality soles might be cut from the same hide. Ultimately both these objectives were attained by development of a method for impregnating leather with polymers.[5]

The tightly woven condition of the natural fibers of leather tends to limit the materials with which it may be impregnated. Thus, the Bureau's early attempts to use various solutions of commercial polymers as impregnants were not successful, and research was for a time directed toward impregnating the leather with monomers for polymerization *in situ*. Then, as a result of other research on pore-size distribution in leather and particle-size distribution in rubber latex, it became apparent that leather could be impregnated by soaking the crust leather (tanned, but not finished) in solutions of specially prepared or selected commercial polymers. On the basis of these findings, a method of treatment was developed.

Laboratory tests have shown that the treatment increases wear by about 80 percent and reduces water absorption by about half. Since crust sole leather containing a minimum amount of uncombined tannins is used, considerable saving in tanning materials is effected. Furthermore, impregnation may increase the wear of belly and shoulder leather to equal that of high-quality sole leather.

To bridge the gap between laboratory investigation and large-scale industrial application of the process, pilot-plant studies are being conducted at NBS under sponsorship of the Navy Bureau ot Supplies and Accounts. These studies have shown that by varying the impregnating process, long wearing leathers can be produced having various degrees of waterproofness, flexibility, and water-vapor transmission. Methods have also been developed for imparting a finished appearance to the impregnated leather.

STABILITY AND SERVICEABILITY

The aging qualities of leather depend principally on its tannage, environment, and use. However, investigations of the mechanism of degradation have shown that highly ionizable acids, either added during manufacture or adsorbed from the atmosphere, are a major factor n leather deterioration.

Over 20 years ago the Bureau made a thorough study of the effect of acid on leather and published a series of papers on the subject. Some of the more important results of this investigation were the development of a standard procedure for determining acidity in leather and the determination of the optimum pH to prevent change in the properties of leather during prolonged storage. Other factors in leather deterioration which the Bureau has studied include temperature, oxygen, moisture, and the catalytic effect of traces of copper and iron salts in the leather.

Before World War II mildew on leather was not considered very important and little effort was made to prevent its growth. However, military forces stationed in tropical areas soon found that the growth of mildew on numerous items of equipage was a serious problem. The Army therefore initiated a project at the Bureau for the development of fungicidal treatments and test methods.[6]

These studies showed that the principal effect of mildew on leather, other than appearance, is the removal of greases, which causes stiffness and loss in strength. As a result of the investigation, a specification for the fungicidal treatment of leather was prepared and quantitative methods were developed for the determination of fungicides in leather. This work has been continued with the development of new fungicides and

[5] *Improved techniques for impregnating leather*, NBS Technical News Bull. 39: 96. July 1955.

[6] *Prevention of mildew on leather*, NBS Technical News Bull. 32: 84. July 1948.

establishment of procedures for reliable evaluation of all fungicidal materials.

TEST METHODS

Much of the Bureau's work on leather has been concerned with the development of new or improved methods or equipment for testing leather and leather products. The results have been used both in procurement specifications and in evaluation and development work.

For many years the accurate determination of moisture in leather was a serious problem to analysts, as the results for all other chemical constituents are expressed on the oven-dry basis. In 1941 NBS research showed that control of the atmospheric humidity in the drying oven would permit moisture determinations to be made with considerable precision. This method has since been adopted as the ultimate standard in Federal Specifications.

Because the properties of leather vary considerably over the area of a hide, it is important that a test sample represent as nearly as possible the average for the hide. Bureau scientists devised a sampling procedure[7] for shoe upper leather that permits selection of sampling locations so that the fewest specimens are required to give the desired accuracy for a particular property. The sampling procedure is based on a mathematical relationship involving the coefficient of correlation between the value obtained for a particular test from a specific location and the average for that test over the corresponding side. The most suitable sampling location on a hide for all tests required in acceptance testing was also determined.

A number of techniques and devices have been worked out for making performance tests of leather products. Much of this work has dealt with water-vapor permeability. Other developments have been concerned with measurement of abrasion resistance, flex life, accelerated aging, and compressibility.

Recently, in work sponsored by the Office of the Quartermaster General, the Bureau has developed a nondestructive method for testing leather, based on the transmission of sound waves.[8] The chief instrument employed is a pulse propagation meter which measures and records the speed of a generated sound pulse through the leather. As a result, the specimen under test is left unharmed, in contrast to the tearing or other destructive effects of other test procedures. Good correlation has been found between sonic measurements and the results of tensile and breaking elongation tests.

FUTURE PLANS

In the near future the Bureau expects to begin a study of leather degradation by radiation. The newly developed technique for amino acid determination will be used in this work. This method of approach should show the exact point of attack in the collagen molecule and thus give a clearer explanation of the mechanism of breakdown.

Recently developed methods for determining particle size of polymers will also be utilized to study the size of particles in tannins and leather impregnants. Comparison of these results with data on leather pore size should not only provide additional information on the mechanism of tanning but should also make possible a better understanding of the nature of the tanned material.

[7] *Sampling of upper leather for shoes*, NBS Technical News Bull. 35: 6. Jan. 1951.

[8] *A sonic technique for testing leather*, NBS Technical News Bull. 40: 35. March 1956.

There are agents in nature able to make the particles of bodies stick together by very strong attractions. And it is the business of experimental philosophy to find them out.—NEWTON

BOTANY.—*Additional Fijian mosses, III.* EDWIN B. BARTRAM, Bushkill, Pa.

(Received September 25, 1956)

The mosses collected by Dr. A. C. Smith on his latest expedition to Fiji, April to December 1953, under the auspices of the Smithsonian Institution and the National Science Foundation, are represented by 136 numbers, many of which are in generous quantity for wide distribution. For the most part the collections duplicate previous gatherings but are of interest from the standpoint of local distribution. Three new species, *Syrrhopodon vitiensis*, *Thyridium parvifolium*, and *Chaetomitrium smithii*, together with a new variety of *Chaetomitrium orthorrhynchum*, a species new to the local flora, and *Thamnium ellipticum*, not previously known from Fiji, are the outstanding features of the series. The list of Fijian mosses now numbers about 288 species of which 75, or approximately 25 per cent, are endemic. Further explorations may expand the list to some extent, but it seems likely that the flora as now known is reasonably complete.

A representative series from this collection is in my herbarium and a complete set in the United States National Herbarium.

FISSIDENTACEAE

Fissidens vitiensis Dix.

Ovalau: Hills east of Lovoni Valley, alt. 300–500 m, dense forest, on rich humus, no. 7361.

Fissidens mangarevensis Mont.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–300 m, dense forest, on rocks along stream, no. 8842. Taveuni: Summit of adjacent slopes of Mount Manuka, east of Wairiki, alt. 700–850 m, dense forest, on caudex of tree-fern, no. 8226. Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest, on caudex of tree-fern, no. 8040.

Fissidens filicinus Doz. & Molk.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on rocks in dry stream bed, no. 8346.

DICRANACEAE

Trematodon longicollis Mx.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on clay banks along stream, no. 8673b.

Campylopodium integrum (C.M.) Par.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on clay banks along stream, no. 8673a.

Campylopus samoanus Broth.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on wet rocks along stream, no. 7122. Ovalu: Summit of Mount Ndelaiovalu and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on wet humus-covered rocks, no. 7573.

Leucoloma tenuifolium Mitt.

Viti Levu: Namosi: Hills north of Wainavindrau Creek, between Korombasambasanga Range and Mount Naitarandamu, alt. 250–450 m, dense forest, on tree trunks, no. 8452.

LEUCOBRYACEAE

Octoblepharum albidum Hedw.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, in masses of humus on trees, no. 7842. Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–400 m, dense forest, on tree trunks, no. 8204.

Leucobryum pentastichum Bry. jav.

Viti levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, in dense mats on decayed wood, no. 8857. Ngau: Hills east of Herald Bay, inland from Sawaicke, on slopes of Mount Vonda (Lion Peak) and toward Waikama, alt. 30–200 m, on humus at roots of trees in open forest, no. 7994.

Leucobryum sanctum Hpe.

Viti Levu: Serua: Hills between Wainінggere and Waisese Creeks, between Ngaloa and

Wainiyambia, alt. 50–100 m, dry forest, in dense mats on humus-covered logs, no. 9514. Viti Levu: Namosi: Hills north of Wainavindrau Creek, between Korombasambasanga Range and Mount Naitarandamu, alt. 250–450 m, dense forest, in dense masses on humus, no. 8461.

Leucobryum scalare C. M.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, on wet banks along road, no. 7013.

Exodictyon dentatum (Mitt.) Card. ? poor condition.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on bark, no. 7148.

Calymperaceae

Syrrhopodon mamillatus C. M.

Twelve collections from Viti Levu, Ngau, and Ovalau showing a broad distribution in the local area.

Syrrhopodon smithii Bartr.

Viti Levu: Serua: Hills between Waininggere and Waisese Creeks between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on tree trunks, mixed with hepatics and lichens, no. 9538.

Syrrhopodon (Calymperidium) vitiensis Bartr., sp. nov.

Laxe caespitosus, caespitibus fuscescenti-viridibus, opacis. Caulis brevissimus. Folia sicca crispatula, humida erecto-patentia, ad 12 mm longa, e basi ovata sensim anguste lineari-subulata; marginibus remote denticulatis, in parte superior vaginae sat dense serrulatis; costa valida, excurrente; cellulis laminalibus minutis, rotundatis, diam. circa 5μ, vix incrassatis, marginibus versus 2–3 seriebus bistratosis, cancellinis male definitis. Fructus ignotus.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on tree trunks, no. 7103.

This species evidently has some affinity with *S. subulatus* Lac., but the much smaller lamina cells and the leaf margins closely and sharply serrate at the shoulders and distantly denticulate above are good diagnostic characters.

Thyridium parvifolium Bartr., sp. nov.

Caespitosum, caespitibus laxis, lutescentibus. Caulis repens, ramis vix 1 cm altis. Folia sicca erecta, incurva, humida erecto-patentia, valde undulata, ad 2 mm longa, e basi amplexicaule, oblonga, obtusa, limbata. Limbus folii inferne 8–10 seriatus, fere ad apicem folii productus, superne tenuiter denticulatus vel integrus. Cellulis laminalibus rotundatis, diam. 8–10μ, chlorophyllosis, papillosis, cancellina superne rotundata; costa infra apicem folii evanida. Seta 5–6 mm. longa, tenuis, rubra; theca erecta, oblongo-cylindrica, deoperculata 1.8 mm. longa.

Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on tree trunks, no. 7312.

Slightly more robust than *T. flavum* (C.M.) Fleisch. and obviously distinct in the bluntly obtuse leaves with the hyaline border more pronounced and extending nearly to the apex.

Thyridium luteum Mitt.

Five collections from Viti Levu, Ovalau, and Taveuni. Frequent on most of the larger islands.

Calymperes serratum A. Br.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on tree trunks, no. 8198. Ovalau: Hills west of Lovoni Valley, on ridge south of Mount Korolevu, alt. 400–500 m, dense forest on decayed wood, no. 7660.

Calymperes tahitense (Sull.) Mitt.

Viti Levu: Serua: Hills between Navua River and Wainiyavu Creek near Namuamua, alt. 100–200 m, no. 9007. Viti Levu: Serua: Hills east of Navua River, near Nukusere, alt. 100–200 m, dense forest on tree trunks, no. 9142.

Calymperes tahitense var. **truncatum** Ther & Dix.

Viti Levu: Serua: Hills between Waininggere and Waisese Creeks, between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on boulders, no. 9390.

Pottiaceae

Rhamphidium veitchii Dix.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest on clay banks along stream, nos. 8681, 8673.

Barbula inflexa (Duby) C. M.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, dense forest on rocks along stream, no. 8840a.

Bryaceae

Brachymenium indicum (D. & M.) Bry. jav.

Viti Levu: Serua: Flat coastal strip in vicinity of Ngaloa, alt. near sea level, on humus-covered rocks in village, no. 9502. Ngau: Hills east of Herald Bay, inland from Sawaicke, on slopes of Mount Vonda (Lion Peak) and toward Waikama, in pockets of humus on bare rocks of open hillside, alt. 30–200 m, no. 7957.

Bryum nitens Hook.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, on rocks along stream, no. 8840.

Bryum greenwoodii Dix.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, on humus-covered rocks in dry stream bed, no. 8338.

Rhizogoniaceae

Rhizogonium spiniforme (Hedw.) Bruch forma **samoana** Mitt.

Two collections. Frequent throughout the islands.

Rhizogonium setosum Mitt.

Eight collections from Viti Levu, Ovalau, and Ngau. A common species in the local flora.

Bartramiaceae

Philonotis pilifer Dix.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, on clay banks along stream, no. 8680.

Hypnodendraceae

Hypnodendron subspininervium (C. M.) Jaeg.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on trees, no. 7722. Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on tree trunks, no. 7612. Taveuni: Hills east of Somosomo, west of old crater occupied by small swamp and lake, alt. 660–900 m, dense forest, on tree trunks, no. 8382.

Hypnodendron vitiense Mitt.

Taveuni: Hills east of Somosomo, west of old crater occupied by small swamp and lake, alt. 660–900 m, on rocks along stream, no. 8371.

Spiridentaceae

Spiridens balfourianus Grev.

Ngau: Slopes of Mount Ndelaitho, on northern spur, toward Navukailangi, alt. 350–500 m, dense forest, on trees trunks, no. 7884.

Spiridens aristifolius Mitt.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, dependent from tree trunks and branches, no. 7726. Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, epiphyte, no. 7371.

Spiridens flagellosus Schp.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on tree trunks, no. 7725. Tavenuni: Valley between Mount Manuka and Mount Koroturanga (Des Voeux Peak), east of Wairiki, alt. 600–700 m, dense forest, in masses on trees, no. 8278.

Orthotrichaceae

Macromitrium subtile Schwaegr.

Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest on tree trunks, no. 8052.

Rhacopilaceae

Rhacopilum spectabile R. & H.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, on decayed wood, no. 8841.

Pterobryaceae

Garovaglia smithii Bartr.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, on tree trunks, nos. 7742, 7827.

Endotrichella graeffeana C. M.

Viti Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on tree trunks and branches, no. 8884.

Euptchium setigerum (Sull.) Broth.

Ovalau: Summit of Mount Tana Lailai and adjacent ridge, alt. 500–550 m, dense bush and thickets of crest, on tree trunks, no. 7724.

Symphysodon vitianus (Sull.) Broth.

Five collections from Viti Levu, Ngau, and Ovalau. A frequent species on tree trunks and branches on the larger islands.

Meteoriaceae

Floribundaria seruginosa (Mitt.) Fleisch.

Viti Zevu: Tailevu: Hills east of Wainimbuka River, in vicinity of Wailotua, alt. 100–150 m, on damp rocks at mouth of cave in dense forest, no. 7236.

Neckeraceae

Calyptothecium urvilleanum (C. M.) Broth.

Viti Levu: Namosi: Northern slopes of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 450–600 m, dense forest, on decayed wood, no. 8740.

Himantocladium implanum (Mitt.) Fleisch.

Ngau: Hills east of Herald Bay, inland from Sawieke, alt. 300–450 m, dense forest on tree trunks, no. 7753.

Homaliodendron flabellatum (Dicks.) Fleisch.

Taveuni: Summit and adjacent slopes of Mount Manuka, east of Wairiki, alt. 700–830 m, dense forest, in masses on tree trunks, no. 8233.

Thamnium ellipticum (Bry. jav.) Kindb.

Ngau: Hills east of Herald Bay, inland from Sawaieke, alt. 300–450 m, dense forest, on wet rocks along stream, no. 7862.

New to Fiji. Area: Sumatra, Java, Borneo, Philippines.

Hookeriaceae

Distichophyllum vitianum (Sull.) Besch.

Three collections from Ovalau and Taveuni. A frequent local species on dead wood.

Cyclodictyon blumeanum (C. M.) Broth.

Vitu Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on rocky banks along stream, no. 8889.

Callicostella vesiculata C. M.

Ovalau: Valley of Mbureta and Lovoni Rivers, alt. 20–50 m, on roots of *Inocarpus* trees along trail, no. 7673.

Callicostella papillata (Mont.) Jaeg.

Seven collections from Viti Levu, Taveuni, and Ovalau. A common species on decayed wood.

Callicostella papillata var. **brevifolia** Fleisch.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Vocux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8256a.

Chaetomitrium orthorrhynchum (D. & M.) Bry. jav. var. **vitiense** Bartr., var. nov.

A typo foliorum marginibus superne minute denticulatis differt.

Species new to Fiji. Quite distinct from the typical form in the upper leaf margins minutely denticulate instead of sharply serrate. Otherwise, the agreement seems to be complete.

Ovalau: Summit and adjacent slopes of Mount Korotolutolu, west of Thawathi, alt. 500–589 m, dense forest, on tree trunks, no. 8048.

Chaetomitrium (**Leiocarpus**) **smithii** Bartr., sp. nov.

Caespitosus, caespitibus laxis, depressis, viridibus. Caulis procumbens, irregulariter pinnatim ramosus, ramis late patentibus, 5–8 mm. longis, parce ramulosis, valde complanatis. Folia ramea patentia, ovato-lanceolata, concava, acuminata, 1.5–2 mm. longa; marginibus erectis, fere ad basin serrulatis; costis binis, bene notatis; cellulis anguste linearibus, laevissimis. Seta 12–15 mm. longa, inferne laevis, superne papillosa; calyptra ubique dense hispida, ad basem longe ciliata.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Ndakuivuna, alt. 100–200 m, dense forest, on bark, no. 7172.

The seta smooth below and weakly papillose above will at once separate this species from either *C. depressum* Mitt. or *C. rugifolium* Sull. The habit is more irregular and less dense than in *C. densum* Dix., the leaves more slenderly pointed and the leaf cells essentially smooth.

Leucomiaceae

Leucomium aneurodictyon (C. M.) Jaeg.

Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on bark, no. 7592; Hills west of Lovoni Valley, on ridge south of Mount Korolevu, alt. 400–500 m, dense forest, on decayed wood, no. 7624.

Thuidiaceae

Thuidium samoanum Mitt.

Ovalau: Summit of Mount Ndelaiovalau and adjacent ridge, alt. 575–626 m, dense bush and thickets of crest, on decayed wood, no. 7598.

Thuidium cymbifolium (D. & M.) Bry. jav.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Voeux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8258.

Entodontaceae

Campylodontium flavescens (Hook.) Bry. jav.

Viti Levu: Namosi: Valley of Wainavindrau Creek, in vicinity of Wainimakutu, alt. about 150 m, on tree trunks in thickets along stream, no. 8817.

Sematophyllaceae

Trichosteleum hamatum (D. & M.) Jaeg.

Eleven collections from Viti Levu and Ngau. Frequent locally and widely distributed in the southwest Pacific.

Trichosteleum boschii (D. & M.) Jaeg.

Four collections from Viti Levu. Not uncommon on decayed wood.

Trichosteleum fissum Mitt.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, on tree trunks, no. 8206.

Taxithelium lindbergii (Bry. jav.) R. & C.

Viti Levu: Namosi: Hills east of Wainikoroiluva River, near Namaumau, alt. 50–200 m, dense forest, on decayed wood, no. 8913a. Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on tree trunks, no. 7311.

Taxithelium kerianum (Broth.) Fleisch.

Three collections from Viti Levu, Ovalau, and Taveuni. Rather frequent on tree trunks and decayed wood.

Hypnaceae

Vesicularia reticulata (D. & M.) Broth.

Viti Levu: Namosi: Hills bordering Wainavindrau Creek, in vicinity of Wainimakutu, alt. 150–250 m, dense forest, on rocky banks along stream, no. 8889a.

Vesicularia calodictyon (C.M.) Broth.

Ovalau: Hills east of Lovoni Valley, alt. 100–300 m, dense forest, on wet rocks along stream, no. 7299.

Isopterygium minutirameum (C.M.) Jaeg.

Viti Levu: Namosi: Hills east of Wainikoroiluva, near Namaumau, alt. 50–200 m, dense forest, on bark, no. 9050.

Ectropothecium molle Dix.

Viti Levu: Namosi: Valley of Wainambua Creek, south of Mount Naitarandamu, alt. 250–350 m, dense forest, on wet stones along stream, no. 8792.

Ectropothecium adnatum Broth.

Taveuni: Valley between Mount Manuka and Mount Koroturanga (Des Voeux Peak), east of Wairiki, alt. 600–700 m, dense forest, on wet rocks along stream, no. 8256.

Ectropothecium percomplanatum Broth.

Viti Levu: Tailevu: Hills east of Wainimbuka River, in vicinity of Wailotua, alt. 100–150 m, on damp rocks at mouth of cave in dense forest, no. 7237.

Ectropothecium longicaule Bartr.

Taveuni: Slopes of Mount Manuka, east of Wairiki, alt. 300–600 m, dense forest, in masses on tree trunks, no. 8188.

Ectropothecium cyathothecium (C.M.) Jaeg.

Viti Levu: Namosi: Northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, alt. 250–400 m, dense forest, on tree trunks, no. 8638. Viti Levu: Serua: Hills between Waininggere and Waisese Creeks, between Ngaloa and Wainiyambia, alt. 50–100 m, dry forest, on decayed wood, no. 9639. Ovalau: Slopes of Mount Korotolutolu, west of Thawathi, alt. 300–500 m, dense forest, on decayed wood, no. 8006.

Polytrichaceae

Pogonatum graeffeanum (C.M.) Jaeg.

Four collections from Viti Levu. A frequent local species.

ENTOMOLOGY.—*New species of* Helicopsyche *from the Western Hemisphere*[1] (*Trichoptera, Helicopsychidae*).

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(Received September 4, 1956)

Extensive collections of material from Mexico and smaller collections from other parts of Central and South America have brought to light several species of the genus *Helicopsyche* which prove to be new to science and are herein described.

The genus *Helicopsyche* is of unusual interest because the larva makes a coiled sand-grain case resembling a snail shell, and these queer cases have aroused the interest of many entomologists. A considerable number of species have been described from various parts of the world, including the West Indies and the Americas, but a moderate number of these descriptions are based only on larvae or females, for which forms we do not yet know adequate specific characters to allow positive identification of material.

The American species show a number of phylogenetic trends which are well marked. All these species have a mesobasal lobe or shoulder on the male clasper. In one evolutionary line this shoulder has become separated from the body of the clasper by a wide, arcuate incision (Figs. 5, 6) and has culminated in the species *incisa* and *quadrosa*. In the other well-marked evolutionary line, the mesobasal lobe first became cushion-like, as in Fig. 8, then developed into a wide process appearing to arise from the extreme base of the clasper, as in Figs. 9 and 10. Accompanying this change of the mesobasal lobe, the apical margin of the clasper became rounded and its posterodorsal portion became expanded to form a curious boomerang-shaped structure (Fig. 10). Successive stages in this line are illustrated by *planata*, *borealis*, and *selanderi*, and the present known culminating species are *vergelana* and *piroa*.

It is a curious fact that all the Old World species also have a mesal process arising from the basal edge of the clasper. The initial inference suggests that these Old World species arose from a form such as *vergelana*. In the Old World species, however, the wing venation is more primitive than in the American forms, and the shape of the body of the claspers suggests that they also arose from a type having claspers more like those found in *extensa* or *dampfi*, as apparently the specialized American forms did also. On this basis there seems no doubt that the New World and Old World forms of the genus represent two separate phylogenetic groups, and that the common ancestor of the two combined the more primitive venation of the Old World forms with a primitive clasper perhaps much like that found in some of the New World forms.

DESCRIPTION OF NEW SPECIES

The species described below are virtually identical in size, color, and general structure, as follows: Length from front of head to tip of folded wings, 6–8 mm; color various shades of medium brown except for the antennae and legs which are chiefly straw colored; sixth sternite of the male bearing a fingerlike process; third, fourth, and fifth sternites of both males and females with a fenestrated network of sclerotized thickenings.

Material treated in this paper is in the collection of the Illinois Natural History Survey, unless otherwise indicated.

Helicopsyche extensa, n. sp.

Male: Genitalia as in Fig. 1. Lateral aspect of ninth segment with moderately wide ventral edge; cercus attached just above lateral apodeme. Tenth tergite moderately long and curved downward apex. Clasper with lateral aspect elongated, bearing a truncate dorsal projection toward the base, and with the apical portion truncate; ventral aspect having a wide mesobasal shoulder at base, the mesal edge of the shoulder bearing

[1] This paper is a joint contribution from the Section of Faunistic Surveys and Insect Identification, Natural History Survey, and the Department of Entomology, University of Illinois.

three straight spines; apical portion beyond shoulder narrow.

Holotype male.—Santa Isabel, Valley of the Cosnipata, Department of Cusco, Peru, December 1951, Felix Woytkowski. *Paratype.*—Same data, 1 female.

Helicopsyche woytkowskii, n. sp.

Male: Genitalia as in Fig. 2. Ninth segment with fairly long ventral margin; cercus attached a short distance above lateral apodeme. Tenth tergite moderately short, with a depression at its base. Claspers with lateral aspect short and regular, with relatively sharp anterodorsal and posterodorsal angles; ventral aspect with the fairly large mesobasal shoulder occupying nearly half the length of the clasper and bearing an irregular row of 5 or 6 stout setae along its mesal edge.

Holotype male.—Santa Isabel, Valley of the Cosnipata, Department of Cusco, Peru, January 9, 1952, Felix Woytkowski. *Paratype.*—Same data but December 19, 26, 1951, and January 1, 1952, 3 females.

The short, regular clasper, combined with the simple mesobasal shoulder will differentiate this species from other described species of the genus.

Helicopsyche dampfi, n. sp.

Male: Genitalia as in Fig. 3. Ninth segment with fairly long ventral margin; cercus attached slightly above lateral apodeme. Tenth tergite long, fairly straight, and tapering to a point at apex. Clasper with lateral aspect moderately long and somewhat rectangular; the anterodorsal corner is produced into a short truncate process, the posterodorsal corner is produced into a moderately sharp point; in ventral aspect, the mesobasal shoulder is relatively large and wide, with a row of stout bristles; from this view the apical portion of the clasper is fairly long, with the dorsal portion curved mesad.

Holotype male.—Finca Germania, Chiapas, Mexico, June 20, 1935, A. Dampf. *Paratype.*—Yepocapa, Mun. Yepocapa, Chimaltenango, Guatemala, April 27, 1948. Elev. 4,800 feet. R. L. Wenzel, 1 female (in the collection of the Chicago Natural History Museum).

Distinctive features of this species are the shape of the apex of the clasper and the broad mesobasal lobe with its cushion of setae.

Helicopsyche truncata, n. sp.

Male: Genitalia as in Fig. 4. Ninth segment with moderately long ventral margin, the cercus inserted very close to lateral apodeme. Tenth tergite short and blunt at apex. Lateral aspect of clasper irregular; anterodorsal corner rounded, posterodorsal corner almost quadrate; ventral margin with the mesobasal lobe projecting as a large triangular process. Ventral view of clasper with basal process appearing narrow but sharp, with an irregular mesal cushion of spines.

Holotype male.—Finca Vergel, Chiapas, Mexico, May 19, 1935, A. Dampf. *Paratypes.*—Same data but May 23, 1 male; same data but May 28, 1 male; Huehuetan, Chiapas, November 9, 1932, A. Dampf, 1 male; Mexico, without definite locality, 8 males.

This species is distinguished from other members of the genus by the triangular and shoulder-like mesobasal lobe, as seen in lateral view.

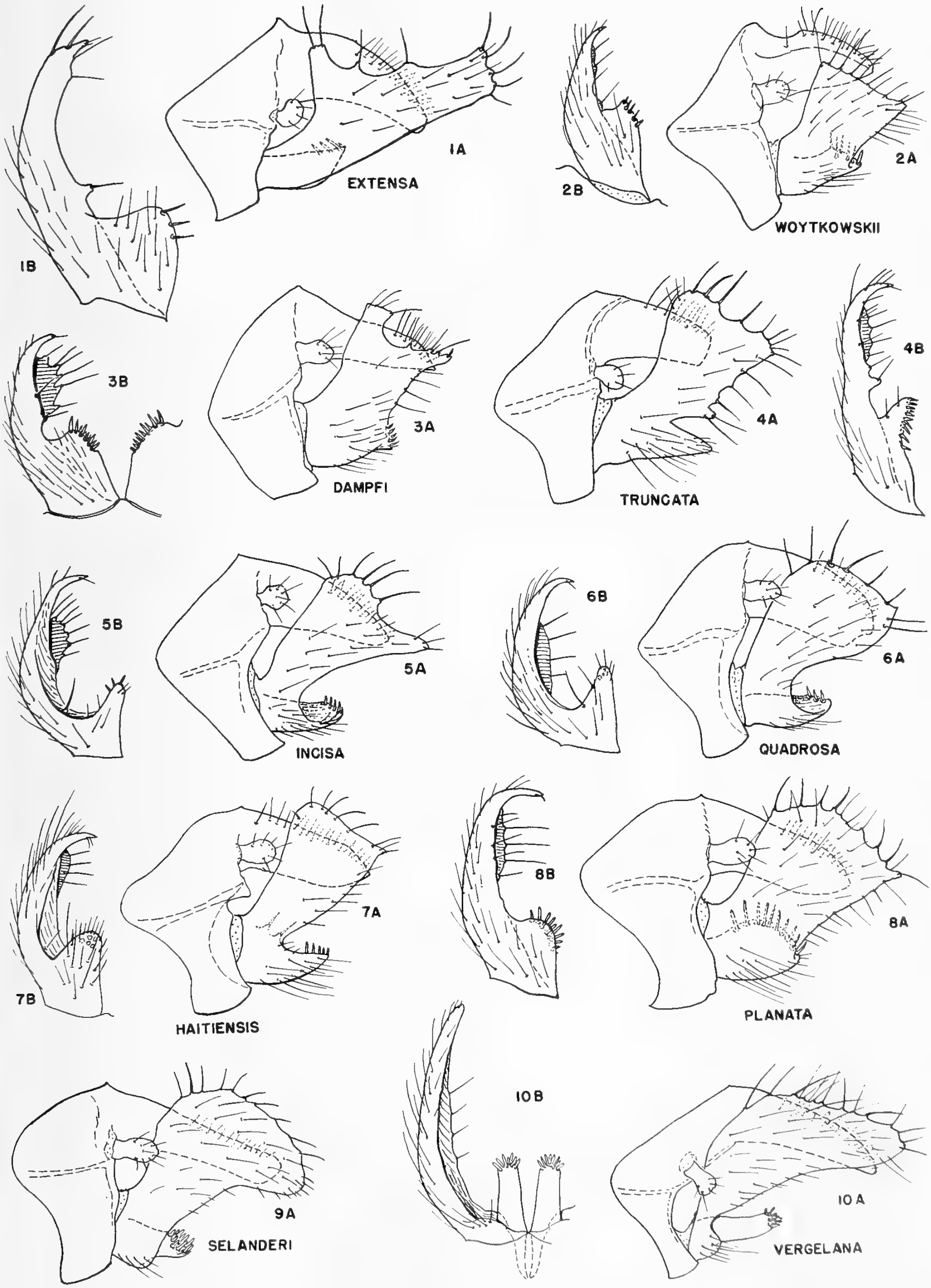
Helicopsyche incisa, n. sp.

Male: Genitalia as in Fig. 5. Ninth segment with moderately long ventral margin, the cercus situated a considerable distance above the lateral apodeme. Tenth tergite of moderate length and sloping gradually to apex. Clasper deeply incised toward the base in such a way that the mesobasal lobe is a narrow mesal projection separated from the main part of the clasper by a wide, arcuate incision; lateral aspect of clasper narrowed above mesobasal lobe, dorsal portion expanded, its anterodorsal corner large and rounded, its posterodorsal corner narrow, elongate and sharp; mesobasal lobe of clasper with a small cushion of short teeth.

Holotype male.—Finca Esperanza, Chiapas, Mexico, May 2, 1938, A. Dampf. *Paratypes.*—Same data but April 4 and April 12, 2 males, and May 30, 1 male; Finca Vergel, Chiapas, May 19–31, 1935, A. Dampf, 7 males; Finca Victoria, Chiapas, May 15, 1938, A. Dampf, 1 male; Mexico (no definite locality), 1 male.

This species forms a small complex with the next (*quadrosa*), the two differing from other members of the genus in having the arcuate incision between the mesobasal lobe of the clasper and the main body of the clasper. In *incisa* the apical margin of the clasper has an excavated area between the two corners, whereas in *quadrosa* the apical margin is evenly rounded.

Both *incisa* and *quadrosa* are probably most closely related to *haitiensis* Banks (Fig. 7), which differs from the two Mexican species in having a narrower but sharper incision between the meso-basal lobe and the body of the clasper. There is



Figs. 1–10.—Male genitalia of *Helicopsyche*: *A*, Lateral aspect; *B*, ventral aspect of left clasper. All but Fig. 7 drawn from the holotypes.

every indication that *haitiensis* represents a form ancestral to the two Mexican species.

Helicopsyche quadrosa, n. sp.

Male: Genitalia as in Fig. 6. Lateral view of ninth segment with ventral margin moderately short, and with the cercus inserted considerably above the lateral apodeme. Tenth tergite fairly deep. Clasper with mesobasal process long and narrow, separated from body of clasper by an arcuate incision; lateral view of clasper constricted above meso-basal lobe, the dorsal portion expanding rapidly, with a rounded anterodorsal corner, a quadrate and relatively massive posterodorsal corner, and an even apical margin.

Holotype male.—Finca Victoria, Chiapas, Mexico, June 1, 1935, A. Dampf. *Paratypes.*—Same data but June 2, 1 male; Finca Vergel, Chiapas, May 28, 1935, A. Dampf, 1 male.

This species is most closely related to *incisa*, differing in the shape of the clasper as described under the preceding species.

Helicopsyche planata, n. sp.

Male: Genitalia as in Fig. 8. Lateral aspect of ninth segment with fairly wide ventral margin and with the cercus situated a short distance above the lateral apodeme. Tenth tergite fairly long and moderately deep. Clasper with lateral aspect somewhat rectangular, its apical portion moderately expanded, the anterodorsal corner rounded, the posterodorsal corner pointed but not greatly produced; in ventral view the mesobasal lobe forms a rounded shoulder bearing a cluster of spines.

Holotype male.—San Cristóbal, Chiapas, Mexico, July 7, 1926, A. Dampf. *Paratype.*—Same data, 1 male.

This species is most closely related to *borealis* (Hagen) on one hand and the *mexicana-arizonensis-limnella* complex on the other. From *borealis*, *planata* differs in the sharp posterodorsal corner of the clasper, the less bowed dorsal margin of the clasper, and in the short aedeagus, which in *planata* is one and a half times the length of the tenth tergite and in *borealis* about twice the length of the tenth tergite. From *mexicana* and its allies *planata* differs in the narrower apex and the regularly rounded anterodorsal corner of the clasper.

Helicopsyche selanderi, n. sp.

Male: Genitalia as in Fig. 9. Lateral aspect of ninth segment with fairly wide ventral margin, and with the cercus attached just above the lateral apodeme. Tenth tergite elongate and relatively shallow. Lateral aspect of main body of clasper fairly narrow and angular at the base, tapering toward apex, the apical portion itself greatly enlarged and forming a large, rounded posteroapical expansion; the anterodorsal corner is evenly rounded; the mesobasal lobe forms a tubular process which in ventral view is about the same width and about half the length of those shown in Fig. 10*B*, capped with the same cluster of spines.

Holotype male.—20 miles west of Morelia, Michoacán, Mexico, July 19, 1955, R. B. and J. M. Selander. *Paratype.*—Same data, 1 male.

This species forms an interesting annectant step between *borealis* and the *piroa* complex. From *borealis* it differs in the produced posterodorsal area of the clasper and in the well differentiated mesobasal lobe. From the *piroa* complex, *selanderi* differs in the wider basal portion and shorter posterodorsal area of the clasper.

Helicopsyche vergelana, n. sp.

Male: Genitalia as in Fig. 10. Lateral aspect of ninth segment with the ventral portion unusually narrow and small, and with the cercus attached a short distance above the lateral apodeme. Tenth tergite moderately long and moderately shallow. Main body of clasper with lateral aspect small and narrow at base, expanding toward apex into a greatly developed posterodorsal lobe; mesobasal lobe forming a long flat process, in ventral view appearing to rise from the extreme mesal corner of the base of the clasper; each lobe is capped with a cluster of spines. In the holotype this process is as long as in Fig. 10; in some of the paratypes it ranges to only two-thirds this length.

Holotype male.—Finca Vergel, Chiapas, Mexico, May 30, 1935, A. Dampf. *Paratypes.*—Huehuetan, Chiapas, Mexico, November 9, 1932, A. Dampf, 1 male; Chipitlan, Cuernavaca, Mexico, May 3, 1941, A. Dampf, 1 male; Rancho Monter, Oaxaca, Mexico, Dec. 14, 1937, A. Dampf, 1 male; Hacienda Vista Hermosa, Villa Santiago, Nuevo León, Mexico, June 16, 1940, Hoogstraal and Knight, 5 males, 3 females; Sabinas Hidalgo, Nuevo León, Mexico, June 16, 1939, H. Hoogstraal, 4 males, 2 females. Additional larvae and pupae were collected by Harry Hoogstraal on rocks in a spring at the last locality.

This species is most closely related to *piroa* Ross, from which it differs in the typical narrow process of the sixth sternite, the shallow tenth tergite and the narrower and usually more elongate mesobasal process of the clasper. In *piroa* the ventral process of the sixth sternite is wide and flat, forming a broad flap; the tenth tergite is deep and bears a ridged hump at the base; and the mesobasal process is only slightly longer than that in *selanderi*, but much wider than in *vergelana*.

The above material from the vicinity of Nuevo León was previously considered as belonging to *piroa* and was included in the original description of that species. More critical examination of differences instigated by the discovery of *selanderi* has led to a more critical diagnosis of these forms.

SMALL ARMS AND AMMUNITION

The American Revolution might have been fought—on the side of the colonies—with bows and arrows. They still were better weapons, in some respects, than the available muskets of the day—as emphasized by Benjamin Franklin in a 1776 letter to Gen. Charles Lee, who then was engaged in fortifying the port of New York:

> These were good weapons, not lightly laid aside: Because a man may shoot as truly with a bow as with a common musket. He can discharge four arrows in the time of charging and discharging one bullet. His object is not taken from his view by the smoke of his own side. A flight of arrows, seen coming upon them, terrifies and disturbs the enemies' attention to their business. An arrow striking in any part of a man puts him hors-du-combat till it is extracted. Bows and arrows are more easily provided everywhere than muskets and ammunition.

This is cited by Col. Berkeley R. Lewis, of the Frankfort Arsenal, Philadelphia, in a comprehensive treatise[1] on small arms and ammunition, especially as used in the United States military service, which has just been published by the Smithsonian Institution.

There was a good deal to be said for Franklin's position for, after more than four centuries, firearms still were in a rather primitive stage and, even such as they were, the colonies were poorly equipped to produce them. Just when firearms first were used in battle is somewhat debatable, Colonel Lewis points out. Artillery was used first. Some cannon were made in Italy around 1312. They were stone-throwing mortars.

The first hand firearms were crude iron or copper tubes, fired by applying a live coal to a touchhole. This was a shallow cup at the top of the breech, whence a small hole led downward into the powder chamber. This device usually—not always—fired the charge.

Most of the trouble with firearms during the succeeding 500 years was due to this ignition system. All this time at least one misfire could be expected in ten shots.

The first pistols, known as "bombardelles," appeared in Italy about the middle of the fourteenth century. The barrels were 9 inches long. In 1544 French cavalry were armed with "pistols" whose barrels were 25 inches long.

Hand cannon were brought to England in 1471. This weapon, weighing between 60 and 70 pounds, was carried by two men. It was difficult to load and uncertain in range and accuracy—quite inferior to the crossbow or longbow then still in use.

Early in the fifteenth century Spaniards invented the arquebus with a matchlock trigger mechanism. It was probably inferior to the longbow in battle. About 1521 Spanish inventors produced the "mousquet," musket. It was 6 to 7 feet long, weighed 60 to 70 pounds, and was very slow in loading. The oldest rifles date from the end of the fifteenth century. At first they were considered purely as sporting weapons.

When the first settlers came to North America they brought with them the firearms then in use in Europe. There were local gunsmiths, but most of them were engaged in repair of arms, and rebuilding of weapons damaged beyond repair, by combining parts of two or more. At the start of the Revolution the only military arms of any consequence in the hands of the colonists were the European weapons left over from the French and Indian wars. During the war anything that would shoot was pressed into service. Small local manufactures were expanded, however, and new ones started under patronage of the various colonies.

From this point Colonel Lewis traces the evolution of small arms through the various American wars up through the Civil War.

[1] *Small arms and ammunition in thd United States Service* [1776–1865], by Col. Berkeley R. Lewis, 338 pp., 52 pls. Smithsonian Institution, Washington 25, D. C. $8.00.

MAMMALOGY.—*A new species of murine opossum (genus* Marmosa*) from Peru.*

Charles O. Handley, Jr., U. S. National Museum.

(Received September 4, 1954)

Mammals collected by representatives of the Pan American Sanitary Bureau during investigations of plague in Peru and Ecuador are being studied in the U. S. National Museum. Among these specimens are two murine opossums (*Marmosa*) from the western flank of the Andes in central Peru which are strikingly different from other named forms. They are the northernmost representatives of a group that includes the species *elegans*, *janetta*, *marmota*, and *pusilla*, inhabiting parts of Chile, Argentina, Bolivia, and Paraguay. The place of capture is almost a thousand miles northwest of the known range of their nearest relative.

For the opportunity to study these specimens, which have been deposited in the National Museum, I am indebted to Dr. Fred L. Soper, Director, and Dr. E. C. Chamberlayne, adviser, Communicable Diseases Branch, Pan American Sanitary Bureau, Washington, D. C. I am also grateful to Dr. Philip Hershkovitz, Chicago Natural History Museum, for the loan of comparative material of *M. janetta* and *M. marmota*.

This animal is named in honor of the late George H. H. Tate, whose revision of the genus *Marmosa* (Bull. Amer. Mus. Nat. Hist. **66** (1): 1–250, 1933) went far toward bringing order to an extremely complex group.

Marmosa tatei, n. sp.

Holotype.—U.S.N.M. no. 302915; adult male, skin and skull (skinned from alcohol); collected December 1955, by José Maria de la Barrera; Chasquitambo (710 m, lat. 10° 18′ 48″ S., long. 77° 37′ 20″ W.), Ancachs, Peru; original number 53/139.

Distribution.—Known only from the type locality.

Description (of holotype; coloration possibly slightly altered by 3 months immersion in alcohol; capitalized color terms from Ridgway, 1912, *Color standards and color nomenclature*).—Fur long (12 mm on rump, 8 mm on anterior abdomen) but not woolly or wavy; mass effect of dorsum between Benzo Brown and Fuscous, rather sharply distinguished from sides, which are Mouse Gray, washed on mid-flanks with Drab; dark dorsal patch extends forward as a thin line to snout; flank color extends on dorsal surfaces of forearms and legs to wrists and ankles; face much paler than dorsum or flanks, about Drab-Gray; black eye-ring prominent, 2 mm wide around eye and extending 4 mm behind and 8 mm in front of eye; longest labial vibrissa 33 mm; ears dark gray, long and broad; antihelix large; spina helicis not lobed; underparts white, hairs gray-based toward sides; throat gland large; feet and hands small, pure white; claws short (2 mm); external anterior and posterior pads of hind foot separate; pads between second and third and third and fourth hind toes subequal, the latter slightly smaller; tail relatively short, incrassated (about 8 mm thick near base before skinning), basal two-thirds sharply bicolor (Fuscous-Black above, white below), distal third whitish, extreme tip (13 mm) pure white; body-fur extends only 5 mm on base of tail; scales of tail in annular arrangement, about 32 rows per centimeter at base.

The paratype, U.S.N.M. no. 302916, a young adult by Tate's scale (*op. cit.*), is similar to the holotype in coloration but is slightly brighter. Its tail is very sharply bicolor proximally, the dorsal portion being almost black; the distal 10 mm are pure white.

Skull strong, heavily built, and relatively angular; nasals slightly expanded anterior to frontomaxillary suture, acute posteriorly; interorbital region broad anteriorly, tapering to narrowest point at "postorbital constriction" of Tate (*op. cit.*); supraorbital ridges indistinct, forming slight triangular postorbital prominences, continuous with temporal ridges which converge to form a low crest on frontals, parietals, and interparietals, where they merge with prominent lambdoidal crests; braincase narrow; zygomata thick and heavy; palate in the younger specimen exceedingly fenestrated, in the adult less so but still with large posteroexternal vacuities; posterior margin of palate produced into a thick wall 7 mm high, recurved over palate; "palatal bridge" (alisphenoid-ethmoid portion of basicranium) long and very narrow; auditory bullae relatively far apart, large, and attenuated anterointernally into pointed processes.

Canine strong (crown of upper canine measuring 3.3 mm in height from alveolus); P^2 without distinct cingulum; P^3 higher and longer than P^2; molars relatively broad (crown of M^4 in transverse diameter 2.4 mm.

Measurements (of holotype, in millimeters, taken according to Tate's directions (*op. cit.*)).—Basal length 30.7, greatest length 33.4, zygomatic breadth 17.9, palatal length 17.7, least breadth across pterygoid wings of alisphenoids 2.0, breadth of auditory bulla 3.5, greatest breadth across auditory bullae 10.5, greatest breadth across styliform processes of petrosals 8.8, greatest length from anterior wall of auditory bulla to posterior border of petrosal 5.8, greatest breadth of palate across outer corners of M^3 9.6, maxillary tooth row (M^{1-3}) 5.1, greatest length of nasals 14.2+, greatest breadth of single nasal 1.5, breadth of postorbital constriction 5.0, breadth of braincase 12.2. Head and body 123, tail vertebrae 132, hind foot 16, ear from notch 22, greatest breadth of ear 19.

Fig. 1.—Skulls of *Marmosa tatei* and its relatives. Upper row, dorsal aspect; lower row, ventral aspect; left to right: *M. elegans*, Guillermo Mann 101; *M. tatei*, U.S.N.M. no. 302915; *M. janetta*, C.N.H.M. no. 50973; *M. marmota*, C.N.H.M. no. 26760.

Comparisons.—Sharply defined dorsal and flank colors; large ears; small hands and feet; short, thick tail with annular arrangement of scales; slightly expanded nasals; highly fenestrated palate; long, narrow palatal bridge; large auditory bullae; and large P^3 stamp *M. tatei* as a member of the *Marmosa elegans* group. Large size, narrowed postorbital region, narrow braincase, and convergent temporal ridges relate it to the *elegans* section of that group (Fig. 1).

Numerous characters distinguish *M. tatei* from all other members of the *elegans* section: Dorsal coloration grayer, tail more extensively white tipped, nasals more expanded anterior to fronto-maxillary suture and more acute posteriorly, temporal ridges converging to form a more prominent sagittal crest, palatal bridge narrower, canines longer, and molars relatively broader. It most resembles *M. marmota* of southern Paraguay (C.N.H.M. no. 26760) but is smaller, and has a narrower skull, less distinct supraorbital ridges (thus interorbital region smoother and less angular), a more extensive eye-ring, and whiter underparts. *M. tatei* is similar in size and proportions to *M. janetta* of southern Bolivia (C.N.H.M. 29169, 29170, 50972, and 50973), but otherwise is distinguished by having underparts whiter, auditory bullae larger; P^3 larger; interorbital region broader anteriorly, narrower posteriorly, not constricted before postorbital process, and lacking prominent supraorbital ridges. *M. tatei* is more remotely related to *M. elegans* of Chile (U.S.N.M. nos. 1705 and 269806), from which it differs in having whiter underparts, blacker, more extensive eye-ring; much more heavily ossified skull; and interorbital region much broader anteriorly.

Remarks.—Members of the *elegans* section are widespread, seldom collected opossums. The forms *marmota*, *janetta*, *tatei*, and *elegans* are well differentiated, but collecting in intermediate areas might show some or all of them to be conspecific.

Specimens examined.—Two from the type locality.

NEWS OF MEMBERS

The International Business Machines Corporation has announced plans for a new research center, employing 1,600 persons, to consolidate all fundamental research aimed at improving the company's products. The laboratory will be under the direction of Dr. EMANUEL R. PIORE.

GEORGE GAMOW was awarded UNESCO's Kalinga prize for 1956 in recognition of his outstanding interpretation of science to the general public. He received £1,000 sterling and an invitation to spend a month visiting and lecturing in India.

DONOVAN S. CORRELL has joined the staff of the Texas Research Foundation as chief botanist and head of the Botanical Laboratory.

Man's work must ever end in failure,
Unless it bears the stamp of mind.
The head must plan with care and thought,
Before the hand can execute.—SCHILLER

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