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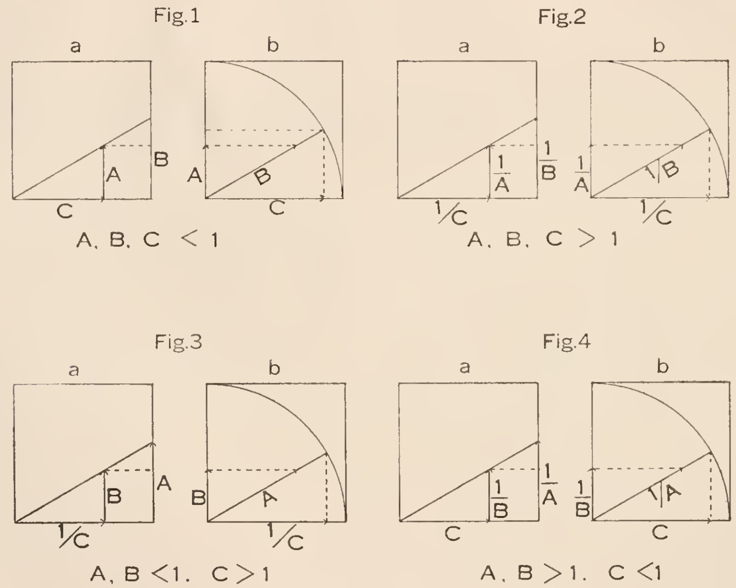
MATHEMATICS.—*A simple device for the graphical solution of the equation $A = B \cdot C$.* F. E. Wright, Geophysical Laboratory.

The equation $A = B \cdot C$, in which the letters may represent numbers, or powers of numbers, or functions of variables as sines, cosines, tangents, logarithms, exponentials, etc., is essentially a simplified form of the equation of proportion, $A : B = C : D$ (rule of three) and is so common in physical and technical problems that different graphical methods have been suggested for its solution. A brief discussion of these methods was given several years ago by the writer[1] and the conclusion was reached that, "in all cases it is essential: (a) that the graphical means employed represent the relations adequately and as free from distortion as possible, and (b) that they be easy of application. The first principle requires that in any graphical representation the relative accuracy over the entire field be uniform and comparable to that which obtains in nature." In order to apply this principle effectively to the solution of a given equation it may be necessary to increase the uniformity in the plotting scale by taking some function of the values in the equation such as the logarithmic function or by raising the values to some power.

[1] Graphical methods in microscopical petrography. Am. Jour. Sci., Ser. 4, **36**: 509–542. 1913. See also R. A. Harris: On uses of a drawing board and scales in trigonometry and navigation. Science, N.S., **18**: 108–112. 1903. A diagram or chart for finding the sun's azimuth. Science, N.S. **22**: 469. 1905. C. Runge. Graphical Methods. New York. 1912.

In case A, B, C are functions of variables the equation $A = B \cdot C$ may be considered to express relations between the functions themselves, namely, between A, B, and C rather than between the variables; fundamentally, of course, the equation expresses relations between the variables, and the increments are so taken. The procedure adopted below amounts practically to the representation of each function by a scale so chosen that the resulting curves are straight lines. Straight lines can be



Figs. 1 to 4. Diagrams for graphical solution of certain equations.

drawn more readily and more accurately than curves; straight line diagrams are, moreover, easier to read. In the paper cited above a number of straight line diagrams are included which serve for the graphical solution of the equations encountered in microscopical petrography. These diagrams have been found in practice to be useful and time saving.

Recently a device has been adopted by means of which these equations and others of the same general form can be solved without requiring a special plot for each type of equation. Its construction is based on the fact that an equation of the type $A = B \cdot C$ can always be expressed in such form that each factor has a value less than unity; for, in case a factor is greater than unity, the equation can be so written that the reciprocal of this factor is taken, which is then less than unity. The graphical solution of the equation by a straight line diagram can be accomplished either by a method of similar triangles or by a method of projection which, however, is also a method based on similar triangles. Both methods furnish results of the same order of exactness. Convenient forms of solution by the two methods are illustrated in figures 1 to 4, in which *a* refers in each case to the solution by similar triangles while *b* represents the solution by the method of projection. In figure 1 A, B, C are less than unity; in figure 2 A, B, $C > 1$; in figure 3 A, $B < 1$, $C > 1$; in figure 4 A, $B > 1$, $C < 1$.

In case it is inconvenient to use reciprocal values, it is possible to extend the range of the solution by changing the scale of the base line from 1 to 10, or to 100 or to any power of 10. This amounts simply to the shifting of the decimal point in one of the factors.

In the first method (figs. 1a, 2a, 3a, 4a) it is evident that if the values of A, B, C be plotted along the side lines the remainder of the solution is simply a matter of rectangular coordinates; and similarly for the solution by the method of projection.

The graphical solution on the basis of the above relations is readily accomplished by attaching permanently to a small drawing board of the usual size (19″ x 26″) a sheet of 1 mm. coordinate paper, 50 cm. square, at one corner of which a straight edge fits in a fixed socket so that it can be rotated about this corner as axis (fig. 5). To solve an equation such as $\sin A = \sin B \cdot \sin C$, two sine scales are first prepared by marking off the sine values directly (listed in sine tables) on a narrow slip of 1 mm. coordinate paper; these are then attached to the bottom and right side of the large sheet of coordinate paper as indicated in figure 5. In case B and C are known, set the edge of the rule at the value of B (40° in figure 5), find the abscissa C (41° in figure 5) and pass along its ordinate to the intersection with the edge of the rule;

the horizontal line through this point intersects the ordinate scale on the right at 25° which is the desired value of A.

To save time it is well to prepare at the outset pairs of scales of all the trigonometric functions, of logarithms, of reciprocals of numbers, their squares and square roots, and of any other functions which may be employed. Such scales are then always ready for use.

In case the observer has only a few types of the general equation to solve it is convenient to plot the scales for each type of

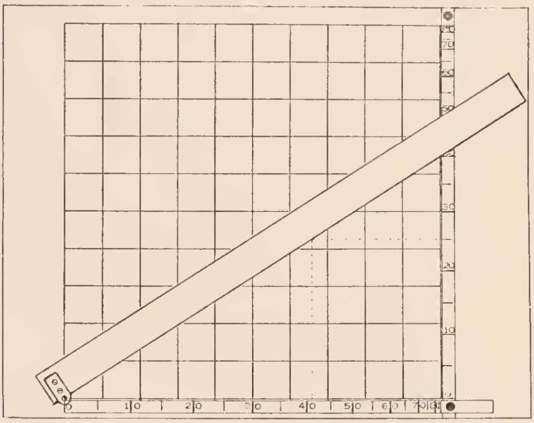


Fig. 5. Device for graphical solution of equation $A = B \cdot C$.

equation along the sides of a large sheet of coordinate paper, which then serves directly for the solution of the given equation. The bother of adjusting the scales to the sides of the plot is thus eliminated; a special sheet of coordinate paper is, however, required for each equation.

The degree of accuracy attainable by this device depends on the care taken to read the scales. In case the reading is correct to $\frac{1}{2}$ mm., the result is accurate to one part in a thousand.

Typical examples of the kinds of equations which can be solved by this graphical method of proportional parts are:

$$y = ax; \; pv = c; \; y = ax^2; \; y^2 = ax; \; y = a^x, \text{ or } \log y = x \log a;$$
$$y = x^n, \text{ or } \log y = n \log x.$$
$$\sin i = n \cdot \sin r; \; D = \sin A \cdot \sin A^1; \; \tan^2 V = \tfrac{A}{B};$$
$$\cot A = \sin B \cdot \sin C; \; \tan A = \sin B \cdot \cot C; \; \cos A = \cos B \cdot \cos C;$$
$$\sin A = \sin B \cdot \sin C; \; \tan A = \sin B \cdot \tan C.$$

This list is by no means complete but it serves to indicate the variety of equations which are of the form $A = B \cdot C$ and which can therefore be solved graphically with a fair degree of accuracy.

GEOLOGY.—*A geological protractor.* F. E. WRIGHT, Geophysical Laboratory.

In geological field and map work a protractor is commonly used for plotting angles of strike and dip. For the drawing of a vertical cross section it is also desirable to determine the line of slope of any given bed on the section. Heretofore this has been accomplished either by graphical methods or by computation or by use of a graphical computation chart.[1] It is possible, however, by slightly modifying the protractor, to combine with it a slope angle computer such that the apparent dip of a bed can be read off directly for any angle of dip of stratum and for any azimuth of vertical section.

The principles on which the slope computer is based are presented in detail in the foregoing paper. The equation to be solved is of the form $\tan C = \sin B \cdot \tan A$ in which A is the true angle of dip, B the direction angle between the line of strike of the bed and that of the vertical section, and C the apparent dip angle on the vertical section. In solving this equation by the graphical method here proposed it is important to note that,

[1] A chart of this nature was first described by W. G. Woolnough, Proc. Australasian Association for the Advancement of Science, **1909**: 244–249. Practically the same chart was published later by D. F. Hewett without knowledge, however, of Woolnough's chart. Economic Geology, **7**: 190. 1912; and still later by H. Bancroft, Bull. Am. Inst. Mining Engineers, July 1914, p. 1769. A straight line chart was first prepared by the writer. Journ. Wash. Acad. Sci., **4**: 440–444. 1914.

because the radius of the protractor circle is taken to be unity whereas the tangent values may range from zero to infinity, three different cases are to be distinguished:

(a) Angles A and C are less than 45°; $\tan A$, $\tan C < 1$;
(b) Angles A and C are greater than 45°; $\tan A$, $\tan C > 1$;
(c) Angle A greater than 45° ($\tan A > 1$);
angle C less than 45° ($\tan C < 1$);
$\cos B$ is always less than unity.

To adapt the ordinary protractor to the solution of these problems a thin celluloid arm is so attached that it can be rotated

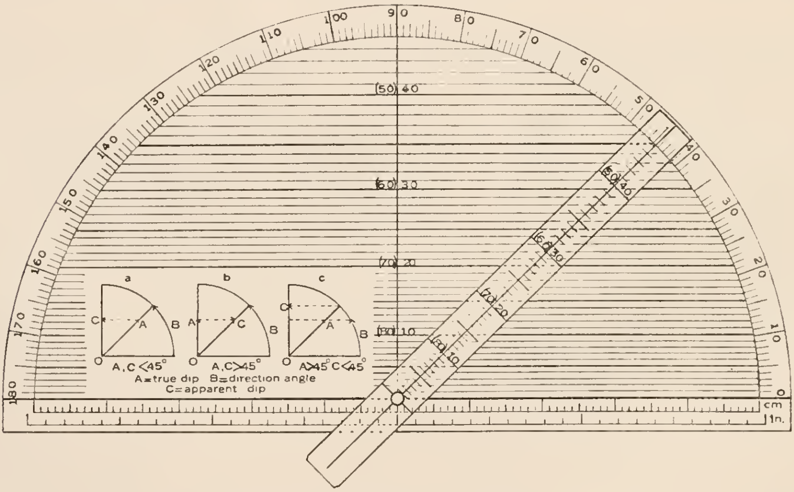


Fig. 1. A geological protractor.

about the center of the circle as an axis (fig. 1). On this arm a tangent scale is printed from 0° to 45°. A series of lines parallel to the base line of the protractor is printed on the face of the protractor as indicated in the figure. The extension of the rotating arm below the axis enables the geologist to use the protractor as a hand goniometer for the measurement of the angles between crystal faces. A scale of inches, divided into tenths, and a scale of millimeters are added below the base line of the protractor.

The methods of solution for the three cases noted above are indicated in figure 1*a*, *b*, *c*. In figure 1*a* OA ($= \tan A$) is the true dip; B, the direction angle, is read off directly on the graduated circle; OC ($= \tan C$) is the apparent dip; thus the line of intersection of a stratum, dipping at an angle of 35° (OA), with a vertical section which includes an angle 44° 30′ (B) with the line of strike of the bed, has a slope angle (OC) of 26.1°. In figure 1*b* the angles A and C are greater than 45° and the numbers in parentheses on the scales are used; thus on a vertical section including an angle of 44° 30′ (B) with the line of strike of a bed dipping at an angle of 72° (OA) the apparent dip is 65.1°. In figure 1*c* the angle A is greater than 45° while C is less than 45°; in this case the numbers in parentheses on the scale of the rotating arm are used, while for the angle C the unbracketed numbers along OC are read; thus the trace of a bed, dipping at 60°, on a vertical section, which includes an angle of 24° with the line of strike of the bed, has a slope angle of 35.2°.

CHEMISTRY.—*The reaction of soil and measurements of hydrogen-ion concentration.* L. J. GILLESPIE, Bureau of Plant Industry. (Communicated by OSWALD SCHREINER.)

The reaction of soil is conceded to be of great influence upon soil fertility. Certain plants seem to require a certain degree of acidity, and may flourish at an acidity sufficient to be very harmful to others. That excessive acidity is a common cause of infertility in long-cultivated soils is generally recognized. On the other hand, sodium carbonate frequently occurs in the alkali soils of arid lands and imparts an excessive alkalinity. The study of the reaction of soil is therefore not only of considerable scientific but also of great practical importance.

Let us consider briefly the case presented by a sour soil. Two questions are of especial interest: (1) What is the quantity of acid substance? and (2) what is the intensity of the acidity? The amount of liming or other ameliorative treatment required to neutralize the acidity will depend upon the quantity of acid substance. It seems probable, on the other hand, that characteristic effects of acidity upon soil fertility will be more clearly correlated with the intensity of acidity than with the quantity of acid substance. However this may be, a complete study of soil acidity must take both factors into consideration.

The lime requirement method of Veitch[1] and its numerous modifications, as well as all other titrimetric methods, for example, that of Baumann and Gully[2] and that of Daikuhara,[3] are an attempt to measure the quantity of acid substance, not the intensity of acidity. Furthermore, since a complete determination of the acids and bases in soils is as yet impossible, one cannot calculate the intensity of acidity from the quantity of acid substance, even if this could be determined by any of the methods yet proposed. The intensity of acidity, or of alkalinity, can only be determined experimentally by a measurement of the hydrogen-ion concentration.

In a study of the acids and colloids of humus Fischer[4] measured the hydrogen-ion concentrations of some soils by the electrometric method. He added, when necessary, just enough water to the soil to make possible an intimate wet contact between the soil and the wire electrode. He was able to demonstrate the acid nature of Hochmoor sphagnum (six samples). These showed a hydrogen-ion concentration of $9.6 \cdot 10^{-4}$ to $6.5 \cdot 10^{-4}$. Two Flachmoor samples were slightly acid ($6 \cdot 10^{-6}$ and $1.1 \cdot 10^{-6}$); another soil and a sample of compost were slightly alkaline ($2.7 \cdot 10^{-8}$ and $4 \cdot 10^{-8}$). Litmus did not respond to the weak acidities or alkalinities of these samples, but did give an acid reaction with the samples of Hochmoor sphagnum. Fischer states that it can be concluded from this that adsorption processes are not to be assumed to vitiate tests of acidity made by means of indicators.

Fischer had no other test with which to check his electrometric results, and his electrometric procedure was one that would not be expected to lead to a quick attainment of equilibrium. He was therefore obliged to continue the observations until the potential became constant. Seven to eight hours were required for this, and in the case of the soils which showed

[1] Journ. Am. Chem. Soc., **24**: 1120. 1902.

[2] Naturw. Ztschr. Forst- u. Landw., **6**: 1. 1908.

[3] Bull. Imp. Cent. Agr. Exp. Sta., Japan, **2**: 1. 1914.

[4] Kühn-Archiv (Halle), **4**: 1–136. 1914.

a hydrogen-ion concentration of about 10^{-6} or lower (and which were therefore feebly acid, neutral, or alkaline), constant potentials could not be obtained. It is objectionable to prolong the measurement unduly, as a platinized platinum electrode may become "sick," a phenomenon frequently observed after continued use. Hasselbalch and Gammeltoft[5] state that for this reason measurements on blood must not take more than one hour.

As a step toward the satisfactory determination of hydrogen-ion concentration in soil the writer has attempted to apply the hydrogen electrode to mixtures of soil and water and to apply indicators to extracts prepared by centrifuging such mixtures.

GENERAL PROCEDURE IN THE PRESENT INVESTIGATION

Since it seemed to be impossible to apply either the hydrogen electrode or indicators to soil in the condition in which we are most interested, namely, at optimum moisture content, it was decided to add enough water, in this series of experiments, to facilitate the determinations. For the hydrogen electrode work a suitable quantity was found to be 2 cc. per gram of dry soil. The same quantity was used for the colorimetric, or indicator, work, though it was much more than is necessary. For expediency the soil was air dried, though in some cases the drying was interrupted when the soil was still somewhat damp. Without forcing or grinding, the soils were put through a coarse sieve to remove sticks and stones, and in four cases through a one-millimeter sieve in the same way in order to remove fine woody material which interfered with the pipetting of the fluid after the use of the centrifuge.

Twenty-two soils were taken for investigation. They included samples of muck, sandy loam, loam, silty loam, silt loam, clay loam, and clay. Some reacted strongly acid to litmus paper, some neutral, and some alkaline.

The hydrogen ion concentration has been expressed, in the customary manner, as the hydrogen-ion exponent of Sörensen.[6]

ELECTROMETRIC DETERMINATIONS

In figure 1 is shown the electrode vessel together with the electrode in position, the soil and water mixture and the junction between the

[5] Biochem. Ztschr., **68**: 206. 1915.
[6] Biochem. Ztschr., **21**: 131. 1909.

saturated potassium chloride solution and the soil extract. By means of a motor the vessel could be swung about an axis at x; during the motion the body of the electrode vessel turned from an inclination of 3° to the horizontal to an inclination of about 33° to the horizontal. The electrode vessel had a capacity of about 65 cc., measured from the brim to the stopcock.

Fifteen grams of dry soil were introduced into a test-tube 17 by 3 cm., 30 cc. of distilled water were added, and the mixture was well shaken and permitted to stand about 10 to 20 minutes for sedimentation.

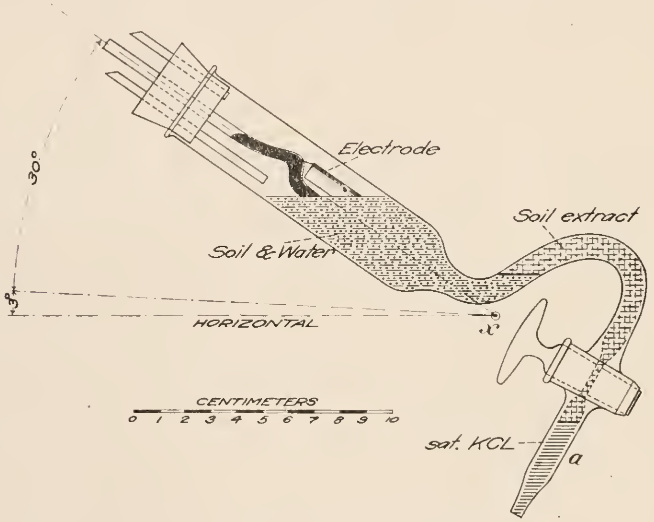


Fig. 1. The filled electrode vessel.

The neck of the electrode vessel, including the bore of the stopcock, was filled with a portion of the soil extract so obtained and the stopcock was then closed. The end-tube a was filled with saturated potassium chloride solution by means of a capillary pipette. The rest of the soil mass was now well agitated and immediately poured into the vessel, which was then fastened to the shaking device. A rubber tube, filled with the saturated potassium chloride solution which led to the calomel electrode through a closed, ungreased stopcock, was joined to the tube a, and the vessel was closed with a well-fitting rubber stopper carrying the electrode and tubes for the entrance and exit of hydrogen. A volume of about 140 cc. of dry hydrogen, electrolytically generated from caustic potash solution with iron electrodes, was rapidly swept through the space over the soil mixture, the current of hydrogen was stopped by closing the exit, and the vessel was shaken 10 to 20 times. In order to remove residual atmospheric nitrogen another portion of hydrogen was passed through in the same way, and after shaking again 10 to 20 times the hydrogen entrance was also closed and the vessel shaken at the rate of 70 to 90 complete swings per minute for five minutes. The motor was stopped, the potassium chloride contact was made in the tube *a*, the shaking was started again, and the electromotive force of the combination of the electrode with a saturated KCl calomel electrode[7] was determined at once. The vessel was shaken continuously during the measurement, according to the proposal of Hasselbalch for measurements on biological fluids,[8] this procedure being especially advantageous for work with fluids poor in regulating capacity. From this difference of potential and the temperature the hydrogen-ion exponent was calculated from the figures given by Michaelis.[9] The temperature was observed in a bottle which took the place of the usual potassium chloride trough; it remained between 25.5° and 28.5°C. during all the determinations. Tests of the calomel electrode on regulator mixtures of known exponents showed no error due to the calomel electrode. The hydrogen electrode is shown in figure 2. A large sheet of plati num was used which measured 2.54 cm. by 3.3 cm. It was freshly coated with palladium black for each determination after complete removal of the previous coating. In constructing the hydrogen electrode it was necessary to support the sheet of platinum at both top and bottom, and also to provide leads for the current at two opposite points, in order to secure an even deposit of palladium black. The electrode remained partially (about half) submerged during the shaking.

Fig. 2. Hydrogen electrode.

The arrangement used for measuring the potentials was that described by Hildebrand.[10] A capillary electrometer was used as a null-point instrument. A voltmeter was used which read directly to 20 millivolts.[11] The potential could be estimated accurately to 2 millivolts and often to 1 millivolt. The voltmeter was calibrated

[7] Michaelis and Davidoff, Biochem. Ztschr., **46**: 131. 1912.

[8] Biochem. Bulletin, **2**: 367. 1913.

[9] Die Wasserstoffionenkonzentration, 157. 1914.

[10] Journ. Am. Chem. Soc., **35**: 847. 1913.

[11] For further work a high-grade potentiometer will be available.

against an accurate potentiometer with the kind assistance of Dr. William Mansfield Clark, of the Bureau of Animal Industry.

In order to see whether a substantially correct potential had been obtained, the shaking was continued after the first measurement for 5 to 9 minutes longer and the potential was determined again in the same way. This was done in all cases but one. In 7 cases the potential observed was the same, in 10 cases it had fallen (1 fall of 3, 1 of 2, and 8 of 1 millivolt), and in 4 cases it had risen (1 rise of 3, and 3 of 1 millivolt). No relation could be seen between the changes and the values of the potential. A possible interpretation of the falls of potential is that a more complete saturation of the water with acid substance was attained during the second shaking. The rises may have been due to hydrolyzation of soil minerals. No difficulty was encountered even with the measurement of soils which gave neutral or alkaline results.[12]

COLORIMETRIC DETERMINATIONS

Fifteen grams of dry soil were treated in a centrifuge tube of 60 cc. capacity with 30 cc. of distilled water. After thorough wetting of the soil was accomplished by means of shaking or of slight stirring the tube was closed by the hand and violently shaken fifty times. Not more than 8 soils were thus treated at a time. The entire determination was now carried out without delay. The tubes were centrifuged for 10 to 20 minutes. The supernatant fluid in some cases was almost clear, in many cases there was considerable turbidity, and in a few cases there was a heavy turbidity together with a yellowish color. With a pipette provided with a rubber tube and mouthpiece 15 to 20 cc. were withdrawn, and 5 cc. were put into each of 3 test-tubes. Indicator solution was added and admixed and the color so developed was compared with the colors obtained on adding the same quantity of the same indicator solution to tubes containing 5 cc. of various "regulators" of known hydrogen-ion concentrations. With all fluids it was possible to make a satisfactory comparison by means of at least one indicator, and with most fluids it was possible to make an independent comparison with a second indicator. This was done whenever possible. When the color which developed in the soil extract was the same as that in a particular regulator, the hydrogen-ion exponent of that regulator was

[12] In preliminary experiments the use of soil and water in such quantities that agitation of the mass during shaking was inefficient was found to prevent the attainment of approximately equilibrium conditions within five minutes.

recorded as the result. When the color was intermediate between the colors of two successive regulator tubes, the value of the hydrogen-ion exponent was estimated to one-half or one-third of the interval.

TABLE I

NO.	SOIL	ELECTROMETRIC RESULTS		COLORIMETRIC RESULTS			MEAN, BOTH METHODS
		Potential*	Hydrogen-ion exponent	Indicator	Hydrogen-ion exponent	Mean indicator result	
1	Loam, from Maryland.............	515	4.55	t-br-ph-s-pht	4.3		
				methyl red	4.3	4.3	4.4
2	Silty loam, from Maine...........	524	4.7	t-br-ph-s-pht	4.4		
				methyl red	4.6	4.5	4.6
3	Loam, from Maine.................	527	4.75	methyl red	5.15		
				dipropyl red	5.2	5.2	5.0
4	Sandy loam, from Virginia........	532	4.8	methyl red	4.9		
				dipropyl red	4.9	4.9	4.85
5	Silty loan, from Maine............	542	5.0	methyl red	5.2		
				dipropyl red	5.4	5.3	5.15
6	Sandy loam, from Virginia........	546	5.1	methyl red	5.2		
				dipropyl red	5.25	5.2	5.2
7	Silty loam, from Virginia.........	549	5.1	methyl red	5.2		
				dipropyl red	5.4	5.3	5.2
8	Silty loam subsoil, from Maine...	556	5.2	methyl red	5.3		
				dipropyl red	5.6	5.45	5.3
9	Silt loam, from Maine............	561	5.3	methyl red	5.6	5.6	5.45
10	Silty loam, from Virginia.........	567	5.4	methyl red	5.2		
				dipropyl red	5.3	5.25	5.3
11	Silt loam, from Virginia..........	571	5.5	methyl red	5.5		
				dipropyl red	5.6	5.55	5.5
12	Loam subsoil, from Maine........	576	5.6	methyl red	5.5		
				dipropyl red	5.7	5.6	5.6
13	Silt loam, from Maine............	591	5.8	methyl red	5.75		
				br-th-s-pht	5.75	5.75	5.8
14	Muck, from Maine................	591	5.8	dipropyl red	5.9		
				br-th-s-pht	5.9	5.9	5.85
15	Muck, from Maine................	594	5.9	br-th-s-pht........	5.45	5.45	5.7
16	Silt loam, from Maine............	628	6.45	br-th-s-pht	6.05	6.05	6.25
17	Clay loam subsoil, from Maine...	644	6.7	br-th-s-pht	6.4		
				ph-s-pht	6.95	6.7	6.7
18	Silt loam, from Virginia..........	666	7.1	br-th-s-pht	6.9		
				ph-s-pht	7.0	6.95	7.0
19	Clay, from Montana..............	727	8.1	ph-s-pht	8.0		
				ph-pht	7.9	7.95	8.0
20	Loam, from Utah.................	736	8.3	ph-s-pht	8.1		
				ph-pht	8.1	8.1	8.2
21	Clay, from Montana..............	739	8.3	ph-s-pht	8.2		
				ph-pht	8.2	8.2	8.25
22	Loam, from Utah.................	763	8.7	ph-s-pht	8.4		
				ph-pht	8.5	8.45	8.6

* Potential in millivolts, corrected by means of calibration curve.

Twenty regulator mixtures were prepared for the work, the exponents were determined electrometrically and the colorimetric work was done while the solutions were fresh. The reaction varied from one tube to the next in the series by a step of about 0.3 in the value of the exponent. From the exponent 3.5 to 5.1 the regulators were prepared from a given quantity of n/10 sodium hydrate and decreasing quantities of n/2 acetic acid and water. The concentration of the sodium acetate formed in the mixing was m/200 in all cases. From 5.3 to 6.8, mixtures of m/10 potassium acid phosphate and m/10 sodium hydrate and water were used which had the same concentration of primary and of secondary phosphate as prescribed by Sörensen[13] and were thus m/15 with phosphate; and from 7.1 to 9.4, other mixtures of the same two solutions were used (without addition of water), in which the concentration of phosphate decreased from m/16 to m/20, owing to the dilution involved in the use of sodium hydrate instead of the disodium phosphate used by Sörensen.

The following six indicators were used: (1) tetrabromphenolsulfonephthalein (abbreviated in the table to t-br-ph-s-pht), 3 drops from a capillary pipette of a solution of 0.1 gram in 250 cc. alcohol; (2) methyl red, 2 drops of a solution of 0.1 gram in 300 cc. alcohol and 200 cc. water; (3) dipropyl red, 4 drops from a capillary pipette of a solution made in the same way as the methyl red; (4) bromthymolsulfonephthalein (br-th-s-pht), 6 drops from a capillary pipette of a solution of 0.1 gram in 200 cc. alcohol; (5) the sodium salt of phenolsulfonephthalein (ph-s-pht), 1 drop of a 0.06 per cent aqueous solution; and (6) phenolphthalein (ph-pht), 1 drop of a 0.5 per cent solution in 50 per cent alcohol. The first, third, and fourth are new indicators recently prepared and described by Lubs and Clark.[14] Solutions of these were kindly given to me by Dr. H. A. Lubs. These three new indicators would seem to have considerable value in this type of investigation.

The colorimetric results are given, together with the electrometric results, in the table herewith (Table I).

DISCUSSION OF THE RESULTS

In the table are given the hydrogen-ion exponent for each of the 22 soils as determined by the electrometric method and by the different indicators, and also the mean colorimetric result and the mean of the

[13] Biochem. Ztschr., **21**: 131. 1909; **22**: 352. 1909.

[14] Jour. Wash. Acad. Sci., **5**: 609. 1915.

two methods. The soils are arranged in the order of decreasing acidity. An exponent of 7 means neutrality; a smaller one, acidity; and a larger one, alkalinity. It will be seen that values were obtained between 4.4 and 8.6. Some of the acidities found are rather intense, from a biological point of view. Thus Brünn[15] has found that typhoid bacilli are killed with certainty by exposure for 24 hours to an acidity corresponding to an exponent of 5, and four of the soils show as high, or a higher acidity. One soil gave a neutral result and the four western alkali soils gave distinctly alkaline results.

A study of the results for each soil obtained by the use of the various indicators and by the electrometric method shows that the agreement between the two indicators is very good except in one instance (No. 17), and that the agreement between the colorimetric and the electrometric methods is good in every case. Such agreements show that the two methods give comparable results and give ground for inferring that such results are approximately correct.

It would seem premature at this time to apply the results obtained in this way to the soil as it exists in the field, since carbon dioxide is lost during the drying and the natural "soil solution" is diluted for the determinations. Nevertheless it may well happen that the errors so introduced (from a field standpoint) are not great enough to obscure the differences observable between different soils. Further work will be required to ascertain whether this is the case.

SUMMARY

Procedures have been devised for the electrometric and colorimetric determination of hydrogen-ion concentration in soil admixed with two parts of water. Twenty-two soils of various types and reactions were examined by means of these procedures. The hydrogen-ion exponents so determined were from 4.4 to 8.6. Some of the values are acid, some nearly neutral, and some distinctly alkaline. Of the acid values some represented rather intense acidity.

In 19 cases two different indicators could be used for the colorimetric test, and in these cases there was a good agreement between the two results so obtained. In all cases there was a good agreement between the electrometric and the colorimetric

[15] Dissertation, Berlin, 1913; quoted by Michaelis in the book cited above.

results. Such agreements show that the two methods give comparable results and give ground for inferring that such results are approximately correct.

CONTINUATION OF EXPERIMENTS

The experimentation is being continued. Special effort will be made to develop the colorimetric method into a convenient and practical test and to determine its reliability as applied to soils under field conditions.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Triangulation in West Virginia, Ohio, Kentucky, Indiana, Illinois and Missouri.* A. L. BALDWIN. U. S. Coast and Geodetic Survey Special Publication No. 30. Pp. 67. 1915.

This publication contains the positions of 369 triangulation stations which lie within the limits of the six states mentioned in the title, and most of which form that part of the Transcontinental Triangulation extending from the Atlantic to the Pacific. The publication supplements the information given in Special Publication No. 4 which appeared in 1900 and contained features of special interest to scientists. Positions are there given of only the principal stations and only a few of them are described. Since the appearance of Special Publication No. 4 the United States Standard Datum, called the North American Datum since its use by Mexico and Canada, was adopted and it became necessary to place the old positions on that datum. In Special Publication No. 30 there are given the geographic positions, on the North American Datum, of all stations in the area covered, together with all available descriptions of these points.

In addition to the above-mentioned data, this publication gives the results of a trigonometric connection made in 1914 between the detached pieces of triangulation to the north and south of Louisville, Kentucky. It includes also the results of a primary base line measured in 1879 with six-meter contact-slide bars. Such apparatus is no longer used in the field in the United States, as the long invar tapes or ribbons have recently superseded all forms of bars in base line measurements. The field work covered by this publication was done between 1871 and 1914, but all details are omitted, except for the primary triangulation done in Indiana in 1914.

Aside from its scientific interest, the volume has a large practical value, as it offers to the engineer and map maker a large number of points determined trigonometrically and correlated on one geodetic datum. These stations or points are a part of a framework, composed of the connected triangulation of the country, from which the state, county or private surveyor may extend triangulation of a lower grade for the control of detailed work. A. L. B.

GEOLOGY.—*The Pleistocene of Indiana and Michigan and the history of the Great Lakes.* FRANK LEVERETT and F. B. TAYLOR. U. S. Geological Survey Monograph 53. Pp. 529, maps and illustrations. 1915.

This monograph describes the glacial features of Indiana and the southern peninsula of Michigan and the great glacial lakes which bordered the receding ice front. Brief mention is also made of related glacial and lake features in Ohio, New York, Ontario and Wisconsin.

Glacial drift of Illinoian age extends 50 to 100 miles south of the border of the Wisconsin drift in Indiana and probably underlies the whole extent of the Wisconsin drift in the area described. Till of pre-Wisconsin age has been penetrated by borings over considerable areas in the Saginaw valley.

At its maximum extension the Wisconsin ice sheet was not very definitely lobate but by the time the recession of the ice margin had progressed 75 to 100 miles the Huron-Erie lobe on the east began to be sharply separated from the Lake Michigan lobe on the west and a well defined reentrant appeared between them. Terminating at first in northern Indiana, this reentrant rapidly widened and extended northeastward into Michigan until the Saginaw lobe became a distinct feature. All three of the ice lobes retreated in an oscillating manner and made a series of moraines. Readvances appear generally to have been relatively small, but in one or two cases they amounted to at least 20 to 25 miles.

The report deals at length with the development and relations of the three lobes and their effects on drainage and on the great lakes which gathered in the great valleys whose natural outlets were temporarily obstructed by the ice.

Among the moraines the Port Huron morainic system is particularly well marked, being identifiable from eastern Wisconsin to western New York. This system appears to mark a longer step of retreat and readvance than the average. During a later stage drumlins were formed over a considerable area around Charlevoix, Michigan, and a few in other places.

The rivers that issued from the great reentrants of the ice front carried enormous quantities of sediment, the coarser parts of which were spread over extensive areas in front of the ice. The soils thus produced are lower in fertility than those of the intervening moraines and till plains.

The larger lakes began with glacial Lake Maumee which first appeared as a small crescent-shaped body of water bordering the ice front with its outlet at Fort Wayne, Indiana. In a similar manner glacial Lake Chicago soon appeared at the south end of the Lake Michigan basin. The bearing of certain facts observed in Ohio on the attraction of the ice sheet upon the lake waters near it is discussed in connection with Lake Maumee. Remarkable ice ramparts formed in connection with the same lake are also described. With further recession of the ice these lakes expanded northward until Lake Maumee found a lower outlet westward across the "thumb" of Michigan 50 miles north of Detroit. About this time a lake made its appearance in the Saginaw valley and from this point the history of lake waters is involved in considerable complexity. This complexity arose mainly from the oscillation of the ice front, and from its relation to certain parts of the land whose form and relief caused them to become barriers at climaxes of readvance but not at climaxes of recession. These barriers were: (1) the broad low ridge forming the "thumb" of Michigan, and (2) the northward sloping front of the highlands south of Syracuse, N. Y. In both of these regions, first on the "thumb" and then near Syracuse, outlets for the lake waters were alternately opened and closed by the oscillating ice front and the level of the waters was alternately lowered and elevated correspondingly. Following Lake Maumee, the waters underwent a number of changes of level and of outlet, forming successively Lakes Arkona, Whittlesey, Wayne, Warren, and Lundy.

At length the lowland between the Huron and Erie basins was left dry and St. Clair and Detroit rivers began their post-glacial existence. Similarly the lowland between Lakes Erie and Ontario emerged and Niagara River and the great cataract came into being. Soon after the appearance of early Lake Algonquin in the south half of the Huron basin the waters in the three upper basins, those of Superior, Michigan, and Huron were united, forming the great Lake Algonquin, the largest of the glacial lakes of the region. Twice the recession of the ice opened outlets for Lake Algonquin, but on both occasions these were closed by differential elevation of northern lands. The first was at Kirkfield, Ont., and the second at North Bay, Ont. The uptilting of the land at the north is recorded in northward splitting and divergence of breaches and the relatively rapid rate of the uplift is shown by a wide interval in the north below the upper group of Algonquin beaches.

The opening of the outlet at North Bay marks the final disappearance of the ice sheet from the Great Lakes region and the end of its influence in lake history. At this stage the upper lakes, known as Nipissing Great Lakes, were not very different from the present Great Lakes except that their outlet was eastward through the Mattawa and Ottawa rivers to the sea near Ottawa. Uplift of the land finally changed the outlet of these post-glacial lakes from North Bay to Port Huron and established the present system.

In the closing chapter the possible causes of the deformation of shore lines, such as resilience with ice removal following depression by ice weight, eustatic movements, and crustal creep are considered, but final conclusions are not reached.

F. B. T.

GEOLOGY.—*Contributions to Economic Geology, 1913, Part II, Mineral Fuels.* M. R. Campbell, and David White. U. S. Geological Survey Bulletin 581. Pp. 187, 11 plates, 6 text figures. 1915.

This volume contains two classes of reports on occurrences of oil and coal: (a) Short reports giving comparatively detailed descriptions of fuel resources that have economic interest but are not of sufficient importance to warrant a lengthy report; (b) preliminary reports on economic investigations, the results of which are to be published later in more detailed form. The papers included in the volume are the following:

Woodruff, E. G., and Day, D. T. *Oil shale in northwestern Colorado and northeastern Utah.*

Lupton, C. T. *Oil and gas in the western part of the Olympic Peninsula, Washington.*

Barnett, V. H. *The Moorcroft oil fields, Crook County, Wyoming.*

Barnett, V. H. *Possibilities of oil in the Big Muddy Dome, Converse and Natrona Counties, Wyoming.*

Pack, R. W., and English, W. A. *Geology and oil prospects in Waltham, Priest, Bitterwater, and Peachtree Valleys, California.*

Wegemann, C. H. *The Coalville coal field, Utah.*

E. S. B.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 298th meeting was held in the lecture room of the Cosmos Club on October 27, 1915.

INFORMAL COMMUNICATIONS

G. F. Loughlin described an occurrence of hübnerite, wolframite, pyrite, etc., at Leadville, in deposits intermediate in nature between contact metamorphic deposits and ordinary veins.

W. F. Hillebrand exhibited a liquid alloy composed mostly of gallium, with a small percentage of indium and zinc. This had been produced in a zinc metallurgical plant, appearing as drops sweated out of zinc-lead dross-plates. It was learned by correspondence with the manager of the works that the particular ore from which it had been derived was uncertain and that in any case the amount which could be produced was probably small.

In reply to questions from Spencer, Martin, and Wells, Hillebrand said that at present there was no use to which gallium was put. It has been obtained previously from zinc ores and indications of its presence were often found in spectroscopic work.

REGULAR PROGRAM

E. T. Allen: *Chemical studies in copper sulphide enrichment.* It was shown from a study of the copper sulphides that chalcocite was a mineral of variable composition, made up of cuprous sulphide with a varying amount of dissolved cupric sulphide. There are two crystalline forms of cuprous sulphide, with a transition point at 91°. Only the lower temperature form has so far been found in nature. It was explained how the system Cu-Fe-S was being studied through the dissociation pressure curves of the various sulphides of Cu and Fe. A preliminary study of gossans has been made, with the result that all appear to be amorphous and to show a thermal behavior similar to limonite. A comparative study of the rates of oxidation of the commoner sulphides, in pure condition, has been made and much attention has been given to the chemical study of the enrichment process. The action of copper sulphate solutions on the most important sulphides has been studied at 200°, 100°, and 40°. In all cases the final product has been cuprous sulphide. Covellite, and chalcocite containing dissolved cupric sulphide, appear as intermediate products. The logical conclusion from the data is that secondary chalcopyrite, bornite, and covellite are earlier stages of a process which was interrupted before it was complete. Many reactions, such as the synthesis of bornite and chalcopyrite in the wet way, have been worked out.

Discussion: G. F. Loughlin inquired regarding rate of oxidation of galena in comparison with sphalerite. Allen replied that with galena the action is rapid at first but an insoluble coating soon forms and action ceases. E. S. Bastin spoke of a phenomenon he had observed in field work. In a certain type of enrichment covellite, chalcocite, etc. form; in another type only chalcopyrite. In the latter case galena, sphalerite and carbonates are prominent accompanying minerals. He asked Allen if he had any explanation. Allen replied that his experiments did not offer any suggestion. He emphasized the fact that the end product of true equilibrium between sulphide ores and copper sulphate solutions is not chalcopyrite but chalcocite. A. C. Spencer asked if it were possible that in processes of secondary enrichment migration of copper in carbonate solutions had taken place. Allen thought that an obstacle to such a conception was the lack of the necessary oxidizing agent.

C. Wythe Cooke: *The age of the Ocala limestone of Florida.* The Ocala limestone, which has heretofore been thought to represent the concluding stage of the lower Oligocene (Vicksburg group) and to overlie the Marianna and "Peninsular" limestones, occurs at Marianna, Florida, lying unmistakably beneath the Marianna limestone, which is of Vicksburg age. Critical study of the list of fossils from Ocala published by Dall in 1903 shows that the formation is of upper Jackson (Eocene) age. The "Peninsular" limestone is in large part identical with the Ocala but may include other formations.

Discussion: R. S. Bassler spoke of the great difficulties encountered in working out stratigraphic relations in the Southern States, due principally to lack of satisfactory outcrops. T. Wayland Vaughan referred to some of the structural relations which had led former workers astray. One of the chief factors was the presence of an erosion unconformity and the lack of certain members in certain type sections. L. W. Stephenson thought that one of the chief points brought out by the paper was the necessity for very careful paleontologic work.

C. N. Fenner, *Secretary.*

The 299th meeting was held in the lecture room of the Cosmos Club on November 10, 1915.

INFORMAL COMMUNICATIONS

W. T. Schaller described briefly a kaolinite from Oklahoma which was of very pure composition, but remarkable for intumescence before the blowpipe.

REGULAR PROGRAM

Edgar T. Wherry: *Notes on the geology near Reading, Pennsylvania,* (*Illustrated.*) The Cambrian, Ordovician, and Triassic formations of the region, and their structures, were briefly described. The Cambrian comprises a quartzite and two limestones; the Ordovician, limestone, cement-rock, and shale; and the Triassic, shale, sandstone, conglomerate basalt, and diabase. The beds are greatly disturbed, being in places overturned to 45°, elsewhere intricately folded, and cut by three systems of faults: thrust-faults from the southeast, dating from late Ordovician time; normal faults with the drop on the southeast, which formed during the Triassic deposition; and normal faults crossing the other two systems nearly at right angles, which were developed at the close of Triassic time.

Discussion: G. W. Stose referred to the remarkable amount of faulting exhibited in this area. In an area 20–30 miles to the south, whose structure had been worked out, there is almost none. He remarked also on the well-defined characteristics of the Martinsburg shale in this section. In an adjacent section it is difficult to distinguish between the Martinsburg shale and certain shaly strata in the Cambrian.

J. W. Gidley: *The relations of vertebrate fossils to stratigraphy.* (No abstract.)

N. H. Darton: *Some geologic features of southeastern California.* (*Illustrated.*) The results of a reconnaissance made near the line of the Santa Fé Railroad from Needles to Cajon Pass in 1906 and 1914 were outlined. Some of the facts have been published in the Guide Book to Geology, etc., of the Santa Fé Railroad, but many technical details regarding rocks, structure, and fossils were necessarily omitted from that publication. Six general series of rocks were found: (1) A widely exposed basement of pre-Cambrian granites and schists, mostly appearing in high ridges; (2) a succession of Paleozoic rocks which yielded Cambrian to Carboniferous fossils at several localities, notably in Iron Mountain and its northern continuation, Providence Mountain, to which a side trip was made from Kelso; (3) intrusive quartz-monzonites and similar rocks cutting the Paleozoic strata and altering limestones to marbles; (4) a thick series of Tertiary (Rosamond, etc.) volcanic rocks, largely breccia, tuffs, ash, and sediments, with interbedded effusive sheets, and some intrusive masses; (5) the valley fill of the desert plain, with lake beds and salt, gypsum, etc.; (6) recent volcanic cones and flows, notably the very fine examples near Amboy and Pisgah. Many details of structure were determined, but it was found that most of the ridges and valleys were not closely related to faults as popularly supposed.

Discussion: F. C. Schrader inquired whether it was possible to make correlations among the various volcanic series of different sections; also as to the manner in which mineralization was associated with the igneous rocks. Darton replied that the volcanic rocks of the younger series were variable, so that successive beds could not be identified individually but the general history and succession could be worked out. Mineralization seems to be associated with igneous rocks of all descriptions, but no very important mines have been developed. T. WAYLAND VAUGHAN spoke of the faulting and inquired if the great block faulting of the West Indies found a parallel in southern California. He had formed the impression from talks with R. T. Hill that such was the case. Darton replied that in his work the details of faults had not been determined. He had found, however, that the topographic lineaments of the region were not due to faulting.

C. N. FENNER, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 544th meeting of the Society was held at the Cosmos Club, Saturday, November 6, 1915 with President Bartsch in the chair; 90 persons present.

On recommendation of the Council, Gilbert F. Bateman, Trinidad, Colorado was elected to active membership.

The first paper of the regular program was by O. P. HAY: *A new Pleistocene sloth from Texas.* Dr. Hay discussed the finding in Texas of a new member of the genus *Nothrotherium.* This discovery extends the range of the genus from South into North America. The specimen was exhibited and remarks were made on the interrelationships and distribution of the living and fossil American Edentates.

The second paper was by J. N. ROSE: *Botanical explorations in South America.* Dr. Rose gave an account of his botanical explorations in South America. He outlined first the field work which he and Dr. N. L. Britton had planned in connection with the cactus investigations of the Carnegie Institution of Washington, and then described the great cactus deserts of South America which he had visited. During his last trip to South America he spent six weeks in the state of Bahia, Brazil, six weeks in the state of Rio de Janeiro, Brazil, and three weeks in Argentina. Large collections were obtained and many living plants were sent back to the United States for cultivation, the living collection being now on exhibition in the New York Botanical Garden. Several remarkable generic types of cacti were discovered. Dr. Rose's paper was illustrated by numerous lantern slides of the regions visited and of cacti in their native environment, and by many interesting botanical specimens.

The last paper of the evening was by L. O. HOWARD: *Some biological pictures of Oahu (Hawaii).* Dr. Howard showed a large number of lantern slides from photographs made by him during a short stay on the island of Oahu during the past summer. Special emphasis was laid on those which dealt with agricultural problems and economic entomology.

M. W. LYON, JR., *Recording Secretary.*

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PHYSICS.—*The constants of the quartz-wedge saccharimeter and the specific rotation of sucrose.* Part I: *The constants for the 26 gram normal weight.*[1] Frederick Bates and Richard F. Jackson, Bureau of Standards. (Communicated by G. K. Burgess.)

The control of the quartz-wedge saccharimeter has previously been based upon the experimental work of Herzfeld[2] and Schönrock.[3] The former prepared pure sucrose and determined the sugar equivalents or values of a number of carefully selected quartz plates, making the comparison upon quartz-wedge saccharimeters illuminated by Welsbach gas mantles, the light of which was filtered through a potassium bichromate solution. The rotations of these plates were then measured by Schönrock in terms of the D lines of the sodium spectrum. These measurements showed that the normal quartz plate caused a rotation of 34°657 at 20°0 C. The normal quartz plate is one which causes the same rotation on the saccharimeter as the normal sugar solution which is the fundamental basis of standardization. The rotation of the normal plate in terms of monochromatic light is designated the Conversion Factor because it may be used to determine the sugar value of any other quartz plate whose rotation in terms of monochromatic light is known.

[1] The complete paper will appear in the Bulletin of the Bureau of Standards.
[2] Zs. Ver. Zuckerind. **50**: 826. 1900.
[3] Zs. Ver. Zuckerind. **54**: 521. 1904.

For the present investigation the purest granulated sugar of commerce was dissolved in its own weight of distilled water, clarified with washed alumina cream and filtered. The clear solution was boiled in a glass vacuum boiling apparatus at about 35°C. until it reached a concentration of about 80 per cent sugar. The supersaturated syrup was poured out and allowed to crystallize while in continuous motion. The crystals were separated from the mother liquor by a powerful centrifugal machine and washed with pure alcohol. They were then redissolved and recrystallized repeatedly until deemed of sufficient purity to test.

The progress of the purification was studied by testing for such impurities as could be detected. By weighing the ash left after ignition, inorganic impurities were found to be satisfactorily removed after two crystallizations.

The test for reducing substance was complicated by the fact that sucrose itself possessed a slight reducing power. Nevertheless a diminution of reducing power indicated the elimination of foreign reducing substances. By boiling a 10 gram sample of the original granulated sugar with 50 cc. of the Striegler[4] reagent, a precipitate of 20 mg. of Cu_2O was obtained. After one recrystallization, this precipitate diminished to 9 mg., and after two crystallizations it became 7 mg. This latter quantity proved to be a minimum. To show that this precipitate was caused mainly by sucrose itself, analyses were made with a modification of the Soldaini reagent[5] consisting of about 300 grams $KHCO_3$ and 1 gram $CuSO_4$ $5H_2O$ in a liter of solution. By boiling a 10 gram sample with 50 cc. of this solution for two minutes a precipitate of 1.1 mg. Cu_2O was obtained. To another sample 0.01 per cent or 1 mg. of invert sugar was added and the mixture boiled with the copper solution. The invert sugar caused an increased precipitation of 1.9 mg. Hence even if the entire precipitate of 1.1 mg. Cu_2O were due to impurities, the latter could amount to but $\frac{1.1}{1.9} \times 0.01$ per cent $= 0.006$ per cent.

[4] von Lippmann, Die Chemie der Zuckerarten, **1**: 606. 1904.

[5] Ibid.

A study of the reaction velocities of the copper solution with sucrose (a slow reaction) and with invert sugar (a rapid reaction) showed that a great part if not all of the 0.006 per cent reducing substance was due to pure sucrose. The recrystallized substance was consequently concluded to be free from reducing sugar.

In order to be certain of the elimination of impurities which could not be detected by direct test, a quantity of sugar was fractionally crystallized. In this process those fractions which supposedly contained impurities of about the same solubility were united, in order to prevent too great a subdivision of the original substance. In this way five fractions were obtained after 32 crystallizations which upon test yielded essentially identical rotations. This was concluded to be evidence of the purity of the substance.

In the elimination of moisture it was necessary to heat the substance for such a time and at such temperature as to avoid decomposition into caramel. The rates of decomposition were measured in several series of experiments and the results plotted. The curve showed the time at each temperature required to form caramel equivalent in reducing power to 0.01 per cent invert sugar. The data are: 100°C., 0.015 hrs.; 79°.5, 0.57 hrs.; 66°.6, 10.9 hrs.; 50°.0, 107.0 hrs.; 39°.0, 476 hrs. In preparing the sugar for polarization care was taken to avoid sensible decomposition.

In studying the elimination of moisture the substance was subjected to high vacuum, to the highest permissible temperature, and to various drying agents for long periods of time. The conclusion was reached that a few hours heating at 50° to 60°.C in a vacuum of 0.001 mm. of mercury and in the presence of quicklime would eliminate all but negligible quantities of moisture.

The solution used for polarization was never of exactly normal concentration. For preparing it the approximate normal weight was transferred to a weighed volumetric flask. Flask and sugar were then subjected to the drying operations before the final weighing.

The volume of the total solution was found either by filling to the graduation mark of calibrated flasks or was calculated from the weight and density. Density was taken from published tables in which it was coupled with percentage of composition of solutions. These two methods of determining the volume of solution checked satisfactorily.

The measurements of the absolute rotations of the solutions were made on a large polarimeter with a silver scale reading to thousandths of a degree. The temperature of the solutions was controlled by an air bath placed between the polarizing and analyzing systems of the instrument. It was cooled below 20°C. by ice water and then heated electrically to 20°C. Regulation

TABLE I

SUMMARY OF DATA ON THE ROTATION OF THE SOLUTIONS

EXP.	WT. OF SUGAR (AIR, BRASS WEIGHTS)	WT. OF SOLUTION (AIR, BRASS WEIGHTS)	PER CENT SUGAR SUGAR BY WT. IN VACUO	DENSITY K.N.E.K. TABLES	VOLUME OF SOLUTION CC. Computed from wts. and density	VOLUME OF SOLUTION CC. By flask mark	AV. ROT. OF SOLUTION FOR TWO SACCHARIMETERS. DEGREE SUGAR	ROT. OF NORMAL SOLUTION ON THE SACCHARIMETER. DEGREE SUGAR.	ROT. OF NORMAL SOLUTION FOR λ=5461*A*. CIRCULAR DEGREES
1	2	3	4	5	6	7	8	9	10
	grams	*grams*							
25	24.370_8	101.570	23.986_6	1.09891	92.514	92.518	101.19_2	99.90_2	40.757
26	26.207_2	109.497	23.926_1	1.09863	99.761	99.750	100.89_6	99.88_0	40.770
27	34.052_3	142.665	23.861_0	1.09834	130.010	130.012	100.61_4	99.88_2	40.761
28	24.029_2	101.546	23.655_7	1.09741			99.68_7	99.89_3	40.763
29	23.856_3	101.381	23.523_3	1.09680	92.518	92.520	99.04_4	99.87_0	40.751
30	34.018_3	142.636	23.841_9	1.09825	130.000	129.997	100.56_0	99.92_1	40.773
31	24.181_1	101.496	23.817_0	1.09814			100.41_8	99.88_8	40.749
32	26.003_3	109.533	23.732_4	1.09775			100.05_1	99.91_4	40.769
33	34.326_1	143.045	23.988_7	1.09892			101.23_2	99.90_4	40.771
34	25.881_3	109.610	23.604_5	1.09717			99.43_8	99.89_7	40.767
							Mean	99.89_5	40.763

was secured more closely than 0°.05 C. The light source was the so-called yellow-green line, $\lambda = 5461\ A$, from a quartz mercury-vapor lamp.

Three different makes of saccharimeters were used in order to eliminate the possibility of some peculiarity of instrument construction affecting the measurements. They were a Bates type Fric, a Schmidt and Haensch, and a Julius Peters. Two instruments were used in each experiment, one of which was always the Bates type Fric. It was enclosed in a wooden thermostat with automatic temperature control to within a few hundredths of a degree. The saccharimeter readings were made in a large thermostated room with a content of about 15 cubic meters. With two observers in the large thermostat the maximum variations were about 0°3 C.

The polarization tubes were of glass. Careful measurements established the fact that the tubes filled with distilled water gave a negligible rotation.

The polariscopic measurements included a long preliminary series and a final series of ten experiments. The latter are given in Table 1. It will be observed from the values given in column 9 that the normal sugar solution gave a rotation of but $99°89_5$–S[6] on a saccharimeter calibrated according to the Herzfeld-Schönrock standard. This calibration was obtained by the use of two quartz plates whose absolute rotations and sugar values had been determined by the Reichsanstalt, the Institut für Zuckerindustrie, and also by us. It was, therefore, concluded that the Herzfeld-Schönrock standard was too large by over 0°1 S.

The data were then recalculated on the basis of the reading of the normal solution which must be 100°00 S on the true scale. The sugar values of the two quartz plates were thus compared directly with the normal solution and their sugar values calculated. Since the values of the plates were known in terms of monochromatic light, the new conversion factors followed by direct calculation. For $\lambda = 5892.5$ A this became 34°620 and for $\lambda = 5461$ A it became 40°690.

On the same day that the solutions were read on the saccharimeters their rotations were also measured on the polarimeter in terms of monochromatic light, $\lambda = 5461$ A. For this wave length the normal solution caused a rotation of 40°763.

The ratios of the rotations of quartz and of sugar solutions for the two wave lengths were determined

For quartz

$$\frac{\phi_{\lambda = 5892.5\ A}}{\phi_{\lambda = 5461\ \ A}} = 0.85085$$

and for sugar

$$\frac{\phi_{\lambda = 5892.5\ A}}{\phi_{\lambda = 5461\ \ A}} = 0.84922$$

[6] The symbol S signifies a Sugar Degree, i. e., one-hundredth part of the rotation of the normal sugar solution on the saccharimeter.

From the data on the rotation of the normal solution for $\lambda = 5461\ A$ and the latter ratio, the value for $\lambda = 5892.5\ A$ was computed to be 34°617 at 20°

For $\lambda = 5892.5\ A$ the normal plate has 0°003 greater rotation than the normal solution, while for $\lambda = 5461\ A$ it has 0°073 lower rotation. The rotary dispersion curves of the plate and solution thus cross at about $\lambda = 0.585\ \mu$.

The slight differences between the rotary dispersions of quartz and of sugar cause differences in the saccharimeter readings when illuminated by various light sources. If, instead of the Welsbach mantle the saccharimeter is illuminated by the source $\lambda = 5892.5\ A$ the calculated reading would be 99°99 S.

The normal solution causes a rotation of wave length 5461 A which is by calculation $0.19_2\ S$ higher than that of wave length 5892.5 A. Experimentally the difference was found to be $0°18_5\ S$.

By combining data of two previous investigators on the rotation of quartz 1 mm. thick with our values for the rotation of the normal plate, the thickness of the latter is found. This calculation yielded the two values 1.5934 mm. and 1.5940 mm.

The measurements of the rotations of the normal solutions for monochromatic light, afforded sufficient data for the exact calculation of the specific rotations since rotations, length of solution, and concentration were accurately known. The following values were obtained:

$$[\alpha]^{20.0}_{\lambda=5892.5\ A} = 66°529$$
$$[\alpha]^{20.0}_{\lambda=5461\ \ A} = 78°342$$

The mean of the best previous determinations of the specific rotation of the normal solution for $\lambda = 5892.5\ A$ is 66°502 with which our value is in substantial agreement. On the other hand Schönrock calculated the specific rotation from the conversion factor 34°657 and the saccharimeter reading of the normal solution for $\lambda = 5892.5\ A$. This gave for the rotation of the normal solution 34°667 and the specific rotation 66°627 which value is considerably too high. Our own value of the specific rotation calculated either from direct observations on the rotation of the normal solution for monochromatic light, or by the method of Schönrock, in which, however, the conversion factor 34°.620 is used, lies in essential agreement with the previously accepted value. This is concluded to be corroborative evidence of the correctness of the new value 34°.620 of the conversion factor.

GEOLOGY.—*Subdivisions of the Thaynes limestone and Nugget sandstone, Mesozoic, in the Fort Hall Indian Reservation, Idaho.*[1] G. R. MANSFIELD, Geological Survey. (Communicated by F. L. RANSOME.)

INTRODUCTION AND SUMMARY

In the field season of 1913 the writer with a U. S. Geological Survey party made an examination of the Fort Hall Indian Reservation in southeastern Idaho. The reservation, which has an irregular shape and includes approximately 800 square miles, lies mostly between the meridans 112° and 112° 45′ W. and between the parallels 42° 30′ and 43° 15′ N. (See fig. 1.)

Fig. 1. Index map of Idaho, showing the location of the Fort Hall Indian Reservation.

Although the main purpose of the work was a mineral classification of the land, considerable attention had to be paid to the stratigraphy of the region, and it was found necessary to map some of the formations in detail. This made it desirable to subdivide certain Mesozoic formations, particularly the Thaynes limestone, Lower Triassic, and the Nugget sandstone, Jurassic or Triassic. The strata involved, together with the intervening Ankareh sandstone, have a thickness of about 6,800 feet.

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

TABLE I

Mesozoic Formations of Fort Hall Indian Reservation, Idaho

Geologic age	Formation	Description	Thickness in feet
Jurassic	Twin Creek limestone	*a.* Yellow, calcareous, fossiliferous sandstone with some beds of massive, gray limestone. *b.* Laminated, shaly, gray limestone. *c.* Basal, yellow, calcareous sandstones; massive, with intercalated massive, gray limestone with oyster shells.	Est. 2500
Jurassic or Triassic	Nugget sandstone	*a.* Brick red and light-colored sandstones, typical Nugget; thickness not shown but estimated at not less than 1500 feet. *b.* Wood shale member; bright red, weathering to red soil; 200–250 feet. *c.* Deadman limestone member; gray to purplish, dense limestone of almost lithographic quality, in some places with gray and greenish chert. *d.* Higham grit member; coarse, pink to white, gritty or conglomeratic sandstone.	1500 250 150± 500±
Lower Triassic	Ankareh sandstone	Somewhat sugary, yellowish to grayish sandstone in beds 1–3 inches thick, weathering with pinkish tinge.	800
	Thaynes group *a.* Portneuf limestone	Siliceous, cherty, gray to yellowish limestone in massive beds; rounded elongated nodules and streaks of chert, fossiliferous; fossils often silicified.	1500±
	b. Fort Hall formation	Yellowish and grayish limestone and sandstone, the limestone siliceous and cherty; the sandstone calcareous, fossiliferous.	800±

TABLE I—Continued

GEOLOGIC AGE	FORMATION	DESCRIPTION	THICKNESS IN FEET
Lower Triassic..	c. Ross limestone	Dense, gray, non-fossiliferous, thin-bedded limestone; olive-drab, platy, calcareous shale; purplish gray, thin-bedded and massively-bedded limestone with pelecypod and brachiopod faunas and with ammonite zones near base.	1350±
	Woodside shale	Olive-drab, platy, calcareous shale with interbedded reddish brown limestone more abundant near the top and crowded with pelecypods.	900

The Thaynes limestone has in this area been raised to the rank of a group consisting of three formations, and the Nugget sandstone has been subdivided into four members. The Ankareh shale, owing to change in lithologic character, becomes the Ankareh sandstone. Additional interesting features were observed in the Woodside shale.

The purpose of this paper is to describe briefly the formations which were subdivided and to explain the names used. The writer is indebted to Dr. G. H. Girty for his help in joint study of the formations in the field and for the determination and discussion of the fossils collected.

GENERAL STRATIGRAPHY OF THE REGION

The stratigraphic sequence in the Fort Hall Indian Reservation is rather full, including all the great Paleozoic and later systems except the Cretaceous. There is, too, a great body of igneous rocks, chiefly extrusives, in both massive and fragmental form. The structure is complex, with folding and much faulting. Some of the systems are poorly represented and the identification of strata tentatively assigned to them uncertain. This is particularly true of the Silurian. The Paleozoic formations of the reservation probably agree in name and number with those of northern Utah, as described by Richardson,[2] although it was not practicable in the field work to give much attention to the lower formations. The Mesozoic formations are shown in the accompanying table (Table I).

WOODSIDE SHALE

The Woodside shale, the lowest Mesozoic formation in the district, takes its name from Woodside Gulch, in the Park City Mining District, Utah.[3] It has been described in a number of reports and only differences from the usual types need be mentioned here. In Utah and near Paris, Idaho, some of the beds of the Woodside shale are red, whereas in most of the southeastern Idaho region the formation is characterized by yellowish and olive-drab tints. Near the base in the Fort Hall Indian Reservation the beds have a distinctive reddish brown tint and are relatively sandy.

The base of the Woodside shale, which in regions previously studied has been rather sharply distinguished from the underlying Phosphoria formation of Permian(?) age by a lithologic as well as a faunal change, is not so clear here. A Paleozoic fauna, consisting chiefly of the brachiopod Ambocoelia in abundance, together with pelecypods suggesting Paleozoic characteristics but not definitely identified, is found in the Rex chert member of the Phosphoria formation above the chert. It occurs in brownish yellow, sandy shales and limestones not easily distinguished lithologically from the Woodside, although the faunas of the adjacent formations where well developed are very different. Particular interest attaches to this feature because it appears to indicate that the change from Paleozoic to Mesozoic conditions, which in many places is marked by a sharp stratigraphic break, was here more gradual.

[2] Richardson, G. B. *The Paleozoic section in northern Utah.* Amer. Jour. Sci., N. S., **36**: 406–416. 1913.

[3] Boutwell, J. M. *Stratigraphy and structure of the Park City Mining District, Utah.* Jour. Geol., **15**: 434–458. 1907.

THAYNES GROUP

The Thaynes limestone, which it is here proposed to call the Thaynes group, takes its name from Thaynes Canyon, in the Park City Mining District, Utah. In northeastern Utah and in the Slug Creek and Montpelier districts of southeastern Idaho the Thaynes forms platy, calcareous shales and brown weathering limestones with a massive limestone at the top. In that district the Thaynes limestone is about 2,000 feet thick. In the Fort Hall Indian Reservation the formation shows a marked tendency to differentiate into several units that can be mapped separately. These beds have there a thickness of 3,600 feet, yet according to G. H. Girty[4] fossils similar to those of the upper limestone were found by C. L. Breger in shales underlying the Ankareh shale in Montpelier Canyon, Montpelier quadrangle. Thus the thicker group in this district occupies the same stratigraphic interval as the Thaynes limestone farther southeast. It has been found advisable to subdivide the group into three formations, the Ross limestone at the base, the Fort Hall formation, and the Portneuf limestone.

Ross limestone. The Ross limestone takes its name from Ross Fork Creek, in the upper waters of which this limestone is well exposed. The base of the formation lies conformably upon the Woodside shale and is marked by the "Meekoceras beds" recognized by the Hayden Survey and referred to the Triassic and later referred by Hyatt and Smith[5] to the Lower Triassic.

The Meekoceras zone consists of gray to reddish brown limestones about 50 feet thick containing numerous Ammonites the chambered shells of which appear on the weathered surface of the rock. In the Fort Hall Indian Reservation the fossils do not weather out so readily and the horizon is not so conspicuous as in the Slug Creek quadrangle farther east. The Tyrolites and Columbites zones, which have been recognized by Smith in the region of Paris, Idaho, 250 and 275 feet, respectively, above the

[4] Personal communication.

[5] Hyatt, A., and Smith, J. P. *The Triassic cephalopod genera of America.* U. S. Geol. Survey Prof. Paper **40**: 17–19. 1905.

Meekoceras zone,[6] have not been recognized here, but there is evidence of more than one Ammonite horizon.

Above the Meekoceras zone for about 800 feet are massively-bedded and thin-bedded gray to brown limestones containing large numbers of small brachiopods, chiefly Pugnax and terebratuloids, and pelecypods, Myalina and others, with intervening calcareous shales. The lithology of the shales and thinner-bedded limestones is much like that of the Woodside. The limestones weather with a sort of velvety appearance and are very fossiliferous. The presence of the small brachiopods in the massive limestones near the base is a convenient guide to the Ross limestone where the Meekoceras zone is not available.

The upper part of the Ross limestone for about 500 feet consists of a dense calcareous shale, gray to olive-greenish in color and weathering brown to yellow. These shales form conspicuous cliffs and are mainly non-fossiliferous.

G. H. Girty contributes the following faunal discussion of the Ross limestone:

The fauna of the Ross limestone consists chiefly of brachiopods, pelecypods, and cephalopods. The brachiopods and cephalopods are largely restricted to zones which are narrow and possibly of small extent, but where found at all they are abundant. The brachiopods comprise a Lingula, a Terebratula, and a Rhynchonella, those terms being employed in a broad and general sense. The Rhynchonella closely resembles the Carboniferous species *Pugnax utah* and, as the Triassic occurs in the general region from which the type specimen was obtained, typical *Pugnax utah* may indeed be the Triassic form, as was suggested to me several years ago by Mr. Breger. A few specimens of a small Discina have also been collected.

The pelecypods consist mostly of pectinoids of which there are many species. They probably include representatives of both the Pectinidae and Limidae and they occur in some places in vast numbers either alone or associated with other forms. Like most of these Triassic fossils, they belong to undescribed species, though one form can probably be referred to *Aviculipecten thaynesianus*. Other types of pelecypods are much less common. The one most frequently found is that described by White as *Volsella platynota*, but if my specimens really belong to White's species I believe that it is a Myalina. A small alate shell, which may belong to Bakewellia or Pteria, has been found, and also forms which suggest the genera Schizodus, Cardiomorpha, and Pleurophorus.

[6] SMITH, J. P. *The distribution of Lower Triassic faunas.* Jour. Geol., **20**: 17. 1912.

These last are so poorly preserved that their generic relations, even as based on external characters, are conjectural.

The cephalopods have been carefully investigated to the almost complete neglect of the rest of the Triassic fauna of this region. The Ross limestone is the horizon of the cephalopods par excellence, the Meekoceras zone. Nevertheless, the collections studied, which were not made with special reference to any one group of organisms, contain neither very numerous nor very complete specimens. The following species have been identified with more or less certainty: *Meekoceras muchbachanum, Meekoceras gracilitatis, Parananites aspenensis, Ophiceras dieneri, Flemingites russelli, Clypites tenuis.*

Gastropods are so rare in the Ross limestone that they might with little loss be neglected in a hasty survey of its fauna. One collection contains an abundance of small naticoid shells (*Natica lelia*?), but of much more interest is the occurrence in another collection of a species of Bellerophon. There can hardly be a doubt of the generic relationship of this form which resembles the Pennsylvanian species *B. crassus.* The Bellerophontidae, though profusely developed in the Paleozoic and almost confined to that era, have been known in other parts of the world to range also up into the Mesozoic.

Fort Hall formation. The Fort Hall formation is named from old Fort Hall, the site of which is in the valley of Lincoln Creek, which appears on some maps as Fort Hall Creek. The formation occupies a prominent ridge along the north side of this valley. The rocks lie conformably on the Ross limestone. The dividing line is drawn on both lithologic and faunal grounds. There are four fairly well defined subdivisions.

(1) The base of the formation is a soft and somewhat sugary, yellow calcareous sandstone about 50 ± feet thick, sparingly fossiliferous and containing at one locality a bed of yellowish sandy limestone about 15 feet thick, with plicated oyster-like pelecypods, terebratuloids, and other forms. This bed is overlain by white calcareous sandstone weathering red or pink.

(2) Above these sandstones there is a gray or yellowish, siliceous, dense limestone containing large pectinoids and irregular cherty nodules and streaks that weather with a rough surface and project along the bedding planes. This limestone forms rough ledges and high points. The thickness of this series is estimated at 100 ± feet.

(3) Above (2) and observed at only two localities, secs. 36 and 26, T. 3 S., R. 37 E., Boise M., is a set of sandy and shaly gray

limestones about 50 feet thick including an oolithic bed 6 to 10 feet thick.

(4) The remainder of the section, estimated at about 600 feet, consists of yellow to grayish cherty and sandy limestones in thin beds represented chiefly by fairly smooth slopes strewn with yellow and reddish sandy and cherty fragments.

Fossil collections were made at a number of places in the Fort Hall formation. The following faunal discussion is contributed by G. H. Girty:

The Fort Hall formation might appropriately be called the *Aviculipecten idahoensis* zone, for it is particularly characterized by that species, which occurs in most of the collections and in many of them is very abundant. With *A. idahoensis* are associated a few other types of pelecypods, among which a large Bakewellia or Pteria and two or three species of pectinoid shells are the most common. There is also a form resembling Myalina (possibly the *Volsella platynota* of the Ross limestone, but smaller and less abundant), and several types which are too poorly preserved to be identified but in general expression suggest Myacites, Schizodus, and Pleurophorus. A small naticoid (*Natica lelia*?) is rather abundant in places, but otherwise, gastropods are practically absent.

In contrast to the preceding formation, the Fort Hall does not contain any cephalopods nor, with the single exception noted below, any brachiopods. As regards the pelecypods, the pectinoid shells, except *A. idahoensis*, are much less abundant in the Fort Hall formation, and some of the species of the Ross limestone appear not to occur there at all. On the other hand, *A. idahoensis* appears to be restricted to the Fort Hall formation.

One collection shows a remarkable and interesting variant of the Fort Hall fauna. It is distinguished by the absence of most of the pectinoids, even of *A. idahoensis*, and by the abundance of terebratulas, of which there are four or five varieties or species. Of the pelecypods the most noteworthy are a large Lima (n. sp.) and a sharply plicated oyster, besides which there are two species of Myacites?, a large Bakewellia? and one or two other forms. The gastropods are represented by *Natica leila* and by another species, possibly a Pleurotomaria.

Portneuf limestone. The Portneuf limestone is named from the Portneuf River, at the head of which the limestone is well exposed. The rock is a massively bedded, siliceous, and cherty, gray to yellowish limestone. The chert occurs in rounded and elongated nodules and in streaks. Silicified fossils, including Spiriferina n. sp. (?), *Terebratula semisimplex*, and other terebratuloids, and *Myaphoria lineata*(?), project from the weathered surfaces.

The formation is fairly resistant to erosion and forms low, broad ridges and sloping interfluvial areas. Its thickness is estimated at about 1,500 feet, although there is some uncertainty because of complexities of structure.

Numerous collections were made from this formation by G. H. Girty, who furnishes the following discussion of the fauna:

The Portneuf fauna is the most varied and interesting of the three Triassic faunas of the Fort Hall Reservation. Echinoid spines occur in a number of locations but they are not plentiful. On the other hand, segments of the stems of Pentacrinus are often found in great abundance. In two localities bryozoa are abundant, small branching types, superficially resembling the Carboniferous genus Batostomella. Several new genera and species are indicated by thin sections. Brachiopods are abundant, but confined to two families. This is the horizon of *Terebratula semisimplex*, but there are also several other terebratuloid types which are apparently undescribed. An undescribed species of Spiriferina occurs in many of the collections, and there may be a second species.

Pelecypod types are so numerous, and at the same time so poorly preserved in many cases, that it would be inexpedient to do more than mention the most interesting. No species is more frequently met in this fauna than one which was figured by Meek as *Myaphoria lineata*?. The locality of Meek's specimen is given as Weber Canyon, and the horizon as Jurassic. I can not but think that there is some mistake in the stratigraphic position of his material, which was said to be above the quarry rock, the quarry, I assume, being then as now in the Nugget sandstone. Compared with their abundance in the two lower formations, Pectens are scarce in the Portneuf. A large form with very coarse ribs occurs in several collections, and there are other species, both large and small. A large Pteria or Bakewellia has been found at many localities; also a Myalina or Mytilus. Leda is present, and Nucula, together with types suggesting Pinna, Myacites, Pleurophorus, Astarte, Cuculaea, and other forms. One locality has furnished a few specimens of Ostrea, not only a plicated form similar to that of the Fort Hall formation, but also a smooth type.

The scaphopods too are represented in this fauna by one or two species of Dentalium.

Gastropods are less abundant than pelecypods, the only common type being a small Natica, probably *N. lelia*. Several small species of Pleurotomaria? have been collected, and also shells suggesting the genera Holopea, Nerita, and Macrocheilina. The most interesting representative of this type, however, is a beautiful little species apparently belonging to the Carboniferous genus Schizostoma, or at all events to the euomphaloid group.

Cephalopods are practically absent in this formation, as they are in the Fort Hall. One specimen only was obtained; it is apparently identical with *Pseudosageoceras intermontanum.*

ANKAREH SANDSTONE

The Ankareh sandstone derives its name from Ankareh Ridge in the Park City mining district of Utah. In its type locality, Big Cottonwood Canyon near Salt Lake City, and as originally described, the formation is called a shale and consists chiefly of clay shale of deep maroon or chocolate color, showing little lamination where fresh but commonly breaking down after exposure into thinner-bedded shaly material. It includes also some pale greenish, clayey and sandy and limy strata.

In the Fort Hall Indian Reservation the beds that occupy this stratigraphic interval are not shales but are somewhat sugary, yellowish to grayish sandstones in beds 1 to 3 inches thick, and in some places more massive beds. They are non-fossiliferous, so far as observed, and weather into smooth depressions or slopes between the more resistant formations on either hand. The sandstone is generally of uniform character and in some places weathers with a pinkish tinge. The base of the sandstone rests with apparent conformity upon the massive and siliceous Portneuf limestone, while the top is overlain by the Higham grit. Thus the formation is in most places clearly defined.

THE NUGGET SANDSTONE

The Nugget sandstone as originally described by Veatch[7] in southwestern Wyoming is about 1,900 feet thick and consists of two distinct members, a lower brightly colored red bed member 600 feet thick, and an upper light-colored sandstone member.

In the Fort Hall Indian Reservation there is a considerable variation in the character of the Nugget from that at the type locality. The formation is well developed and may be differentiated into several units, at least four of which may readily be mapped. These are (1) the Higham grit member at the base,

[7] Veatch, A. C. U. S. Geol. Survey Prof. Paper 56: 56. 1907.

(2) the Deadman limestone member, (3) the Wood shale member, and (4) the main sandstone or typical Nugget.

Higham grit member. The basal member of the formation is named from Higham's Peak in sec. 23, T. 3 S., R. 37 E., the highest summit in the northeastern part of the reservation, which is composed of this rock. The grit is a coarse, white to pinkish, gritty or conglomeratic sandstone, the component particles of which are coarse and subangular. Locally the rock is almost a quartzite. The Higham grit is distinct lithologically from other rocks of the region and is prominent topographically. It forms important strike ridges that are marked by rough, craggy ledges in many places. The pebbles are all of quartzite so far as observed, without material derived from immediately underlying formations. The grit appears to lie conformably on the Ankareh sandstone. The rocks are much fractured and slickensided as a result of severe deformations, a condition which causes them to weather in pinnacled and castellated forms. The thickness is about 500 feet.

Deadman limestone member. Above the Higham grit member is a dense purplish-gray limestone of almost lithographic quality, with subordinate amounts of gray and greenish chert. This member is named the Deadman limestone after a creek in the northeastern part of T. 4 S., R. 38 E., Boise M., in the northeastern part of the reservation, near the headwaters of which the rock is exposed. The limestone is resistant and in favorable places forms topographically prominent ledges. Ordinarily, however, it is rendered inconspicuous by the proximity of the more resistant member below. No fossils have been observed in this limestone. The latter is about 150 feet thick.

Wood shale member. Above the Deadman limestone member is a bright red shale that weathers to a red soil. This member is called the Wood shale from Wood Creek in T. 3 S., R. 38 E., Boise M., in the northeastern part of the reservation, which cuts across the entire Nugget formation. It is less resistant to erosion than the adjacent members on either hand and occupies depressions or gullies. Outcrops are few but the shale may be traced by patches of bright red soil. It is apparently 200 to 250 feet thick.

The main sandstone or typical Nugget. The main sandstone which constitutes the greater part of the formation is typical Nugget sandstone. In many places it consists of brick-red, platy, fine-textured sandstone in beds 1 to 6 inches thick, which form rounded hills that are strewn with angular, platy blocks weathered from the ledges. In other places the sandstone is somewhat firmer, coarser textured, and pinkish to whitish in color. Markings resembling footprints and other impressions were collected from these sandstones, but they proved to be too indistinct for identification. The lighter colored sandstones are somewhat quartzitic and weather into angular blocks that form a dark purplish talus. The top of the sandstone is not exposed, or has not been recognized, for the stratigraphically overlying Twin Creek limestone has been faulted irregularly across the formation. The thickness of the main sandstone has not been measured but it is estimated at not less than 1500 feet.

The thickness of the entire formation appears to be as much as 2400 feet in the Fort Hall Indian Reservation and it may be somewhat greater.

BOTANY.—*The systematic position of the "rain tree,"* Pithecolobium Saman. E. D. MERRILL, Bureau of Science, Manila, P. I. (Communicated by WILLIAM R. MAXON.)

The genus *Pithecolobium* as interpreted by Bentham is rather a heterogeneous assemblage of plants. Some of the species placed under this name differ so radically from typical representatives of *Pithecolobium* that in some instances sectional differences within the genus are decidedly greater than the distinctions between some of the universally recognized genera of the Mimosoideae, while within the section *Samanea* the same statement holds for specific differences. It is believed that *Pithecolobium* will be a much more natural group if certain species be removed from it. At the present time, however, I am concerned especially with but a single one, the well known "rain tree," *Pithecolobium Saman* Benth., a native of tropical America but now extensively planted in most tropical countries.

Among other species placed in the section *Samanea* of *Pithe-*

colobium by Bentham I am confident that the Malayan *Pithecolobium moniliferum* Benth. should be removed as the type of a distinct genus, *Cathormion*, as Hasskarl[1] has already proposed. In transferring this species from *Inga* to *Pithecolobium* Bentham inadvertently transcribed the specific name *moniliformis* as *moniliferum*, in which he was followed by Hasskarl. The correct specific name and synonymy are as follows:

CATHORMION Hassk.

CATHORMION MONILIFORME (Hassk.) Merrill.
Inga moniliformis DC. Prodr. **2**: 440. 1825.
Pithecolobium moniliferum Benth. in Hook. Lond. Journ. Bot. 3: 211. 1844.
Inga monilifera DC. ex Benth. loc. cit. in syn.
Cathormion moniliferum Hassk. Nat. Tijdschr. Ned. Ind. **10**: 231. 1856.

The type of this species was from the Island of Timor, and the plant is cultivated in the Botanical Garden at Buitenzorg, Java.

Aside from the question of the generic limits of *Pithecolobium*, however, the application and validity of the name itself warrant some consideration. Mr. S. C. Stuntz, of the United States Department of Agriculture, has called my attention to the fact that *Pithecolobium* was originally published by Martius[2] as *Pithecellobium*, the name being correctly derived from πίθηκος (monkey) and ἐλλόβιον (earring), so that there was no need to change the spelling to *Pithecollobium*, as Martius[3] did in 1837, nor to *Pithecolobium*, as Bentham[4] did in 1844, the latter making the derivation of the latter part of the name from the Greek λοβός, the lobe or lower part of the ear.

The original publication is as follows:

PITHECELLOBIUM Mart. (Inga Auct). Affenohrring XXIII. 1.
cyclocarpum Mart. (Ing. W.)
Caracas. ♄ C.
inundatum Mart. Bras. ♄ C.
Unguis Cati Mart. Bras. ♄ C.

[1] Nat. Tijdschr. Ned. Ind. **10**: 231. 1856.
[2] Hort. Reg. Monac. 188. 1829.
[3] Flora, **20**²: Beibl. 114. 1837.
[4] Hook. Lond. Journ. Bot. **3**: 195. 1844.

Mr. Stuntz would regard the first species as the type of the genus, as it is the only one of the three enumerated that can be connected with a previously published binomial, *Inga cyclocarpa* Willd. This selection of the type would be most unfortunate as *Inga cyclocarpa* Willd. (= *Pithecolobium cyclocarpum* Mart.) is an *Enterolobium*, so that the species now placed in *Enterolobium* would have to be transferred to *Pithecolobium*, while the more numerous ones now placed in *Pithecolobium* would need a new generic name. *Zygia* as published by Boehmer[5] would thus become the generic name for our *Pithecolobium* species, a name much older than the latter, although *Pithecolobium* is retained in the supplementary list of *nomina conservanda* adopted by the Brussels Botanical Congress.[6]

By absolutely strict rules of priority *Inga cyclocarpa* Willd. is undoubtedly the type of the genus *Pithecolobium*, and Martius undoubtedly derived his generic name *Pithecellobium* from the fruit characters of this species; yet it seems possible to save the name in its currently accepted sense by the selection, somewhat arbitrarily if necessary, of another species as the type. In the original publication the species are alphabetically arranged. There are no descriptions. The first species has a definite reference to *Inga cyclocarpa* Willd.; the second is a *nomen nudum*, apparently never further considered; while the third is manifestly a transfer of *Mimosa unguis cati* L. (= *Inga unguis cati* Willd.), although no synonym is hinted at other than in the general statement, following the generic name: "Inga Auct." The selection of this species as the type of the genus *Pithecolobium*, or *Pithecellobium* as originally published, will save the name in its currently accepted sense.

Again it is worth while to examine the original description of the genus as given by Martius.[7] It includes "Pithecolobium" and "Enterolobium" characters, but the *Pithecolobium* fruit character "legumen . . . . tortum" appears before the *Enterolobium* character "aut pluries cochleatum." The first species described is a true *Pithecolobium*, *P. tortum* Mart., the description of which

[5] Ludwig, Defin. Gen. Pl. 72. 1760.

[6] Act. Congr. Int. Bot. Brux. **1**: 114. 1910.

[7] Flora, **20**^{2}: Beibl. 114. 1837.

precedes the generic diagnosis. Following the generic diagnosis are cited *Inga excelsa* Kunth, *I. unguis cati* Willd., *I. bigemina* Willd., *I. cyclocarpa* Willd., *I. cochleata* Willd., and *I. contorta* Willd., and the original descriptions of *P. auaremotemo* Mart., *P. cauliflorum* Mart., and *P. gummiferum* Mart. Of the ten species mentioned or described six are now placed in *Pithecolobium*, three in *Enterolobium*, and one in *Inga*.

I have merely stated the case for and against two possible interpretations of the type of the genus *Pithecolobium*. Convenience will certainly be served much better by the selection of *P. unguis cati* as the type. With this introductory statement regarding the genus *Pithecolobium* itself it is now proposed to consider a single species, long placed in the genus, but which the author considers to be generically distinct.

In the year 1800 the species under consideration was originally described by Jacquin from South American material as *Mimosa Saman*. It was transferred to *Inga* by Willdenow a few years later and subsequently by other authors successively to *Pithecolobium*, *Calliandra*, *Albizzia*, and *Enterolobium*. Thus in less than one hundred years it has been considered by different writers under six generic names. As the various genera are now interpreted, *Pithecolobium Saman*, to use its generally accepted name, differs radically from all. *Mimosa*, *Inga*, *Calliandra*, and *Albizzia* can be dismissed without discussion, as the rain tree cannot possibly be referred to any of these genera. As between the two remaining genera, *Pithecolobium* and *Enterolobium*, it cannot possibly belong to the former as it has somewhat fleshy, at least pulpy, straight, indehiscent, and septate pods. Its true alliance is unquestionably with *Enterolobium*, where Sir David Prain has placed it; and yet in its straight or nearly straight, fleshy or pulpy pods and pedicelled flowers it is decidedly anomalous in *Enterolobium*, while in facies it is very strikingly different from the representatives of this genus known to me. Prain's[8] discussion is so lucid and to the point that it is here reproduced:

When Mr. Bentham tentatively placed the species [*Enterolobium saman* Prain] in *Pithecolobium* he explained that the tree was unknown

[8] Journ. As. Soc. Beng. 64[2]: 252. 1898.

to him. Dr. Grisebach, who had the advantage of studying the tree in the living state, at once recognized that it cannot possibly be a *Pithecolobium* and placed it in *Calliandra*, no doubt owing to the sutures of the pod being thickened as in that genus. That the pods are septate and indehiscent militates however against his proposal, for the crucial test of a *Calliandra* is that its pods, which may *not* be septate, shall dehisce elastically from apex to base. The Index Kewensis has therefore replaced the "Rain-Tree" in *Pithecolobium;* this however is a step which in turn similarly mars the generic limits of that group, since the pods of *Pithecolobium* must not be septate. The writer places the species with more confidence in *Enterolobium*, owing to its possessing the septate pods characteristic of that genus. The pulpy, in place of spongy at length indurated mesocarp, and the shortly pedicelled in place of sessile florets, cannot, in view of the variability of these characters within adjacent genera, be considered more that comparatively trivial deviations from the hitherto recognized characters of *Enterolobium*. The writer is unable, both on academic and on practical grounds, to agree with the proposal, made by some botanists, to amalgamate *Calliandra, Pithecolobium, Enterolobium* and *Albizzia*.

I am in entire agreement with Prain, except that after having had an opportunity to study several species of *Enterolobium* I am thoroughly convinced that, although the alliance of *Pithecolobium Saman* Benth. is unquestionably with *Enterolobium* and not with *Pithecolobium*, it represents a group generically distinct, and that if placed in *Enterolobium* it will be anomalous in that genus, although not to the same extent as in *Pithecolobium*. I propose therefore to raise to generic rank Bentham's section *Samanea*, which is typified by the species under consideration. I am confident, however, that many of the species ultimately placed by Bentham in this section are not congeneric with *Samanea* as typified by *Pithecolobium Saman*, and I am equally confident that some of them cannot be logically considered as representatives of the genus *Pithecolobium*. Several species are, however, unquestionably congeneric with *Samanea* and should be transferred here.

Samanea (Benth.) Merrill, gen. nov.

Pithecolobium Mart. § *Samanea* Benth. in Hook. Lond. Journ. Bot. **3:** 197. 1844.—Trans. Linn. Soc. **30:** 585. 1875.

Flores 5-meri, hermaphroditi. Calyx infundibuliformis, breviter lobatus. Corolla subinfundibuliformis, petalis usque ad medium connatis, valvatis. Stamina ∞, basi in tubo connata, longe exserta; antherae parvae, eglandulosae. Ovarium sessile, ∞-ovulatum, stylis filiformibus, stigmate minuto, capitato. Legumen rectum vel leviter curvatum, indehiscens, crassocompressum, epicarpio tenue crustaceo, mesocarpio pulposo, endocarpio firmiter crustaceo, continuo, inter semina septa formante, suturis incrassatis. Semina numerosa, transversa, oblongo-ovata, leviter compressa, nitida, exarillata, utrinque cum areola anguste oblonga instructa, funiculo filiformi.

Arbor procera, coma expansa, inermis. Folia abrupte bipinnata. 4–6-juga, glandulis interjugalibus instructa, foliolis deorsum minoribus, pinnis superioribus 6–8-jugatis, inferioribus 3–5-jugatis. Stipulae lanceolatae, parvae, deciduae. Pedunculi solitarii vel subfasciculati, elongati, in axillis superioribus subterminales. Flores rosei, pedicellati, inter *Mimoseas* mediocres, in capitulis globosis dispositi.

The genus as above defined is most closely allied to *Enterolobium*, differing especially in its straight or nearly straight, pulpy, not indurated pods, and its pedicelled not sessile flowers. *Pithecolobium* differs in its cochleate, curved or twisted, nonseptate, dehiscent pods, the seeds often arillate. *Albizzia* differs especially in its thin, dehiscent, nonseptate pods.

Samanea Saman (Jacq.) Merrill.

Mimosa Saman Jacq. Fragmenta 15. *pl. 9.* 1800.
Inga Saman Willd. Sp. Pl. **4**: 1024. 1806.
Pithecolobium Saman Benth. in Hook. Lond. Journ. Bot. **3**: 101. 1844.
Calliandra Saman Griseb. Fl. Brit. W. Ind. 225. 1864.
Albizzia Saman F. Muell. Select Extra-Trop. Plants 27. 1891.
Enterolobium Saman Prain, ex King in Journ. As. Soc. Beng. **66**^{2}: 352. 1897.

Other synonyms given by Bentham are *Inga cinerea* Humb. & Bonpl., *Inga salutaris* H.B.K., *Mimosa pubifera* Poir., *Calliandra tubulosa* Benth., and *Pithecolobium cinereum* Benth.

Samanea Saman, though apparently a native of the northern part of South America, is now widely distributed in cultivation in most tropical countries. It is remarkable for its exceedingly fast growth, the ease with which it can be transplanted, and the rapidity with which it recovers from the most severe pruning when transplanted. The tree reaches large proportions, and on account of its widely spreading branches forms a magnificent shade tree. The sweet pulpy pods are produced in great abundance and are relished by cattle. In fact in some countries the cultivation of the tree has been recommended on account of the forage value of its pods. Because of the ease with which it can be propagated and its very rapid growth it gives promise of being of great value in reafforestation work in some tropical countries. While of comparatively recent introduction into the tropics of the Old World, it is now of very wide distribution and in some countries has already established itself. It was introduced into the Philippines in about the year 1860 and is now by far the most common shade tree to be found in the larger towns throughout the Archipelago. The wood, which is dark in color, appears to be of some value, especially for interior finishings.

In tropical America *Samanea Saman* is known as *guango, samán, cenízaro*, and *arbol de la lluvia*, in the Philippines as *acacia*, in various British tropical colonies as rain tree, and in Hawaii as monkey pod. The common English name, rain tree, and its Spanish equivalent, *arbol de la lluvia*, probably owe their origin to the fact that the "sleep" or closing of the leaflets is a very conspicuous phenomenon, occurring at the approach of and during rains, and at night. The author has never observed, in this species, any dripping of water from hydathodes, such as has been noted in some tropical trees. In tropical countries with which the author is familiar flowering occurs at the height of the dry season. In those countries having a decided dry season the tree is deciduous, but the new leaves appear within a few days after the fall of the old ones, followed at once by anthesis which continues for several months.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearingi n this issue.

GEOPHYSICS.—*Researches of the deparment of terrestrial magnetism (vol. II): Land magnetic observations, 1911-1913, and reports on special researches.* L. A. BAUER and J. A. FLEMING: Carnegie Institution of Washington Pub. No. 175 (Vol. II). 278 pages, 13 plates, and 9 text-figures. 1915.

The first portion of this publication contains the results of all magnetic observations made on land by the Department of Terrestrial Magnetism from January, 1911 to the end of 1913.

New magnetic instruments of light and portable types are described; these include two universal-magnetometer designs, viz., a combined magnetometer and dip circle, and a combined magnetometer and earth inductor. The stations at which magnetic observations were made between 1911–1913 may be summarized as follows: Africa, 207; Asia, 83; Australasia, 264; Europe, 38; North America, 48; South America, 247; Islands of the Atlantic Ocean, 16; Islands of the Indian Ocean, 14; Islands of the Pacific Ocean, 16; Antarctic Regions, 30; the total number of stations is thus 978. The table of results gives names of stations, geographic positions, values of the three magnetic elements, dates and local mean times of observations, references to instruments used, and the initials of observers. From about 18 per cent of the results, data for the determination of the secular variation have been obtained. Extended extracts from the observers' field reports are given; following these are descriptions of the magnetic stations occupied during the period of 1911–1913.

The first special report describes in detail the newly-erected research buildings of the Department at Washington. The second report is devoted to L. A. Bauer's inspection trip of 1911, in the course of which he visited various magnetic institutions, and to the observations secured at Manua, Samoa, during the total solar eclipse on April 28, 1911. On Plate 10 is a full-size reproduction of the photograph obtained of the eclipse, showing the coronal extensions corresponding to a period of minimum sun-spot activity.

The concluding report is concerned with the results of the comparisons of magnetic standards obtained by observers of the Department, during 1905 to 1914, both at magnetic observatories and in the field among themselves. It has been found possible with the aid of the accumulated data to fix on world or "international magnetic standards" designated I.M.S., which apparently yield values of the magnetic elements within an absolute accuracy of about 0.′1 or 0.′2 in declination and inclination, and about 0.01 or 0.02 per cent in the value of the horizontal intensity.

J. A. F.

ZOOLOGY.—*A review of the American moles.* Hartley H. T. Jackson. North American Fauna No. 38, Bureau of Biological Survey, U. S. Department of Agriculture. Pp. 100, plates 6, text figures 27. September 30, 1915.

This paper includes descriptions of the 28 species and subspecies of moles inhabiting America. One subspecies, *Scapanus orarius schefferi* is described as new. Pages 5 to 26 are devoted to introductory matters, in which are discussed among other topics the habits and economic status of moles, characteristics and development of the young, pelages and molts, time of molting, manner of molting, geographic variation, individual variation, sexual variation, age variation, seasonal variation, and history. There are two keys to the genera of American moles; one based upon external characters, the other upon cranial and dental characters.

The American moles include five genera: *Scalopus, Scapanus, Parascalops, Condylura,* and *Neürotrichus.* A detailed description of each genus is given, following which are a key to the species and subspecies of that genus and a systematic discussion of each form. Under each species or subspecies are given the synonymy, type locality, data of type specimen, geographic range, general characters, color, description of skull, measurements, remarks upon the relationships and distribution of the form, and an enumeration of the specimens examined.

The illustrations include maps of the distribution of each form, etchings of external parts showing generic characters, and half-tones of skulls.

H. H. T. J.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 760th meeting was held on October 16, 1915, at the Cosmos Club, President Eichelberger in the chair; 35 persons present.

Mr. E. C. Crittenden presented an illustrated paper giving the results of an investigation in collaboration with Messrs. E. B. Rosa and A. H. Taylor on *Effect of atmospheric pressure on the candlepower of various flames.* In order to calibrate flame standards of candlepower by comparison with electric standards it is necessary to know the effects of various atmospheric conditions on the flames. Humidity and atmospheric pressure are the conditions which cause most variation. The former varies considerably from season to season, and its effect has been determined by observations extending over several years. The natural variations in pressure from time to time at any one place are not great enough to determine their effect with precision, and at any rate extrapolation to other pressures would be unreliable. By using a set of tanks in which air could be supplied at high or at low pressure, the variation of the candlepower of pentane and Hefner lamps over a wide range of barometric pressure has now been determined. The variation is not linear. In general the intensity of a flame increases with increasing pressure, but at a decreasing rate, until the flame becomes smoky, when a further increase in pressure may cause a slight decrease in intensity. Conversely, decrease of pressure in general causes a decrease of candlepower, which is more and more rapid as the flame gets farther from the smoking condition. The pressure presumably affects the rate of diffusion of oxygen through the fuel. When the pressure is increased the diffusion is slower, the process of combustion is retarded, and the time during which the carbon particles exist in the glowing state is increased. Consequently at any one time there are more particles giving out light. On the other hand the average temperature of the particles is lowered, as is shown by the increasing redness of the flame, so that the light emitted by each particle is greatly reduced. Eventually such a condition is reached that the decrease in temperature counterbalances any further increase in number of glowing particles. Besides the data for the standard lamps, curves were shown to indicate the effect of variation in air pressure on the candlepower of gas burned in several types of burners. The effect of humidity on a gas flame, an acetylene flame, and a kerosene standard lamp was also shown. As an application of the data presented, a detailed discussion of the significance of gas candlepower tests, as made at present, was given.

Mr. P. D. Foote then spoke on *The "center of gravity" and "effective wave-length" of transmission of pyrometer color-screens, and the extrapolation of the high temperature scale.* (Published in full in Journ. Wash. Acad. Sci. **5**: 526. 1915.)

The same speaker then presented informally some remarks on *A new relation from Planck's law.* Numerous displacement laws may be derived from the Planck relation representing the spectral distribution of the energy radiated by a black body. A new displacement law was derived which states, that the product of the absolute temperature ϑ and the λ-component of the center of gravity of the spectral energy curve λc is a constant, as follows: $\lambda c = 0.37021 c_2$, where c_2 is the characteristic constant of the Planck equation.

The two communications by Mr. Foote were discussed by Messrs. Swann, C. A. Briggs, Gray, Priest, Crittenden, and Sosman, particularly with reference to details of optical arrangements, the use of absorbing mirrors, and variations between observers.

Mr. E. F. Mueller then presented a paper on *Methods of resistance measurement.* In the design of a Wheatstone bridge, the 0.01, 0.001, and 0.0001 decades were to be provided by varying the shunts on three coils, r_1, r_2, and r_3, permanently connected in the variable arm of the bridge. The problem is to select suitable values for r_1, r_2, r_3, and for the shunting-coils. The values will be completely determined if the condition be imposed that $r_1 + r_2 + r_3 = \rho$ and that the r's be so chosen that the effect of errors in the shunting-coils, due, e.g., to contact resistances in the dial switches, shall be a minimum. There are, however, obvious advantages in choosing the r's so that the shunting-coils for all decades are the same. This requires that $r_1 = r_2 \cdot \sqrt{10} = r_3 \cdot 10$ as may be seen from the formula used: viz., that the change in r, due to a shunt R, is equal to $\frac{r^2}{r+R}$. If r^2 is chosen so as to be divisible by the numbers from 1 to 10, e.g., $r^2 = 0.6048$, simple values for the shunting-coils are obtained.

The paper was discussed by Mr. White with regard to variations in shunts.

J. A. Fleming, *Secretary.*

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GEOLOGY.—*Some littoral and sublittoral physiographic features of the Virgin and northern Leeward Islands and their bearing on the coral reef problem.* Thomas Wayland Vaughan,[1] Geological Survey.

The Virgin Islands rise above a bank extending eastward from Porto Rico from which they are separated by water up to 17 fathoms deep. The St. Martin group, comprising Anguilla, St. Martin, St. Bartholomew, and a number of islets, lie a little south of east from the Virgins across the Anegada Passage, which exceeds 1000 fathoms in depth. St. Croix is due south of the Virgins across a chasm, a great fault valley, which at a distance of 22½ miles south of St. Thomas attains a depth of 2580 fathoms (15,480 feet). Saba is south of St. Martin. The west end of the St. Christopher Chain, to which St. Eustatius, St. Christopher, and Nevis belong, is south of St. Bartholomew; while Antigua and Barbuda are east of the St. Christopher Chain.

The ocean bottom off the shores of the Antilles shows three distinct types of profiles, and a fourth type is furnished by Saba and other banks. The first is that found off the volcanic islands, such as Saba and the members of the St. Christopher Chain, into the sides of which the sea has cut relatively narrow platforms (see fig. 1).[2] There are suggestions of submerged flats off the northwest end of St. Eustatius and southeast of Nevis.

[1] Published by permission of the Director of the U. S. Geological Survey and of the President of the Carnegie Institution of Washington.

[2] The profiles illustrating this paper were draw by Miss Irene Pistorio, who also drew the contours on the hydrographic charts here discussed.

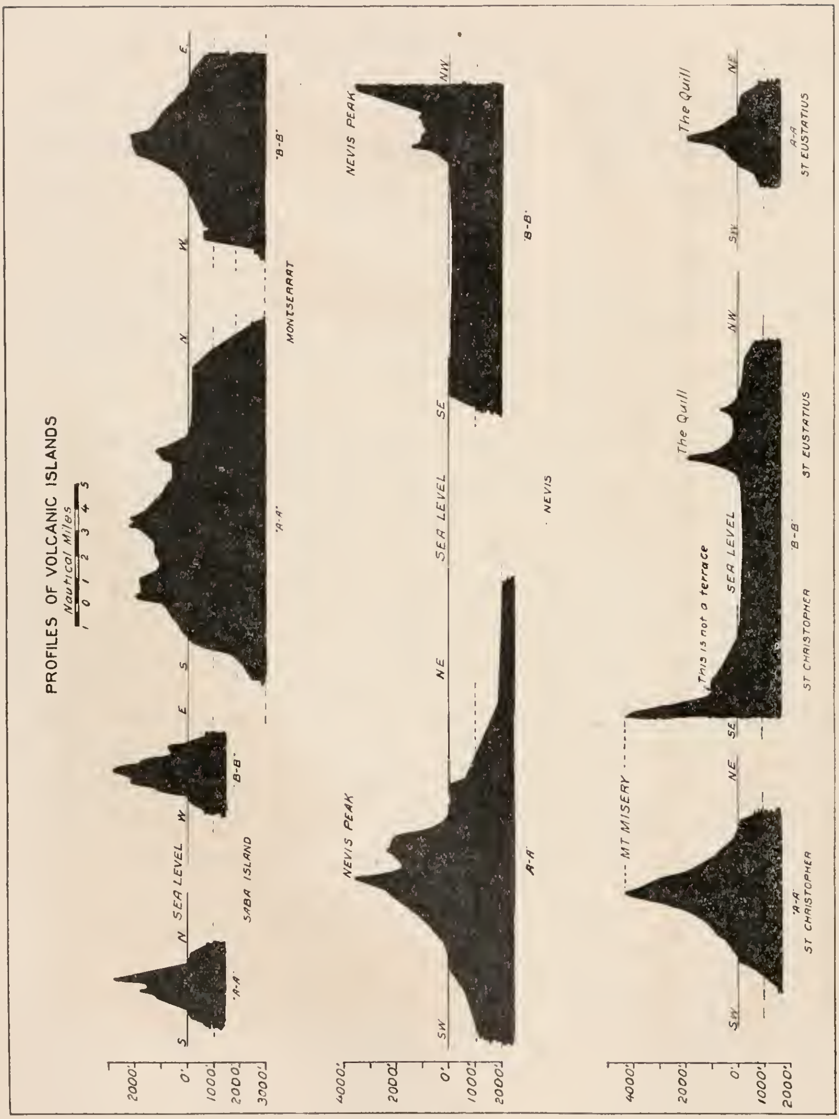


Fig. 1. Profiles of volcanic islands, West Indies. Vertical scale 7 times the horizontal.

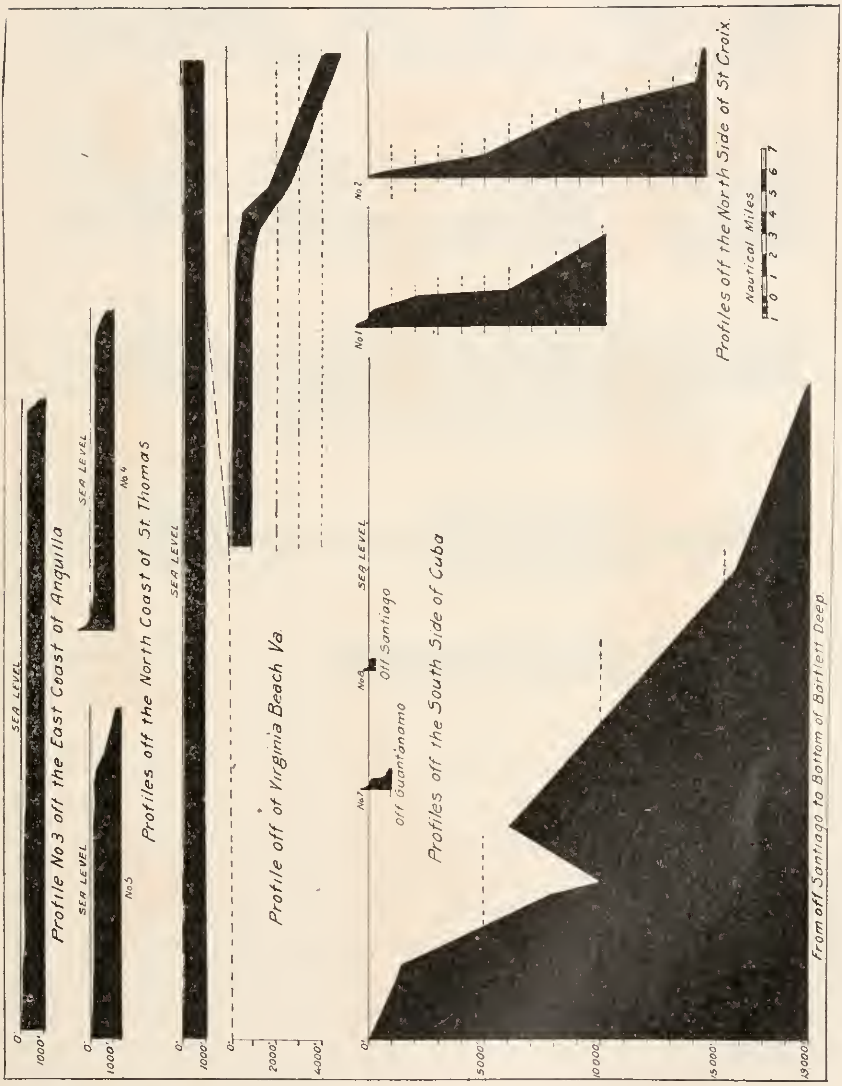


Fig. 2. Profiles off West Indian Islands and Virginia Beach, Va. Vertical scale 7 times the horizontal.

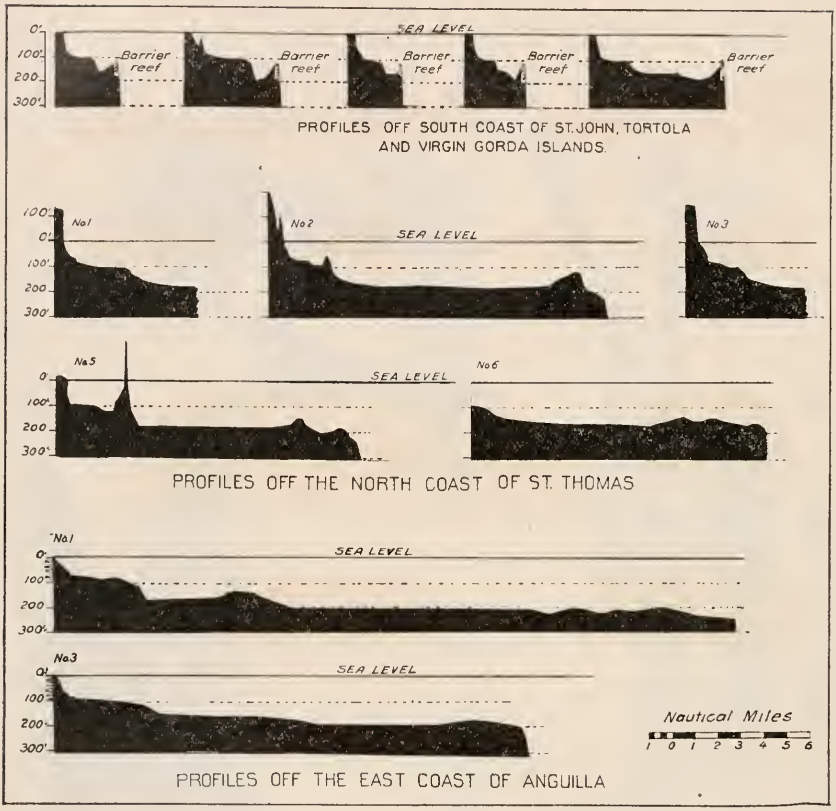


Fig. 3. Profiles off Virgin Islands and Anguilla. Vertical scale 70 times the horizontal.

The second type of submarine profile is well represented off the north shore of St. Croix and the south shore of Cuba (see fig. 2). The precipitous character of these profiles indicates faulting and the geologic structure supports this interpretation. There is a downthrown block between St. Croix and the Virgin Group, and another downthrown block between Cuba and Jamaica.

The third type of profile (see fig. 2), represented by shores off which are extensive shallow flats, occurs where planation agencies have long been active. Here the rocks often, if not usually, dip under the sea at relatively gentle angles.

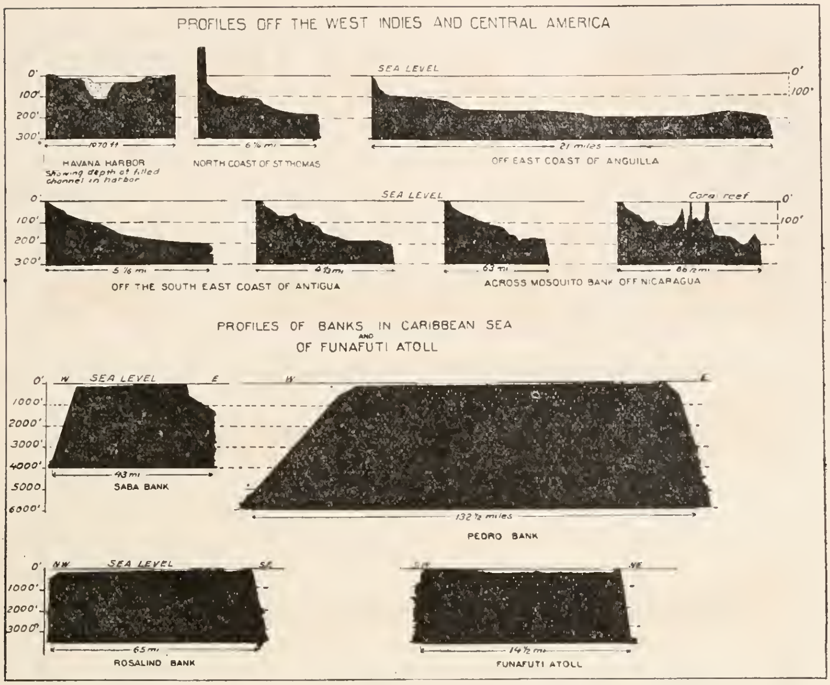


Fig. 4. Profiles off West Indies and Central America, of banks in the Caribbean Sea, and of Funafuti atoll. Vertical scales on sides, horizontal distance stated below profiles.

The fourth type of profile is represented by the extensive submerged banks or platforms which have no bordering lands and whose upper surfaces range in depth from 9 to 30 fathoms (54 to 180 feet). Good examples are Saba Bank, southwest of Saba Island; Pedro Bank, southwest of Jamaica; and Rosalind Bank, off Mosquito Bank, which is the Continental Shelf northeast of Nicaragua and Honduras (see fig. 4). That the depth of water on these banks is essentially the same as in many atolls of the Pacific, especially the Paumotus, has been repeatedly pointed out, but apparently the fact has not yet been sufficiently emphasized. The profile of Funafuti atoll in figure 4 is very similar to the profiles of the West Indian banks, which are many times its dimensions.

The third type of profile (that showing submarine terraces around islands) will now be discussed in some detail. From shore line characters and other evidence the conclusion was reached that the Virgin Islands, the members of the St. Martin Group, and Antigua and Barbuda have recently undergone submergence to an amount of about 20 fathoms.[3] Assuming this conclusion to be correct, should the sea level have remained stationary for a period of appreciable length before this submergence, there should be a submerged scarp or facet indicating its former stand; should there have been a succession of temporary stands there should be a series of submarine terrace flats separated by scarps. The available sources of information were the charts of the U. S. Hydrographic Office and of the British Admiralty. The Virgin Bank and the St. Martin Plateau were selected for special study. The charts of the former, on a scale of slightly more than 1 mile to an inch, and that of the latter, on a scale of about 2½ miles to an inch, were contoured on a 2 fathom interval from the shore to a depth of 40 fathoms, and on an interval of 10 fathoms from 40 to 100 fathoms.

The Virgin Group will be described first. The shore line shows indentations indicative of submergence, and that the sea has stood at its present level long enough for alluvial filling of the heads of harbor digitations, while sea-cliffs occur at the ends of promontories. The chart of the nearby sea-bottom shows that south of St. John, Tortola, and Virgin Gorda there are two distinct submerged terraces and a less definite third terrace (see fig. 3). The outer terrace flat lies at depths between 26 and 28 fathoms on its landward and between 28 and 30 fathoms on its seaward margin, and it ranges in width from ½ mile to 3 miles. On its sea-front is a ridge which is inferred to be a submerged barrier coral reef. On its landward side a scarp rises from a depth of 26 to 28 fathoms to about 17 fathoms. Above this scarp is a second terrace flat, which has a depth of 14 to 15 fathoms on its landward and a depth of 14 to 20 fathoms on its seaward face, and ranges in width from one-third of a mile to 2 miles. Apparently the outer margin of this flat also bears

[3] Bull. Am. Geog. Soc., **46**: 426–429. 1914.

a coral reef. These are the two principal terrace flats. The scarp separating them is indicated by crowded contours, and chart No. 1832, U. S. Hydrographic Office, shows its continuity for 36 nautical miles or about 1½ land miles farther than from Washington to Baltimore. A third, still higher terrace flat is suggested between depths of 6 and 10 fathoms, above which a fourth terrace may now be in process of formation, but the information regarding these is at present not definite enough to warrant a positive statement. The *continuity* of the upper one of the two well-marked flats needs to be emphasized. It should be noted that east of Virgin Gorda there has been an uptilt.

On the windward (northern) side of St. Thomas, there is an extensive outer flat, bounded on its landward side by a steep escarpment which in places is nearly 160 feet high (see fig. 3). The landward margin of the plain is between 26 and 28 fathoms in depth; the seaward margin has a depth between 30 and 34 fathoms; the width is as great as 10 miles and for distances as great as 8½ miles, in depths between 29 and 31 fathoms, the range in relief of the surface may be as small as 2 fathoms. Its outer margin is cut by reentrants which have bottoms about 40 fathoms deep and simulate hanging valleys. There are also near the outer margin of this flat, banks or ridges the upper surfaces of which are relatively flat, between 17 and 20 fathoms in depth. One of these banks has a total basal width of about 4 miles and a length of more than 5 miles. As its form is not that of a coral reef, it can only be the base of what was an island, which had been reduced almost to a smooth surface by marine planation and then, as indicated by other evidence, submerged. As all the other shoals with one exception are truncated at nearly the same level it seems that most of them should be ascribed to a similar origin. These shoals usually show escarpments between 20 and 30 fathoms on their windward sides and more gradual slopes on the leeward sides. The outer flat on the north side of St. Thomas corresponds to the lower flat on the south side of St. John, Tortola, and Virgin Gorda. Both are submarine plains, which several lines of evidence show were developed when sea-level was about 20 fathoms or slightly more, lower than now. The escarpment extending from the islands north of Culebra Island, east of Porto Rico, across the Virgin Passage, and along the north side of St. Thomas, and the escarpment on the face of the outlying shoals apparently can be explained in no other way.

The indentations on the outer margin of the outer flat may have been caused by emergence and stream cutting after its formation, or they may be due to initial marginal irregularities which have not been obliterated.

The approximate accordance in level of the tops of the outlying shoals at depths between 17 and 20 fathoms has been mentioned. These summits accord in height with a flat or gently sloping zone, which lies above and nearer shore than the deeper flat and represents the 14 to 20 fathom flat south of St. John and Tortola. It is scarcely represented on the seaward side of the promontories, viz.: Cockroach and Cricket rocks, and Outer Brass and Little Hans Lollick islands. However, it spreads out on the flanks of the promontories and ranges from half a mile to nearly $1\frac{1}{2}$ miles in width; it is separated on its seaward side by a steep slope or escarpment from the deeper flat and on its landward side by a less distinct escarpment, in places about 26 feet in height, from a less developed flat which has a depth of 7 to 10 fathoms. The descent is sudden from the shore to about 6 fathoms which is near the landward margin of the highest submarine flat. This flat, also, is narrow on the tips of the promontories mentioned, but widens on their flanks and along the shores of the main island. The submerged valley in Charlotte Amalia Harbor has a depth of 10 fathoms.

The narrowness or absence of the 14 to 20 fathoms flat on the promontory tips, while it is so well preserved in protected places, especially off the south sides of St. John and Tortola, shows that it is older than the deeper flat and in exposed places was cut away during the formation of the latter, subsequent to the formation of which, after perhaps a brief interval of still lower stand of sea-level, the entire area has been re-submerged, to an amount about the same as that of the initial submergence.

There is doubt as to the interpretation of the 7 to 10 or 12 fathoms flat. In places it seems to be distinct and older than the one next lower, but it may represent the submarine terrace being formed at present sea-level.

According to the physiography of the sea-bottom, the Virgin Islands were joined to Porto Rico during the cutting of the scarp separating the deepest from the next higher flat. The biogeographic evidence shows conclusively that the two were united and have been severed in Recent time by submergence. Stejneger says in his Herpetology of Porto Rico: "It is then plain that the 16 species of reptiles and betrachians found in St. Thomas and St. John form only a herpetological appendix to Porto Rico." Doctor Bartsch informs me that the testimony of the land Mollusca is the same as that of the reptiles and batrachians. The biogeographic evidence substantiates the deductions based on the purely physiographic study.

There are three tiers of coral reefs in the Virgin Islands. They rise above (a) basements 10 fathoms or less in depth; (b) above the outer edge of the 14 to 20 fathoms flat; (c) above the outer edge of the 28 to 34 fathoms flat. As the escarpment within the outermost reef could not have been cut during the presence of such a reef, the flat must be older than the reef and the reef must have developed during subsequent submergence. The flat therefore cannot be due to the growth of the reef.

The members of the St. Martin Group have indented shorelines, seacliffs, and an unusually fine development of bay bars. The relations on the windward side of the St. Martin plateau are similar to those north of St. Thomas (see fig. 3). The outer, deeper flat, from 26 to 36 fathoms in depth, has a maximum length east and west of over 30 miles. It seems composed of two terraces. The scarp on its landward side is distinct and in places is about 50 feet high, in depths between 20 and 28 fathoms, as off the east end of Scrub Island, east of Anguilla Island.

As some of the submerged valleys on the east side of the St. Martin plateau resemble valleys in the Upper Cretaceous Anacacho limestone of Texas, it appears that not only must the scarp line which has been pointed out be interpreted as a former shore-line but these channels with steep heads must be interpreted as former drainage lines which were subaerially cut and afterwards submerged. The Anacacho limestone in the Brackett quadrangle (of the U. S. Geological Survey) is similar in general character to the limestone which composes Anguilla and Tintamarre.

While the shore-line stood some 20 fathoms lower than now, most of the St. Martin plateau must have been above sea-level. The biologic evidence is in accord with this interpretation, but at present it alone is not sufficient to be decisive.

Antigua is another island with an indented shore-line. It shows typical instances of submerged valleys, and fairly good examples of pouch-shaped harbors. Profiles off the southeast shore are shown in figure 4. These exhibit essentially the same features as the profiles on the Virgin Bank and the St. Martin plateau. If sea-level stood 20 fathoms below its present stand, Antigua and Barbuda would be united. Dr. Bartsch has especially studied the land Mollusca and says: "The land shells show that these islands must have been connected in very recent time."

The deduction that there has been in Recent geologic time submergence to an amount of about 20 fathoms in the Virgin Islands, on the St. Martin plateau, and on the Antigua-Barbuda bank, it seems to me, may be accounted demonstrated.

The upper part of figure 4 shows a set of profiles, all on the same vertical scale. They represent profiles (a) across Havana Harbor, showing depth of filled channel; (b) off the north side of St. Thomas; (c) off the west side of Anguilla; (d) off the southeast coast of Antigua; (e) Mosquito Bank, off Nicaragua. All these profiles indicate a rise of sea-level by an amount of about 20 fathoms. There is in the Virgin Islands and in Cuba clear evidence of a lowering of sea-level by about 20 fathoms, perhaps more, previous to resubmergence. Although the evidence for the other areas is not definite as to the return of sea-level to a former stand, the similarity of the profiles suggests that it also occurred in them. What caused this lowering and subsequent rise of sea-level? As it affects a large area, it appears too widespread to be explained by local crustal movement. The changes in position of strand line here noted are more reasonably explained by a lowering of sea-level due to the withdrawal of water in the Pleistocene ice epochs to form the great Continental glaciers and the raising of sea-level after each epoch through the melting of the glaciers, but the volume of evidence supplied by this area is perhaps not large enough to justify a general conclusion as to the relations of Recent coral reef development to glaciation and deglaciation.

Figure 5 is a map of Florida showing the superposition of upper Oligocene reef corals and coral reefs on the Ocala limestone, which has been traced under and beyond the reefs by means of natural exposures and numerous well borings. The general geologic history of the Floridian plateau has been especially considered by Vaughan[4] and by Matson and Sanford.[5] A paper by Vaughan and Shaw in which the oscillations of the Florida reef tract are discussed is also cited.[6]

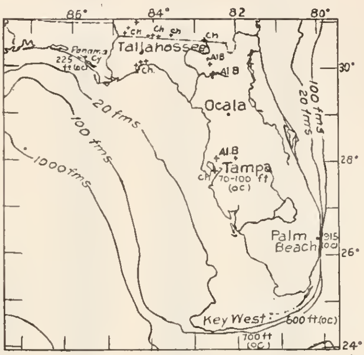


Fig. 5. Map of Florida showing depth in feet below sea-level to upper surface of the Ocala limestone and the location of the superposed upper Oligocene coral reefs and reef corals. Oc = Ocala limestone; Al. B. = fossil reef corals or coral reefs in the Alum Bluff formation; Ch = fossil reef corals or coral reefs in the Chattahoochee and Tampa formations.

A brief comparison will now be made with the Great Barrier Reef of Australia. Figure 6 presents profiles, all on the same horizontal and vertical scales, the latter about seventy times the former. The uppermost profile, along a line running due east from Virginia Beach, Virginia, is introduced for comparison with those of the Continental Shelf and the Great Barrier Reef off the eastern Queensland coast. The Australian profiles are based on the

[4] *A contribution to the geologic history of the Floridian plateau.* Carnegie Inst. of Washington, Pub. 133, pp. 99–185, 15 pls. 1910.

[5] *Geology and ground waters of Florida.* U.S. Geol. Surv., Water-supply Paper 319. Pp. 445, 17 pls. 1913.

[6] Carnegie Inst. of Washington, Year Book No. 14, pp. 232–238. 1916.

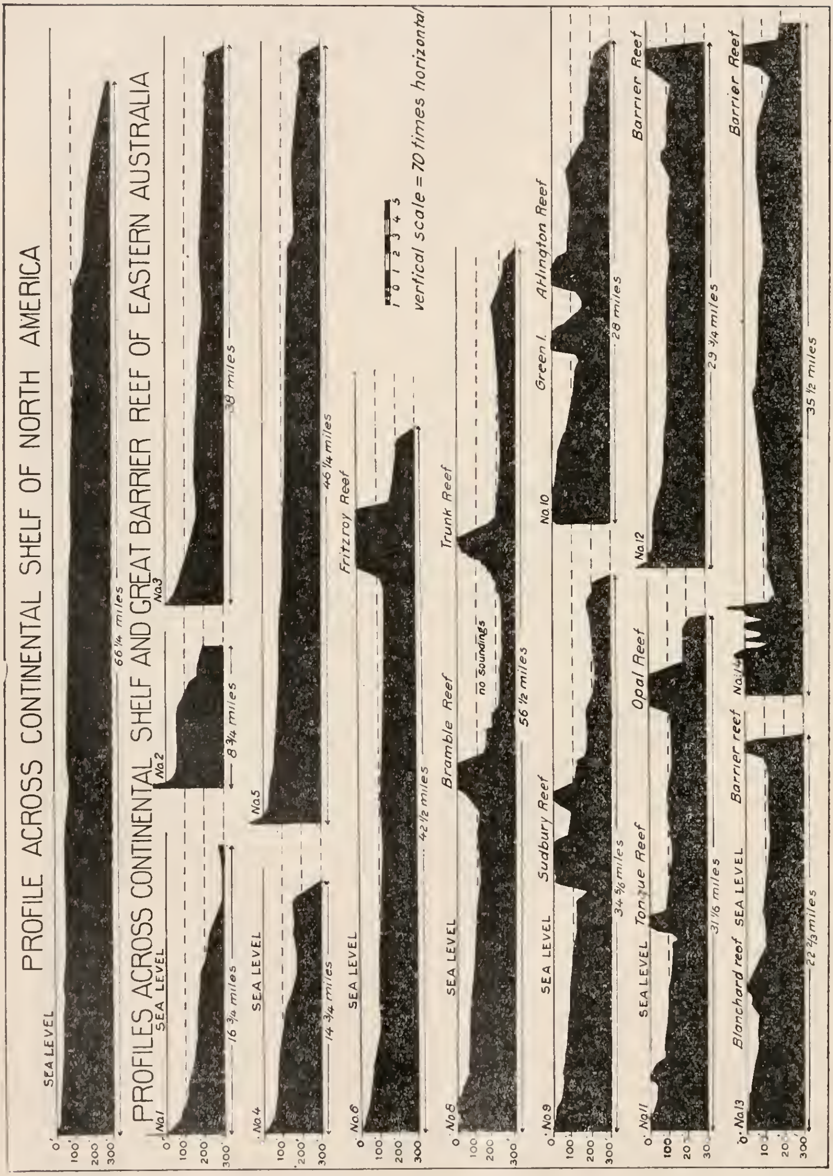


Fig. 6. Profiles off Virginia Beach, Va., and across Continental Shelf off Queensland, Australia. Vertical scale 70 times the horizontal.

British Admiralty charts. The latitude at the intersection of each profile with the shore-line is followed by a statement of the direction of the profile from the shore.

South of the southern end of the Great Barrier Reef.

1. From Burleigh, S. Lat. 28° 4′ 30″, North 73° East.
2. From North Point, S. Lat. 27° 1′ 45″, North 3° East.
3. From Shore east of Leading Hill, S. Lat. 25° 26′ 15″, South 82° East.
4. From base of Sandy Cape, S. Lat. 24° 53′ 40″, North 68° East.

Southern end of the Great Barrier Reef.

5. From Toowong Hill, S. Lat. 24° 22′ 4″, North 45° East, passing between Lady Elliot and Lady Musgrove islands.

Across the Great Barrier Reef.

6. From Rodd Peninsula, S. Lat. 24° 0′ 0″, North 50° East.
8. From Georges Point, Hinchinbrook Island, S. Lat. 18° 25′ 40″, North 72° 30′ East.
9. From Malbon Thompson Range, S. Lat. 17° 7′ 15″, North 68° 30′ East.
10. From Yarrabah Mission, S. Lat. 16° 54′ 30″, North 37° East.
11. From mouth of Daintree River, S. Lat. 16° 18′ 25″, North 78° 30′ East.
12. From half way between Cape Flattery and Lookout Point, S. Lat. 14° 56′ 10″, North 46° East.
13. From Cape Sidmouth, S. Lat. 13° 25′ 45″, North 85° East.
14. From Cape Grenville, S. Lat. 11° 58′ 25″, North 85° East.

These profiles show the continuity of the platform from the area south of the Great Barrier, and that there is an outer, deeper flat about 200 feet deep. As except near its north end the reef stands back from the seaward edge of the Continental Shelf, apparently the idea that the platform was formed by infilling behind the reef may be permanently set aside. The similarity of the conditions here presented to those off Nicaragua and in the West Indies is obvious. The evidence in favor of a shore line between about 25 and 30 fathoms below present sea-level antecedent to Recent submergence is strong, if not conclusive, and supports the deduction that the living barrier reef is growing on what was a land surface in Pleistocene time, an interpretation essentially that proposed by E. C. Andrews in 1902.

The relations around the Pacific Islands off which barrier reefs occur are those of continuous platforms surmounted or margined by discontinuous reefs. These relations indicate the superposition of reefs on antecedent platforms which have undergone geologically Recent submergence. E. C. Andrews so interprets the conditions of formation of the barrier reefs off the Fiji Islands.[7] It appears to me that the conditions governing the development of the living reefs in the West Indies, Central America, Brazil, Florida and Australia are clear. The reefs have grown upon antecedent basements during Recent submergence. The history of these basements is complex, but during Pleistocene time they stood higher with reference to sea-level than now, their outer margins were remodeled by marine cutting and marine planation, and they were then resubmerged. These changes in height of sea-level accord with the demand of the glacier control theory. It would be remarkable if the conditions in the tropical western Pacific Ocean were exceptional, and the present available facts indicate that they conform to the principles governing reef development in the other areas. Here it should be said regarding the charts for the Pacific, that as they have been made primarily for navigation purposes the depths of lagoons and lagoon channels are often given in a way fairly satisfactory, but on only a few charts can the submarine profiles outside the reefs be determined. The coral reef problem cannot be regarded as satisfactorily solved until the relations in the Pacific islands have been ascertained. In my opinion but little further advance in understanding the problem can be expected from purely biologic studies or from physiographic investigations of the dry land surface alone. As apparently the greatest present need is for more accurate information on the detailed submarine relief in depths between 15 and 50 fathoms, especially on the seaward margins of the platforms, both outside the reefs and off the breaks in the reef lines, the efforts of those interested in such investigations should be concentrated on getting additional hydrographic surveys in coral reef areas.

[7] Am. Jour. Sci. 41: 135–141. 1916.

MINERALOGY.—*Intumescent kaolinite.* W. T. SCHALLER and R. K. BAILEY, Geological Survey.[1]

A sample of kaolinite from eastern Oklahoma was sent in to the Geological Survey for identification by Dr. C. N. Gould of Oklahoma City. According to Dr. Gould, the mineral was received by him from Mr. Tom Wall of Poteau, Oklahoma, who stated that it forms vertical white streaks, one of which appears to be about 20 inches thick, on Back Bone Mountain, about two miles north of Williams, Le Flore County, Oklahoma. The deposit lies near the boundary of sections 2 and 3, T. 8 N., R. 26 E., Le Flore County. The mineral formed small compact lumps with a glistening or fine satiny appearance. Examined microscopically, the material was seen to be pure, homogeneous, and well crystallized in minute hexagonal plates and crystals which had all the appearance of kaolinite. The crystals average about the following dimensions: c axis = 0.02 mm., b axis = 0.04 mm., a axis = 0.06 mm. In testing the fusibility of the mineral it was found to intumesce strongly and as no reference to any intumescent kaolinite was found in the literature the material was examined further for definite identification. It was found to differ from kaolinite only in its intumescence.

The crystals are too small and the birefringence too low for reliable results as to extinction angles and interference figures. The refractive indices were readily determined and are as follows:

$$\alpha \text{ (approx. parallel to } c \text{ axis)} = 1.561$$
$$\beta \text{ (approx. parallel to } a \text{ axis)} = 1.563$$
$$\gamma \text{ (parallel to } b \text{ axis)} = 1.567$$
$$\text{Birefringence } (\gamma - \alpha) = 0.006$$

These values are close to those given for kaolinite. Kaiser[2] gives the refractive index as between 1.551 and 1.559, with a birefringence of 0.005–0.006. His values for the refractive indices are slightly lower than those here given. A possible ex-

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] Kaiser, Erich, Über Verwitterungserscheinungen an Bausteinen I. Neues Jahrb. f. Min. Geol. Pal., **1907**: Band 2, 42–64.

planation is that the liquids used were not checked for their indices. It is very essential to redetermine frequently the index of these liquids. It was found, for instance, that our liquids had increased 0.003 from the value determined a year ago. Dick[3] gives the mean index as 1.563 with a birefringence of 0.006. Further Dick gives $(\gamma - \beta) = 0.004$ (on basal plane) and $(\beta - \alpha) = 0.002$, values identical with those found on the material from Oklahoma. The value 1.54, given in some books as the mean index of kaolinite is doubtless too low.

The mineral after intumescence, examined microscopically, is opaque and nearly all of it has lost its perfect crystal outline. Most of the pieces have a form which suggests that during the heating (and intumescence?) the escape of the water took place in such a way as to practically disrupt the crystal structure of the mineral.

The chemical analysis, by R. K. Bailey, gave the results shown under (1), and for comparison under (2) is given an analysis of kaolinite from Saitzewo near Nikitowka (Donez-Becken) by Samojloff,[4] and under (3) the theoretical composition.

	(1)	(2)	(3)
SiO_2	46.55	46.51	46.50
Al_2O_3	38.90	39.45	39.56
H_2O[a]	14.04[b]	14.10	13.94
	99.49	100.06	100.00

[a] Loss on ignition.
[b] Average of the two determinations, 13.97 and 14.10.

A comparison of the figures given above shows the chemical identity of the mineral from Oklahoma with kaolinite. The water in it apparently behaves normally, for it was found that the total loss on heating the mineral to 330° was insignificant, the total loss of water being 0.09 per cent at 145°, 0.11 per cent at 220°, and 0.12 per cent at 330°.

[3] Dick, A. B., Supplementary notes on the mineral Kaolinite. Mineral Mag. **15**: 124–127. 1908.

[4] Samojloff, J., Über das Wasser des Kaolinits. Bull. Acad. St. Petersburg, **3**: 1137–1152. 1909.

BOTANY.—*Tidestromia, a new generic name.* PAUL C. STANDLEY, U. S. National Museum.[1]

The three species of Amaranthaceae, tribe Gomphreneae, generally known under the name Cladothrix form a very natural and well defined genus. All are natives of the more arid regions of the western and southwestern United States and northern Mexico, two of them being rather local in their distribution, the third, however, ranging from Kansas and Utah to Texas and to Zacatecas and Sinaloa in Mexico. All three are much alike in general appearance, but they differ constantly among themselves in details of floral structure. The genus is distinguished from all the other genera of the Gomphreneae by having the flowers merely glomerate rather than regularly capitate or spicate. Moreover, the leaves subtending the inflorescence become indurate and more or less connate in age, so as to form a sort of involucre.

The oldest and best known species was published by Nuttall in 1820 as *Achyranthes lanuginosa.* In 1849 it was transferred by Moquin to *Alternanthera.* Watson in 1880 established the genus *Cladothrix,* including not only this species but another described by Torrey in 1859 as *Alternanthera suffruticosa.* The first appearance of the generic name *Cladothrix* in literature is in 1849, when Moquin cites a manuscript or herbarium name of Nuttall, *Cladothrix lanuginosa,* as a synonym of his own *Alternanthera lanuginosa.* The mere citation of the generic name in synonymy would not, of course, give it any standing under either of the codes of nomenclature now followed by most botanists and *Cladothrix* when used in this connection must, consequently, date from 1880. Unfortunately for the maintainance of this name in the Amaranthaceae a genus *Cladothrix* of the Schizomycetes had been proposed by Cohn in 1875. Cohn's genus is properly published and is generally accepted by mycologists. It is evident, therefore, that the name *Cladothrix* can not be maintained in the Amaranthaceae and that another must be subst tuted for it. Since none is available, the writer proposes the

[1] Published by permission of the Secretary of the Smithsonian Institution.

name *Tidestromia*, given in honor of Mr. Ivar Tidestrom, an indefatigable student of the plants of the United States, who has given many years to systematic herbarium and field studies of the plants of many parts of our country, especially of Maryland and Virginia, California, Arizona, and Utah.

TIDESTROMIA Standley, nom. nov.
Cladothrix Nutt.; Moq. in DC. Prodr. **13**^{2}: 359. 1849, as synonym; S. Wats. Bot. Calif. **2**: 43. 1880.

Tidestromia lanuginosa (Nutt.) Standley.
Achyranthes lanuginosa Nutt. Trans. Amer. Phil. Soc. n. ser. **5**: 166. 1820.
Alternanthera lanuginosa Moq. in DC. Prodr. **13**^{2}: 359. 1849.
Cladothrix lanuginosa Nutt.; Moq. in DC. Prodr. **13**^{2}: 360. 1849, as synonym; S. Wats. Bot. Calif. **2**: 43. 1880.

Western Kansas to southeastern Utah, south to Arizona, western Texas, and Zacatecas and Sinaloa, Mexico.

Tidestromia oblongifolia (S. Wats.) Standley.
Cladothrix oblongifolia S. Wats. Proc. Amer. Acad. **17**: 376. 1882.
Cladothrix cryptantha S. Wats. Proc. Amer. Acad. **26**: 125. 1891.

Southeastern California to western Nevada and Arizona.

Tidestromia suffruticosa (Torr.) Standley.
Alternanthera suffruticosa Torr. U. S. & Mex. Bound. Bot. 181. 1859.
Cladothrix suffruticosa S. Wats. Bot. Calif. **2**: 43. 1880.

Western Texas and southern New Mexico to Coahuila, Mexico.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1913 and 1914.* Daniel L. Hazard. U. S. Coast and Geodetic Survey Serial Publication No. 19. 1915.

This publication is in continuation of the series giving the results obtained at the Cheltenham magnetic observatory since its establishment in 1901. It contains a summary of the monthly determinations of the scale-values of the horizontal intensity and vertical intensity variometers; the base-line values derived from the weekly absolute observations; diurnal variation tables for the magnetic elements D, H, and I, the total force F, and the rectangular components X, Y, Z; hourly values of D, H, and Z, together with daily and hourly means for each month; a tabulation of the earthquakes recorded on the seismograph; a list of the magnetic disturbances of considerable magnitude and reproductions of the magnetograms showing the more marked disturbances. Attention is called to the fact that beginning with 1913 intensity results obtained by this Bureau have been reduced to the international standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Published results for earlier years must be diminished by one part in a thousand to reduce them to that standard.

D. L. H.

GEOLOGY.—*A peculiar oölite from Bethlehem, Pennsylvania.* Edgar T. Wherry. Proceedings of the U. S. National Museum, **49**: 153–156, pl. 40–41. Aug. 13, 1915.

The material described occurs in a quarry in magnesian limestone. In one layer the oöids are divided parallel to the bedding into a light and dark portion, the latter being the lower. Analyses of the rock of this bed and of oöids which have weathered out are given. By calculating the mineral compositions from these, and also the composition of the matrix, assuming that the oöids make up half the rock, it is shown that the oöids are notably higher in dolomite, quartz, kaolin, limonite, and carbon, and lower in calcite and siderite than the matrix. This oölite has probably formed by solution of original aragonite, causing the insoluble carbon and nuclei to fall to the bottom of the cavities; secondary dolomite subsequently filled the latter; and still later the carbon precipitated some pyrite, which has altered to limonite. Figures are given to bring out the various stages of the process.

E. T. W.

GEOLOGY.—*An ancient volcanic eruption in the upper Yukon Basin, Alaska.* STEPHEN R. CAPPS. U. S. Geological Survey Prof. Paper 95-D, pp. 59–64, with text figure and illustrations. 1915.

In the upper Yukon Basin there is a persistent and widespread layer of volcanic ash, commonly overlain by a few inches or a foot or two of soil, silt, or vegetable humus, but in places appearing in great drifts or dunes devoid of vegetation. In general the ash follows closely the present topography, and, although locally overlain by recent stream deposits, is much younger than the glacial materials deposited during the last great period of glaciation. In thickness, the ash ranges from a thin film, at the borders of the area within which it is known, to several hundred feet near the point from which it is thought to have been ejected. It covers a known area of about 140,000 square miles and the estimated volume of the ash is about 10 cubic miles. Microscopic study shows the ash to be an andesitic pumice.

On White River a stream bluff shows the ash to be covered by 7 feet of peat. An estimate of the rate of accumulation of the peat there, gives a figure of approximately 200 years to the foot of peat. On that basis the volcanic eruption that caused the ejection of the ash took place some 1400 years ago.

S. R. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 761st meeting was held on October 30, 1915, at the Cosmos Club. President Eichelberger in the chair, 33 persons present.

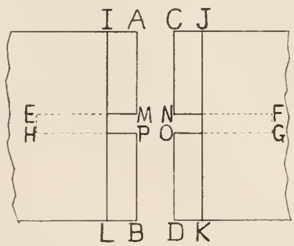
Regular Program

Mr. F. E. Fowle presented a paper on *The transparency of air and water vapor.* Radiant energy ($e_{o\lambda}$) coming through the air from a heavenly body suffers five losses: 1, non-selective, as to wave-length, in the permanent gases of the air; 2, non-selective associated with water vapor; 3, selective in the permanent gases; 4, selective in the water vapor; 5, losses due to the dust. The losses (1) have been shown to be due to the scattering by the molecules of the air and may be computed accurately from the number of molecules in the path; it is expressed by coefficients, $a_{a\lambda}$ (Astrophysical Journal, **40**: 435. 1914; **38**: 392. 1913). The losses (2) are greater than would be expected from the number of molecules of water vapor and are treated in the same paper; they are expressed by coefficients, $a_{w\lambda}$; coefficients for (1) and (2) vary slowly with the wave-length. The losses (3) and (4) are treated in detail in the present communication. The first are practically only in bands of limited wave-lengths and are expressed empirically as a function of the length of path, m, through the air. The losses (4) are similar to (3) but are expressed as a function of the amount of water vapor, w, in the path. The losses (5) due to dust vary at sea level from day to day but are nearly invariable with the wave-length in the region considered here. At Washington they may vary on good days from 3 to 11 per cent or more; above an altitude of about 1000 meters they are generally negligible. The resultant energy may be expressed by $e = e_{o\lambda} \left(a_{a\lambda} a_{aw}^{w}\right)^{m}$. Tables were given showing the losses from the incomng solar energy in calories and per cents due to scattering and absorption for sea level and other altitudes, various amounts of water vapor and zenith distances of the sun; also percentage absorptions due to water vapor at various wave-lengths and formulae for computing the various losses for particular cases.

Discussion: Mr. C. A. Briggs cited a practical application of absorbing power of water vapor by the use of a steam curtain before doors of steel-heating furnaces. Messrs. Swann, Wells, and Bauer asked regarding presence of dust and possible effects at higher altitudes. Mr.

Humphreys referred to the assumption of three regions of dustiness which offers the easier explanation of sky polarization measurements, viz: (1) lower atmosphere hardly reaching the altitude of Mt. Wilson and a region of large dust particles; (2) region of smaller dust particles extending from (1) to an altitude of about two miles, about the height of the ordinary convection clouds, and (3) thence to highest limit of convectional atmosphere and under surface of isothermal region and beyond, ordinarily very free of dust; region (1) would be most effective in scattering. Mr. Fowle noted that the losses at altitudes above 1000 meters were practically nothing, probably $\frac{1}{2}$ per cent. Messrs. C. A. Briggs and Priest referred to certain anomalous halo phenomena which Mr. Humphreys explained as well-known cases discussed in works on meteorological optics.

Mr. I. G. Priest then spoke on *A simple spectral colorimeter of the monochromatic type.* The possibility of so-called "monochromatic color analysis" is due to the experimentally observed fact that any color sensation (except purples) can be "matched" by the sensation caused by a suitable mixture of some one monochromatic light with white light. From a philosophical point of view, this is the most natural and the simplest method of defining a color, but the experimental difficulties and uncertainties of putting it into practice have been considerable. The chief trouble has been due to the necessity of making a photometric comparison between colored light and white light in each color determination. The purpose of the present device is to eliminate this difficulty. The novel and essential feature of the instrument is the system of slits shown in the diagram.



A B C D is a bilateral slit the width of which can be adjusted and measured by a micrometer screw. *E F G H* is a slit cut in the jaws of slit *A B C D* and perpendicular to it. (Actually, the jaws of slit *A B C D* consist of four wings, adjustable on two plates so that the width of the slit *E F G H* can be adjusted by sliding.) *I J K L* is a bilateral slit similar to *A B C D* with its jaws sliding on the jaws of the latter and placed so that their center-lines are coincident. This slit system is mounted in the focal plane of the collimator of a spectroscope so that the slit *E F G H* has the ordinary position of a spectroscope slit; and provision is made for moving the whole system in its own plane, in the direction *A B* in such a way that the displacement can be measured. The whole slit system is illuminated by a uniform white diffusing surface. A slit parallel to the direction *E F* is placed in the focal plane of the observing telescope of the spectroscope; and observations are made with the eye at this slit. "Dominant hue" is varied by displacement of the slit system in the direction *A B* and is determined by the position of the slit *E F G H*. "Purity" is varied by varying the relative widths of the slits *A B C D* and *I J K L* and is computed from these slit widths, the ocular slit width, the width of $EFGH$, the "visibility" function, and the dispersion. Comparison with a sample is made by means of a Lummer-Brodhun cube before the objective of the observing telescope. Relative "brightness" is determined by relative slit widths. Scale values of slit width AC can be changed by means of neutral absorbing films covering $ACNM$ and $BPOD$ and not covering $EFGH$. This instrument was planned in April, 1915. The new slit system has been constructed, mounted, and tried qualitatively with improvised accessory apparatus. A complete instrument adapted to precise work is now to be designed and constructed, after which quantitative tests of its functioning will be undertaken.

INFORMAL COMMUNICATIONS

Mr. I. G. Priest exhibited a newly-designed slide-rule for the rapid computation of the ratio $\tan\vartheta/\tan\lambda$ where the angles have values between 6° and 84°; this slide-rule is particularly useful for laboratory reductions of observations with Marten's photometer and the Koenig-Marten spectrophotometer. Mr. Priest also exhibited a graphical device designed to evaluate equations of the form $y = x^n$ for values of x and y between 0.01 and unity and for values of n between about 0.1 and 10; this device is especially useful and permits rapid computation of transmission for a given thickness when the transmission for some experimental thickness of material is known.

Mr. J. A. Fleming exhibited a combined magnetometer and earth inductor with a portable galvanometer of the Kelvin type for field use designed and constructed by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and spoke of some severe field trials showing the availability of this instrument for such use. The high degree of accuracy attainable was indicated by a résumé of recent observatory intercomparisons of magnetic standards using an instrument of this type at Eskdalemuir in Scotland, Kew, Greenwich, and Stonyhurst in England, Cheltenham, Maryland, and Honolulu, Hawaii; these results indicate a readily attainable absolute accuracy of 0′.2 to 0′.3 in declination and inclination and about one five-thousandth part or less in horizontal intensity. The work reported on is the first practical successful application to field use of the earth inductor. Mr. Bauer, discussing this communication, referred to the great improvement effected in magnetic instruments since his comparisons of observatory standards in 1899, and to the work of Schering at Darmstadt about 1899 with an earth inductor and galvanometer of moving-coil type which was used with great inconvenience at field stations but could not be considered practically applicable for field work.

Mr. F. E. Wright stated that in his work with microscopes he had found that the better position of the plane of vibration of the polarizer is parallel to the vertical cross-hair of the eyepiece when observations are made in the early morning or late afternoon and parallel to the horizontal cross-wire at noon. (Journ. Wash. Acad. Sci. **5**: 641. 1915.)

Mr. H. L. Curtis reported on a method to measure the thickness of a moisture film which forms on a metallic plate by determining the increase of capacity caused by the deposit between two metallic plates.

Mr. W. J. Humphreys spoke on the cause and results of a terrific explosion outside of a 250-gallon tank of "casing-head" gasoline, an especially volatile gasoline, in south Oklahoma, due to volatilization of the gasoline because of exposure to the heat of the sun and carelessness in opening the screwcap over the dome of the tank instead of applying some cooling agent, as water, to reduce the vapor tension inside the tank. Some curious effects on nearby structures, due to the explosion, were detailed.

The 762nd meeting was held November 13, 1915, at the Cosmos Club; President Eichelberger in the chair; 52 persons present.

Regular Program

Mr. D. L. Hazard presented a communication on *The magnetic work of the U. S. Coast and Geodetic Survey.* The growth of the work to meet the needs of the navigator and surveyor was traced from the reorganization of the Coast Survey in 1843 to the present day, and showed the progress made in the systematic magnetic survey of the United States, begun in 1899. Since that date an average of about 250 new stations and 75 repeat stations have been occupied annually. The first stage of the survey, the establishment of a network of stations 25 or 30 miles apart, is nearly completed as far as the accessible portion of the country is concerned, and the investigation of areas of local disturbance is in progress. The work on land has been supplemented by observations at sea on the vessels of the survey. The observations at repeat stations have supplied the data needed to determine the change of the earth's magnetism with time. Magnetic observatories have been in continuous operation at Cheltenham, Md., since 1901; Honolulu and Sitka since 1902; Vieques, P. R., since 1903; Baldwin, Kansas, from 1900 to 1909, and Tucson, Arizona, since 1909. The results are published as promptly as possible in suitable form to meet the varying demands. The success of the work is due largely to Charles A. Schott, for 50 years chief of the Computing Division, and to Dr. L. A. Bauer, inspector of magnetic work from 1899 to 1906.

Discussion: Mr. W. Bowie stated that this work was an excellent example of applied science or engineering and praised the comprehensive and systematic scheme followed which supplies both theoretical and practical needs; the prompt publication of results is an admirable feature.

Mr. R. L. Sanford then gave an illustrated paper on *Uniformity of magnetic test bars.* This paper dealt with the examination of test bars for magnetic uniformity, the nature of non-uniformities that commonly exist in such bars and their effect on the accuracy of magnetic measurements. All precision methods for magnetic measurement on straight bars assume uniformity along the length of the specimen. If this assumption is not met, errors are introduced which are impossible to calculate and may be of considerable magnitude. It is therefore important that bars, which are to be used as standards for comparison of different methods, or whose properties it is desired to measure with high accuracy, should be examined for uniformity. A method was described which clearly indicates the position, nature, and magnitude of non-uniformities which exist in a test bar. Curves were given showing the effects of non-uniformities on the accuracy of magnetic measurements. Such results naturally lead to a consideration of the possibility of examining ferrous material for soundness and the detection of flaws. Curves were given showing some of the possibilities in this direction.

Mr. J. H. Dellinger then spoke on *Rationalization of the magnetic units*. There are two distinct sets of magnetic units in common use. The first set consists of the *c g s* units, which are consistent with the ordinary electromagnetic equations. The second set involves the use of the ampere-turn, which introduces certain changes into the equations. In the first set of units, the current use of the name "gauss" both for the unit of induction and the unit of magnetizing force is questionable. The two quantities are sometimes looked upon as physically the same. There are preponderating reasons, however, for considering them to have an essentially different nature, induction corresponding to the magnetized state of the medium, and magnetizing force being the agency tending to produce that state. The double use of "gauss" is an inconvenience in practice. There have been various proposals from time to time to rationalize the units, i.e., to use units such as to redistribute the factor 4π in the equations. The first proposal, that of Heaviside, had much to recommend it but required a radical change of all the electric and magnetic units. Subsequent proposals have involved less change of existing units, but have all had the disadvantage of incorporating 4π in the value of permeability of vacuum. It is pointed out herein that the use of the ampere-turn leads to a rationalized set of units, without either of these disadvantages.

Discussion: Messrs. Swann, Silsbee, and Rosa discussed this communication. Such proposals for rationalization are of distinct value to emphasize the sometimes illogical designation of units; the advisability, however, of radical changes from the existing systems is to be questioned since it is difficult to revolutionize practice. Although the two systems of magnetic units sometimes cause ambiguity, simplification as proposed would lead probably to greater confusion, particularly so because of radically different usage by investigators. The incorporation of the factor 4π is quite natural since it has a physical significance in distribution of force over a spherical surface. Mr. Rosa suggested that an International Committee on units and nomenclature is desirable.

INFORMAL COMMUNICATIONS

Mr. F. E. Wright exhibited a graphical device for solving equations of the general form $A = B \cdot C$. (Published in full in Journ. Wash. Acad. Sci. **6**: 1–3. 1916.)

J. A. Fleming, *Secretary*.

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 545th meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday evening, November 20, 1915; called to order by President Bartsch with 50 persons present.

On recommendation of the Council Leo D. Miner, E. O. Wooton, A. M. Groves, all of Washington, D. C., were elected to active membership.

Under the heading Brief Notes: Mr. Lewis Radcliffe called attention to recent efforts of the Bureau of Fisheries in rearing shad in ponds. Young fish thus raised attained twice the size of those of the same age in their natural environment. Specimens of both kinds were exhibited.

The regular program consisted of three papers, as follows: Frederick Knab, *The dispersal of some species of flies;* Alex. Wetmore, *Notes on the habits of the duck hawk;* Elmer D. Merrill, *Geographic relationships of the Philippine flora.*

The 546th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday evening, December 4, 1915; called to order by President Bartsch, with 55 persons present.

On recommendation of the Council Dr. R. W. Shufeldt, Washington, D. C., and Arthur deC. Sowerby, Tien Tsin, were elected to active membership.

On recommendation of the Council the following resolutions were read and adopted:

Whereas: Dr. George M. Sternberg, former Surgeon General of the U. S. Army, a distinguished worker in the biological sciences as applied to medicine, long time an active member of the Biological Society of Washington and its President during the years 1895 and 1896, has passed from this life, therefore be it

Resolved: That the Biological Society of Washington keenly regrets his death and offers its warmest sympathy to Mrs. Sternberg, and will always be grateful to his memory for the important part which he took in the affairs and discussions of the Society and for the distinction which his eminent name adds to its list of past Presidents.

Signed, L. O. Howard,
Frederick V. Coville,
Paul Bartsch.

Under the heading Brief Notes, Exhibition of Specimens: Dr. O. P. Hay exhibited the skull of a walrus from the southern Atlantic coast of the United States and called attention to other specimens of walrus from localities now far south of its present range. It was Dr. Hay's opinion that the walrus had followed the retreating ice sheet northward. Dr. L. O. Howard called attention to the cluster-fly (*Pollenia rudis*), an insect resembling the house fly but collecting in houses in autumn and leaving a yellow stain when crushed. Its life history was unknown until recently, a foreign entomologist having now shown that the larvae are parasitic in earthworms in France. Dr. Howard is having large numbers of earthworms examined for such larvae, but so far without success. He hoped that anyone finding any grubs parasitic in earthworms would communicate with him.

The first paper of the regular program was by Dr. Charles H. T. Townsend, "*Identification of the stages in the asexual cycle of Bartonella bacilliformis, the pathogenic organism of verruga, and their bearing on the etiology and unity of the disease.*" (Published in full in this Journal, **5**: 662–667, December 19, 1915.)

The second and last paper of the program was by A. A. Doolittle, "*The Mississippi River dam at Keokuk, Iowa: Its effect upon biological conditions, especially those of the plankton.* The speaker stated that the Bureau of Fisheries has been examining the new conditions caused by the damming of the Mississippi River at Keokuk, Iowa, to develop electric power. The water is raised to 40 feet above 0 of the river gauge at Keokuk, that is, to the 525-foot level above sea. The water power company must maintain the lake between the 519 and 525-foot levels. The effect of the dam runs out at Oquawka, Ill., 54 miles from Keokuk. In the lower third of its course Lake Cooper, as the impounded waters are called, fills the gorge of old Des Moines Rapids. In the middle third of its course is the greatest lateral expanse, 4 miles or more, covering much island and farm lands. Forests are removed from only a little of the submerged area. Water persicaria seems to be the only water weed establishing itself in great quantity. In the upper third the threatened banks are being enclosed by levees and will be drained by pumping stations. Tributaries are filled for some distance from the river-lake, the larger ones being navigable for upwards of 3 miles in small launches.

There are present the usual characteristics of a river lake: increased regularity of water stages; decreased current; decreased turbidity; establishment of rooted aquatic plants. The most immediate effects of economic importance, biologically, are the destruction of the famous mussels of the rapids, and the interference with the usual passage of fish up and down the river, especially the periodic migrations.

The dominant zooplankton were several species of Entomostraca (*Moina*, *Diaphanosoma*, and *Cyclops viridis*); the phytoplankton included *Conferva* spp., *Anabaena* spp., and *Clathrocyctis.* Estimates of the abundance of plankton were based upon the cubic yard. Above the influence of the dam about 50 entomostracan individuals constituted the plankton, with traces of algae. At Keokuk this was increased in July to 1500 individuals, in August to 270,000 (volume estimated at 26 cc.), and in September to 1500. Green algae measured 0.14 cc. in July, 29 cc. in August, and 5 cc. in September. Blue-green algae measured traces in July, 2.6 cc. in August, and the same in early September. Below the dam at the maximum for the season the run-off contained 3,000 Entomostraca per cu. yd., 1.17 cc. green algae, and traces of blue-greens, a marked enrichment over that of normal river conditions. In weedy waters, additional heavy-bodied Entomostraca occurred (*Sida*, *Scapholeberis*, *Simocephalus*), varying in numbers with the density of growth to a maximum of 178,000 individuals, with estimated volume of 23 cc. per cubic yard.

Streams and sloughs filled with back flow from the lake "ripened" earlier than the main lake body, and contained upwards of 50,000 Entomostraca per cu. yd. in July, with less, usually, in August. Algae were less than in the lake. Where tributaries were filled by their own waters, plankton was of different character. When in flowing streams often protozoans (*Euglena*) or rotifers (*Asplanchna*) were dominant, with little algae. When tributaries were filled with seepage water the plankton again was of special character, holozooplanktonic, with one or another Entomostracan species dominant, as *Cyclops leuckarti* and *Diaptomus* spp. Some of these characteristic forms could be traced into the main stream, but they did not survive. It is evident that there is a vast increase of fundamental food for some species of fishes.

The paper was illustrated with map, diagram and slides showing the conditions existing in the summer of 1914. It was discussed by the Chair, and by Messrs. Coker, Marsh, and William Palmer.

The 547th and 36th annual meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, December 18, 1915; called to order by President Bartsch, with 27 persons present.

On recommendation of the Council the following persons were elected to active membership: H. R. Rosen, U. S. National Museum; Miss Virginia Boone, U. S. National Museum; Ira N. Gabrielson, Biological Survey; James Silver.

Annual reports of officers and committees were submitted.

Election of officers for the year 1916 resulted as follows: *President*, W. P. Hay; *Vice-Presidents*, J. N. Rose, A. D. Hopkins, Hugh M. Smith, and Vernon Bailey; *Recording Secretary*, M. W. Lyon, Jr.; *Corresponding Secretary*, W. L. McAtee; *Treasurer*, W. W. Cooke; *Councillors*, N. Hollister, J. W. Gidley, William Palmer, Alex. Wetmore, E. A. Mearns.

President Hay was elected as the Society's representative upon the board of the Washington Academy of Sciences.

The president announced the following committees: *Committee on Publications:* N. Hollister, W. L. McAtee, W. W. Cooke; *Committee on Communications:* Wm. Palmer, Alex. Wetmore, Lewis Radcliffe, J. W. Gidley, William R. Maxon, H. S. Barber.

M. W. Lyon, Jr., *Recording Secretary.*

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ELECTRICITY.—*Quantitative experiments with the audion.* L. W. Austin, U. S. Naval Radiotelegraphic Laboratory.

The extent to which vacuum tube detectors of electrical waves have come into general use both for damped and undamped oscillations has made it desirable to determine the law of response of these instruments, especially as they are often used with shunted telephones for making estimates of the strength of received signals in radiotelegraphy.

The form of vacuum detector chosen for investigation was the DeForest three-electrode audion.[1]

As is well known the audion can be used either as an ordinary detector (old audion connection) with the secondary receiving circuit connected to the hot filament and the intermediate electrode (grid), or by connecting to the grid and cold plate (ultraudion connection) local oscillations may be set up in the receiver so that signals may be received by the beat method.

For determining the laws relating to the strength of the received waves and the response of the detectors, the circuit containing the audion was excited by a wave meter in which oscillations of varying strength were produced either by an oscillating audion for undamped or by a buzzer for damped excitation.

As it is impossible to use a galvanometer directly in the telephone circuit of the audion on account of the continuous current flowing through it from the dry battery, the following arrange-

[1] For description, see Bulletin Bureau of Standards, **6**: 540. Reprint 140, 1911.

ment of apparatus was employed: The primary of an iron core telephone transformer was placed in series with the telephones and to its secondary a silicon detector in series with a sensitive galvanometer was connected. The changes in current strength which affect the telephones produce similar effects in the telephone transformer and give rise to alternating currents in the secondary which in turn are rectified in the silicon detector and are thus made to affect the galvanometer. The galvanometer deflections have been shown to be proportional to the square of the alternating currents in the detector[2] and therefore to the square of the telephone pulses in the main circuit. When the audion was made to produce local oscillations these were found to affect the detector slightly, but their influence was entirely eliminated by placing a condenser of 0.1μf across the detector.

The strength of the high frequency oscillations which were sent out from the sending wave meter was measured by means of a thermoelement connected in the wave meter circuit.

TABLE I

OLD AUDION

DAMPED EXCITATION		
I_1^2	I_2^2	$\frac{I_1^2}{I_2}$
20	2	14.1
30	4	15.0
50	13	13.9
75	28	14.2
107	57	14.2
121	70	14.5
154	107	14.9
173	145	14.4

The first experiment was intended to determine the law of response of the circuit in old audion connection, the sending wave meter being excited by a buzzer. The results are shown in Table I. Here I_1^2 represents the readings of the thermo-

[2] Bulletin Bureau of Standards, **6**: 530. 1911.

element galvanometer in the sending circuit and I_2^2 the readings of the detector galvanometer in the telephone transformer. I_1 is proportional to the high frequency sending currents and therefore to the high frequency currents received; I_2 is proportional to the value of the current pulses in the receiving telephone circuit. Column three, Table I shows that the telephone pulses (response) are proportional to the square of the high frequency currents received. An experiment similar to the above except that the receiving circuit had the ultraudion connection, but so adjusted that no local oscillations were produced, shows that the same law holds as in the case of the old audion connection.

TABLE II

OSCILLATING ULTRAUDION

DAMPED EXCITATION		
I_1^2	I_2^2	$\frac{I_1}{I_2}$
11	9	1.11
20	19	1.02
33	29	1.06
52	46	1.06
71	64	1.05
90	84	1.03

TABLE III

OSCILLATING ULTRAUDION

UNDAMPED EXCITATION		
I_1^2	I_2^2	$\frac{I_1}{I_2}$
1	2	0.71
3	4	0.87
5	8	0.79
7	11	0.80
9	16	0.75

Tables II and III show the results with the audion in ultraaudion connection and oscillating. In Table II the sending waves are damped as in Table I, while in Table III the sending waves are undamped, the sending wave meter being excited by an oscillating audion. Here the note in the receiving telephone is produced by the beats between the local and incoming oscillations, being rough from the damped oscillations but clear and musical from the undamped.

Column three in each of the last two tables shows that the response in the case of the local oscillations is proportional to the received high frequency current and not to its square as was the case in the non-oscillating audion. The value of the ratios in the third columns shows that the response of the receiving telephone is greater for undamped oscillations than for damped, other things being equal, in the ratio 1.4 to 1. But assuming equal decrements in the sending and receiving circuits, which is probably at least approximately correct, this represents equal sensitiveness, since in the case of undamped waves $I = \frac{E}{R}$ and in the case of damped $I = \frac{E}{R\sqrt{1 + \frac{\delta_1}{\delta_2}}}$ where $\frac{\delta_1}{\delta_2}$ represents the ratio of decrements in the two circuits.

In addition to the experiments with the detector and galvanometer, determinations have also been made of the relative sensibility of the old audion and the oscillating ultraudion connections. For this the shunted telephone method was used with spark excitation, either distant signals or from the buzzer. It was found that for unit audibility with the old audion connection the oscillating ultraudion gave from three hundred to one thousand audibility, but as the law of response is different in the two cases the ratio will of course decrease as the signals grow stronger. With the non-oscillating ultraudion the signals are from twenty to forty times as strong as with the old audion. This ratio becomes greater if the ultraudion is brought nearer to the oscillating condition.

The experiments show that the atmospheric disturbances are but little louder in general with the oscillating audion than with the old audion; the sounds are more continuous in the former, however.

PALEOBOTANY.—*Notes on two conifers from the Pleistocene Rancho La Brea asphalt deposits, near Los Angeles, California.*[1] F. H. KNOWLTON, Geological Survey.

The famous asphalt deposits or so-called "tar-pits" of the Rancho La Brea, near Los Angeles, California, are now well and widely known from the vast numbers of animal remains that have been exhumed from them. From the many hundreds of skulls and tens of thousands of skeletal bones that have been brought to light, it is said that more than fifty species of birds, and nearly or quite as many kinds of mammals, have been identified. Considering the marvelous degree of perfection with which these animal remains have been preserved, it has been—at least to the writer—a matter of speculation as to why it was not equally fitted to preserve such hard parts of plants as seeds, fruits, cones, wood, etc., as must have chanced to fall into it. Be this as it may, plant remains, at least so far as recorded observations go, appear to be exceedingly rare, and it is, therefore, with especial pleasure that I am able to record the discovery of two perfectly preserved coniferous cones that were recently sent me for identification.

These cones were received, through Mr. H. W. Henshaw of the Biological Survey, from Mr. Frank S. Daggett, Director of the Museum of History, Science, and Arts of Los Angeles, in which institution they are now deposited. They are said to be the only cones thus far discovered in these deposits, which, if true, seems a very remarkable condition. They are, of course, thoroughly impregnated with the asphaltum and are black in color. They have suffered no distortion and are in practically perfect condition. The species represented are: *Pinus attenuata* Lemmon, *Cupressus macrocarpa* Hartweg.

The knobcone pine, according to Sudworth's "Forest Trees of the Pacific Slope," ranges throughout the Coast Mountains of southern Oregon and of California, and also in the southern Cascades of Oregon and northern California Sierras, while the Monterey cypress is confined to a few miles of the central Cali-

[1] Published with the permission of the Director of the U. S. Geological Survey.

fornia coast on the peninsula between Monterey Bay and Carmel Bay. This shows that the knobcone pine is, at least in part, living in the same general area it occupied in Pleistocene time, whereas the cypress has retreated for some hundreds of miles up the coast, where apparently it has made its last stand.

It is perhaps presumptuous with the data available to venture to draw any conclusion as to the climatic and other conditions that obtained when these cones were entombed in the Rancho La Brea deposits, but such as it is it may be presented. According to Sudworth the knobcone pine now occurs usually on dry, exposed, steep southern slopes, but often in deep gulches and protected ravines, growing on poor, dry, rocky, or gravelly and sandy soils. It endures seasonal changes of temperature from zero to 95° F., with occasional heavy snows and an annual rain fall up to 45 inches.

The Monterey cypress in its natural state appears to require quite different conditions. It grows on rocky sea cliffs in clay loam soil, under a mild equable temperature, never at freezing point and rarely above 90° F. The annual rain fall is about 17 inches, but the moist sea winds keep the air humid for the greater part of the year. As it is often planted in other parts of California for wind-breaks, it has been found that it will not only thrive in fresh soils away from the influence of the sea, but is capable of withstanding a greater range in temperature than that of its native range. If planted in dry soils where the temperature falls below freezing, it will grow well and mature its wood before frost.

Inasmuch as the trees themselves, judging from these two cones, appear to have changed very little between the Pleistocene and the present time, it at least suggests that their climatic requirements have likewise suffered little change.

ETHNOBOTANY.—*Quichua names of sweet potatoes.* O. F. COOK, Bureau of Plant Industry.

Quichua was the language of the Incas at the time of the Spanish conquest of Peru, and is still spoken by a large native population. The ancient center of the Quichuas is in the region about Cuzco on the eastern slope of the Andes, from an altitude of over 14,000 feet at the Pass of La Raya, down to Santa Ana, at an altitude of 3000 feet. The lower valley of the Urubamba river was visited by the writer in May, June, and July, 1915, as a member of the Yale Peruvian Expedition conducted by Prof. Hiram Bingham, of Yale University, in cooperation with the National Geographic Society and the United States Department of Agriculture.

At 6000 feet and below, the sweet potato (*Ipomoea batatas*) is one of the principal root-crops. At Santa Ana it appears to be somewhat less important than *rumu* (Manihot) or *uncucha* (Xanthosoma), but much more important than *achira* (Canna). Two classes of sweet potatoes are recognized under separate names, *apichu* for the sweet varieties and *cumara* for the starchy. A similar distinction is often made in the United States between "sweets" and "yams." The Quichua language seems to have no inclusive term that can be applied to all kinds of sweet potatoes. For this purpose Spanish-speaking Quichuas use the word "*camote*."

Both cumaras and apichus are represented by numerous varieties differing in shape and color of roots and foliage. At San Miguel, in the valley under Machu Picchu, with an altitude of 6000 feet, three varieties of cumaras were noted: *yuracjcumara* (white), *pucacumara* (red), and *compillicjlla*, the last a very short turnip-shaped purple root. Of apichus there were also three varieties, *yuracjapichu*, *pucaapichu*, and *azulapichu* (blue, a combination of Spanish and Quichua). Other names, learned at Santa Ana, are *oqquechuto*, *cusicumara*, and *pucacusicumara*, the last mentioned said to mean "red-long-cumara." Another with deep purple flesh like a beet, that stains the tongue, is called *incampamaccasccan*. At Lima the Quichua names are not recognized, only *camote* being used. Two varieties grown between Lima and Callao are called *supano* and *luriniano*, the former with leaves very deeply cut, the latter with nearly entire leaves. Supe and Lurin are places on the coast not far from Lima.

Wild sweet potatoes are said to be of common occurrence in the valleys of the interior. At San Miguel a plant identified by the Indians as *cusiapichu* was found growing spontaneously in a place not recently cultivated. At Santa Ana three distinct kinds, to judge from the foliage, were found as common weeds in cultivated land. But to certify that any plant is a genuine native species seems out of the question in a region where all of the land has probably been cleared many times and cultivated intermittently for centuries. On the other hand, there is no reason to deny that the sweet potato may have been domesticated in the Peruvian region, as many other plants appear to have been.

The words *apichu* and *cumara* have been recorded before, but without indications of their concurrent use and distinct applications among the Quichuas. Markham's Quichua *Vocabulary* gives *apichu* as the name of the sweet potato, but overlooks *cumara* altogether. Reference might also be made to Holguin's *Arte y Diccionario* without finding *cumara,* since the word does not appear in its alphabetic position, but under *apichu* we find: "Apichu, cumar, *nom.* Camote." Martius's *Ethnographie* has neither *apichu* nor *cumara,* but gives *camote* as the Quichua name, with a derivation from the Mexican *camotli.* Cobo, whose *Historia* was written in Peru less than seventy years after the conquest (though not published till 1890), recorded *apichu* as the Quichua name, *tutuca* as the Aymara name, and *camote* as the name used by the Spaniards of Peru, borrowed from the language of Mexico. Cobo appears to have visited the interior of Bolivia, but not the interior of Peru.

No reason is apparent for questioning the status of *apichu* and *cumara* as genuine Quichua words. Etymologies would be easy to invent. For *apichu* such a combination as *api* (maize pudding) and *pichu* (flesh) or *pichi* (root) would be appropriate, while *cumara* might be related to *ccumu* or *kumu,* meaning crooked or hunch-backed. Other Quichua names analogous to *cumar* or *cumara* are *pallar* (Phasaeolus), *quiñuar* (Buddleia), *quisuar* (Polylepis), *ancara* (gourd), *sara* (Zea), *tara* (*Caesalpinia tinctoria*), and *achira* (Canna).

The sweet potato was not known to Europeans before the discovery of America. The first name that the Spaniards learned and carried back to Spain was *batata,* the original of our word potato, but the Mexican name *camote* is now more widely known in Spanish America. Many names in local languages have probably been lost, but some have been placed on record. Martius collected the following series from native tribes of Brazil: *coutarouti, coundi, gnunana, hetich, ictig, imazaka, jetica, joto, mapas* (?), *m'aporu, mapuey, mouka, napi, orairai, quaiu, tsa*, and *zamaygua.*

In the Kekchi language of eastern Guatemala, a member of the Maya family, the sweet potato bears the name *is.* The Kekchis do not raise many sweet potatoes, this crop being distinctly less important than *osh* (Xanthosoma) or *piyak* (Dioscorea), yet sweet potatoes often grow as weeds in cultivated lands. The potato (*Solanum tuberosum*) is called by the Kekchis *kashlanis*, meaning "foreign sweet potato."

Several of the early Spanish historians of the West Indies recorded the name *age* or *aje*, but whether this belonged properly to the sweet potato or to some other root-crop has been uncertain. Some of the accounts evidently refer to Manihot, but Gray and Trumbull settled upon Dioscorea as the correct application.[1] Gomez de la Maza claims both *age* and *boniato* as indigenous Cuban names of sweet potatoes. More than a score of Cuban varieties are listed, mostly with names derived from native languages of the Island. *Boniato* is the name in regular use in Cuba, *batata* being scarcely known.[2] *Batata* is used in Puerto Rico, Venezuela, and Panama; but two indigenous names, *araba* and *deki*, are reported by Pittier from primitive tribes living on the Atlantic slope of Costa Rica.[3]

Among all these names of sweet potatoes in other parts of America there appears to be no definite resemblance to either of the Quichua words, *apichu* and *cumara.* Perhaps the nearest approach to similarity is between *cumara* and the Mexican *camote* or *camotli.* Yet the number and diversity of the native names are not without significance as indications of the American

[1] Gray A., and Trumbull, J. H. Review of de Candolle's Origin of Cultivated Plants; with annotations upon certain American species. American Journal of Science, Third Series, **25**: 250. 1883.

[2] Gomez de la Maza, M. Diccionario Botanico de los Nombres Vulgares Cubanos y Puerto-Riqueños. 1889.

[3] Pittier, H. Plantas Usuales de Costa Rica, 165. 1908.

origin of the sweet potato or, at least, of its wide distribution in prehistoric times.

The general interest of the Quichua names lies in the fact that *cumara* or *kumara* is also the name of the sweet potato in the Polynesian Islands. This was first pointed out by Seemann, a botanist who had visited the Pacific Islands and the west coast of South America about fifty years ago. Seemann's observation appeared as a brief editorial note in connection with a statement by the ethnologist Crawfurd, to the effect that no communication could have taken place between the American continent and the Pacific Islands.[4]

The presence of the Quichua name in Ecuador is readily understood, the native kingdom of Quito having been conquered and occupied by the Incas. Some of the early Spanish historians of Peru recorded Inca traditions of voyages to islands in the Pacific, but such a possibility of communication between the American continent and the Pacific Islands has not seemed worthy of serious consideration. Nevertheless, cultivated plants of American origin appear to have crossed the Pacific before the arrival of Europeans. Among these trans-Pacific plants are the coconut palm, the bottle-gourd, and the sweet potato. Coconuts and gourds may be supposed to have floated to the Islands and established themselves without human assistance, but the sweet potato and its name could hardly be conveyed in this manner. Nor is it to be taken as a mere coincidence that a Quichua name not shared with other American languages should be associated with the same crop in the Pacific Islands.

[4] Crawfurd, John. On the migrations of cultivated plants in reference to ethnology. Seemann's Journal of Botany, 4: 328. 1866.

"The Sweet Potato, or tuber-yielding Convolvulus, appears to be a native of many parts of the tropical Old and New World. Some have alleged that it was first made an object of cultivation by the native Americans, but when the South Sea Islands, which had assuredly no communication with the American people, were discovered, the sweet potato was found to be in cultivation, and known by a native name throughout, the word being essentially the same, and a native one varying only in pronunciation, as *kumava*, *humaa*, and *gumala* abbreviated *mala*."

Seemann's comment on the above statement was as follows: "[*Kumara* or *umara*, of the South-Sea Islanders, is identical with *cumar*, the Quichua name for sweet potato in the highlands of Ecuador.—Ed.]

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*Some qualitative tests for gum arabic and its quantitative determination.* C. E. WATERS and J. B. TUTTLE. Bureau of Standards Technologic Paper No. 67. Pp. 15. 1916.

A study of many of the published tests for the gum, as well as a search for others than the few that proved to be reliable. It was found that basic lead acetate gives the most characteristic reaction, while mixtures of copper sulphate and sodium hydroxide, and of neutral ferric chloride and alcohol are of value as confirmatory tests. Dextrin and gum ghatti were subjected to the same tests.

A summary of the more important methods that have been proposed for the quantitative estimation of gum arabic is next given, followed by a description of the steps that led the authors to the use of alcoholic copper acetate-ammonia solution for this determination. C. E. W.

CHEMISTRY.—*The determination of barium carbonate and barium sulphate in vulcanized rubber goods.* JOHN B. TUTTLE. Bureau of Standards Technologic Paper No. 64. Pp. 5. 1916.

Specifications for purchasing rubber goods frequently permit the use of barytes (barium sulphate) as a mineral filler without having the sulphur which it contains count as part of the specified total sulphur. In such cases the barium sulphate must be determined in order to properly correct the total sulphur.

When barium sulphate only is used, the amount present is readily ascertained by determining the total amount of barium present. If barium carbonate is used, it is necessary to separate the two salts. By means of tests made on compounds of known composition prepared at the Bureau of Standards, a method has been devised which permits the quantitative determination of barium carbonate in the presence of either lead sulphate or barium sulphate, the two sulphates most commonly used in rubber goods. The accuracy of the determination is satisfactory for all practical purposes. J. B. T.

GEOLOGY.—*The stratigraphy of the Montana group.* C. F. Bowen. U. S. Geological Survey Professional Paper No. 90, pp. 95–153. 1915.

Because of differences of opinion which have arisen regarding the age and stratigraphic position of the Judith River formation, a study of the stratigraphy of the Montana group was undertaken.

It is shown that the Judith River formation has been traced continuously from areas where its position beneath the Bearpaw shale is undisputed into the western part of the type area (namely, at the mouth of Judith River) and has been found to be identical with the Judith River at that locality.

The paleontologic evidence shows: (1) that the argument that the Judith River formation overlies the Fox Hills is unfounded; (2) that the flora of the Judith River formation is of Montana age; (3) that the invertebrates of the Judith River formation are more closely allied to the Belly River than to the Lance; (4) that if the Judith River is to be made the equivalent of the Lance on the basis of the similarity of the vertebrate fauna, the Belly River must on the same evidence also be made the equivalent of the Lance formation; (5) that the Ceratopsidae, which form so important an element of the Lance fauna, are generically and specifically unlike the representatives of that family in the Belly River and Judith River faunas. The palaeontologic evidences therefore indicating a closer relationship between the Belly River and Judith River than between either of these formations and the Lance are in accord with the stratigraphic evidence, which shows conclusively that both the Judith River and Belly River formations are separated from the Lance by a marine formation which is of undoubted Cretaceous age. R. W. S.

GEOLOGY.—*Erosion intervals in the Eocene of the Mississippi embayment.* E. W. Berry. U. S. Geological Survey Professional Paper No. 95, pp. 73–82. 1915.

The older Tertiary deposits of the Gulf Coastal Plain, comprising several thousand feet of sands, clays, marls, lignites, and impure limestones, have always been considered as forming an uninterrupted and conformable series, extending from the lower Eocene to the top of the

Oligocene. It is shown in this paper that the sedimentation of Eocene time was interrupted during several intervals, which were of considerable duration in terms of organic evolution. Such intervals occurred between the Midway or basal Eocene deposits and the overlying Wilcox group and between the Wilcox and the Claiborne.

It is concluded that the strand line migrated back and forth over the Mississippi embayment several times during the period represented by the older Tertiary deposits. R. W. S.

GEOLOGY.—*The Willow Creek district, Alaska.* S. R. Capps. U. S. Geological Survey Bulletin No. 607. Pp. 86, with maps, sections, and illustrations. 1915.

The geologic formations exposed consist of mica schists, possibly of Paleozoic age; quartz diorites and gneisses, probably Mesozoic; Eocene arkoses, conglomerates, shales, and sandstone, with some interbedded basaltic lava flows; and Quarternary glacial deposits and recent stream gravels. The Tertiary beds are somewhat folded, but have prevailing dips of 20° to 50° to the southward.

Gold quartz veins fill fissures in the quartz diorite, and occur in two predominant sets, one striking northwest, and the other northeast. The prevailing dip is 30° to 50° to the westward. The veins show little surface oxidation and no secondary enrichment and promise to maintain the same characters with depth that they display near the surface.

Some gold placer deposits have been worked, but most of the concentrations of placer gold that must have resulted from the erosion of the gold-bearing quartz veins were swept away and scattered by the vigorous glaciers which occupied the valleys during the height of the Quarternary ice invasion. S. R. C.

GEOLOGY.—*The Ellamar district, Alaska.* S. R. Capps and B. L. Johnson. U. S. Geological Survey Bulletin No. 605. Pp. 125, with maps, sections, and illustrations. 1915.

The rocks exposed include the Valdez group of interbedded slates and graywackes, possibly of Paleozoic age, and the Orca group, possibly Mesozoic, including in ascending order: (1) fine black slates; (2) slates and graywackes; (3) ellipsoidal lavas and massive diabase flows with some interbedded sediments; (4) conglomerates and sandstones; and (5) another series of slates and graywackes. The dominant structural trend is northwest-southeast, and the beds have prevailing dips to the northeast. The rocks of the Valdez group overlie those of the Orca group, as the result of a great overthrust fault. In the almost complete absence of fossils the age of the various formations has not been conclusively determined.

The sulphide ore veins of the district, most of which are mined chiefly for their copper content, but one of which is now producing gold ores, occur in zones of fracture and shearing along fault planes. Most of the mines and prospects occur in the greenstones, but the largest mine is in slate and graywacke, stratigraphically beneath the greenstone. The shear zones in many places are particularly well developed in slates and graywackes interbedded with the greenstones, as these sedimentary beds yielded to the deformational stresses more readily than the greenstones themselves. The ores are, in part at least, replacements of the crushed rock, but in the largest mine they are believed to replace calcareous sedimentary beds. The copper in the veins as well as the gold is believed to be genetically connected with granitic intrusives and not derived from the greenstones as has been previously suggested.

S. R. C.

GEOLOGY.—*Rhode Island coal.* GEORGE H. ASHLEY. U. S. Geological Survey Bulletin No. 615. Pp. 62, 5 plates. 1915.

Coal occurs at a number of places near Providence and Newport, Rhode Island. Attempts to use it as fuel began nearly 150 years ago, but in spite of its favorable situation as regards markets and transportation these have not met with success.

The rocks of the Rhode Island coal field have been subjected to intense lateral pressure which folded them in great folds with accompanying crushing, squeezing, and shearing. As in regions of intense pressure and folding the softer rocks tend to yield, flowing away from points of greatest pressure, so the Rhode Island coal has moved under pressure and accumulated as irregular lenses in places of less pressure. The pressure and accompanying heat changed the coal to anthracite containing a high percentage of fixed carbon, and in places to graphite. The graphite is localized where the metamorphism was greatest. In general, the thinner the coal at any point, the larger the percentage of graphite it contains.

Crevices in the coal have locally become filled with quartz or asbestos.

The breaking open and recementing of the coal appears to have let into it more or less of the adjoining shale, so that where the coal is thin from having been squeezed it is higher in ash. The coal in the same mine therefore may be high in graphite and ash where it is thin, and freer of both ash and graphite in the wider pockets.

The field as a whole appears to have been subjected to large regional differences in pressure and there are corresponding regional differences in the coal.

Rhode Island coal is a high-ash, high-moisture, graphitic anthracite of high specific gravity. R. W. S.

GEOLOGY.—*The Broad Pass region, Alaska.* FRED H. MOFFIT, *with sections on Quarternary deposits, igneous rocks, and glaciation,* by JOSEPH E. POGUE. U. S. Geological Survey Bulletin No. 608. Pp. 80, with maps, section and views. 1915.

The region described lies south of the axis of the Alaska Range and includes part of the headwaters of Susitna, Chulitna, and Nenana rivers. Rocks ranging in age from Devonian to Tertiary are exposed and in addition unconsolidated deposits of glacial, glacio-fluvial, and fluvial origin are present.

The Devonian rocks include limestone, slate, and conglomerate, all of which are folded and otherwise altered. In places the slate and conglomerate have become schistose. Rocks tentatively referred to the Triassic are basaltic lavas apparently overlain by dark-blue and black slates with interstratified arkose and graywacke. Other dark-blue and black slates interbedded with graywacke and conglomerate are tentatively referred to the Jurassic and a complex of sedimentary rocks, chiefly slate and limestone, are considered to be probably Mesozoic. The principal Tertiary rocks are the Cantwell formation (Eocene), a massive conglomerate, locally containing fossiliferous shale beds. It is folded and in its eastern extension takes on a schistose structure.

All the consolidated sediments are cut by intrusives, most of which are granitic or porphyritic and of felsic (acid) character. The youngest intrusives are of Tertiary age.

The Broad Pass region has been profoundly glaciated, as is plainly shown by its topography.

Mining has not been established here. The region, however, is favorable for prospecting. F. H. M.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

MAMMALOGY

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BAILEY, V. *Revision of the pocket gophers of the genus Thomomys.* North American Fauna No. 39. Pp. 1–136, *plates 1–8, figs. 1–10.* November 15, 1915. (Monograph of the species and subspecies, with maps of distribution; *Thomomys sheldoni*, from Tepic, is described as new.—N. H.)

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GOLDMAN, E. A. *A new spider monkey from Panama.* Proceedings of the Biological Society of Washington, **28**: 101–102. April 13, 1915. (Description of *Ateles dariensis*, sp. nov.—N. H.)

GOLDMAN, E. A. *Five new rice rats of the genus Oryzomys from Middle America.* Proceedings of the Biological Society of Washington, **28**: 127–130. June 29, 1915. (New forms: *Oryzomys guerrerensis*, *O. nitidus alleni*, *O. alfaroi dariensis*, *O. couesi regillus*, and *O. fulvescens lenis*.—N. H.)

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HOLLISTER, N. *A new name for the white-tailed jack rabbit.* Proceedings of the Biological Society of Washington, **28**: 70. March 12, 1915. (*Lepus campanius* proposed, to replace *L. campestris*, preoccupied.—N. H.)

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HOLLISTER, N. *The specific name of the striped muishond of South Africa.* Proceedings of the Biological Society of Washington, **28**: 184. November 29, 1915. (The Cape form of the striped muishond to be known as *Ictonyx striatus*.—N. H.)

HOWELL, A. H. *Revision of the American marmots.* North American Fauna No. 37. Pp. 1–80, *plates 1-15.* April 7, 1915. (History, habits, economic relations, and systematic account of the American woodchucks and marmots. *Marmota monax petrensis*, from British Columbia, and *Marmota flaviventris sierrae*, from California, are described as new.—N. H.)

HOWELL, A. H. *Descriptions of a new genus and seven new races of flying squirrels.* Proceedings of the Biological Society of Washington, **28**: 109–113. May 27, 1915. (The generic name Eoglaucomys is proposed for the Himalayan *Sciuropterus fimbriatus*, and new species and subspecies of American flying squirrels are named.—N. H.)

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY OF WASHINGTON

The 106th regular meeting of the Botanical Society of Washington was held at the Cosmos Club, Tuesday, October 5, 1915, at 8 p.m. Thirty members and two guests were present. The following scientific program was given:

Some recent investigations in sugar-beet breeding (lantern slides): F. J. Pritchard. The speaker presented a large number of tables and figures based upon 10 years' experiments in sugar-beet breeding from which the following conclusions were drawn: Differences in the size, total sugar content, and percentage of sugar of individual beet roots show no evidence of inheritance. There is no correlation between percentage or quantity of sugar of roots of ordinary sizes and their yield of seed nor between their yield of seed and the average percentage of sugar in their progeny. Fluctuations in percentage and yield of sugar of beet families planted in progeny rows in alternation with check rows greatly exceed their real differences. The discontinuance of selection for one generation caused no deterioration but some apparent gain in percentage of sugar. No improvement was obtained in yield or percentage of sugar from continuous selection; both the good and the poor families transmitted average qualities. Fluctuations in percentage and yield of sugar are caused chiefly by irregularities of the soil; the nutritive conditions which favor the production of a large root cause a large tonnage of beets but a low percentage of sugar; even with a uniform stand certain rows and certain parts of the field produce a relatively small root and consequently a high percentage of sugar, while neighboring areas produce a large root and a low percentage of sugar. As the fluctuations in percentage and yield of sugar are large they obscure real differences between varieties or families, but real differences may be distinguished by planting each variety or family a large number of times.

Notes on plant-parasitic nematodes (lantern slides): L. P. Byars. After a few introductory remarks concerning the general characteristics of the three groups of nematodes—the free living, animal-parasitic, and plant-parasitic—the speaker indicated some of the more important anatomical and life-history features of species belonging to the last group. Emphasis was laid on the economic importance of and present distribution of *Tylenchus dipsaci*, the bulb and stem-infesting nematode; *Tylenchus tritici*, a nematode living in wheat kernels; *Aphelenchus armerodis*, the violet bud organism; and *Heterodera radicicola*, the gall-forming nematode, all of which are parasites introduced into this country. Illustrations and drawings were used to show the speaker's method of growing *Heterodera radicicola* in pure culture and to indicate the effect of this parasite on its host.

The first Washington Botanical Society: P. L. Ricker. While collecting material for the bibliography and biography in the forthcoming Flora of Washington the speaker first learned[1] of the existence of a Washington Botanical Society organized on March 13, 1817 with thirteen charter members: John Boyle, W. A. Bradley, Dr. John A. Brereton, Samuel Elliot, Jr., William Elliot, J. W. Hand, Dr. Henry Huntt, Maj. James Kearney, Rev. Dr. James Laurie, Dr. Alexander McWilliams, J. M. Moore, John Underwood, and George Watterson. Subsequently six additional members were elected and three honorary members: Dr. Jacob Bigelow, Dr. William Darlington, and Dr. William P. C. Barton. Meetings of the society were held until March 27, 1826, when the society adjourned *sine die.* It was ordered that the library of the society be deposited in the Washington Library. The herbarium was placed under the care of Dr. McWilliams, but its subsequent disposition has not been learned. The records of the society eventually found their way into a local second hand book store and were presented to the late Lester F. Ward in 1883, remaining in his possession until his death, when his library was given to Brown University. After correspondence with the librarian of Brown University, formal request was made to the Trustees of that institution by the Secretary of this Society for the return of the records to Washington, which request was granted. The proceedings of the meetings for the first few years show considerable progress in the study of the local flora and offer many interesting historical data.

The 15th annual meeting of the Botanical Society of Washington was held at the Department of Agriculture, Tuesday, October 19, 1915 at 1.30 p.m., with twenty-four members present. The report of the Executive Committee showed the following facts concerning the activities of the society for the preceding year. Average attendance of 73 members and guests. Seven members were lost during the year: one by resignation and six by change of residence. Eighteen new members were elected, making a total net membership of 143. One joint meeting was held with the Washington Academy of Sciences. Twenty-one formal scientific papers were presented and the following visiting botanists were entertained: Prof. J. C. Bose, Dr. Camillo Schneider, Dr. F. Kolpin Ravn, Dr. Otto Appel, and Dr. Gentaro Yamada.

The customary reports were presented and approved and the following officers elected for the ensuing year: *President,* Prof. A. S. Hitchcock; *vice-president,* Dr. J. W. T. Duvel; *recording secretary,* Chas. E. Chambliss; *corresponding secretary,* Mr. W. E. Safford; *treasurer,* Dr. C. E. Leighty. Dr. R. H. True was nominated as the representative of the Society upon the Board of the Washington Academy of Sciences.

Perley Spaulding, *Corresponding Secretary.*

[1] Coville, Frederick V. Early Botanical Activity in the District of Columbia. Records of the Columbia Historical Society, 5: 176–194. 1901.

The 107th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club, at 8 p.m., Tuesday, November 2, 1915. Forty-five members and six guests were present. The following papers were presented:

Relation of catalase and oxidases to respiration in plants (with lantern): Chas. O. Appleman. (To be published in full as Bulletin No. 191 of the Maryland Agricultural Experiment Station.)

The chemical mechanism of respiration in plants is very complex and imperfectly understood. Enzyme action undoubtedly plays the most important rôle. Among the enzymes which have been assigned various functions in respiration we find the oxidases and catalase, although their relation to this process is almost entirely hypothetical. Respiration in potato tubers is not only greatly accelerated by various artificial treatments, but is subject to fluctuations under natural conditions, such as greening and sprouting. The rate of respiration also varies in different parts of the same tuber and tubers of different varieties. Since these tubers also contain very active catalase and oxidase, they were chosen as specially favorable material in making a quantitative study of the relation of both catalase and oxidase activity to the intensity of respiration. The data seem to justify the following conclusions:

1. The oxidase content in potato juice gives no indication of the intensity of respiration in the tubers. In other words, there is no correlation between oxidase activity and the rate of respiration in these organs. The author does not disclaim any rôle of the demonstrable oxidases in respiration, but they certainly are not the controlling factor in regulating the rate of respiration in potato tubers.

2. Catalase activity in the potato juice shows a very striking correlation with respiratory activity in the tubers.

Some Philippine botanical problems: E. D. Merrill. (To be published in full elsewhere.)

Botanical notes of a trip to Japan: W. T. Swingle. (To be published in full elsewhere.)

The 108th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Tuesday, December 7, 1915, at 8 p.m. Thirty-two members and three guests were present. Messrs. A. T. Speare, James Johnson, H. R. Rosen, and H. C. Rose were elected to membership. The following papers were presented:

Dr. W. Ralph Jones: An appreciation: C. L. Shear.

Dr. Jones was quiet and retiring in disposition and of excellent habits. He had a great aversion to taking animal life and would not take courses in zoology involving the death of higher animals; neither would he hunt nor fish. His chief recreation and amusement were novel reading and music. He was very fond of reading good French novels in the original, and of the opera. He showed an interest in natural science early in life and as a boy began a collection of minerals and also an herbarium of flowering plants. His interests in botany were broad and his training in languages, chemistry, and physiology were such as to give a broad and substantial foundation for research. He possessed three of the fundamental requirements for success in scientific work, namely, love for truth, combined with thoroughness and accuracy. His notes, drawings, and manuscripts were models of neatness and accuracy. He had undertaken several lines of investigation in connection with blackberry, currant, and gooseberry diseases, but had practically completed only one of these. This was a study of what appears to be a new species of *Thielavia* isolated from diseased dewberry plants. It is to be deeply regretted that a man so well equipped by temperament and training for research should be cut down in the prime of life and usefulness.

Experimental study of the life duration of seeds (with lantern): WM. CROCKER. (To be published in full elsewhere.)

Notes on variations in Chinese chestnuts (specimens): P. L. RICKER. (To be published in full elsewhere.)

The 109th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Friday, January 14, 1916, at 8 p.m. Seventy members and five guests were present. Messrs. RODNEY B. HARVEY, G. MCMILLAN DARROW, and ROLAND MCKEE were elected to membership. The program consisted of the following papers:

Economic botanical exploration in China (with lantern): FRANK N. MEYER.

Mr. Meyer, an agricultural explorer of the United States Department of Agriculture, has spent nine years in China and adjoining countries studying the flora of this region and searching for plants of economic value for introduction into the United States. He found quite recently a hickory in China which has never been recorded in botanical literature. As yet no sycamores nor any papaw (*Asiminia triloba*) or leather-wood (*Dirca palustris*) have been found in China. Field work in botany in China is extremely difficult because most of the wild vegetation near densely settled parts has been exterminated. However Buddhist and Tavist priests have preserved many specimens in their temple compounds. Mr. Meyer made reference to the discovery of the wild peach in the provinces of Shansi, Shensi, and Kansu, and to the expertness of Chinese gardeners in grafting. He expressed the opinion that in this country there is great need of national arboreta and permanent botanical collections.

The recent outbreaks of white pine blister rust: PERLEY SPAULDING.

When this disease first reached this country, it was thought repeated annual inspections of the lots of diseased trees would soon result in the complete eradication of the disease. Experience since that time, together with increasing knowledge of the characteristics of the disease, show that this is not true. Apparently the only method of completely eradicating this disease in any lot of infected trees is that of total destruction of that lot. While large numbers of plantings of diseased imported trees were made in 1909, the careful inspection work done since that time by the states has kept the disease in them almost completely in control. It has become increasingly evident that our great danger lies in lots of diseased trees which were imported before 1909. These in most cases we know nothing about and of course have not been able to give them the necessary inspection. In the years 1909 to 1914, inclusive, there were 11 outbreaks of this disease, that is, cases where it escaped from the diseased pines onto neighboring currents or gooseberries. In 1915 the weather conditions were so favorable for the disease that it spread very readily and for relatively long distances. Last year 12 outbreaks occurred. These areas vary in extent from only a few currant or gooseberry bushes up to a single area of some 400 or 500 square miles. Experiments have shown that the wild currants and gooseberries of the Pacific Coast and Rocky Mountain regions are susceptible to it. In fact it may be stated that all species of currants and gooseberries, so far as they have now been tested, are susceptible. The ordinary cultivated black currant, *Ribes nigrum*, however, is far more susceptible than any other species. While it is not grown in large quantities, it is very widely scattered; enough so that the disease during the past season readily spread upon this single species for miles. The future of the white pine, which has been quite largely depended upon for the forests of the northeastern states, is very seriously threatened by this disease, unless efficient efforts are made to control it. The character of this fungus is such that the removal of all wild and cultivated currants and gooseberries from the affected areas will stop its further spread in those areas. If the cultivated black currant could be eliminated from the nursery trade, so that it would not be sold and its use could gradually be discontinued everywhere within the affected states, a great step would be taken toward the control of this disease. But more than this, state officers must have absolute power to destroy diseased pines and currant and gooseberry bushes, in order that unanimous action can be carried out within these affected areas. With this power should also be given the power to declare and enforce quarantines against shipments of stock from other states. When compared with the minute search which is required in finding gypsy and brown-tail moth nests in southern New England, the search for wild and cultivated currants and gooseberries is comparatively simple. It also is comparatively easy to carry out when compared with the climbing of trees 75 to 100 feet in height in certain sections of New England for the removal of brown-tail moths' nests, as is done every year. An efficient fight against this disease even now is not impossible, but it very shortly will be if not started at once.

Catha edulis: A narcotic of the southern Arabs (with specimens): Paul Popenoe.

The kat (Arabic *qat*) shrub is a native of Africa, but much cultivated in Yaman, where its use is increasing so that the town of Aden now consumes annually more than 2,000 camel-loads of the leaves and twigs, which are chewed for their stimulating properties. The plant contains small quantities of an alkaloid called *katrine*, which seems to resemble cocain. It has been introduced into the United States by the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, and grows well in the South. The dangers from its use have probably been much exaggerated. This plant may present commercial possibilities as the source of a new beverage to compete with tea.

W. E. SAFFORD, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 548th meeting of the Biological Society of Washington was held at the Cosmos Club on Saturday evening, January 15, 1916; called to order by President Hay, with 40 persons present.

The President noted the recent death of F. M. Webster, long a member of the Society.

Upon recommendation of the Council the following were elected to active membership: H. F. TAYLOR, Bureau of Fisheries, DOUGLAS C. MABBOTT, Biological Survey; WALLACE M. YATERS, Department of Agriculture.

Under the heading of Brief Notes and Exhibition of Specimens Mr. WM. PALMER exhibited a specimen of seahorse which actually came from near Colonial Beach, Chesapeake Bay, but which had attained much newspaper notoriety as having been caught in the Tidal Basin, D. C. He also exhibited the collector's sketch of a pipefish which had actually been captured in the Tidal Basin.

The regular program consisted of a communication by W. W. COOKE, *Notes on Labrador birds.* Mr. Cooke gave an interesting account of Mr. CLARENCE BIRDSEYE's experiences and travels in Labrador during the past four years while engaged in farming silver gray foxes for their fur, describing the difficulties under which he labored and the disastrous effect of the European War on the fur market. The speaker then gave an historical survey of Labrador ornithology from the early days of Cartwright to Mr. Birdseye's latest observations which include the extension of range of several species of birds. Mr. Cooke's paper was illustrated with lantern slide views of maps of Labrador, maps of migrations of certain birds, and views of several birds which had lately been observed for the first time in eastern Labrador. Mr. Birdseye's observation on Labrador birds will appear in full in the April *Auk.*

The paper was discussed by Messrs. WM. PALMER and ALEX. WETMORE.

M. W. LYON, JR., *Recording Secretary.*

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MINERALOGY.—*A peculiar intergrowth of phosphate and silicate minerals.* Edgar T. Wherry, National Museum.[1]

A green and white substance occurring associated with variscite in fissure veins in metamorphosed slate near Manhattan, Nevada, was recently submitted to the U. S. National Museum for identification by Mr. Percy Train of that place.[2] It appears to be of sufficient interest to justify this preliminary announcement of its character.

The material presents the form of a "sulphate" green, glassy mass, traversed by numerous sub-parallel wavy white lamellae, varying from 1 mm. down to 0.05 mm. in thickness, but at the latter size becoming too translucent to be distinguished, so that the variation may well continue to still thinner dimensions. Both minerals are practically amorphous, showing between crossed nicols only traces of weakly doubly refracting material.

A small sample of the purest green material which could be separated by hand picking was submitted to J. E. Whitfield for analysis; it was free from visible lamellae, although it may have contained indistinguishable ones. Its composition proved to be: CaO 6.30, CuO 1.25, MgO 0.80,[3] Al_2O_3 25.90, Fe_2O_3 2.14, P_2O_5 24.76, SiO_2 7.32, H_2O below 100° 21.90, above 100° 9.20, sum 99.57. These figures lead to no simple formula, but as it

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] U. S. National Museum Catalogue No. 92909.

[3] Determined by the writer on a separate sample.

seemed probable that the silica might be due to lamellae which are present but unrecognizable because of their thinness, an attempt was made to determine the composition of the white lamellar mineral. It proved impracticable to separate the lamellae from the green ground-mass with any degree of completeness, but a very small sample, containing perhaps one-third of the latter, was analyzed by the writer with the following results: CaO+CuO 9.0, MgO 0.5, $Al_2O_3+Fe_2O_3$ 23.3, P_2O_5 12.1, SiO_2 30.0, H_2O below 100° 10.4, above 100° 14.8, sum 100.1.

Although amorphous colloidal minerals like these do not necessarily possess definite formulas, it seemed worth while to attempt to determine at least their approximate nature. The known aluminium phosphate minerals fall into four divisions with reference to the ratios of the Al_2O_3 to P_2O_5, as shown in the following table:

$Al_2O_3:P_2O_5$	1 : 1	3 : 2	2 : 1	3 : 1
Formula	$AlPO_4$	$(AlOH)''_3(PO_4)_2'''$	$(AlOH)''(AlO_2H_2)'(PO_4)'''$	$(AlO_2H_2)'_3(PO_4)'''$
Excess $H_2O:Al_2O_3$				
0: 1	berlinite	trolleite	augelite	
1: 1	planerite		peganite	spherite
2: 1		ceruleolactite (and turquois)		some "richmondite"
3: 1		wavellite	fischerite	
4: 1	callainite, lucinite and variscite		some "richmondite"	evansite
5: 1		vashegyite (two varieties)		
6: 1	some "richmondite" and zepharovichite			

The ratio $Al_2O_3(+Fe_2O_3):P_2O_5$ shown in analysis 1 is 3.1: 2, so that this mineral evidently belongs to the second of these divisions. It is also very high in water, and accordingly lies toward the bottom of the table. The possibility of its identity with vashegyite must therefore be considered. The latter mineral was described by Zimányi[4] as a dense (*dicht, derb*) white, meerschaum-like substance with the (rather improbable) ratios $Al_2O_3 : P_2O_5 : H_2O = 4:3:30$, associated with a similar material with the ratios 3:2:17. It seems likely that these are really the same mineral, the apparent difference in ratios being due to the impure character of the samples analyzed. In Doelter's Handbuch der Mineralchemie this mineral is listed as amorphous,[5] but a specimen labeled vashegyite in the collection of Colonel Roebling has been found by Dr. E. S. Larsen, Jr., to be cryptocrystalline with an index of refraction of 1.480 and double refraction 0.002.[6] A comparison of the properties of the present mineral and vashegyite is given below:

	Manhattan mineral	*Vashegyite*
Color	pale green	white to yellowish
Luster	vitreous	dull
Hardness	3.5	2.5
Specific gravity	1.98	1.964
Structure	amorphous, glass-like	compact, meerschaum-like
Optical character	isotropic	anisotropic, cryptocrystalline
Index of refraction	variable, 1.48 to 1.50	1.480
Double refraction	absent	very weak, about 0.002
Ratio $Al_2O_3 : P_2O_5 : H_2O$	about 3:2:18	3:2:17 or 4:3:30
Impurities	considerable, including copper oxide, yielding the green color	very small in amount
Occurrence	associated with variscite	"In the immediate neighborhood of variscite"

The differences in optical properties can be explained as due to the vashegyite examined by Dr. Larsen being a "metacolloid," a colloid exhibiting incipient crystallization, while the Manhattan mineral is still essentially amorphous; the difference in color is attributable to the presence of copper in the latter.[7] The two minerals thus agree to a sufficient extent for them to be regarded as identical.

[4] Math. term. Ert. **27**: 64. 1909; Zeits. Kryst. Min. **47**: 53. 1909.

[5] Handbuch der Mineralchemie, **3**: 465. 1914.

[6] Private communication.

[7] The copper probably replaces either some of the $(AlOH)''$ groups or H therein.

The nature of the white lamellar mineral can not be definitely made out from the data at hand. Of the constituents found in the second analysis, all of the P_2O_5 and part of the Al_2O_3 and H_2O are undoubtedly due to the admixed green material; if this amounted to one third of the whole, then the approximate composition of the white mineral would be CaO 17, Al_2O_3 17, SiO_2 47 and H_2O 19, corresponding roughly to the ratios of these four constituents, respectively, 2: 1: 5: 7. No amorphous mineral of this composition appears to be on record, although the crystalline zeolite laubanite differs only in having slightly less water. However, the mean index of laubanite, as determined by Dr. Larsen[8] is 1.475, while that of the present mineral is higher, varying from 1.53 to 1.54, so the two must be entirely distinct. It may be noted that the mineral fuses with intumescence before the blowpipe, so that it evidently belongs to the zeolite group, but under the circumstances it would be unsafe to assign a name to it.

Although in many aluminium phosphates siliceous impurities have been found to be present, no definite intergrowth relations have heretofore been reported to exist between the two. The structure here shown is not difficult to explain, however, when the colloidal character of the materials is considered. The lamellae have the aspect of forms produced by rhythmic precipitation in gels, such as obtained in many of the experiments described by Liesegang[9] and others. In this case if, while the phosphate gel was still soft, a solution containing calcium and silica flowed over it, reaction might readily have occurred, with removal of part of the phosphoric acid and formation of a calcium aluminium silicate with the liberated alumina.

The material studied is regarded, then, as a colloidal vashegyite traversed by rhythmically precipitated laminae of a calcium aluminium silicate of probably zeolitic nature.

[8] Private communication.

[9] Geologische Diffusionen. Dresden and Leipzig, 1913.

PALEOBOTANY.—*A Lower Cretaceous flora in Colorado.* T. D. A. COCKERELL, University of Colorado.

During the past summer Mr. Terry Duce, working for the Geological Survey of Colorado, was so fortunate as to find a new locality for Mesozoic plants, with fairly abundant remains. The locality is on the high point between Cutthroat Gulch and Hovenweep Canyon, Lat. 37°, 53′ N., Long. 108°, 57′ W. The greater part of the section there exposed is assigned to the McElmo, presumed to be Jurassic. Above the McElmo black shales alternate with massive sandstone, the two combined including the uppermost 131 feet of the whole exposure, which measures some 410 feet. The plants are preserved in hard white quartzose sandstone, with occasional iron concretions, about 10 feet below the top of the section. This flora is of peculiar interest, not only for the light it throws on the age of the strata, but especially because it belongs to the period when angiospermous plants were just beginning to appear. One of the greatest puzzles in evolution is the apparently sudden arrival of the angiosperms during the Mesozoic; at first represented by few species, but presently developing a remarkable series of broad-leafed trees, including generic types apparently identical with those now living. Any plant material from the period which saw the dawn of the higher plants in North America is therefore of particular value, although we must doubtless go to some very different part of the globe to find, if they ever are found, the immediate ancestors of the Cretaceous angiosperms.[1]

At the beginning of my studies of Mr. Duce's material I sent photographs of the best specimens to Dr. A. C. Seward and Dr. Edward W. Berry, both of whom very kindly reviewed and criticised my preliminary determinations. There is in the collection only one species which can claim to be an angiosperm. Elongate-lanceolate willow-like leaves, at first rather suggesting some *Podozamites*,[2] are seen on closer inspection to have lateral

[1] For a most interesting discussion of this problem, see Weiland, G. R.: Amer. Journ. Sci. **38**: 541–460. 1914.

[2] See, Seward, A. C., Jurassic Plants from Caucasia and Turkestan: Mém. d. Comité-Géolog. (St. Petersbourg), N. S., **38**: *pl. 8, fig. 68.* 1907.

veins leaving a midrib, curving more or less, and at least toward the apex of the leaf uniting to form a series of arches. These leaves are evidently those of *Sapindopsis,* and may well belong to the species *S. variabilis* Fontaine, although the lateral veins appear to form a more acute angle with the midrib than in that species as figured by Berry.[3] Berry refers this genus with confidence to the modern family Sapindaceae, but we should like to see the reproductive parts. Is it possibly something more than a coincidence that the venation is of the same type as that of *Gnetum,* the modern broad-leafed gymnosperm?

Equisetaceous stems, the larger about 8 mm. in diameter, with about nine striae, may well represent the species *Equisetum*

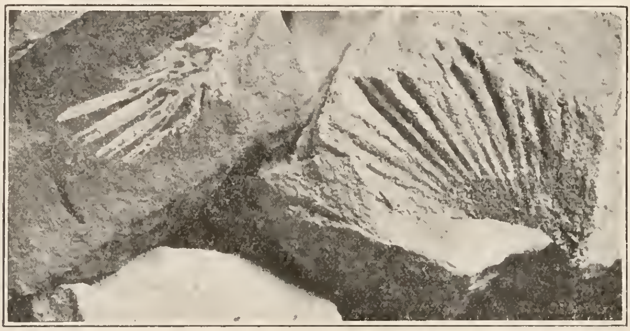

Fig. 1. *Cycadospadix* (?) sp. About natural size.

burchardti (Dunker) Brongn., but the sheaths are unfortunately wanting.

Some curious palmlike structures, certainly not palms, closely resemble *Cycadospadix.*[4] They represent possibly more than one organism, and one of the specimens, Dr. Berry notes, has some resemblance to the base of a fern such as *Matonidium;* it appears that Lignier, some years ago, actually described fern-remains of this type as a Jurassic palm.

The best preserved specimens in the collection are elongate

[3] Maryland Geol. Surv., Lower Cretaceous, *pl. 83.* 1911.

[4] Schenk, A., in Zittel, Handb. Palaeontologie, Abt. II, Palaeophytologie, 228. 1890. Also, Dr. Seward, after examining the photographs, suggests comparison with Trans. Roy. Soc. Edinburgh, **47**: 699, *pl. 7, fig. 18.* 1911.

pinnae which I refer with confidence to *Matonidium althausii* (Dunker) Ward. Although the sori, from the nature of the sandstone matrix, are poorly preserved, the structure appears to agree exactly with this species, especially as figured by Seward.[5] Dr. Seward, also, after examining the photographs, states that he has little doubt that the specimens belong to *Matonidium.* This plant is a fern of peculiar interest, as it appears to be the ancestor of the isolated modern genus *Matonia,* found in Borneo and the Malay peninsula. *Matonidium althausii* is a well-known European fossil, but the Colorado specimens present no differences that can be seen.

Fig. 2. *Matonidium althausii* (Dunker) Ward. About natural size.

The collection also contains some ferns which agree very well with *Todites,* so far as appearances go, but there are no sori, and exact determination is not possible. Some specimens could belong to *Weichselia,* or even better, as Dr. Berry suggests, to *Cladophlebis.* One fragment appears to agree exactly with *Onychiopsis.*

Searching for a corresponding flora in the records, we find the nearest approach in the Fuson formation of the Black Hills, from which 26 species have been recorded by Ward and Fontaine.[6] The Fuson list contains *Matonidium althausii, Sapindopsis variabilis, Equisetum burchardti, Cladophlebis,* and *Weichselia.* According to Berry this is approximately contemporaneous with the Patapsco of Maryland and Virginia; which, however, contains a much greater variety of angiosperms. The Fuson list includes, in addition to *Sapindopsis,* fragments referred to *Ulmiphyllum, Quercophyllum,* and *Ficophyllum.* Berry notes

[5] Jurassic Flora. I. The Yorkshire Coast, 76. *fig.* 7A. 1900.

[6] U. S. Geol. Surv., 19th Ann. Rept., pt. 2. 1899.

that the first of these is really a fern, and that the last is at any rate not a true *Ficophyllum*. The *Quercophyllum* could possibly be *Dictyophyllum*, a fern. Thus the angiospermous flora of the Fuson is not beyond suspicion, and apparently the beds may be regarded as somewhat older than the Patapsco. It would be possible to regard the Colorado material as contemporaneous with the Fuson, or somewhat older, but apparently younger than the Kootanie.

A note may be added concerning *Weichselia reticulata* (Stokes & Webb) Ward, reported from the Fuson. Seward[7] gives a detailed drawing of the venation of a specimen from Bernissart, Belgium, and it must be said that this is rather strikingly different from the venation of the pinnules of the Black Hills plant, as shown in Ward's report. It may be, therefore, that our Lower Cretaceous plant is a distinct species. Seward remarks on the absence of fructification in specimens of *Weichselia*, and suggests that it may not be a true fern, but Zeiller,[8] recording specimens from Peru, states that he found fertile fronds, and that the plant is really a fern, perhaps a member of the Marattiaceae.

BOTANY.—*Inophloeum, a new genus of the mulberry family.* HENRY PITTIER, Bureau of Plant Industry.

Under the name *Olmedia? armata* Miquel described briefly in 1854 a remarkable moraceous tree, a meager specimen of which was collected by Seemann on the Cupica River in the Colombian Darien. That he remained in doubt as to the proper place of the species is shown by the question mark following the generic name and by the following remark preceding the description: "Valdopere dolendum, stirpem admodum memorabilem ex unico parvulo ramulo vix certe definiendam nec apte describendam esse."[1]

In the course of the botanical survey of Panama I have collected specimens of the same tree at several places in the forests to the east of the Canal, and from a specimen of the bark in the

[7] Fossil Plants, 2: 495. 1910.

[8] Compt. Rend., Acad. Sci. (Paris), June 6, 1910.

[1] In Seemann, Bot. Voy. Herald, 196.

Museum of the National Institute at Panama City it may be inferred that its area extends to the westward as far as the Coclé Mountains, on the Atlantic water-shed.[2]

Unfortunately, though the material now at hand is more copious, it hardly throws more light on the systematic position of the tree under consideration, because, notwithstanding strenuous efforts, I have been unable to obtain specimens of the male inflorescences. It is obvious, however, that this species cannot continue figuring under *Olmedia*, which is characterized by having its female flowers single in a many-bracteate, more or less loose involucre, while in the former these are in clusters of 4 or more, connate, and with the receptacle bractless, or the bracts coalescent so as to be singled out only with difficulty, except for an occasional free tip. The next possible genus would be *Castilla*, which, however, differs in having the many-flowered, cuplike receptacles provided with several rows of imbricate bractlets, and in the pulpous mesocarp of the nutlets.

The aculeate limbs, bracts, petioles, and main nerves of the leaves and the habit of the tree are secondary characters which may be of some weight in justifying the recognition of this species under a new generic name, *Inophloeum*, which I have selected on account of the thick, fibrous bast, to which further reference will be made later.

Following are the characters of the proposed genus and a description of its only species:

Inophloeum Pittier, gen. nov.

Flores dioici. Masc. ignoti. Fem.: Receptaculum pauciflorum obsolete bracteatum, vel bracteae confertim coalescentes. Perianthia crassa, tubulosa basi inter se connata, apice libera, 4-dentata. Ovarium semiinferum uniloculare, ovulo unico ex apice cavitatis pendulo anatropo. Stylus brevis, crassus, inclusus, stigmatibus 2 brevibus angustis acutis. Nucula perigonio concrescente coriaceo obtecta.—Arbor armata, foliis distichis 3-nerviis integerrimis, stipulis amplexicaulibus aculeatis, inflorescentiis axillaribus, receptaculis parvis cum perianthiis concrescentibus. Species unica panamensis.

[2] If I remember correctly, the specimen, consisting of a large piece of bark made into a garment, is labelled: "Vestido de un Indio de Penonomé, hecho de la corteza de una palmera," which, translated, means: "Clothing of a Penonomé Indian, made *from the bark of a palm*." This label had been written by a Dr (?) Marquis, professor of botany and author of an extensive and extraordinary paper on the palms of Panama!

Inophloeum armatum (Miquel) Pittier.

Olmedia ? armata Miquel in Seemann, Bot. Voy. Herald, 196. 1854.

Arbor mediocris, ramulis, petiolis, costa foliorum subtus, stipulisque aculeatis, foliis distichis, coriaceis, petiolo crasso subtereto laminis lato-ovatis, obliquis, basi rotundatis vel subcuneatis apice obtusiusculo-apiculatis, glabris, utrinque 7–8-costatis, costis subtus prominentibus, stipulis convolutis, subspathaceis, cicatricem obliquam circularem reliquens; receptaculis foemineis axillaribus, 3–7-floribus, perianthio ovoideo-tubuloso, coriaceo, stylo incluso, stigmatibus linearibus, erectis, contiguis, fere adnatis. Bacca coriacea, et caetera ignota.

Arbor 10–20 metralis, trunco erecto, cortice crasso, sublaevi. Aculei conici, basi crassi, apice acuto, hyalino, ampulliformi, circa 3 mm. longo. Petioli 1.5–2.5 cm. longi; laminae 14–40 cm. longae, 11–25 cm. latae. Stipulae 2–2.5 cm. longae. Perianthium foemineum ca. 6 mm. longum.

PANAMA: Around Dos Bocas, Fató Valley, province of Colón, in forests, female flowers, August 16, 1911, *Pittier* 4202. Alhajuela, on the shady banks of the Chagres River, leaves only, May 25, 1911, *Pittier* 3731. Lake shore in the Gatún Valley, in forest, May, 1914, *Pittier*, without number. Around Pinogana, southern Darien, April, 1914, *Pittier*, without number.

Miquel mentions white, setulose hairs mixed with the aculei of the stipules and bracts. In our specimens such hairs, when extant, are so scarce and inconspicuous as not to be worth mention. The larger dimensions of the leaves are those given by the same author; in our specimens they are not over 25 cm. long and 18 cm. broad.

The liber of this tree is very thick and the fibers of its many layers are strong and crossed. After a convenient preparation, which consists mainly of soaking in running water for several days and a thorough beating with a wooden club to separate the outer cortical part, it is used by the Chocó, Cuná, and Guaymí Indians as the usual covering of the women, as well as for small hammocks, blankets, etc. In former times, as reported by Seemann,[3] the larger pieces were made into sails for the native canoes. This use of the bark of *Inophloeum*, however, is not exclusive, others being similarly applied. For instance, it is said that in Costa Rica and Panama species of *Brosimum* and *Castilla* are treated in the same way for identical purposes, while in other parts the bark of *Ficus* species is preferred.

The known natives names of *Inophloeum armatum* are *namagua* in the Cupica district of the Colombian province of Chocó, *maragua* in Darien, and *cocuá* in the negro villages on the Atlantic coast, close to the territory of the San Blas Indians.

[3] Bot. Voy. Herald, 196.

ZOOLOGY.—*Seven new genera of echinoderms.*[1] AUSTIN H. CLARK, National Museum.

The past ten years has witnessed an activity in the study of the echinoderms far surpassing that of any previous decade. In every class important and comprehensive memoirs, many of them monographic in scope, have been published which include more or less complete revisions of genera, of families, and of higher groups. Little by little the former wide differences of opinion in regard to the internal systematic arrangement in each class have disappeared, and today such diversity as exists chiefly relates to the refinement of generic limits and the allocation of a few anomalous types.

Along these lines there is still much work remaining to be done, and it is in the hope of throwing additional light on certain obscure points that I am calling attention to the following four crinoid and three starfish types which appear to me to be well worthy of generic rank.

Comatonia, new genus

Genotype.—*Actinometra cristata* (P. H. Carpenter, MS.) Hartlaub, 1912.

A genus of Capillasterinae (Comasteridae) in which the size is small; there are 10 arms only; the cirri are not excessively slender; there are no carinate processes on the basal segments of the proximal pinnules; terminal combs occur only on the pinnules of the first pair (P_1 and P_2), from one or both of which they may be absent; the combs usually arise about, or within, the proximal third of the pinnule, and are composed of exceptionally large rounded teeth which usually much exceed in height the lateral diameter of the segments which bear them; the fourth-seventh brachials bear prominent spinous median knobs or keels; usually one or more of the earlier segments of P_1 are twice as long as broad, or even longer.

The only species of this genus, *Comatonia cristata* (Hartlaub), ranges from North Carolina to Key West, Florida, in from 7½ to 132 fathoms.

Austrometra, new genus

Genotype.—*Oligometra thetidis* H. L. Clark, 1909.

This new genus of Colobometridae is most closely related to *Analcidometra*, with which it agrees in possessing expanded genital pinnules, a character not known elsewhere in the family. Both *Austrometra*

[1] Published with the permission of the Secretary of the Smithsonian Institution.

and *Analcidometra* are related to *Oligometrides* more closely than to any other type.

The third-fifth segments of the genital pinnules are more or less expanded to protect the genital glands; there is a single median transverse ridge of moderate height on the cirrus segments; P_1, though longer and stouter than P_2, is not exceptionally so.

Austrometra thetidis (H. L. Clark), the only species of the genus, occurs off the coast of New South Wales in 55 to 56 fathoms.

Cotylometra, new genus

Genotype.—*Oligometra gracilicirra* A. H. Clark, 1908.

This genus of Colobometridae in general resembles *Oligometra;* but there are 30 or more cirrus segments of which only the basal bear transverse ridges, these after the proximal fourth of the cirrus transforming into very long dorsal spines, and P_2 has at most 12 segments instead of at least 15.

The single species of this genus, *Cotylometra gracilicirra* (A. H. Clark), ranges from the Andaman Islands to the Malay Archipelago and the Philippine Islands in from 44 to 49 fathoms.

Daidalometra, new genus

Genotype.—*Antedon hana* A. H. Clark, 1907.

A genus of Thalassometrinae (Thalassometridae) in which the centrodorsal is small, low, hemispherical or thick discoidal, the broad dorsal pole beset with irregular rather long spines, the sides bearing 10 closely approximated columns of cirrus sockets of from one to three (usually two) each; the cirri are XII–XX, 51–75, slender, from about one-half to three-fourths as long as the arms; the longer proximal segments are usually about three times as long as broad; the basal three or four segments bear dorsally a fine median carination ending distally in a small but prominent spine; the disk is moderately plated; the division series and arms in general are as in *Stenometra*, but the arms are only from 10 to 12 in number, and the earlier brachials have only a faint low median keel; the pinnules are as in *Stenometra*.

Of the two species referable to this genus, one, *Daidalometra hana* (A. H. Clark), occurs off southwestern Japan in between 107 and 139 fathoms; the other, *Daidalometra acuta* (A. H. Clark), was dredged south of Timor in 40 fathoms.

Mariaster, new genus

Genotype.—*Johannaster giganteus* Goto, 1914.

This new genus belongs to the subfamily Goniasterinae of the family Goniasteridae.

The general form is stellato-pentagonal, with greatly produced, narrow, evenly tapering rays which are somewhat more than two and one half times as long as the distance from their base to the center of the disk. The size is very large, up to R = 338 mm., r = 87 mm.; R: r = 3.9 to 4.8: 1.

The abactinal plates are very numerous, irregularly polygonal, largest in the radiating papular areas and along the center of the arms, diminishing in size slightly toward the center of the abactinal surface and very markedly toward the superomarginals bordering the disk and the proximal third of the arms; on the outer two thirds of the arms the abactinal plates are subequal, irregularly polygonal; an irregular carinal row of plates is sometimes traceable from the outer half of the disk along the arms.

The madreporic plate, which is large, conspicuous, and polygonal, is situated near the center of the abactinal surface and is covered with very fine striae which radiate from the center.

The abactinal plates are uniformly covered with crowded granules, which are much finer than those on the actinal intermediate plates.

The papulae are segregated in conspicuous petaloid areas which extend from a central papular region and radiate onto the arms, reaching nearly to the middle of the latter.

Many of the plates in the papular areas bear small pedicellariae, of which there may be as many as three or four on the larger plates; the plates of the interradial areas also bear pedicellariae, though here they are much less numerous.

The superomarginals increase gradually both in length and in breadth from the center of the interbrachial arc to the arm bases; in the interbrachial arc they are confined to the side wall of the body and overhang the inferomarginals; on the arm bases they become more recumbent, so that a greater part of their breadth (about two thirds) lies on the dorsal surface. Pedicellariae, sometimes three or four to a plate, occur in the interbrachial arcs, but they gradually become less frequent and are rare in the distal half of the arms.

The inferomarginals increase in length, but decrease in breadth, from the center of the interbrachial arc to the arm bases. In the interbrachial arc they lie well within the actinal surface, the margin of the body being delimited by the superomarginals; on the arms both superomarginals and inferomarginals reach the same vertical plane. The inferomarginals are slightly shorter than the superomarginals; in the center of the interbrachial arc the two series correspond, but from the arm bases outward the former alternate more or less with the latter. The inferomarginals bear pedicellariae similar to those on the superomarginals, mostly situated near the intermarginal suture.

Both superomarginals and inferomarginals are somewhat tumid, and both are covered with small closely packed hemispherical granules.

The actinal intermediate plates are very numerous and decrease in size from the adambulacral series toward the center of the interbrachial arc; those adjoining the adambulacrals are relatively large and regular in arrangement; within these there is a more or less regular second row which may be traced for about half of the distance to the arm bases; but within and beyond these the plates are small, irregularly polygonal, and with no obvious arrangement. All of the actinal intermediate plates are slightly tumid and are uniformly covered with crowded granules; many bear pedicellariae, of which those on the plates adjoining the adambulacrals are conspicuously larger than the others; a plate in this series may bear as many as four pedicellariae. At the oral angle of the interradial area there is usually a large odd plate which may bear as many as six pedicellariae.

The adambulacral plates are about as long as broad, becoming proportionately longer distally; the furrow border is angular; the furrow series consists of from 10 to 15 flattened spines, the outer flattened parallel with, the inner transverse to, the furrow; within these there is a bare area, followed by a row of from four to five prominent stout spines, beyond which are numerous tubercles decreasing in size toward the outer edge of the plate. Most of the adambulacral plates bear one, proximally often two, large high pedicellariae on the inner part near the proximal border.

The mouth plates are small; each of them bears from 12 to 15 very stout flattened spines along the furrow, and a half dozen or more short spines, either forming a single row along the suture line, or more irregularly arranged, on the actinal surface.

Mariaster differs markedly from *Johannaster* in the lack of regularity in the arrangement of the actinal intermediate plates, in the absence of spines on the same plates, and in several other important features. It agrees more nearly with *Lydiaster* and *Circeaster* (especially the former), showing its relationship in the character and arrangement of the actinal intermediate plates, in the character of the armament of the adambulacral plates, in the character and distribution of the pedicellariae, in the form and size of the madreporite, and in other ways; it differs most strikingly from these genera in having narrower and longer arms on which the abactinal plates are not conspicuously larger than those of the disk.

The single species referable to this genus, *Mariaster giganteus* (Goto), is known only from near Misaki, Sagami Bay, Japan, in from 160 to 1120 meters. Five specimens in all are known to have been collected, four of which are in the museum of the Science College at Tokyo.

Pseudonepanthia, new genus

Genotype.—*Pseudonepanthia Gotoi*, new species.

The characters of this new genus, which appears to be referable to the family Asterinidae and the subfamily Asterininae, are included in those of the type species, the description of which follows:

Pseudonepanthia Gotoi, new species

Eight arms; R = 72 mm.; r = 11 mm.; R : r = 6.5 : 1; inferomarginals 111.

The rays are very long and narrow, almost circular in cross section, evenly tapering to the tip; only three are of full size, the remainder being very small; two of the very small rays alternate between the three of full size; the other three are side by side between two of the later.

The gonads extend to the ninth superomarginal.

The interbrachial septum is very deep, extending from the stomach to the lateral interradial body wall, and is membranous except for a broad centrally situated pillar composed of large overlapping plates.

Prominent superambulacral plates are present.

The pedicels are in two rows; they carry large sucking disks and are connected internally with double ampullae.

The plates of the abactinal surface are very numerous, greatly reduced in size, narrow, crescentic with swollen and rounded ends, imbricating outward in the median line and perpendicularly to the mid-radial line elsewhere. Three parallel rows of larger plates occupy the mid-dorsal line of the arms; from the outer of these on either side the smaller plates extend in regular diagonal rows to the superomarginals, in such a manner that the diagonal rows arising at any one point in the median line run both distally and proximally at the same angle with the superomarginals, while the plates of the succeeding rows also form straight and regular transverse rows between, and perpendicular to, the mid-dorsal rows and the superomarginals with which, however, they do not quite coincide.

Externally the lateral plates appear as crescents regularly decreasing in size from the dorsal region to the margin, each crescent partially surrounding a single large papula situated in its concavity, on its abactinal side; the plates of the median rows, while commonly crescentic with the concavity proximal, may be triangular or irregular in shape. The plates of the disk are irregular; most of them are of about the same size as the median plates of the arms, but they become smaller about the anal opening.

To the naked eye the appearance of the abactinal skeleton is somewhat similar to that in such species of *Henricia* as *H. leviuscula*, though the arrangement of the plates is much more regular.

The surface of the abactinal plates is thickly beset with numerous fine spines, of which the larger may bear from 20 to 25. In the proximal third to half these spines are stout, rounded-conical, with a dull surface, but the distal portion is glassy and transparent, in lateral view increasing in diameter at first slowly, later more rapidly, to the coarsely serrate tip, so that they appear narrowly fan-shaped; in end view they are seen to consist of three very delicate glassy calcareous laminae united by their inner edges.

The papulae are large and conspicuous, decreasing in size from the mid-dorsal region of the arms to the superomarginals; they are arranged in very regular diagonal, and also transverse, rows. They are absent from the region between the central portion of the disk and patches at the base of the arms, and from a region including the actinal half of each interbrachial angle and extending thence in a long triangle to about the eighteenth inferomarginal. On the arms there is one papula in the concavity of each of the crescentic abactinal plates, except in the mid-dorsal line, where some plates may be without them, and at the end of the arms, where they occur in a single line on either side of the median line, and a quadruple, later triple and double, line just above the superomarginals. The tip of the arm is entirely without papulae. On the disk papulae occur one to a plate in a more or less triangular area within each arm base; scattered papulae occur in the center of the disk.

In the proximal three-fourths of the arm the superomarginals correspond with the inferomarginals, and are of about the same size; in the distal fourth of the arm they become irregular in position and indistinguishable from the abactinal plates; at first they are narrow and transversely oblong, becoming triangular after the fourteenth. Their armature is the same as that of the abactinal plates, from which they are distinguishable only by their shape.

The inferomarginals, 111 in number, are at first longitudinally oblong, becoming squarish at the middle of the arm, and transversely oblong distally; their armature resembles that of the superomarginals.

The actinal intermediate areas are narrow; the plates are arranged in rows parallel to the furrows; one row reaches to the distal fourth of the arm, or possibly beyond; a second reaches the 25th inferomarginal; the third reaches the twelfth inferomarginal; the fourth extends to the seventh superomarginal; and the fifth to the fifth; beyond the fifth row there are a few additional plates. The armature consists of from 7 to 16 (usually about 12) well spaced sacculate spines with fluted and spinous sides, ending in a tuft of spinelets. On the arms the spines on the actinal intermediate plates resemble those on the abactinal plates rather than those on the interradial regions of the disk (just described), but are larger and longer.

The armature of the adambulacral plates consists of four or five long furrow spines, the inner very slightly the longer, set in a slightly curved comb; beyond these there is a row of four or five spines resembling those on the actinal intermediate plates, but somewhat longer and stouter; this row is rather more strongly curved than the furrow series and is placed diagonally, so that the proximal end is farther from the groove than the distal; this obliquity decreases distally and is not noticeable in the outer two thirds or half of the arm; beyond this second row there are a few additional shorter spines, not distinguishable from those on the adjacent actinal intermediate plates.

The mouth plates are small, bearing on the furrow margin five long flattened spines decreasing in length and stoutness outwardly; these spines are finely fluted, with saw teeth on the ridges; within this furrow series is a second series of five similar but shorter spines; the remainder of the surface of the mouth plates bears four or five spaced spines similar to those on the actinal intermediate plates.

Color in alcohol dark reddish brown.

Type.—Cat. No. 36899, U. S. N. M., from "Albatross" Station 3746, Sagami Bay, Japan, in 49 fathoms.

Glabraster, new genus

Genotype.—*Porania magellanica* Studer, 1876.

This new genus is referable to the family Echinasteridae. The whole animal in enclosed in a thick skin which entirely conceals the plates and all but the tips of the spines; this investment carries minute scattered spicules.

The ampullae are single.

The gonads are attached to the dorsal wall on either side of the interbrachial septum.

The interbrachial septum is complete and rather large, though entirely membranous; it is crossed in the middle, in a line more or less parallel to its curved inner border, by a narrow band of elongate calcareous ossicles placed end to end and not always touching, which actinally curves inward and runs adorally to the mouth plates. This band is more or less interrupted and may be present only in part.

The first ambulacral ossicle is much larger than those succeeding and is widely forked in its proximal half.

The abactinal skeleton is very wide-meshed, reticulate, formed of very narrow elongate overlapping plates with usually pentalobate spiniferous plates at the more important nodes.

There is a central pentalobate plate, the lobes being radial in position, which bears a prominent conical spine; in each interradius about one third of the distance between the central plate and the marginals there is a similar spiniferous pentalobate plate; these five spiniferous pentalobate plates about the central abactinal plate are connected by narrow lines of plates, and from the middle of each of these lines a similar line (radial in position) runs to the central plate; also from each of these five interradial lobate plates lines of plates run out on either side parallel to the interbrachial margin, those from adjacent plates uniting at an obtuse angle in the mid-radial line, so that five triangles which are about twice as wide as high are formed, of which the lines directly connecting the interradial pentalobate plates are the bases. From the apex of each of these triangles, which is marked by a pentalobate plate bearing a small spine, a more or less irregular series of from four to seven similar spiniferous lobate plates runs down the mid-dorsal line of each arm; these plates are connected in the mid-dorsal line by low elongate plates. From the large spiniferous lobate plates in each interradius a double series consisting of five pairs of elongate plates runs to the marginals; the second pair beyond the lobate plate consists of plates with the adcentral ends broadened, and from these there runs to the proximal mid-radial lobate plate at the arm base a series of narrow plates; from a point midway on this series to the arm tips there is a very irregular interrupted series of similar but smaller plates, from which lines of plates run to each superomarginal and to each node in the mid-radial line.

Within the wide meshes between the very narrow lines of plates are large papular areas, the integument of which is abundantly dotted with calcareous granules.

The anal opening, which is large and surrounded with short spines, lies near the apical spiniferous plate.

The madreporite is a separate skeletal element lying between the plates of the first pair below the large lobate plate at the base of the interradial area.

The superomarginals are trilobed and strongly imbricating; in the proximal two thirds of the arm the imbrication is toward the center of the interbrachial arc, in the distal two thirds it is toward the arm tips; a quadrilobate plate imbricating both ways marks the transition.

Except for slightly greater size the inferomarginals are not different from the plates forming the outermost row of the actinal intermediate series, just within them; they are much broader than long in the interbrachial arc, but increase in length outwardly; their imbrication which is slight, is outward. Each inferomarginal bears a prominent flattened spine with a truncated gouge-shaped tip, except for the three or four in the center of the interbrachial arc which bear two similar but smaller spines.

The actinal intermediate plates are elongate, imbricating adcentrally, arranged in regular bands between the inferomarginals and the adambulacrals which correspond to the former but not to the latter. The plates composing these lines form about five regular transverse rows. The row adjoining the inferomarginals has an additional plate in the center. There are no actinal papulae.

The adambulacral plates have a prominent, slender, sharp-pointed spine deep in the furrow, and a much longer and stouter chisel-shaped spine with a truncated gouge-shaped tip on the inner border of the actinal surface; in the terminal portion of the arm there are two of these latter to each plate instead of one.

The mouth plates bear two long flattened spines distally, which increase in diameter to the truncated tip, and a similar spine at the border of the first adambulacrals.

Glabraster magellanica (Studer) is confined to the Magellanic region, occurring in the Straits of Magellan and along the shores of Patagonia from the shore line down to 45 fathoms; *Glabraster antarctica* (E. A. Smith), the only other species of the genus, is known from Kerguelen, Marion Island, Prince Edward Island, the Crozet Islands, and South Georgia, in from 50 to 1600 fathoms.

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WETMORE, A. *A peculiarity in the growth of the tail feathers of the giant hornbill* (Rhinoplax vigil). Proceedings of the U. S. National Museum, **47**: 497–500. October 24, 1914.

WETMORE, A. *Mortality among waterfowl around Great Salt Lake, Utah.* Bulletin of the U. S. Department of Agriculture, No. 217. Pp. 1–10, pls. 1–3. May 26, 1915.

WETMORE, A. *An anatomical note on the genus* Chordeiles *Swainson.* Proceedings of the Biological Society of Washington, **28**: 174–176, fig. 4. November 29, 1915. (Notes the presence of a small gall bladder in this genus, contrary to published records.—C. W. R.)

WILLIAMS, R. W. *Notes on the birds of Leon County, Florida,—third supplement.* Auk, **31**: 494-498. October, 1914. (Notes on 10 species not previously recorded, with additional data on other species.—C. W. R.)

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 763d meeting was held on November 27, 1915, at the Cosmos Club. President Eichelberger in the chair, 42 persons present. The minutes of the 762d meeting were read in abstract and approved.

Mr. E. D. Tillyer presented a paper entitled *A spectrograph for photographing Etalon rings.* A systematic determination of the wave-lengths of a spectrum such as the iron arc by means of the Etalon interference rings requires a spectrograph giving sharp definition along the spectrum lines and not necessarily sharply defined lines. The spectrograph described was intended to be used in the ultra-violet region from about 0.220 μ to 0.320 μ and it was desired to obtain the best possible definition through this region. A true flattening of the field being impossible because of the absence of necessary materials it was decided to use only quartz and rock salt in the optical system and to so proportion the relative powers as to produce a flat though inclined field when used with a 60° rock-salt prism. After setting up the optical equations a solution was obtained which gave the necessary flatness of field when the collimator was an ordinary quartz-rock-salt objective achromatised to reunite $\lambda = 0.220\ \mu$ to $\lambda = 0.320\ \mu$ and the camera lens was composed of two quartz lenses close together and having almost normal field curvatures. The maximum curvature in the hundred millimeters of field is less than a millimeter and could have been further reduced except for the uncertainty of the indices of the materials in the ultra-violet region. In practice this spectrograph will give fairly good definition throughout the visible spectrum by a change of adjustment as well as in the region for which it was designed.

Mr. H. E. Merwin then spoke on *Linear interpolation of wave-lengths in spectrograms.* That the curve for the spacing of lines on a spectrogram is of the same form as a dispersion curve is shown thus: Let i = angle of incidence on prism, Δ = angle of prism, n = refractive index of prism, β = angle between photographic plate and normal to back face of prism, d = distance from line on plate to normal to face of prism; A, B, etc., are constants. Then $d = (A/\sin\beta)\ (\sqrt{n^2 - \sin^2 i} - \sin i . \cot\Delta)$, or, approximately, $d = A\ (Bn - C)$ or $A\ (Dn^2 = F)$ or $d = (Gn-H)$ or $(Kn^2 - L)$. But the dispersion formula is $n^2 = a + \frac{b}{\lambda^2 - c} - d\lambda.^2$

Then $d = M+N\left(\frac{b}{\lambda^2-c}-d\lambda^2\right)$. A table of the complex factor, call it n', is easily computed from Barlow's Tables of Squares and Reciprocals if b, c, and d are taken equal to 0.01, as they are approximately for quartz. But the same table of values of n' will fit values of λ increased or decreased by as much as 30 $\mu\mu$, which is ample to allow three comparison wave-lengths in a spectrogram to be brought into coincidence with the curve. Other wave-lengths are then interpolated by $d = M + Nn.'$ The paper was discussed by Mr. Burgess.

Mr. P. D. Merica then presented an illustrated paper on *Some metallographic methods.* The term metallography connotes in its general sense the study of the structures of metallic substances and the properties of these substances as related to structure; it has often been confused with the microscopic study of metallic substances, which is really only one phase of metallography. Slides were shown to illustrate the crystalline structure and growth of metals and alloys. Defective materials are often to be detected by microscopic examination, such as, for example, the presence of slag or oxide, the application of improper heat treatment, etc. The method of thermal analysis is used to determine the melting points and transformation temperatures of metals and alloys; it has been used to detect the presence of impurities in metallic tin, for example, the presence of 0.3 to 0.5 per cent of zinc. Initial stresses are found in most metallic materials, due to unequal rate of cooling or working; it has been shown that these are often responsible for failures of materials, for example, in the case of brass rods and tubes. A method for determining structural identity or difference according to Hanemann was described. The theories of plastic deformation of metals were discussed and evidence described bearing upon these theories. In conclusion a plea was made for a fuller description of metallic materials used in determinations of constants. The paper was discussed by Messrs. White and Tillyer with reference to methods of getting wire of certain properties for thermo-elements.

The 764th regular meeting and 45th annual meeting of the Society was held at the Cosmos Club, December 11, 1915. Vice-President Briggs in the chair; 33 persons present. The minutes of the 44th Annual Meeting were read.

The report of the Secretaries was read by Mr. Fleming, showing an active membership of 149. Sixteen regular meetings have been held. The report was ordered accepted. The Treasurer's report through December 9, 1915, was read by Mr. Sosman. The total receipts for the year were $1075.09; total expenditures, $1420.09, including purchase of bond of par value $500; total investments, $12,000; cash in hand, $109.72. The report of the Auditing Committee consisting of Messrs. Kimball, Ferner, and Wallis was read by Mr. Kimball. This Committee reported the statements in the Treasurer's report to be correct. The report was ordered accepted and to be filed with that of the Treasurer. The Treasurer's report was ordered accepted.

The following officers were duly elected for the ensuing year:
President: L. J. Briggs.
Vice-Presidents: E. Buckingham, G. K. Burgess, W. J. Humphreys, and William Bowie.
Treasurer: R. B. Sosman.
Secretaries: J. A. Fleming and P. G. Agnew.
General Committee: H. L. Curtis, N. E. Dorsey, R. L. Faris, E. G. Fischer, D. L. Hazard, R. A. Harris, W. F. G. Swann, W. P. White, and F. E. Wright.

It was moved and carried unanimously that this meeting recommend to the General Committee that Messrs. Dall and Abbe, both charter members of the Society, be made honorary life members, and be exempt from payment of further dues.

Jno. A. Fleming, *Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 490th meeting of the Society, held November 2, 1915, in the Public Library, Dr. Walter Hough, of the National Museum, spoke on *Progress in Anthropology in California.* He first discussed the problems connected with the populating of California by the Indians, giving a general view of the geographical obstacles and the avenues to the north and south by which migrants entered. The conditions as to food, water, and means of transportation were shown to have greatly influenced the condition and direction of the migrations. A brief review was given of the numerous stocks of Indians in California and attention was called to the similarity, as regards the large number of tribes present, to the Mexican Gulf area studied by Dr. J. R. Swanton. The Pacific Coast was described as a vast ethnic enclave, a veritable swarming place of tribes, whose origin, antecedents, and development in most instances perplex the ethnologist. California presents a most interesting field of study to anthropologists. Californian historians are alive to the value of these studies as a groundwork for history, and the speaker mentioned the work of H. H. Bancroft, Charles F. Lummis, Robert E. Cowan, and others who have contributed valuable work.

Progress in museum display of anthropological material was noted and the great collections in San Francisco and Los Angeles described. The speaker found evidence of the increasing growth of civic pride in sustaining the work and adding to the effectiveness of museums. It was said also that the University of California is a force for anthropological science in California, and the intelligent patronage of Mrs. Phoebe A. Hearst in this direction was praised since she had made possible the important researches of Dr. A. L. Kroeber and others and the enriching of a great museum through exploration. An account was given of the work in the more than 400 shell mounds of San Francisco Bay carried on by Gieford, Nelson, and Waterman and of the explorations among the Indian tribes.

The two great expositions which California has successfully carried on this year are of great importance to anthropology, especially that at San Diego, where this subject was preeminent, the San Francisco Exposition being mainly devoted to modern progress. The anthropological exhibit of the former was prepared by Prof. W. H. Holmes, Dr. Aleš Hrdlička and others of the United States National Museum in cooperation with Dr. E. L. Hewett, and furnished a superb contribution to the study of man. The speaker said in closing that there is being built up on the West Coast a people of general culture who are appreciative and receptive of the researches of science. It augurs well for the science of anthropology here that it has an alert public which aids in the extension of its activities—a public that demands it and can assimilate its results.

At the 491st meeting of the Society, held in the Public Library, December 7, 1915, Francis LaFlesche, of the Bureau of American Ethnology, read a paper entitled *Right and left in Osage rites.* The Osage, at the formative period of their tribal organization, had arrived at the idea that all life proceeded from the united fructifying powers of two great forces, namely, the sky and the earth They also perceived in these two forces an inseparable unity by which was made possible the continuity of the life proceeding from them. It was upon these conceptions that they founded their complex gentile organization. They first divided the people into two great divisions, one of which they called *Tsi-zhu* (household), symbolically representing the sky, and the other, *Ho^{n}-ga* (sacred), representing the earth. These two great symbolic divisions they brought together to form one body which they likened to a living man. He stood facing the east, the left side of his body, the Tsi-zhu division, being to the north, and the right side of his body, the Ho^{n}-ga, being to the south.

When a war party including men of both the great tribal divisions was being organized. the people pulled down their wigwams and reset them in a ceremonial order, which was in two squares, with a dividing avenue running east and west. In this arrangement the position of the symbolic man was changed so that he faced the west; consequently the right side of his body, the Ho^{n}-ga division, was at the north, and the Tsi-zhu divisions, at the south. All the ceremonial movements were made in reference to the right and left sides of the symbolic man, as was also the placing of the symbolic articles used in the ceremonies. The portable shrine has a right and a left side. When the ceremonies of the tribal war rites were being performed, the shrine was put in its place so that the left was toward the Tsi-zhu and the right toward the Ho^{n}-ga. When a man was initiated into the mysteries of the war rites, the shrine of his gens was temporarily transferred to his keeping. If he belonged to the Ho^{n}-ga division he hung the sacred article at the right side of his door when viewed from within; if he belonged to the Tsi-zhu division, he hung it at the left of his door. A woman for whom a sacred burden-strap had been ceremonially made hung the sacred article at the right side of her door if she belonged to the Ho^{n}-ga division, at the left side if she belonged to the Tsi-zhu division. The observance of right and left pertained to many details connected with the tribal ceremonies and appeared in the daily customs of the people.

The paper was discussed by Miss ALICE C. FLETCHER and Messrs. HODGE, SWANTON, FEWKES, MOONEY, and MICHELSON, among others. Similar dualistic concepts regarding right and left or earth and sky as determining social relationships and fundamental modes of conduct were reported as found in widely separated tribes, such as the Hopi of the Southwest and the Piegan of the north. The discussion centered largely upon the significance of 7 and 6 as sacred numbers, which are found widely spread in ancient and oriental nations as well as in America. Several members referred the origin of 6 as a sacred or occult number to the six "cardinal points," north, south, east, west, up, and down. The number 7 adds to these the concept of the center between the points. Dr. FEWKES referred at length to his earlier studies of the preference given the left hand in the sacred mysteries of the Zunis and what he has called the "sinistral circuit," which was followed, for instance, in Zuni processions and by anyone approaching the kiva. Some theories account for this significance of the left side by this being the side where lies the heart and the side which supports the shield in battle. Miss FLETCHER dwelt upon the intellectual and especially the poetic and anthropomorphic character of the concepts of the Indian thinker who faces nature in the open and feels impelled to think out and give reasons for things. Is not the sky side, the left in the Osage conception, given the place of honor because of a deep feeling of its religious significance?

DANIEL FOLKMAR, *Secretary.*

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BOTANY.—*A remarkable new Eysenhardtia from the west coast of Mexico.*[1] William E. Safford, Bureau of Plant Industry.

In a recent paper on *Eysenhardtia polystachya*[2] the author called attention to the variability of that species and to the consequent difficulty in delimiting the species included in the group to which it belongs. Of those already described *Eysenhardtia orthocarpa* S. Wats. and *E. adenostylis* Baill. are held by some authorities to be specifically identical with *E. polystachya* (Orteg.) Sarg., and *E. amorphoides* H.B.K. is undoubtedly a synonym of it. So distinct from this group and from *Eysenhardtia spinosa* Engelm. and its allies is the plant I am about to describe, that it ought to be placed in a section apart from them. Its ten stamens are monadelphous instead of diadelphous, the style is not geniculate or hooked, the calyx is deeply instead of shallowly and broadly lobed, and it differs conspicuously from hitherto described species of Eysenhardtia in its spreading, compound, paniculate inflorescence and its very large retuse leaflets.

A critical study of the entire genus is greatly to be desired.

Eysenhardtia Olivana Safford, sp. nov.

A tree, 8 to 10 meters high, glandular-punctate throughout; heartwood dense and blackish; branches slender and spreading. Leaves alternate, usually odd-pinnate (only those of flowering branches observed); rachis 10 to 11 cm. long, grooved above; leaflets 7 or 8 pairs,

[1] Published with the permission of the Secretary of Agriculture.

[2] Eysenhardtia polystachya, *the source of the true lignum nephriticum mexicanum.* Journ. Wash. Acad. Sci. **5**: 503–517. 1915.

subopposite, stalked, oval or oblong-elliptical, finely granular-dotted, retuse at apex, rounded at base, the largest (near the middle of the rachis) 4 cm. long, 1.6 cm. broad, glabrous above, sparsely puberulent beneath (as seen under the lens); petiolules about 4 mm. long, densely glandular-tuberculate (in type specimen without stipels). Flowers small (about 8 mm. long), white, turning yellow in drying, crowded in spicate racemes, these forming the ultimate divisions of a spreading terminal compound panicle; branches of inflorescence finely cinereous-tomentose and glandular-punctate; pedicels very short and slender (1 mm. long), subtended by a minute acute sessile lanceolate deciduous bracteole. Calyx funnel-shaped, deeply divided into 5 nearly equal linear-oblong lobes (rounded at the tips), clothed on the outside with minute cinereous hairs and irregularly dotted with resinous globules. Corolla subpapilionaceous, composed of 5 distinct unguiculate petals, the standard (vexillum) twice as broad as the wings and keel petals, emarginate or retuse at the apex, carinate; wings and keel petals nearly similar, equalling the standard in length. Stamens 10, graduated in length, united into a cleft tube, the upper (vexillar) the shortest, the lower slightly exceeding the style; anthers similar, the pollen cells united by a relatively broad connective. Ovary nearly sessile, 1-ovuled, clothed with minute hairs; style terete, slender, not hooked at the tip, but with a slightly broader terminal stigma. Legume not observed.

Type in the United States National Herbarium, No. 385587, collected at La Correa, State of Guerrero, Mexico, at an altitude of 150 meters, October 1, 1898, by E. Langlassé (No. 395). "Arbre 8–10 m., bois précieux noirâtre; fleurs blanches. Nom indigène, *Palo de arco* [bowwood]."

This species is named in honor of the late Dr. Leonardo Oliva, Professor of Pharmacology in the University of Guadalajara, who first indicated the true botanical classification of the Mexican lignum nephriticum and identified *Eysenhardtia amorphoides* H.B.K. with *Viborquia polystachya* Ortega.

The accompanying figure is from a drawing of the type by Mrs. R. E. Gamble.

EXPLANATION OF FIG. 1.

Type specimen of *Eysenhardtia Olivana* Safford, showing the branching inflorescence, leaves, a flower, and the essential parts: *a*, flower with one petal removed, to show the stamens and pistil; *b*, resinous globule, detached from the calyx; *c*, cleft staminal tube with stamens, some of them deprived of their anthers; *d*, carpel, showing pilose ovary and style with terminal stigma; *e*, vertical section of ovary, showing solitary ovule; *f*, vexillar petal (standard); *g*, a wing petal; *h*, one of the keel petals. Leaves and inflorescence natural size; *a*, *c*, *d*, *f*, *g*, *h*, scale 5; *b*, *e*, scale 6.

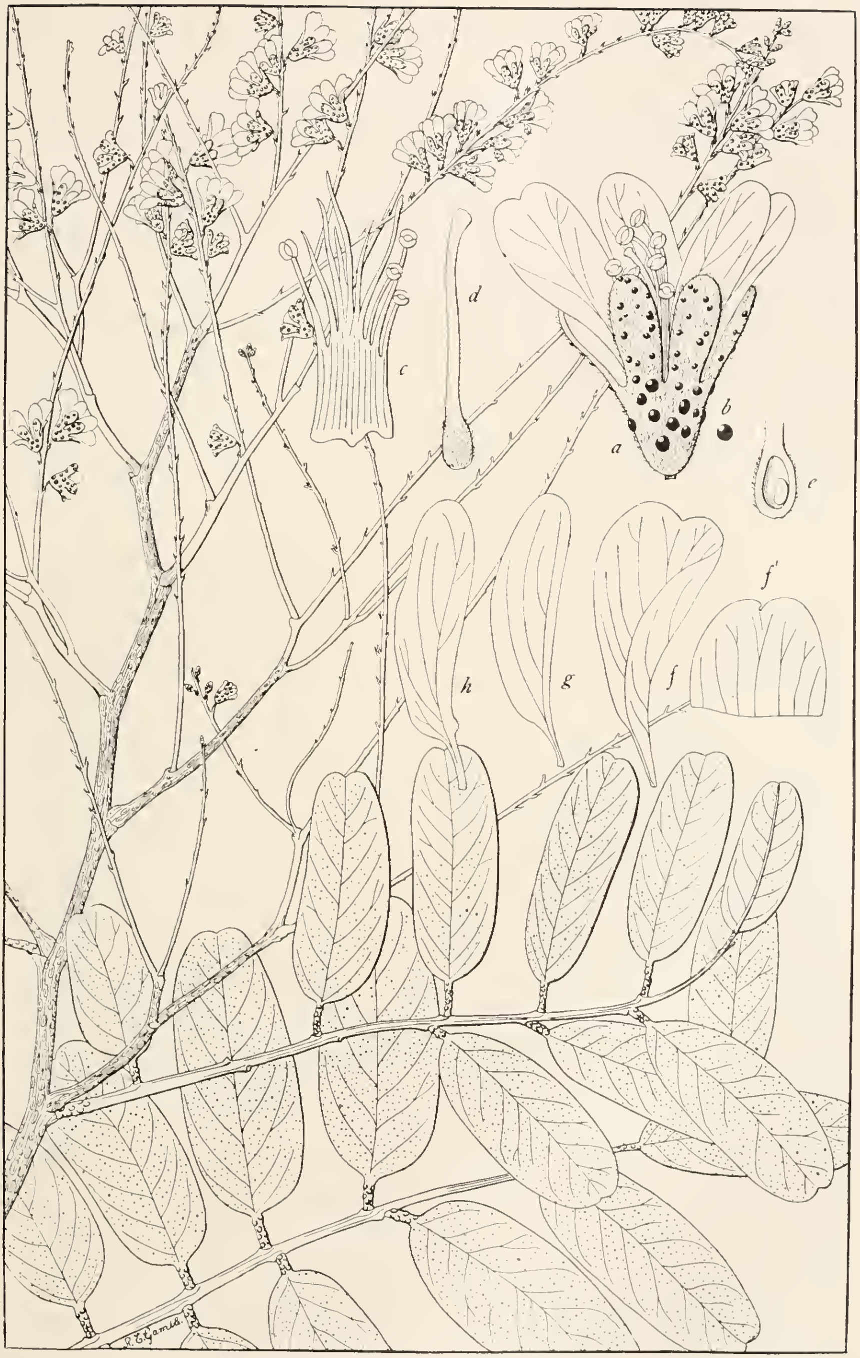

Fig. 1. Type specimen of *Eysenhardtia Olivana* Safford.

ETHNOBOTANY.—*Note on the aboriginal name "aje."* JOHN R. SWANTON, Bureau of American Ethnology.

In Mr. Cook's article in this JOURNAL for February 19, 1916, entitled "Quichua names of sweet potatoes" my attention was attracted to the word *age,* or *aje,* applied to a native root by the aborigines of the West Indies. Mr. Cook says of this: "Several of the early Spanish historians of the West Indies recorded the name *age* or *aje,* but whether this belonged properly to the sweet potato or to some other root-crop has been uncertain. Some of the accounts evidently refer to Manihot, but Gray and Trumbull settled upon Dioscorea as the correct application. Gomez de la Maza claims both *age* and *boniato* as indigenous Cuban names of sweet potatoes."

Dr. Cayetano Coll y Toste in his *Prehistoria de Puerto-Rico* also identifies it with the yam and says regarding it:[1] "Dr. Chanca noted in his letter to the Seville corporation: 'All come laden with *ages,* which are like turnips (nabos), very excellent food.' Oviedo says (lib. VII, cap. III): 'In this island of Hispaniola and in all the other islands and the Mainland, there is a plant which is called *ajes,* which look something like the turnips (nabos) of Spain, especially those which have the bark or surface white above, because there are of these *ajes* white and red, which verge upon violet, and some yellow, and they are very much larger than turnips (nabos) commonly are.' The same author, in chapter 82, distinguishes the *ajes* from the *batatas.* Peter Martyr in his third Decade, book V, chapter III, describes the *ajes* and the *batatas.* Las Casas does not confound them when he says (t.v. page 307): 'There are other roots which the Indians call *ajes* and *batatas:* and there are two species of these: these last are more delicate and of a nobler nature: thy are sowed in hills after the manner of *yuca,* but the plant is different.' There are modern writers like Señor Pichardo, who think that the *aje* is the white *ñame* (yam). This plant, the *ñame,* was brought from Africa with the importation of the negroes into America."

[1] Cayetano Coll y Toste. Prehistoria de Puerto-Rico, pp. 197, 198. San Juan, 1907.

The fact to which I wish to call attention is the close resemblance between this term *age* or *aje* and the terms applied to all kinds of "potatoes" by many of our southern tribes. The Creek and Alabama word is *aha*, but that of the Choctaw and the Hitchiti, the ancient inhabitants of southern Georgia, *ahe*. Along with some qualifying words this is used for the Irish potato, sweet potato, and yam, but it is also applied to a wild root which it is natural to suppose was the original plant so designated. The root to which the Alabama Indians apply the term, plus a qualifying adjective meaning "rough," *tcạgawa*, has been identified for me by Mr. Paul C. Standley, of the National Herbarium, as *Apios apios* (L.) MacM. Presumably this is the same as the Creek *aha akliwahi*, "mud potato," and the Choctaw *ahe kamạssa* or *ahe ahkạmassa*, "hard potato."

We have here the perplexing problem of a very similar name applied originally, to all appearances, to entirely unrelated plants and by derivation to the very same plants. The resemblance may be purely accidental, but I think it more likely that the word was borrowed from the West Indies by the southern tribes, or vice versa, as the name of several roots not perfectly discriminated from each other. Precisely the same thing has happened in the case of the name *kunti*. This was originally applied by the Creek Indians to the roots of several species of Smilax; but after those Creeks who came to be known as Seminole had invaded Florida, they found a Zamia in use there to which they gave the very same term. At first the older *kunti* was distinguished as the "red kunti" and the new plant as the "white kunti;" but later, or at least where only one of them was to be had, the qualifying adjective was dropped. It thus came about that the same word had a totally different application in different sections of the territory occupied by the same people.

TAXONOMY.—*Determining types of genera.* O. F. COOK, Bureau of Plant Industry.

Biological taxonomy is being rebuilt on a new foundation. The older method of naming by concepts is giving place to naming by types. Names are no longer thought of as relating primarily to the definitions of the natural groups, but as attached to the groups themselves, through the medium of types. Each species has its type specimen, each genus its type species.

The method of naming the concepts was used by Linnaeus and his followers for over a century, but had to be abandoned on account of the confusion caused by names slipping away from their original application. Types not being recognized, the applications of the names varied with interpretations of the definitions. Two or more names often became current for the same genus, or the same name for two or more genera. How to place the older names on a type basis is still a problem.

Priority governs the acceptance of names and should also determine the application of names. Priority of application means that a name should remain with its original type. Certainly no practical purpose is served by accepting a name unless the application is determined. Names without applications are worse than useless.

Generic names that have been misapplied need to be restored to their original applications and fixed by the recognition of types. But by using wrong methods in the work of restoration it is possible to damage the taxonomic structure still more. Historical continuity is sacrificed when names are carried away from their original applications. This objection lies against all of the arbitrary methods of fixing types, whether we take as types the last species by elimination, the first species named, or the first species to be designated as type by a later author. The method of elimination is most defective, because it does not give the same results in the hands of different students and because it often leads away from the true type. Obscure names are brought out for prominent genera, and prominent names transferred to obscure species. The confusion is worse than if the transferred names had been discarded altogether.

The need of more care in determining the original applications of names may be illustrated by an example from millipeds. The generic name Spirobolus has been used for a very large group of tropical species with their chief center in South America. The genus was established by Brandt in 1833, with two species named, *S. olfersii* from Brazil and *S. bungii* from northern China. The generic description relates entirely to the characters of the antennae and refers to a drawing of *S. olfersii*, the only species figured. The characters as stated and illustrated are applicable only to *S. olfersii*, so that a strict interpretation would exclude *S. bungii*. It seems plain that Spirobolus was based wholly on *S. olfersii*, and that this species must be considered as the true historical type of the genus.

Nevertheless, *Spirobolus bungii* has been designated as the type of the genus, on the ground that the establishment of Rhinocricus in 1881 had the effect of removing *olfersii*, so that only *bungii* was left. But now it appears that *olfersii* was not really removed, since Rhinocricus needs to be maintained as a distinct genus, with the Porto Rican *Rhinocricus parcus* as type. Even if *olfersii* and *parcus* were congeneric, there would still be no adequate reason why the publication of Rhinocricus should be supposed to take away the historical type of Spirobolus and change the application of the name. Obviously, any later name based on *olfersii*, or on any species truly congeneric with *olfersii*, should be treated simply as a synonym of Spirobolus.

Under the law of priority a name has to be replaced if another is older, but elimination often has the effect of replacing an older name by a later one. Changing the type makes it possible for a later synonym to supplant an old, well-known generic name, which is then slipped along to a different application. To assume that the naming of Rhinocricus could have the retroactive effect of transferring the name Spirobolus from a Brazilian genus represented by *olfersii* to a Chinese genus represented by *bungii*, is neither consistent with priority nor in the interest of stability.

Transferring Spirobolus to China has the effect of giving the same name to a second genus. Altering the application of the name subverts the law against homonyms. Future writers and readers must guard themselves against confusing the two genera to which the name Spirobolus has been applied.

Some taxonomists hold that the first formal designation of a type species, however arbitrary or erroneous, must be maintained; but such a rule leads, in cases like the present, to a mere shuffling of names, without historical warrant or practical advantage. It seems more reasonable to hold that in using *olfersii* exclusively as the basis of his genus Brandt himself designated the type of Spirobolus. The original application of the name should not be subject to change by any later author, either by proposing a new genus in the place of Spirobolus or by designating a different type for Spirobolus. Instead of being taken as the type of Spirobolus, *bungii* should be associated with Arctobolus, the genus of Spirobolidae that is dominant in the temperate regions of North America.

The case is one of many where types are not to be determined from considerations of nomenclature alone. It would be useless to ask a nomenclatorial expert or commission to rule upon Spirobolus without the pertinent facts. Instead of premature regulations and decisions, the need is for more facts and more thorough study of taxonomic problems. Adequate investigation might lead to simple and practical solutions that could be applied by any careful student.[1]

Complications have been increased unnecessarily in the effort to force a general adoption of an imperfect system. Priority has been pushed to extremes in the acceptance of names, only to be disregarded in determining the applications of names. Abortive names and synonyms that might well have remained in oblivion have replaced many well-known names, and others are being misapplied as a result of the practice of elimination. That botanists and zoologists are using different methods of typifying genera also shows how casual the study of taxonomic problems has been. Such divergence of views can only mean that the subject is not adequately understood, for the need of a stable taxonomy is the same in both branches of biological science.

[1] Other phases of the question have been treated in previous papers. See, *Terms relating to generic types,* The American Naturalist, **48:** 308; and *Fiat nomenclature,* Science, N.S., **40:** 272.

ZOOLOGY.—*A new starfish* (Lydiaster americanus) *from the Gulf of Mexico, representing a section of the subfamily Goniasterinae hitherto known only from the Indo-Pacific region.*[1] AUSTIN H. CLARK, National Museum.

One of the most interesting of the new starfishes described in 1909 by Professor Koehler from the collections of the Royal Indian Marine Survey Ship *Investigator* was *Lydiaster johannae* which, with the closely allied genus *Circeaster* decribed at the same time, represented a hitherto unknown type of Goniasterinae. *Lydiaster johannae* was dredged only in a single locality off the southwestern coast of Ceylon in 401 fathoms, while the two species of *Circeaster* were found off the western coast of Ceylon and southern India in from 912 to 1053 fathoms. Thus, so far as known up to the present time, these two genera are confined to the Arabian Sea. The only genus closely related to these two, *Mariaster*, occurs off southern Japan.

But it appears that *Lydiaster* also inhabits the Gulf of Mexico, being represented in this region by a remarkable new species, in some respects intermediate between *Lydiaster* and *Circeaster*. This may be known as

Lydiaster americanus, sp. nov.

Five arms; R = 100 mm.; r = 35 mm.; R: r = 2.9: 1; superomarginals 24.

General form pentagonal, with relatively narrow, evenly tapering arms, the length of which, measured actinally along the curve from a point directly below the commencement of the enlarged plates, is equal to the distance from the same point to the center of the interbrachial arc opposite. The diameter of the arms at the base (at the level of the distal border of the fifth superomarginal) is 19 mm. In the outer half the arms bend gradually upward, so that their terminal portion makes an angle of about 60 degrees with the plane of the disk.

Compared with *L. johannae* the interbrachial arcs are more nearly straight and the arms, which are narrower, appear to arise more abruptly.

The abactinal surface, which is somewhat swollen, is covered with small polygonal plates which are mostly subequal in size and irregular in arrangement; they vary from about 1 mm. to about 2 mm. in diameter, being usually about 1.5 mm.; just before the base of the arms the

[1] Published with the permission of the Secretary of the Smithsonian Institution.

plates become shorter radially, so that they appear to be transversely elongated; on the arms they slowly increase in size, though not in regularity, the largest being something over 3 mm. in diameter; in the distal half of the arm only one row of plates separates the superomarginals, and the last four or five superomarginals are in contact along the mid-dorsal line of the ray.

Each of the abactinal plates is bordered by a ring of flattened granules, there being from 20 to 24 about the largest; in the central portion of the abactinal surface each plate bears from two to six rounded granules, each inserted in a small pit; toward the periphery these become less numerous and less prominent, though they occur nearly to the marginals; the plates on the abactinal surface of the arms are somewhat more flattened than those of the disk, and the isolated granules are less common in their central portion; most of the plates on the disk bear spatulate pedicellariae with usually strongly dentate jaws, each sunk in a deep depression, but on the rays, except for one or two very small and imperfectly formed, these are lacking.

The papular areas, which are confined entirely to the disk, are very large; the only regions free from papulae are the center of the disk and low triangles about three times as broad as high based upon the superomarginals, in which areas also the plates decrease in size toward the border and do not bear pedicellariae. The papulae are smaller and less abundant in the mid-line of each ray than elsewhere, and this causes the mid-radial plates in the peripheral half of the disk to appear somewhat prominent.

The marginal plates of both series are 24 in number; but the inferomarginals are somewhat longer than the superomarginals, so that, although the two series correspond in the interbrachial arcs, in the distal part of the arms they alternate in position. The interbrachial arc as defined by the superomarginals is straight, as defined by the inferomarginals gently concave.

In abactinal view the superomarginals, which are markedly tumid, are seen to increase very slightly in width to the fifth, at the base of the rays, thence decreasing gradually distally; in lateral view they decrease regularly in height from the center of the interbrachial arc, where they are twice as high as the inferomarginals, to the distal third of the arm, where the plates of the two series are of about the same height. In the interbrachial arc the outer third of the superomarginals is vertical, and the inner two-thirds bends inward so that the inner half, which is flat, extends at an angle of about 45 degrees over the dorsal (abactinal) margin; on the arms the inner half becomes more nearly horizontal; here also the inner border of the superomarginals is straight, but on the arms it becomes slightly convex or angular. On the average the superomarginals, as viewed abactinally, are about twice as deep as long, those at the arm bases being somewhat longer, those toward the arm tips slightly shorter.

Each superomarginal carries on its surface numerous widely spaced deciduous granules arranged in the interbrachial arc roughly in five alternating rows of seven or eight each, becoming less numerous distally; the granular area is confined to the median portion of the plate, though in the interbrachial arc it may reach the proximal border; in the interbrachial arc nearly all the superomarginals bear near their actinal border a very small deeply sunken spatulate pedicellaria; a narrow border of flattened squarish granules surrounds each superomarginal.

The inferomarginals are essentially similar to the superomarginal; viewed actinally they are seen to decrease in size from the center of the interbrachial arc to the arm bases, thence much more gradually to the arm tips; in the interbrachial arc in lateral view the inferomarginals are only half as high as the superomarginals (2.5 mm.), but they rapidly increase in height so that on the outer half of the arm the plates of the two series are nearly equal. The inner portion of the inferomarginals is everywhere horizontal, and the inner border is everywhere convex. A border of small squarish granules similar to that on the superomarginals is found on the inferomarginals, and the same granular ornamentation occurs on their surface, though the granules are rather more numerous. In the interbrachial arc the inferomarginals usually carry small excavate spatulate pedicellariae just within the upper border, and one or two additional on the ventral (actinal) surface; pedicellariae of both series occur irregularly to the terminal portion of the arms.

The actinal intermediate areas are extensive; the row of actinal intermediate plates adjacent to the adambulacrals, which extends to the sixteenth superomarginal (the distal third of the arm), is regular and the next row is regular to the arm bases; a partial third row may be traced, but within the triangular area between this and the inferomarginals the plates, which decrease in size, tend to become arranged in columns perpendicular to the inferomarginals.

In the center of each of the actinal intermediate plates is a large pedicellaria which resembles those on the adambulacrals, and is more or less proportionate in size to the plate; on the larger plates this is surrounded by several large rounded tubercles, beyond which are the lower tubercles forming the bordering series of the plates; on the smaller plates only the latter occur.

The adambulacral plates are oblong, from one-third to one-half again as broad as long, with a very slightly curved furrow margin which is not quite parallel to the groove, the proximal end being slightly more distant. The furrow series consists of five stout subequal truncated spines, mostly rounded-quadrate in section, the most proximal of which is so situated that it overlaps the most distal of the preceding series. Behind the furrow spines is a series of three or four tubercles, the most distal abruptly the largest, and behind these a long, low, *Hippasteria*-like bivalved pedicellaria placed somewhat diagonally with its distal end slightly nearer the mid-radial line. Beyond the pedicellaria is a series of two or three large tubercles, and beyond these a series of several smaller tubercles which, with similar tubercles, at right angles to the two ends of this series, delimit the borders of the plate.

The mouth plates are triangular and inconspicuous, about twice as long as broad; the furrow margin is about equal to the edge adjoining the first adambulacral; the furrow series consists of seven short blunt spines, stouter than those on the adambulacrals, of which the innermost is broad, flat, and trapezoidal; just behind the two terminal spines in this series are two large tubercles; the remaining portion of the surface of the mouth plates is covered with about 18 spaced polygonal tubercles resembling those on the actinal intermediate plates, but somewhat larger.

The color in alcohol is white.

Type.—Cat. No. 10872, U. S. N. M., from "Albatross" Station 2395, Gulf of Mexico, in 347 fathoms.

ANTHROPOLOGY.—*The Greenland Eskimo: Pastor Frederiksen's researches.* JAMES MOONEY, Bureau of American Ethnology.

The great Arctic island of Greenland is held by Denmark, having been first colonized by the Norse about the year 1000, and re-occupied from Denmark in 1721, the first colony having become extinct long before, possibly through inroads of the Eskimo. Since the second occupation Lutheran and Moravian missionaries, under the auspices of the home government, have labored with such devotion and success among the aborigines that of approximately 10,000 Eskimo of pure or mixed blood all but a few hundreds along the most remote coasts are civilized, Christianized, self-supporting, and able to read and write in their own language, while living on the best of terms with the handful of colonists. So carefully has the Danish government safeguarded their interests that famine, intemperance, and foul diseases which are so rapidly destroying the race in Alaska and British America are virtually unknown in Greenland, as well as wars and rumors of wars with their white neighbors. Since 1861, with a few breaks, there has been published at Godthaab (Nûngme) on the west coast, a small monthly journal, the *Atuagagdliutit* or "Reading Miscellany," entirely in the Eskimo language, which for press-work, illustrations, and literary content is fairly equal to anything of the same size in this country. Another mission monthly journal, the *Avangnamiok*, is published under the supervision of Rev. V. C. Frederiksen, resident missionary at Holstensborg, one of the northernmost outposts of civilization and well within the Arctic circle. Between pastoral visits and sick calls in an open skin kayak, or by dog sledge, from one to another of the small native settlements scattered for three hundred miles along the dangerous west coast, this devoted missionary—whose only white companions are his wife and two children and a couple of assistants—has found time to give to his charges in their own language a volume of church hymns, a brief history of Greenland, and several literary translations, besides making some important archeologic explorations.

In a paper upon "Eskimo Migrations," published originally in the native language in *Atuagagdliutit,* Mr. Frederiksen arrives at the conclusion, from linguistic, geographic, and archeologic evidence, that the Eskimo tribes reached Greenland from an original nucleus body in the extreme west. He believes that they traveled southward around the coast to the east, the Eskimo of the East Greenland coast representing the oldest migration, and decreasing in number toward the north by reason of the scarcity of game and of building material. The houses also dwindle in size as we proceed northward along the east coast. The Norse occupation about the year 1000 made a wedge of separation between the Eskimo of the east and west coasts for several centuries, but with the extinction of the Norse colony about 1490, probably from attack and final absorption by the natives, some of the eastern bands again moved down toward the south. Of those who remained behind, the most northerly, beyond Angmagsalik, finally became extinct by starvation through the gradual diminution of the whale and seal, while the more southern tribes were saved from the same fate only by the kindly care of the later Danish colonists. The Eskimo of South Greenland have probably a considerable strain of the old Norse blood, which may help to account for their superior capacity for civilization.

The prevailing early house type of the South Greenland Eskimo, on both the east and west coast, as shown by the ruins, was rectangular, but about Sukkertoppen and Holstensborg, 65° to 68° N., Mr. Frederiksen has discovered numerous remains of semi-subterranean houses of circular form, always in groups, sometimes of twenty together, resembling those about Cape York in North Greenland and about the mouth of the Mackenzie and westward. These round houses he considers to represent a later migration or period; in fact, in one instance he found the ruins of the round house within the remains of a larger rectangular house. The stone lamps found in these round houses have always a partition wall, as among some of the far western Eskimo, to separate the oil from the blubber. Other objects found, obtained from whaling ships, would indicate a period not earlier than 1700. The modern Greenland house type is also rectangular, except in the extreme north. In the same neighborhood he found also the remains of a great circular structure, of the type of the assembly house of the Alaskan Eskimo.

ANTHROPOLOGY.—*An archeological note.* TRUMAN MICHELSON, Bureau of American Ethnology.

Squier and Davis in their *Ancient Monuments of the Mississippi Valley*, pages 249, 250, discuss a gray sandstone pipe now deposited in the museum of the Historical Society of New York. They show quite clearly that this is the original of the drawing by Choris in his *Voyage Pittoresque;* and they demonstrate that there must be some mistake as to the provenience of this pipe, for there are no ancient tumuli in Connecticut. The purpose of this note is to elucidate this last point. I call attention to the fact that the Sauk pipe shown in the plate at the end of volume 2 of Beltrami's *Pilgrimage* belongs to the same culture as the one shown in figure 149, page 249, in the work of Squier and Davis. I have seen a photograph of the original of the latter, and it is far closer to the Sauk pipe than the drawing indicates. If the drawing of Beltrami is no closer to the original than is that of Squier and Davis to its original, it is possible that the originals of both are the same. Even if they are not the same, I think the above will have made clear that the provenience of the pipe shown in the work of Squier and Davis must be the upper Mississippi region, near the Rock river, where the Sauk had their principal encampment when Beltrami visited their country, viz., 1823.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICAL CHEMISTRY.—*The preparation of pure iron and iron carbon alloys.* J. R. Cain, E. Schramm, and H. E. Cleaves. Bureau of Standards Scientific Paper No. 266. Pp. 26. 1916.

As previous work on the iron-carbon diagram is unsatisfactory because of the great variation in the materials used, it was thought desirable to produce at the Bureau of Standards a series of alloys of great purity to form the basis of a redetermination of the diagram. The general method pursued consisted in melting electrolytic iron with sugar carbon in magnesia crucibles. The electrolytic iron was prepared from ingot iron anodes in a chloride bath with or without the use of porous cups. The operation of melting the iron with carbon gave great trouble at first, because the ingots obtained were full of blowholes and contained considerable quantities of impurities. These difficulties were overcome by melting in a vacuum furnace, and making the crucibles of especially pure magnesia, made and calcined with great care at the Bureau of Standards. A satisfactory procedure was finally worked out and a series of alloys prepared of the composition Fe + C = 99.96 per cent. H. E. C.

GEOLOGY.—*Mount Shasta—some of its geological aspects.* J. S. Diller. Mazama, **4**: December, 1915, 11–16, illustrations and maps.

Stress is laid on the geologic basis for differentiating the Cascade Range and the Klamath Mountains from the Sierra Nevada and Coast Ranges. Mount Shasta is a mass of hornblende and hypersthene andesites rising more than 10,000 feet above its base of Paleozoic and Mesozoic rocks. It is bordered on the east by later basalts and crowned by 5 small glaciers of which the Whitney glacier, the largest, is $2\frac{1}{5}$ miles in length. Near the summit are several fumaroles, a residual of its waning volcanic heat. J. S. D.

GEOLOGY.—*Geology and mineral resources of Kenai Peninsula, Alaska.* G. C. Martin, Arthur Hollick, Bertrand L. Johnson, and U. S. Grant. U. S. Geological Survey Bulletin No. 587. Pp. 243, with maps, sections, and views. 1915.

The volume consists of five papers entitled:

General features of Kenai Peninsula. G. C. Martin.
The western part of Kenai Peninsula. G. C. Martin.
Correlation of the Kenai flora. Arthur Hollick.
The central and northern parts of Kenai Peninsula. Bertrand L. Johnson.
The southeastern coast of Kenai Peninsula. U. S. Grant.

This volume contains the results of reconnaissance investigations of a region about 9400 square miles in area situated on the Pacific coast of south-central Alaska. It presents a summary of what is known of the geography, geology, and mineral resources. Some parts of the peninsula have been studied in considerable detail, others have been traversed only hastily, and information concerning considerable areas is almost lacking.

The Kenai Peninsula includes two sharply defined, and geographically and geologically dissimilar, districts, the Kenai Mountains and the Kenai lowland. The Kenai Mountains have a general altitude of from 3000 to 5000 (maximum, 6400) feet and are in large part occupied by glaciers. They are composed of thoroughly indurated, partly metamorphosed, and highly folded rocks that include slates and graywackes of undetermined age in the main mountain mass, and Upper Triassic and Lower Jurassic limestones and pyroclastics on the western border. Some intrusive masses, chiefly granitic, but including also felsic (acidic) dikes, are present. The Kenai lowland has a general elevation of from 50 to 200 (maximum, 2000) feet. It is composed of slightly indurated and gently folded Tertiary (Eocene?) coal-bearing (non-marine) sands and clays overlain by extensive Quarternary deposits.

The general stratigraphic sequence in the Kenai Peninsula is as follows:

Quarternary
  Recent alluvial deposits
  Glacial and terrace gravels

Tertiary
- Kenai formation (sands and clays, with lignite beds, and containing fossil plants)

Lower Jurassic
- Tuffs with marine fossils

Upper Triassic
- Limestone and tuff with marine fossils
- Chert

Triassic (?)
- Ellipsoidal lavas

Paleozoic (?)
- Slates and graywackes
- Schists

Metalliferous deposits occur as veins, stringer lodes, and mineralized felsic (acid) dikes, and these follow two sets of fissuring approximately at right angles to each other. The ore deposits are chiefly auriferous, but some copper-bearing lodes have been found. The mineralization is probably due to the action of mineral-bearing solutions (magmatic waters) that were forced out of the deeper parts of the igneous magma during its solidification. G. C. M.

MINERALOGY.—*The chemical composition of bornite.* Edgar T. Wherry. Science, **42**: 570–571. 1915.

Discussion of a paper by Rogers (Science **42**: 386. 1915.) It is suggested that the variability in the composition of bornite (normally Cu_5FeS_4) is due to the presence of submicroscopic inclusions of one or more of the minerals often occurring as visible inclusions in it, namely chalcocite, chalcopyrite, and pyrite. E. T. W.

MINERALOGY.—*Notes on allophanite, fuchsite, and triphylite.* Edgar T. Wherry. Proceedings of the U. S. National Museum, **49**: 463–467. 1915.

A description is given of a specimen of allophanite from Utah. Its index of refraction varies with the water content, being the average of the indices of the constituents, which is regarded as evidence that no complete chemical combination between them exists. Occurrences of fuchsite in Pennsylvania and Colorado are described, and the percentages of chromium oxide present are given. A new locality for triphylite in New Hampshire is announced and its composition discussed. It contains 60 per cent lithio-ferro-triphylite and 37 per cent lithio-mangano-triphylite. E. T. W.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 765th meeting was held on January 8, 1916, at the Cosmos Club. President Briggs in the chair, 50 persons present. The minutes of the 763d meeting were read in abstract and approved.

Mr. H. N. Heck presented by invitation a communication entitled, *Detailed submarine relief, a practical method of development.* The amount of detail required for submarine relief depends upon whether the point of view is scientific or utilitarian. The standard methods of obtaining knowledge of submarine relief were described and the reason given why these are insufficient in many parts of the earth. The development of the wire-drag method was described and that method mathematically defined. The importance of geological accidents in submarine relief was emphasized and two forms of especial importance pointed out. Slides were shown to illustrate cases where submarine relief agrees closely with the adjacent land forms and also to show, by examples selected from all parts of the United States, Alaska, and elsewhere, where there is marked disagreement, or forms entirely unexpected. Two ways were indicated in which geology can assist in determining where the wire-drag method must be applied. The question is open whether it is possible to predict from available geological information the existence or absence of certain forms of submarine relief. The effect of submarine relief on the three principal motions of the sea was briefly discussed.

Discussion: Mr. Wright referred to dangers from hidden rocks experienced during geological expeditions in Alaskan waters. Mr. Hazard asked how often it was necessary to change the height of the drag. Mr. Sosman called attention to the recent discovery of a pinnacle of rock in the Liverpool Channel. Mr. Heck stated that it was sometimes necessary to change the height of drag every 20 minutes. The Chair expressed to Mr. Heck the thanks of the Society for his very interesting communication.

Mr. A. L. Thuras presented a paper entitled, *A method of determining densities at sea and its use in locating ocean currents.* A new method of ocean-density measurement particularly adapted to sea conditions was briefly discussed. The temperature of the water sample was varied until its density was just equal to that of a glass "bobbin." A calibration curve was shown giving the density of the sample at 15°C. in terms of the equilibrium temperature. The accuracy attained was greater than 0.008 per cent. A continuous record of the ocean temperature near the surface was also obtained, and each gave evidence of the location of ocean currents. Charts giving these data and thus locating the Labrador Current and the Gulf Stream in the vicinity of the Great Bank were shown. The density (reduced to 15° C.) of the Labrador Current was about 1.0245, of the Gulf Stream 1.0270; but the actual densities *in situ* were respectively 1.0267 and 1.0266. The width of the Labrador Current at latitude 45° N. was 65 miles and at 44° N. only 25 miles. Detail temperature curves showed beautifully the interdiffusion of the two streams at the southern end of the Great Bank. The results in general corroborate the current charts of Captain C. E. Johnston.

Discussion: Messrs. Sosman, White, and Humphreys discussed the possibility of the Labrador Current diving under the Gulf Stream. Captain Johnston stated that by observing icebergs he had come to the conclusion that the Labrador Current acts like a band; when a great quantity of cold water accumulates it sweeps under the Gulf Stream or breaks through irregularly. Mr. Stillman asked whether it was feasible to measure densities by measuring resistances. Mr. Dickinson stated that salinities could be measured by electrical methods in the laboratory but that difficulties would be encountered at sea. Mr. Swann suggested the use of the string galvanometer for work on board ship.

Mr. P. V. Wells then spoke on *The study of fog at sea.* The speaker described the work on fog done aboard the ice-patrol cutter *Seneca* during a cruise in May, 1915. The nucleation, the number of persistent nuclei per cubic centimeter, was measured three times daily by the corona method of Barus. The error was less than 15 per cent. Generally the nucleation was high in cyclonic areas, from which it was inferred that the nuclei at sea are mainly salt particles—evaporated spray. The nucleation was never below 400, normally 1000, and three times rose to 50,000. The liquid content, or grams of liquid water per cubic meter, was determined by evaporating the fog electrically and measuring the humidity at the higher temperature. A value, 0.7, with an error of less than 20 per cent, was obtained. The size of the fog particle was 5×10^{-4} cm. A rise of 1°.4 C. would dispel this fog, and as an inversion of 2°.5 was observed at the masthead, the fog did not extend that high. The speaker suggested the possibility of seeing from the masthead a powerful light or a flag on the masthead of a nearby ship.

Discussion: Mr. Swann stated that the measured ionization over the sea is about as great as over the land; on land it is possible to account for 5 ions per cubic centimeter, while over the sea it is possible to account for only $1\frac{1}{2}$ ions per cubic centimeter. Mr. Wells stated that the nuclei over the sea were less numerous than over the land, which is in agreement with observations of atmospheric electricity. Barus suspected a connection between nuclei and ionization; it would have been an improvement had it been possible to observe nucleation and ionization simultaneously.

The 766th meeting was held on January 22, 1916, at the Cosmos Club. President Briggs in the chair, 51 persons present. The minutes of the 765th meeting were read in abstract, corrected, and approved.

REGULAR PROGRAM

Mr. C. G. Abbot presented a paper entitled, *New proofs of the solar variability.* The Smithsonian Astrophysical Observatory has investigated for 12 years the intensity of solar radiation. In speaking of the variability of the sun we do not refer to variations caused by the atmosphere of the earth or by the yearly fluctuations of the earth's solar distance. The latter are readily eliminated. The elimination of atmospheric influences depends on spectrobolometric observations at different altitudes of the sun, reduced in accordance with sound theory. Experiments at Washington, Mount Wilson, Mount Whitney, and Bassour (Algeria), under circumstances differing widely as to atmospheric temperature, pressure, humidity, and length of path, are in close agreement in their indications of the intensity of solar radiation outside the atmosphere. The results are further checked by confirmatory observations at different altitudes ranging on the earth from sea-level to Mount Whitney, and by manned balloons to 8000 meters, and by sounding balloons to 25,000 meters. Variations of solar emission of radiation were indicated by Mount Wilson observations and confirmed by simultaneous work at Bassour, Algeria. A correlation coefficient of 50 ± 7 per cent is found between the variations noted at the two stations. This leaves the chance of accidental correlation 1 in 25,000. Four years of pyrheliometry at the Arequipa, Peru, station of the Harvard College Observatory, under direction of Professor E. C. Pickering, are now being published by the Smithsonian Institution. This work confirms the solar variability from day to day, and from year to year, found at Mount Wilson. Measurements of the distribution of radiation along the diameter of the solar image have been made by the Smithsonian observers at Washington and at Mount Wilson. Fluctuations of contrast between the center and the edge of the sun are found to occur in all wave-lengths, but greater for short wave-lengths than for longer ones. These fluctuations occur from day to day and from year to year. Both kinds of changes are correlated in time with changes in solar radiation. Curiously the correlation is in opposite senses for long-period and short-period changes. When great solar activity prevails, as shown by sun-spots, faculae, etc., high solar-radiation values predominate, and a greater contrast of brightness between the center and the edge of the sun is found. But when irregular changes of the solar radiation occur in the short period, they are associated with less contrast of brightness between the center and the edge of the sun. The first type of change was explained as a temperature effect, the second as due to changes of transparency of the outer solar envelope. The paper was illustrated by lantern slides.

Discussion: Mr. Swann pointed out that some of the data determined from variation in the sun's atmosphere were suggestive of selective absorption; he also questioned the extent to which the sun may be treated as a black body, particularly in the ultra-violet region. Mr. Humphreys asked whether there was any connection found between the daily fluctuations of the solar constant and the changing barometric pressure at the same time. Mr. Abbot stated that the work did not indicate selective absorption since the differences from all wave-lengths are not found to be in the same sense; there appears to be no connection between the daily variations of solar constant and barometric pressure.

Mr. L. A. Bauer then presented a paper entitled, *Corresponding changes in the earth's magnetic field and the solar radiation.* Recent investigations with the aid of later solar and magnetic data have confirmed the author's preliminary conclusions of 1914 and 1915. It is again found in the majority of cases (about 80 per cent) that increased intensity of solar radiation, as shown by the changes in solar-constant values possessing the accuracy of those of the Smithsonian Institution, is accompanied by an appreciable decrease in the constant used as a measure of the intensity of the earth's magnetic field. While the magnetic effect, observed on the average, is such as accompanies the heating of a magnet, it is, apparently, not to be referred to such a cause. A preliminary examination of the magnetic effects in different parts of the earth indicates that the seat of the system of forces causing the effects is not within the earth itself but in the regions above us. In conclusion, it was pointed out that, from the standpoint of terrestrial magnetism, observations dependent solely upon the thermal energy of solar radiation can not be given any greater significance than that they may indicate some change in solar activity. Thus changes in the solar constant may not be regarded as a true, or adequate, measure of the various ionizing agencies (ultra-violet light, corpuscular radiations, electrons impinging upon our atmosphere, etc.) which are, at present, believed to be ultimately the cause of the magnetic effects. To the pyrheliometer, the bolometer, and meteorological appliances, must be added the magnetic needle, if we wish to get as complete a representation as possible of the various effects attributable to our sun, directly or indirectly.

Discussion: Mr. Swann stated that computations, assuming the total energy of the spectrum could be wholly absorbed in the upper atmosphere, indicated the resulting ionization would be only 1/100 of that required to account for the diurnal variation if we accept Schuster's theory. Mere heat and light radiation could not account for the conductivity.

INFORMAL COMMUNICATIONS

An apparatus for making hydrostatic weighings, developed for finding the volumes of precision weights, was shown and described by Mr. A. T. Pienkowsky. The chief aim in designing the apparatus was to allow fairly accurate measurements to be repeated quickly, and to provide for the easy handling of several different sized objects in succession. A scale-pan, essentially a flat grid, is suspended by a wire coated with a rough, spongy coating of gold, applied electrolytically. An arrestment table, meshing with the scale-pan and raised or lowered by a rack and pinion, allows the object to be put on or taken off from the scale-pan with the least possible disturbance. A guard ring surrounds the suspension-wire at the surface of the water to help maintain a uniform surface-tension on the wire.

The 767th meeting was held on February 5, 1916, at the Cosmos Club. President Briggs in the chair, 58 persons present. The minutes of the 766th meeting were read in abstract and approved.

REGULAR PROGRAM

Mr. E. C. Bingham presented by invitation a communication, illustrated by lantern slides, entitled, *Plastic flow*. (To be published in a later number of this Journal.)

Mr. E. Buckingham then presented a paper entitled, *Notes on the theory of efflux viscosimeters*. The paper was concerned with the relative determination of the viscosities of liquids, in terms of the viscosity of some standard liquid, by the commonly used efflux method. Instruments for making such comparisons must, in general, be standardized, or have their "scales" determined, by means of a series of liquids of which the relative viscosities have already been found by other methods. The speaker's purpose was to show how the necessity for such a standardization might be obviated and the series of standardizing liquids dispensed with. It was shown, by dimensional reasoning, that whatever be the nature of the orifice or mouth-piece through which the liquid is discharged, if the driving head be so adjusted that its square root is proportional to the rate of discharge, the rate of discharge will itself be proportional to the kinematic viscosity of the liquid. Hence when this adjustment of the conditions has been effected, the kinematic viscosities of two liquids are directly as their observed rates of efflux. A viscosimeter which is so arranged that this adjustment may be made need not be standardized at all, unless absolute values are required; and in that event a single standard liquid of known kinematic viscosity suffices. It was shown that if the viscosimeter is a cylindrical burette with a small oriffice at the bottom, and if the observations consist in readings of the times at which the surface of the liquid passes the marks on the burette as the liquid flows out at the bottom, the inconvenient process of adjustment previously mentioned may be dispensed with and the result obtained graphically. The paper concluded with several suggestions regarding the practice of the proposed method of viscosimetry.

Discussion: Mr. Bauer asked what liquid would be best suited as a standard. Mr. Abbot asked what degree of accuracy is practically desired; if the accuracy wanted is high, is not the adhesion to the side of the tube a difficulty? Mr. Buckingham stated that water would be the best standard but that the practical requirements would make necessary other intermediate standards as the viscosity increases.

Mr. Herschel stated that an accuracy of 5 per cent is sufficient for technical purposes. In investigating efflux viscosimeters he has found a modification of Grüneisen's diagram very helpful. Plot as ordinates $\frac{vd\rho}{\eta}$ and as abscissas $\frac{\pi r^4 ght\rho}{8Vl\eta}$. If the commonly accepted Ubbelohde form of equation were correct, we would have a straight line cutting the X-axis at a distance $\frac{l+\lambda}{l}$ from the origin, where $(l+\lambda)$ is the effective length of capillary, and making an angle whose tangent is $\frac{32l}{md}$ with the X-axis; m is the kinetic-energy coefficient which is 1.12 according to Boussinesq. Mr. Herschel finds that m is variable when a certain velocity is exceeded.

INFORMAL COMMUNICATION

Mr. L. A. Bauer discussed *Some corresponding changes in solar radiation, terrestrial magnetism, and astronomy.* With the aid of lantern slides, striking similarities were shown to exist between the following 3 curves: (1) Curve of changes in the solar constant, 1905–1914; (2) curve of anomalies in the regularly progresing secular variation of the earth's magnetic field, 1905–1913; and (3) curve of mean irregularities in motion of Mercury, Venus, the moon, and the earth, 1905–1913. Astronomers having exhausted the possibilities of explaining the outstanding astronomical motions by gravitational causes, are now seeking for some connection with effects arising from possible interacting magnetic fields of planets. Inquiries received at various times from astronomers, notably from the late Professor Newcomb, have led the speaker to undertake an examination into the various questions involved. As the first step, he has established a tentative formula which gives the magnetic field strength of the sun within 10 per cent of Hale's provisional value, and shows that a magnetic field possibly to be associated with Jupiter may have a strength almost that of the sun, namely, about 68 times that of the earth.

The Chair expressed to Mr. Bingham the thanks of the Society for his most interesting communication.

J. A. Fleming, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 300th meeting was held in the lecture room of the Cosmos Club on November 24, 1915.

INFORMAL COMMUNICATIONS

D. F. Hewett: *Manganese deposits in Virginia.* Among six deposits examined five showed a striking relationship to topographic features. The deposits lie at the base of the Blue Ridge, where the Tertiary plain merges with the hills, and occupy old river channels in the plain. It seems plausible that they were formed while the plain was being developed and during a climatic cycle more favorable than the present one; i.e., under milder and more humid conditions.

Discussion: SIDNEY PAIGE inquired as to the source of the manganese. Hewett replied that there had been considerable speculation on this matter; it seems likely that it was derived from basic silicates in certain shale beds. T. WAYLAND VAUGHAN spoke of the climate of the Eocene in the Gulf States, as shown by marine fossils. In the early Eocene the climate was tropical, in the middle Eocene somewhat cooler, and in the late Eocene tropical again.

REGULAR PROGRAM

L. W. STEPHENSON: *Correlation of the Upper Cretaceous deposits of the Atlantic and Gulf Coastal Plain.* (Illustrated.)

The Upper Cretaceous sediments of the Atlantic and Gulf Coastal Plain are chiefly medium to fine-grained clays, sands, chalks, and marls, ranging in origin from those laid down on low coastal plains, in estuaries or in very shallow seas, to those formed in waters perhaps exceeding 100 fathoms in depth. In our present state of progress the fossils most usable in determining the age relations of the marine sediments formed in waters ranging in depth from moderately shallow to 50 fathoms or more are the representatives of the genus *Exogyra*, which were adapted for life in all but the very shallowest of the Upper Cretaceous marginal seas and which underwent evolutionary changes with sufficient rapidity to form faunal zones traceable through contemporaneous formations.

Three principal zones have been differentiated, which, in ascending order, are: (1) The zone of *Exogyra upatoiensis*, which is at the base of the Eutaw formation in the Chattahoochee region; (2) the zone of *Exogyra ponderosa*, which has been traced from New Jersey to the Rio Grande. On the basis of fossils other than *Exogyra* this zone is separable into two parts,—lower and upper. The former is traceable from Georgia to the Rio Grande, and the latter from New Jersey to the Rio Grande; (3) the zone of *Exogyra costata*, which has been traced from New Jersey to Mexico. This zone is roughly separable into three parts: a lower, characterized by a variety of *Exogyra costata* with broad costae; a middle, characterized by a variety with costae of medium breadth; and an upper, characterized by a variety with narrow costae.

The correlations based on the *Exogyra* zones and subzones are supported by many other molluscan species of restricted stratigraphic range and more or less extended geographic range.

Tables and charts were shown illustrating the physical and age relations of the formations, the stratigraphic position of the species and varieties of *Exogyra*, and the correlation of the formations with each other and with the Upper Cretaceous deposits of the Western Interior and of Europe.

G. R. Mansfield and P. V. Roundy: *Some Jurassic and Cretaceous formations of southeastern Idaho.* (Illustrated.)

In the Montpelier and Wayan 30-minute quadrangles of southeastern Idaho parties of the Geological Survey have found great thicknesses of strata, aggregating 17,000 feet or more, that have hitherto been assigned to the Beckwith and Bear River formations. On the maps of the Hayden Surveys both formations are included in the Laramie. The Beckwith has been assigned to the Cretaceous or Jurassic, and the Bear River to the Upper Cretaceous. There is such lack of agreement between the formations in the quadrangles named and the Beckwith and Bear River formations in their type localities that it now seems inadvisable to continue the use of the names Beckwith and Bear River in this district. Three groups of strata are recognized, the lowest of which is marine Jurassic and rests unconformably upon the Twin Creek limestone, the main Jurassic formation of the region. The two higher groups are non-marine and probably Lower Cretaceous. They are separated from each other by an unconformity, but the lower group appears to be conformable on the Jurassic beds below. The two higher groups have some resemblances to the Kootenai, but the data are at present insufficient for their correlation with that formation. No characteristic Bear River fossils have been found in the district, though such have been found farther north, and there is a possibility that the doubtful beds may grade upward into the true Bear River in that direction. The beds formerly called Beckwith are divided into seven formations and a new name is given to the strata hitherto called Bear River. The paper gives a statement of the stratigraphic problems involved, together with a description of the formations.

Discussion. C. J. Hares asked if the pebbles of the conglomerate described could be attributed definitely to any older formation. Mansfield replied that many different formations were probably represented but could not be definitely recognized. T. W. Stanton remarked on the lithologic and successional differences in this section from those in adjacent sections. He said also that the formations between the marine Upper Jurassic and the marine Upper Cretaceous still needed much study before it would be possible to make definite correlations.

A. C. Spencer: *Gold deposits of the Atlantic and South Pass Districts, Wyoming.* (No abstract.)

At the 301st meeting, held December 8, 1915, the presidential address was delivered by the retiring president, T. Wayland Vaughan: *Some problems in the geologic history of the perimeters of the Gulf of Mexico and the Caribbean Sea.* The address will be published at a later date.

At the twenty-third annual meeting the following officers were elected for the ensuing year: *President,* Arthur C. Spencer; *Vice-Presidents,* W. C. Mendenhall and F. H. Knowlton; *Secretaries,* Carroll H. Wegemann and H. E. Merwin; *Treasurer,* S. R. Capps; *Members-at-large of the Council,* B. S. Butler, C. W. Gilmore, G. F. Loughlin, H. S. Gale and R. W. Pack. C. N. Fenner, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 110th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, February 1, 1916. Fifty-three members and four guests were present. Messrs. Chas. H. Clark, Felix J. Schneiderhan, and T. Tanaka were elected to membership. The following papers were presented:

Egyptian use of date tree products other than fruit (with lantern): S. C. Mason. (To be published in full elsewhere.)

Botanical and economic notes on the dasheen (with lantern and exhibit): R. A. Young.

The dasheens represent one type of the taro, which is well known in the Orient and the islands of the Pacific. All belong to the genus *Colocasia.* The variety under special consideration was the one known as the "Trinidad," from the island of Trinidad; it is believed to have come originally from China. Slides were shown illustrating the differences in floral and other characters between two very distinct types of *Colocasia,* which for the past sixty years have been included under the name *C. antiquorum* (L.) Schott. One of the types, which includes the dasheen, was recognized tentatively by Schott, in 1832, as a good species under the name *C. esculenta* (L.) Schott. In 1856 he reduced it to a varietal rank. The other type, which is represented by the "qolqas" or "colocasia" of Egypt, is the species *C. antiquorum.* It is contended that the reduction of *C. esculenta* to varietal rank, was an error and it is proposed to restore it to specific rank. The true *C. antiquorum* properly includes the common elephant-ear plant, generally referred to as *Caladium esculentum* of Ventenat.

The dasheen is gaining in importance in the far south, and a northern market is developing. Many culinary experiments have been made and a number of delicious and attractive dishes have resulted.

After the program, dasheens which had been parboiled and baked with electric stoves, were served.

The pathological inspection work of the Federal Horticultural Board. Geo. R. Lyman.

The Plant Quarantine Law seeks to prevent the introduction into the United States of injurious plant diseases from abroad by requiring the inspection of imported plant material. The inspection of commercial importations presents few difficulties, inasmuch as the variety of host plants involved is not great and the importations are ordinarily from countries where the diseases are well known. But importations by the Department of Agriculture for experimental and introduction purposes present many problems, since they come from every quarter of the globe and are practically unlimited in variety of host plant. Both host and disease may be new and hence potentially dangerous. All such importations are received in a specially constructed inspection house in Washington, and the packages are opened in the presence of the inspectors, all wrappings being burned. The plant material is closely examined and suspicious specimens are referred to experts of the Department of Agriculture for study and determination. Extraordinary precautions are taken to prevent infection being carried on the hands or clothing of the inspectors.

After inspection the material may be (1) passed, if it is apparently clean; (2) burned, if dangerous diseases are found; (3) ordered fumigated or cleansed when the pests found can be eradicated by such treatment (facilities for treating material are present in the inspection room); or (4) ordered grown in quarantine. The quarantine greenhouse adjoining the inspection room is divided into small units where suspicious plants may be isolated and grown under close observation until the proper disposition of them is determined.

Moreover, much of the material which passes inspection is ordered grown in the propagation gardens of the Government, one of which is situated at Yarrow, Maryland. Here the plants are propagated and grown under observation and are given a last close inspection when finally ready for distribution.

W. E. Safford, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 549th regular meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, January 29, 1916, at 8 p.m.; called to order by President Hay with thirty persons present.

The recent deaths of three members of the Society, G. D. Elliot, A. M. Groves, and C. E. Slocum, were noted by the President. On recommendation of the Council Dr. Walter K. Fisher, of Stanford University, was elected to active membership.

Under the heading "Brief Notes" Dr. L. O. Howard told of some of the published anecdotes regarding the entomologist General Dejean who served under Napoleon I, and of his zeal as a collector even under the excitement of battle. Also, Dr. H. M. Smith called attention to the successful introduction of the tilefish into the markets, restaurants, and homes of the United States.

Under the heading "Exhibition of Specimens" Dr. Howard exhibited a photographic lantern slide of Orsini's statue, *Proximus Tuus*, representing a malarial-stricken Italian peasant. The statue was exhibited at the San Francisco fair and illustrations of it are used in a California antimosquito campaign. By way of contrast Dr. Howard showed a group of healthy children on the formerly malaria-infested Roman Campagna.

Under the same heading Mr. William Palmer exhibited several bones of extinct cetaceans recently collected by him at Chesapeake Beach, Maryland. He called attention to the work of Cope and of other paleontologists on this group and pointed out the relationships of the forms with some of the modern cetaceans.

The regular program consisted of a paper by Dr. Ned Dearborn, *Fur farming in Alaska.* Dr. Dearborn pointed out the possibilities of fur farming in Alaska, stating that at present there are seventy-three localities in that territory where such farming is carried on to a greater or less extent. The possible animals that may be bred for fur are the fox, mink, marten, otter, and beaver; but so far it has only proved practicable with foxes and minks. Silver foxes are successfully bred in the interior and fed on salmon and rabbits to a large extent. Blue foxes are successfully raised along the coast, especially on certain of the islands.

The paper was discussed by Dr. C. W. STILES who called attention to the prevalence of certain forms of hookworms in the dogs and foxes of Europe and Alaska but seldom found in the dogs of the United States.

The 550th regular meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, February 12, 1916, at 8 p.m., fifty persons being present.

On recommendation of the Council, WALTER P. TAYLOR, of the Museum of Vertebrate Zoology, Berkeley, California, was elected to active membership.

Under the heading Brief Notes and Exhibition of Specimens, L. O. HOWARD called attention to the work lately done by Dr. W. V. KING, of the Bureau of Entomology, in demonstrating that *Anopheles punctipennis* was a carrier of both tertian and aestivo-autumnal malaria parasites. He exhibited lantern slides of this mosquito and photomicrographs of the stages of the malaria organism in this hitherto supposedly harmless species of mosquito.

Under the same heading W. L. MCATEE gave some of his recent observations on the vegetation of Virginia in the region south of Washington.

The first paper of the regular program was by HENRY TALBOTT: *Nepigon.* Mr. Talbott gave an entertaining account of a trip made by himself and others to Lake Nepigon. The fishes of the lake and neighboring region were especially dwelt on. Mr. Talbot's paper was discussed by Dr. HOWARD.

The second and last paper of the regular program was by VERNON BAILEY: *Game and other mammals of the Yellowstone Park region.* Mr. Bailey gave a short outline of his recent trip through the Yellowstone Park and the neighboring region, particularly to the south. The ground covered was mainly off the tourist track. The speaker described the beauties of the park from the viewpoint of the lover of wild life; he called particular attention to the loss of fear of men by wild life when protected from guns, dogs and cats; he called to notice the thriving condition of herds of ruminants in the park and the successful efforts now made to supply hay to the needy in winter, and to keep the antelope from wandering out of the park. Mr. Bailey's communication was profusely illustrated with lantern slide views of the park and of its wild life, especially the white-tailed deer, mule deer, elk, moose (recently described as *Alces shirasi*), antelope, bison, some of the smaller mammals and Canada geese.

M. W. LYON, JR., *Recording Secretary.*

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ASTRONOMY.—*The distances of the heavenly bodies.*[1] W. A. Eichelberger, U. S. Naval Observatory.

A year ago our retiring president took the members of the Society into his confidence as follows:

> Cognizant of the fact that my election to the presidency of the Philosophical Society a year ago, obligated me to give an address of some sort one year later, I confidently waited for the inspiration that I felt would suggest a fitting subject for the occasion. The expected inspiration did not, however, materialize.

Undoubtedly because of that fact, and out of the goodness of his heart, towards the close of his address he turned to the present speaker, then presiding, and said:

> I have said nothing whatever about the determination of the distances between the planets nor of the units used by astronomers in reckoning distances of the stars. . . . They form, so to speak, other chapters of the subject which I shall leave to some future ex-president of our Society.

This call, I suppose, was intended to take the place of an inspiration, and wherever I have gone during the past twelve months the call has ever been ringing in my ears. The subject of the evening is presented therefore not as a matter of choice but from compulsion.

Before any attempt was made by the ancients to determine the distance from the Earth of any celestial body, we find them

[1] Presidential address before the Philosophical Society of Washington on March 4, 1916.

arranging these bodies in order of distance very much as we know them to-day, assuming that the more rapid the motion of a body among the stars the less its distance from the Earth; the stars, that were supposed to have no relative motions, were assumed to be the most distant objects.

The first attempt to assign definite relative distances to any two of the bodies was probably that of Eudoxus of Cnidus who, about 370 B.C., supposed, according to Archimedes, that the diameter of the Sun was nine times greater than that of the Moon, which is equivalent to saying that, since the Sun and the Moon have approximately the same apparent diameter, the distance of the Sun from the Earth is nine times greater than that of the Moon.

A century later, about 275 B.C., Aristarchus of Samos gave a method of determining the relative distances of the Sun and Moon from the Earth as follows: When the Moon is at the phase first quarter or last quarter, the Earth is in the plane of the circle which separates the portion of the Moon illuminated by the Sun from the non-illuminated part, and the line from the observer to the center of the Moon is perpendicular to the line from the center of the Moon to the Sun. (Diagram shown.) If, at this instant, the angular separation of the Sun and Moon is determined, one of the acute angles of a right-angle triangle—Sun, Moon, and Earth—is known, from which can be deduced the ratio of any two of the sides, as, for instance, the ratio of the distance from the Earth to the Moon to that from the Earth to the Sun. Aristarchus gives the value of this angle as differing from a right angle by only one-thirtieth of that angle, i.e. it is an angle of 87°, from which it follows that the distance from the Earth to the Sun is nineteen times that from the Earth to the Moon. This method of Aristarchus is theoretically correct, but in determining the angle at the Earth as being 3° less than a right angle, he made an error of about 2° 50′.

Hipparchus, who lived about 150 B.C. and was called by Delambre the true father of astronomy, attacked the problem of the distances of the Sun and Moon through a study of eclipses. Assuming in accordance with the result of Aristarchus that the

Sun is nineteen times as far from the Earth as the Moon, having determined the diameter of the Earth's shadow at the distance of the Moon and knowing the angular diameter of the Moon he found 3′ as the Sun's horizontal parallax. By the Sun's parallax is meant the angle at the Sun subtended by the Earth's semi-diameter and if a = the semi-diameter of the Earth, Δ = the distance to the Sun, and Π = Sun's horizontal parallax, the relation (diagram shown) between these quantities is expressed by the equation:

$$\mathrm{Sin}\, \Pi = \frac{a}{\Delta}$$

The next attempt to determine the distance of a heavenly body was made about 150 A.D. by Claudius Ptolemy, the last of the ancient astronomers and one whose writings were considered the standard in things astronomical for fifteen centuries. To determine the lunar parallax he resorted to direct observations of the zenith distance of the Moon on the meridian, comparing the result of his observations with the position obtained from the lunar theory. He determined the parallax when the Moon was nearest the zenith, and also when it crossed his meridian at its farthest distance from the zenith. From his observations he obtained results varying from less than 50 per cent of the true parallax (57.′0) to more than 150 per cent of that value. According to Houzeau the definitive result of Ptolemy's work is 58.′7.

It is thus seen that the astronomers of two thousand years ago had a fairly accurate knowledge of the distance of the Moon from the Earth, but an entirely erroneous one of the distance of the Sun, the true distance being something like twenty times that assumed by them. This value of the distance of the Sun from the Earth was accepted for nineteen centuries from Aristarchus to Kepler, having been deduced anew by such men as Copernicus and Tycho Brahe.

With the announcement by Kepler, early in the seventeenth century, of his laws of planetary motion, it became possible to deduce from the periodic times of revolution of the planets around the Sun their relative distances from that body, and thus to determine the distance of the Sun from the Earth, by determining the distance or parallax of one of the planets.

From observations of Mars, Kepler obtained the distance of the Sun from the Earth as about three times that accepted up to his time. His value, however, was but one-seventh of the true distance. About fifty years later Flamsteed and Cassini working independently and using the same method as that employed by Kepler obtained for the first time approximately the correct value of the distance of the Sun from the Earth. In a letter, dated November 16, 1672, to the Publisher of the *Philosophical Transactions*, Flamsteed says:

> September last I went to Townley. The first week that I intended to have observed ♂ there with Mr. Townley, I twice observ'd him, but could not make two Observations, as I intended, in one night. The first night after my return, I had the good hap to measure his distances from two Stars the same night; whereby I find, that the Parallax was very small; certainly not 30 seconds: So that I believe the Sun's Parallax is not more than 10 seconds. Of this Observation I intend to write a small Tract, when I shall gain leisure; in which I shall demonstrate both the Diameter and Distances of all the Planets by Observations; for which I am now pretty well fitted.

During the two and a half centuries since Flamsteed's determination there have been more than a hundred determinations of the solar parallax by various methods. In the method used by Flamsteed, the rotation of the Earth is depended upon to change the relative position of the observer, the center of the Earth, and Mars. (Diagram shown.) Another method is to establish two stations widely separated in latitude, and in approximately the same longitude. At one station, the zenith distance of Mars will be determined as it crosses the meridian north of the zenith; at the other station, the zenith distance will be determined as it crosses the meridian south of the zenith. The sum of the two zenith distances minus the difference in latitude between the two stations will give the displacement of Mars due to parallax. These two methods have been successfully applied to several of the asteroids whose distances from the Sun are very nearly that of Mars.

The nearest approach of Venus to the Earth is during her transit across the face of the Sun, and these occasions, four during the last two centuries, have been utilized to determine the solar parallax. Here as in the case of Mars two different methods may be used, either by combining observations at two stations widely separated in latitude, or at two stations widely separated in longitude. (Diagrams shown.)

The methods just described for obtaining the solar parallax, the geometrical methods, were made available, as has been said, by the discovery of Kepler's laws of planetary motion. Newton's discovery of the law of gravitation gave rise to another group of methods, designated as gravitational methods. The best of these is probably that in which the distance of the Sun from the Earth is determined from the mass of the Earth, which, in turn, is determined from the perturbative effect of the Earth upon Venus and Mars. This method is long and laborious but its importance lies in the fact that the accuracy of the result increases with the time. Professor C. A. Young says:

> this is the "method of the future," and two or three hundred years hence will have superseded all the others,—unless indeed it should appear that bodies at present unknown are interfering with the movements of our neighboring planets, or unless it should turn out that the law of gravitation is not quite so simple as it is now supposed to be.

A third group of methods of determining the distance of the Sun from the Earth, called the physical methods, depends upon the determination of the velocity of light in conjunction either with the time it takes light to travel from the Sun to the Earth obtained from observations of the eclipses of Jupiter's satellites, or with the constant of aberration derived from observations of the stars.

In August, 1898, Dr. Witt of Berlin discovered an asteroid, since named Eros, which was soon seen to offer exceptional opportunity for the determination of the solar parallax, as at the very next opposition, in November, 1900, it would approach to within 30,000,000 miles of the Earth. At the meeting of the Astrographic Chart Congress in Paris in July, 1900, it was resolved to seize this opportunity and organize an international parallax campaign. Fifty-eight observatories took part in the various observations called for by the general plan. The meridian instruments determined the absolute position of Eros from night to night as it crossed the meridians of the various observatories; the large visual refractors measured the distance of Eros from the faint stars near it, at times continuing the measures throughout the entire night; and the photographic equatorials obtained permanent records of the position of Eros among the surrounding stars. In addition long series of observations had to be made to determine the positions of the stars to which Eros was referred.

When several years had elapsed after the completion of the observations, and no general discussion of all the material had been provided for, Prof. Arthur R. Hinks of Cambridge, England volunteered for the work. The undertaking was truly monumental. He first formed a catalogue of the 671 stars which had been selected by the Paris Congress for observation as marking out the path of Eros from a discussion of the results obtained by the meridian instruments and from the photographic plates. This done, with these results as a basis, a larger catalogue of about 6000 stars had to be formed from measures on the photographic plates. He was then ready to commence the discussion of the observations of Eros itself. From 1901 to 1910 there appeared in the *Monthly Notices of the Royal Astronomical Society* eight articles covering 135 pages giving the results of his labors.

From a discussion of all the photographic observations he obtained a solar parallax of

$$8''.807 \pm 0''.0027$$

a probable error equivalent to an uncertainty of about 30,000 miles in the distance to the Sun.

From a discussion of all the micrometric observations he obtained

$$8''.806 \pm 0''.004$$

The observations with the meridian instruments gave

$$8''.837 \pm 0''.0185$$

a determination relatively much weaker than either of the others.

A parallax of 8″.80, the value adopted for all the national almanacs twenty years ago, corresponds to a distance of 92,900,000 miles. At present it seems improbable that another parallax campaign will be undertaken before 1931, when Eros approaches still nearer to the Earth, its least distance at that time being about 15,000,000 miles.

TABLE I

Approximate Distance from Earth to Sun as Accepted at Various Times

DATE	DISTANCE
	miles
275 B.C. to 1620 A.D.	4,500,000
1620 Kepler	13,500,000
1672 Flamsteed	81,500,000
1916	92,900,000

When Copernicus proposed that the Sun is the center of the Solar System and that all the planets including the Earth revolve around the Sun, it was at once seen that such a motion of the Earth must produce an annual parallax of the stars. Tycho Brahe rejected the Copernican System because he could not find from his observations any such parallax. However, the system was generally accepted as the true one and the determination of stellar parallax or the distance of the stars became a live subject. Picard in the latter half of the seventeenth century, using a telescope and a micrometer in connection with his divided circle, showed an annual variation in the declination of the pole star amounting to 40″. In 1674 Hooke announced a parallax of 15″ for γ Draconis. About this same time Flamsteed announced a parallax of 20″ for α Ursae Minoris, but J. Cassini showed that the variations in the declination did not follow the law of the parallax.

The period which we have now reached is so admirably treated by Sir Frank W. Dyson, Astronomer Royal, in his Halley Lecture delivered at Oxford on May 20, 1915, that I ask your indulgence while I quote rather freely from that source.

Thus in Halley's time, it was fairly well established that the stars were at least 20,000 or 30,000 times as distant as the sun. Halley did not succeed in finding their range, but he made an important discovery which showed that three of the stars were at sensible distances. In 1718 he contributed to the Royal Society a paper entitled Considerations of the Change of the Latitude of Some of the Principle Bright Stars. While pursuing researches on another subject, he found that the three bright stars—Aldebaran, Sirius, and Arcturus—occupied positions among the other stars differing considerably from those assigned to them in the *Almagest* of Ptolemy. He showed that the possibility of an error in the transcription of the manuscript could be safely excluded, and that the southward movement of these stars to the extent of 37′, 42′, and 33′,—i.e. angles larger than the apparent diameter of the sun in the sky—were established. . . .

This is the first good evidence, i.e. evidence which we now know to be true, that the so-called fixed stars are not fixed relatively to one another. It is the first positive proof that the distances of the stars are sensibly less than infinite.

At the time of the appearance of Halley's paper there was coming into notice a young astronomer, James Bradley, then 26 years old. He was admitted to membership in the Royal Society the same year that Halley's paper was presented. He was exceedingly eager to attack the problem of the distances of the stars. At length the opportunity presented itself. To quote again from Sir Frank Dyson:

Bradley designed an instrument for measuring the angular distance from the zenith, at which a certain star, γ Draconis, crossed the meridian. This instrument is called a zenith sector. The direction of the vertical is given by a plumb-line, and he measured from day to day the angular distance of the star from the direction of the vertical. From December, 1725, to March, 1726, the star gradually moved further south; then it remained stationary for a little time; then moved northwards until, by the middle of June, it was in the same position as in December. It continued to move northwards until the beginning of September, then turned again and reached its old position in December. The movement was very regular and evidently not due to any errors in Bradley's observations. But it was most unexpected. The effect of parallax—which Bradley was looking for—would have brought the star farthest south in December, not in March. The times were all three months wrong. Bradley examined other stars. thinking first that this might be due to a movement of the earth's pole. But this would not explain the phenomena. The true explanation, it is said, although I do not know how truly, occurred to Bradley when he was sailing on the Thames, and noticed that the direction of the wind, as indicated by a vane on the mast-head, varied slightly with the course on which the boat was sailing. An account of the observations in the form of a letter from Bradley to Halley is published in the *Philosophical Transactions* for December, 1728:

When the year was completed, I began to examine and compare my observations, and having pretty well satisfied myself as to the general laws of the *phenomena*, I then endeavored to find out the cause of them. I was already convinced that the apparent motion of the stars was not owing to the nutation of the earth's axis. The next thing that offered itself was an alteration in the direction of the plumb-line with which the instrument was constantly rectified; but this upon trial proved insufficient. Then I considered what refraction might do, but there also nothing satisfactory occurred. At length I conjectured that all the *phenomena* hitherto mentioned, proceeded from the progressive motion of light and the earth's annual motion in its orbit. For I preceived that, if light was propagated in time, the apparent place of a fixed object would not be the same when the eye is at rest, as when it is moving in any other direction than that of the line passing through the eye and the object; and that, when the eye is moving in different directions, the apparent place of the object would be different.

When Bradley's observations of γ Draconis were corrected for aberration, they showed, according to himself, that the parallax of that star could not be as much as $1''.0$, or that the star was more than 200,000 times as distant from the Earth as the Sun.

On December 6, 1781 there was read before the Royal Society a paper by Mr. Herschel, afterwards Sir William, on the *Parallax of the Fixed Stars*. We read:

The method pointed out by Galileo, and first attempted by Hook, Flamstead, Molineaux, and Bradley, of taking distances of stars from the zenith that pass very near it, though it failed with regard to parallax, has been productive of the most noble discoveries of another nature. At the same time it has given us a much juster idea of the immense distance of the stars, and furnished us with an approximation to the knowledge of their parallax that is much nearer the truth than we ever had before. . . .

In general, the method of zenith distances labours under the following considerable difficulties. In the first place, all these distances, though they should not exceed a few degrees, are liable to refractions; and I hope to be pardoned when I say that the real quantities of these refractions, and their differences, are very far from being perfectly known. Secondly, the change of position of the earth's axis arising from nutation, precession of the equinoxes, and other causes, is so far from being completely settled, that it would not be very easy to say what it exactly is at any given time. In the third place, the aberration of light, though best known of all, may also be liable to some small errors, since the observations from which it was deduced laboured under all the foregoing difficulties. I do not mean to say, that our theories of all these causes of error are defective; on the contrary, I grant that we are for most astronomical purposes sufficiently furnished with excellent tables to correct our observations from the above mentioned errors. But when we are upon so delicate a point as the parallax of the stars; when we are investigating angles that may, perhaps, not amount to a single second, we must endeavour to keep clear of every possibility of being involved in uncertainties; even the hundredth part of a second becomes a quantity to be taken into consideration.

Herschel then proceeds to advocate selecting pairs of stars of very unequal magnitude and whose distance apart is less than five seconds, and making very accurate micrometric measures of this distance from time to time. The first condition, should give, in general, stars very unequally distant from the Earth, so that the changing perspective as the Earth revolves in her orbit would give a variation of the apparent distance between the stars, while the small distance, less than five seconds, would eliminate from consideration entirely any effect upon this distance of the uncertainties in refraction, precession, nutation, aberration, etc. Herschel had already commenced the cataloguing of such double stars and in January, 1782, submitted to the Royal Society a catalogue of 269. This work did not enable Herschel to determine the distances of the stars but did enable him to demonstrate that there exist pairs of stars in which the two components revolve the one around the other. In twenty years he had found fifty such pairs.

Coming forward another generation, that is, to a time a little less than a hundred years ago, we find Pond, then Astronomer Royal, writing:

The history of annual parallax appears to me to be this: in proportion as instruments have been imperfect in their construction, they have misled observers into the belief of the existence of sensible parallax. This has happened in Italy to astronomers of the very first reputation. The Dublin instrument is superior to any of a similar construction on the continent; and accordingly it shows a much less parallax than the Italian astronomers imagined they had detected. Conceiving that I have established, beyond a doubt, that the Greenwich instrument approaches still nearer to perfection, I can come to no other conclusion than that this is the reason why it discovers no parallax at all.

Within fifteen years after this statement by Pond, observations had been obtained which showed a measurable parallax of three different stars. The announcements of these results, each by a different astronomer, were practically simultaneous.

W. Struve, using a filar micrometer, determined the distance of α Lyrae from a small star about 40″ distant on 60 different days over a period of nearly three years. He obtained a parallax of 0″.262 ± 0″.025. Bessel, using his heliometer, determined the distances of 61 Cygni from two small stars distant about 500″ and 700″ respectively. He obtained for this star a parallax of 0″.314 ± 0″.020. Henderson, using determinations of the position of α Centauri by meridian instruments, deduced a parallax of 1″.16 ± 0″.11. All three of these results were announced in the winter of 1838–39, and indicate that the three stars are distant from the Earth about 750,000, 650,000, and 200,000 times the distance of the Sun from the Earth.

TABLE II

PARALLAX OF 61 CYGNI

MEAN DATE	OBSERVED DISPLACEMENT	COMPUTED FROM 0″.314
1837 August 23	+0″.20	+0″.18
September 14	+0.10	+0.08
October 12	+0.04	−0.05
November 22	−0.21	−0.22
December 21	−0.32	−0.27
1838 January 14	−0.38	−0.27
February 5	−0.22	−0.23
May 14	+0.24	+0.20
June 19	+0.36	+0.28
July 13	+0.22	+0.28
August 19	+0.15	+0.19
September 19	+0.04	+0.06

Table II exhibits the observed displacement of 61 Cygni by monthly means as given by Main from Bessel's observations. The last column gives the computed displacement on the assumption of a parallax of 0″.314. The reality of the parallax is seen at a glance.

In 1888, fifty years after the first determination of what we now know to be a true stellar parallax, Young in his *General Astronomy* gives, in a list of known stellar parallaxes, 28 stars and 55 separate determinations. Within the next ten years the number of stars whose parallaxes had been determined about doubled, due principally to the work of Gill and Elkin.

Probably the most extensive piece of stellar parallax work in existence is that with the Yale heliometer. The results to date were published in 1912 and contained the parallaxes of 245 stars, the observations extending over a quarter of a century, the entire work having been done by three men, Elkin, Chase, and Smith. In selecting a list of stars for parallax work an effort is made to obtain stars which give promise of being nearer than the mass of stars. At first the brighter stars were selected, and then those with large proper motions. The Yale list of 245 stars contains all stars in the northern heavens whose annual proper motion is known to be as much as $0''.5$. Of these 245 stars, 54 are given a negative parallax. A negative parallax does not mean, as some one has expressed it, that the star is "somewhere on the other side of nowhere," but such a result may be attributed to the errors of observation or to the fact that the comparison stars are nearer than the one under investigation. It is safe to say, however, that somewhat more than half of the 245 stars have a measurable parallax.

Another series of stellar parallax observations, comparable in extent with the one just mentioned, is that of Flint at the Washburn Observatory. This series includes 203 stars and extended from 1893 to 1905. These observations were made with a meridian circle, but not after the method of a century ago. The observations were strictly differential, the general plan being to select two faint comparison stars, one immediately preceding and the other immediately following the parallax star, and to determine the difference in right ascension, the observation of the three stars occupying about five minutes. Here as in the case of the Yale heliometer work a large proportion of the resulting parallaxes are negative; somewhat more than half, however, were found to have a measurable parallax. The average probable error of a parallax was the same in each of these two pieces of work, about 0″.03. The progress of the work during the last two or three generations is given in Table III which contains also a brief statement of the discoveries made during the preceding century due chiefly to efforts to measure stellar parallaxes.

TABLE III

Approximate Number of Known Stellar Parallaxes

DATE	ASTRONOMER	NUMBER OF STARS WITH KNOWN PARALLAXES	DISCOVERIES
1718	Halley	No parallax.	Proper motion.
1728	Bradley	No parallax.	Aberration.
1750	Bradley	No parallax.	Nutation.
1790	Herschel	No parallax.	True binary systems.
1838		3.	
1888		28.	
1898		50 to 60.	
1916		200 to 300.	

A generation ago photography entered the field of stellar parallax work, and has outdistanced all the previously employed methods for efficiency. In 1911, two publications appeared giving the results of photographic stellar parallax work, one by Russell, giving the parallaxes of forty stars from photographs taken by Hinks and himself at Cambridge, England, the other by Schlesinger, giving the parallaxes of twenty-five stars from photographs taken mostly by himself at the Yerkes Observatory, Williams Bay, Wisconsin. In speaking of these two series of observations, Sir David Gill said:

> On the whole, the Cambridge results, when a sufficient number of plates have been taken, and when the comparison stars are symmetrically arranged, give results of an accuracy which, but for the wonderful precision of the Yerkes observations, would have been regarded as of the highest class.

Schlesinger has shown that with a telescope of the size and character of the Yerkes instrument "the number of stellar parallaxes that can be determined per annum, with an average probable error of 0″.013, will in the long run be about equal to the number of clear nights available for the work."

In other words, the Yerkes 40-inch equatorial used photographically determines stellar parallaxes with one-tenth the labor required with an heliometer and with twice the accuracy.

In July, 1913, stellar parallax work was undertaken with the 60-inch reflector of the Mount Wilson Solar Observatory, and at the meeting of the American Astronomical Society at San Francisco in August, 1915 a report on that work was made. The parallaxes of thirteen stars had been determined, with a maximum probable error of 0″.010 and an average probable error of less than 0″.006, giving twice the accuracy of the Schlesinger results with the Yerkes 40-inch and from three to five times that obtained fifteen years ago. What may we not expect when the 100-inch reflector gets to work on Mt. Wilson.

At the meeting of the American Astronomical Society to which reference has just been made, two other observatories reported upon their stellar parallax work. Lee and Joy of the Yerkes Observatory reported the parallaxes of nine stars with a maximum probable error of 0.″014 and an average probable error of 0″.010, and Mitchell of Leander McCormick Observatory reported the parallaxes of eleven stars with a maximum probable error of 0″.012 and an average probable error of 0″.009.

The progress made in the accuracy of parallax results is shown at a glance in Table IV.

TABLE IV

The Accuracy of Stellar Parallax Determinations

DATE	INSTRUMENT		PROBABLE ERROR	OBSERVERS
1838	Micrometric	Dorpat refractor	0″.025	Struve.
1838		Königsberg heliometer	0.02	Bessel.
1880–1898		Cape heliometer	0.017	Gill and Assistants.
1888–1912		Yale heliometer	0.03	Elkin, Chase, and Smith.
1893–1905		Washburn meridian circle	0.03	Flint.
1910	Photographic	Yerkes refractor	0.013	Schlesinger.
1915		Yerkes refractor	0.010	Lee and Joy.
1915		Leander McCormick refractor	0.009	Mitchell.
1915		Mt. Wilson 60-inch reflector	0.006	Van Maanan

From these results it appears that any star whose parallax is as much as 0''.02, i.e., whose distance from the Earth is less than ten million times that from the Earth to the Sun, should give a positive result when subjected to the treatment now employed in parallax investigations, and as eight or ten observatories are devoting their energies to stellar parallax work at present, the combined programs containing over 1000 different stars, we ought soon to have lists of at least a few thousand stars whose parallaxes are known where our present lists contain but a few hundred.

OCEANOGRAPHY.—*On the temperature of the water below the 1000-fathom line between California and the Hawaiian Islands.*[1] AUSTIN H. CLARK, National Museum.

From October 11, 1891 until January 15, 1892 the United States Fisheries steamer *Albatross* was engaged in a cable survey between California and the Hawaiian Islands. On this cruise she occupied 556 stations (Nos. 2655 to 3202 in the records of the *Albatross* as published by the Bureau of Fisheries, Nos. 1 to 556 in the report published by the Navy Department), at nearly half of which the temperature of the bottom water was ascertained. Although these records are individually not so accurate as might be desired, it has seemed possible to make use of them by employing a system of broad averages; that is, by accepting as approximately true the mean of all the readings not obviously erroneous within units of five degrees of longitude.

Abyssal temperatures in the Pacific vary so slightly that if given in the actual figures it is difficult to appreciate the differences. The most graphic exposition of these differences is by presentation as plus or minus departures from the mean temperature for the whole ocean at the depths considered, as ascertained by comparison with the table published by Murray and Hjort.[2]

[1] Published with the permission of the Commissioner of the Bureau of Fisheries.

[2] Depths of the Ocean, p. xvi. 1912.

Using this method we find the following departures from the mean for the depth given between California and the Hawaiian Islands:

TABLE I

DEPTH (FATHOMS)	1000–1500	1500–2000	OVER 2000
120° to 125° W. long.	−0°.20(3)*	−0°.25(6)	−0°.26 (7)
125° to 130° W. long.			−0°.17 (23)
130° to 135° W. long.			−0°.11 (11)
135° to 140° W. long.			−0°.12 (24)
140° to 145° W. long.			−0°.04 (16)
145° to 150° W. long.			−0°.02 (15)
150° to 155° W. long.		+0°.15(2)	+0°.15 (15)
155° to 160° W. long.	±0 (1)		+0°.15 (9)
Maximum variation	0°.20	0°.40	0°.41

* The numbers in parentheses are the numbers of observations.

Below 2000 fathoms we find a maximum variation of only 0°.41 Fahrenheit. The abyssal water is coldest on the California coast; it gradually becomes warmer to long. 130°–140°W., then becomes gradually warmer again at almost the same rate to long. 145°–160°W., from which point it becomes rapidly warmer to long. 150°–160°W. The water between 1000 and 2000 fathoms is also warmer about the Hawaiian Islands than on the Californian coast. (See fig. 1.)

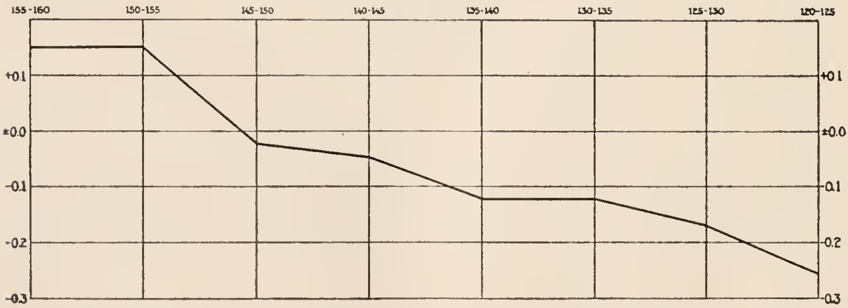

FIG. 1. Diagram illustrating the increase in the temperature of the water below 2000 fathoms between California and the Hawaiian Islands. The temperatures, recorded as plus or minus departures from the mean of the ocean as a whole, are given as averages of all the observations for each five degrees of longitude.

On the basis of the data it would be hazardous to attempt any generalizations; but the regular sequence of the figures suggests that in spite of the individual variation of the observations the averages are more or less reliable, and that the warming of the abyssal water from the Californian coast toward the mid-Pacific may be accepted as a fact.

In this connection it is well to call attention to the relatively high abyssal temperatures on the South and Central American coasts, as contrasted with those from southern California northward, especially off southern California and in the Gulf of Alaska.

PHYSICS.—*Plastic flow.*[1] E. C. Bingham, Richmond College. (Communicated by C. W. Waidner).

Bingham and Durham[2] showed experimentally that the fluidity of a suspension is a linear function of the concentration. The zero of fluidity is reached at a comparatively low volume concentration, as is shown in figure 1. The concentration which has zero fluidity serves to sharply demarcate viscous from plastic flow. All concentrations less than this are viscous and any shearing force, no matter how small, will produce a permanent deformation if exerted long enough. Concentrations greater than this are plastic and it is necessary to use a shearing force of definite magnitude in order to produce a permanent deformation. The laws of plastic flow have never been studied. The method of attack was to force suspensions of clay in water under known

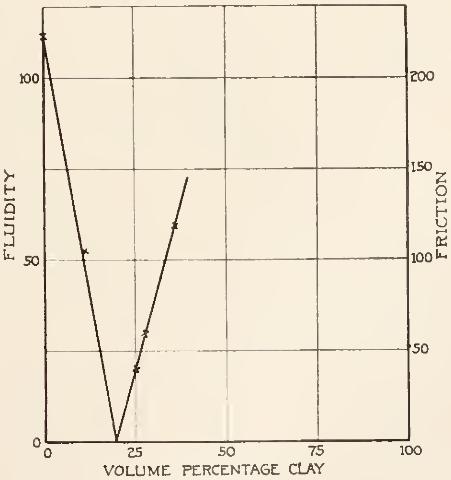

Fig. 1. Relation of fluidity and friction to concentration.

[1] This work has done at the Bureau of Standards.
[2] Amer. Chem. Journ. **46**: 278. 1911.

pressure through capillaries of different dimensions and measure the rates of flow. Some of the values obtained are shown in figure 2. For medium pressures the volume of flow is given

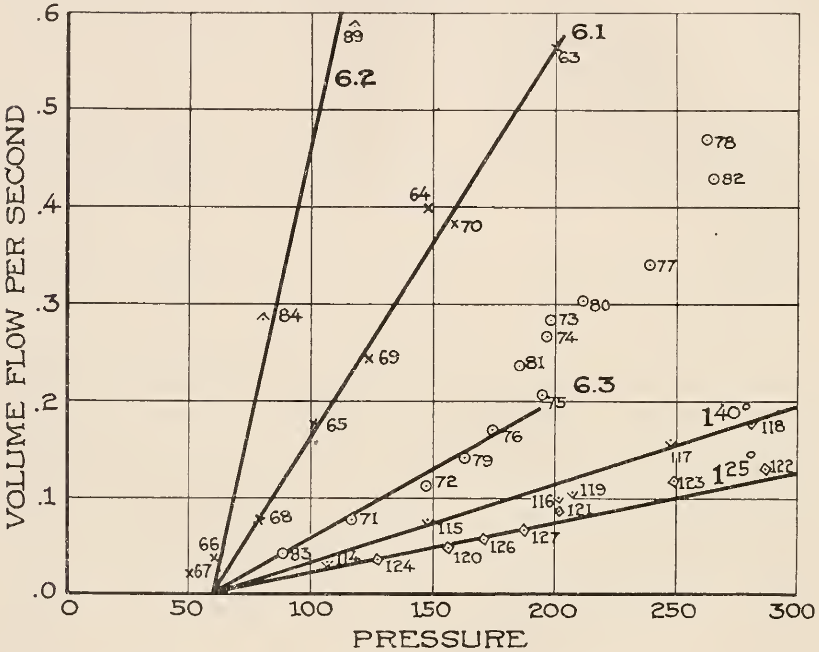

FIG. 2. The flow (in cc.) of 50 per cent clay suspension in water containing 0.1 per cent of potassium carbonate in solution, for pressures (g. per sq. cm.) as shown, and at 25°C., except one series of experiments with Capillary No. 1 which was made at 40°C. The following are the numbers and dimensions of the capillaries used:

Number of Capillary	*Radius in cm.*	*Length in cm.*
1.0	0.02848	2.468
6.1	0.05785	5.011
6.2	0.05811	2.509
6.3	0.05850	9.998

by the formula $v = k\ (P - f)$, where P is the pressure employed and f is the "friction," *i.e.*, the force required to start the flow. Putting $(P - f)$ in place of P in the ordinary Poiseuille formula for calculating the fluidity, we have a means for calculating the "mobility" of plastic substances, analagous to the fluidity of viscous substances. The friction increases as a linear function of the concentration of solid present (fig. 1). It is independent of the length and diameter of the capillary and of the viscosity of the medium. It is, however, affected by the presence of alkalies or acids in the medium. The mobility decreases rapidly as the concentration of the solid is increased, as is seen in figure 3. The mobility is enormously sensitive to the presence of alkalies or acids, the mobility of a neutral clay suspension being increased 330 per cent by the addition of 0.1 per cent of potassium carbonate. At pressures little if any greater than those necessary to overcome the friction there was detected a seepage of the medium past the solid particles (see capillary 6.1, fig. 2). At high pressures there was sometimes a sudden increase in the rate of flow, which is apparently due to slipping (see capillary 6.3, fig. 2). If the solid material consisted of spheres of equal size, the pore space left when the spheres were as closely packed as possible would amount to about 26 per cent, quite irrespective of the radius of the spheres. However, due to the friction of the spheres on each other, the pore space may be larger than this, and this is particularly true if the material is finely divided. As a matter of fact, it was found that on shaking dry clay into a flask the pore space amounted to 81.6 per cent of the total volume. This corresponds closely to the percentage of liquid present in the mixture having zero fluidity, which is 80.5. It is upon this friction that plasticity depends and the plasticity is thus closely related to the fineness of subdivision of the material.

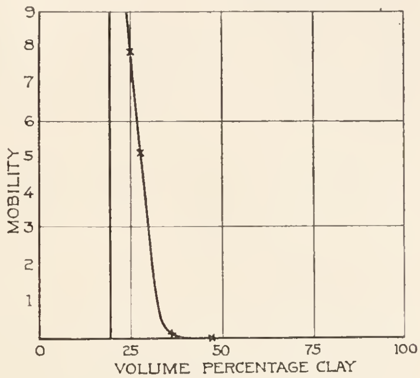

Fig. 3. Relation of mobility to concentration.

GEOLOGY.—*Note on a recent discovery of fossil plants in the Morrison formation.*[1] F. H. Knowlton, Geological Survey.

There has been a good deal of discussion within the past few years regarding the stratigraphic position of the Morrison formation, that is, as to whether it should be placed in the upper part of the Jurassic or the lower portion of the Cretaceous. The divergence of opinion on this point among stratigraphers and paleontologists was well brought out in the symposium on the "Close of Jurassic and opening of Cretaceous time in North America," given before the Paleontological Society at the Philadelphia meeting in 1914,[2] though the concensus of opinion appeared to favor placing it in the Cretaceous.

Heretofore, with the exception of some 20 nominal species of cycad trunks found in the Freezeout Hills in Carbon County, Wyoming, no fossil plants have been reported from the Morrison. This deficiency is now in a small measure supplied by the fortunate discovery of a plant-bearing horizon in the Morrison near Little Cottonwood Creek, in the eastern part of Bighorn Basin, Wyoming. Mr. C. T. Lupton, of the United States Geological Survey, found this locality in 1915 and sent in a small collection. Mr. Lupton has kindly supplied me with the following data regarding the location and stratigraphic relations:

> The fossil leaves I sent in were collected by my assistant, Mr. E. M. Parks, in the NW. ¼ sec. 14, T.47 N., R. 89 W., on the east side of Little Cottonwood Creek, an intermittent tributary of No Wood River. This place is about 5 miles west slightly north of the town of Ten Sleep, and about 1½ miles north of the Worland-Ten Sleep road where it crosses the former stream.
>
> The leaves occur in a thin bed of light shaly sandstone which lies just beneath a prominent 50-foot bed of white ledge-making sandstone containing a little conglomerate at its base. This prominent sandstone is variable in thickness and constitutes the basal part of the Cloverly formation as identified by Darton. The varicolored beds below this conglomeratic sandstone are characterized in many places by gastroliths ('stomach-stones').

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] Papers by Osborn, Lee, Mook, Lull, Berry, and Stanton. Bull. Geol. Soc. America **26**: 295–348. 1915.

The matrix in which the plants is preserved is a white, fine-grained, shaly sandstone, well fitted to retain the details of nervation, and there can be no question as to the identification. The two species present are: *Nilsonia nigricollensis* Wieland[3] and *Zamites arcticus* Göppert.[4] The first species has previously been found only at its type locality in the lower part of the Lakota sandstone, near the summit of the Black Hills rim, 5 miles north of Sturgis, South Dakota. The other species (*Zamites arcticus*) is very abundant in the Kootenai of Montana, and several Canadian localities. It has been reported also from the so-called Shasta flora of California, and from the Kome (Urgonian) of Greenland.

While it is manifestly unsafe to build much of a generalization on two species, yet so far as they go they indicate that the Morrison is Cretaceous.

A word may be added as to the evidence to be derived from the cycad trunks above mentioned from the Freezeout Hills. Although they are referred to a distinct genus (Cycadella) they are certainly very close to, if not indeed identical with, similarly silicified trunks of the genus Cycadeoidea, which are so abundant in the Lakota sandstone of the Black Hills rim and which occur also in the Patuxent formation of Maryland. The internal structure has not been fully investigated in Cycadella, about the only obvious difference between it and Cycadeoidea being the profusion of ramentum in the former, which is a character of doubtful generic value. This evidence also—so far as it goes—argues for the Cretaceous age of the Morrison.

MINERALOGY.—*The lozenge-shaped cavities in the First Watchung Mountain zeolite deposits.* EDGAR T. WHERRY, National Museum.[1]

The zeolite deposits in the basalt of First Watchung Mountain in Passaic County, New Jersey, frequently contain angular cavities representing minerals which crystallized out at an

[3] WIELAND, G. R., in WARD: U. S. Geol. Survey Mon. 48, 319, pl. 73, figs. 15a–d. 1905.

[4] Op. cit., 306, pl. 73, figs. 1–6.

[1] Published by permission of the Secretary of the Smithsonian Institution.

early stage, became surrounded by quartz, prehnite, or zeolites, and at some subsequent time dissolved away. Replacement by quartz also took place at various stages in the history of these crystals, so that the cavities sometimes show lamellae where the quartz entered along cleavage planes, and in other cases have been completely filled by quartz, occasionally yielding a removable core. Two types of crystals are represented, one rectangular in outline, thick to thin tabular in habit, and evidently orthorhombic, the other lozenge or "diamond"-shaped in cross section, prismatic in habit, and monoclinic in symmetry.

Babingtonite was suggested by Dr. C. N. Fenner[2] as the original mineral of the rectangular cavities, and possibly of the lozenge shaped ones as well, while Mr. F. I. Allen[3] has shown that anhydrite was the original occupant of the former in many cases. Reasons are here presented for believing the mineral of the lozenge shaped cavities to have been glauberite, $Na_2Ca(SO_4)_2$.

In connection with studies of the Triassic rocks of the eastern United States the writer has long been interested in the angular cavities occasionally found in the shales, and while examining specimens of these from one mile south of Steinsburg, Bucks County, Pennsylvania, obtained a clue to the nature of the original mineral. Plaster casts of the well-preserved cavities in this shale were prepared, and found to have the angles, habit, and type of oscillatory combination of faces, resulting in striations and rounding of faces, characteristic of glauberite. No trace of the original mineral is here preserved; but in another occurrence, described by Mr. A. C. Hawkins,[4] the crystallization of the mineral in the muds in downward-radiating groups of long slender monoclinic (or triclinic) prisms and the filling of its cavities by secondary analcite and calcite (which contain sodium and calcium respectively) indicate that the original mineral here also was probably glauberite.

Comparison of the lozenge-shaped, prismatic cavities in the First Watchung Mountain zeolites with glauberite thereupon

[2] Journ. Wash. Acad. Sci. **4**: 552–558, 598–605. 1914.

[3] Amer. Journ. Sci. **39**: 134. 1915.

[4] Ann. N. Y. Acad. Sci. **23**: 163. 1914.

suggested itself, and the angles, habit, and curvature of faces (due to oscillatory combination) of plaster casts of a few of them were found to be essentially identical with those of glauberite.[5] That glauberite has not been considered in this connection before is probably due to the fact that the crystals figured in Dana's *System of Mineralogy* happen to be all of tabular habit, although, as noted in the text, this species is not infrequently prismatic, owing to the extension of the form *s*. This form is usually regarded as the unit pryamid, but it may well be questioned whether it might not be made the unit prism.[6] The forms which have been observed on the cavities in the zeolites are *c* (100), $\alpha(334)$, $\epsilon(445)$, $s(111)$, $m(110)$, $a(100)$, and $e(\bar{3}11)$; the most important angles are $s \wedge s'$ 63°42′ (the prismatically developed form), $c \wedge s$ 43° 2′, $c \wedge a'$ 112°11′, $s \wedge \epsilon$ 4°55′, $s \wedge \alpha$ 6°21′, and $a' \wedge e$ 31°42′, variations of several degrees owing to the oscillatory combination of forms being frequent in these angles, a phenomenon observed also in many crystals of the mineral.

The identification of the mineral of these cavities as glauberite, though based primarily on crystallographic data, is confirmed by geological and genetic considerations. At Steinsburg and at Princeton the mineral crystallized in the sediments as a result of concentration of the water in enclosed lakes. Most of the known occurrences of this mineral are in this sort of deposit, and it is always one of the earliest to form. The basalt lava of the First Watchung Mountain, as shown by Dr. Fenner,[7] flowed locally into a similar lake, the waters of which contributed to the formation of the zeolites and other minerals and could readily have furnished the calcium sulphate of the anhydrite and the additional sodium sulphate of the closely associated glauberite. It is noteworthy that glauberite has been observed,[8]

[5] Dr. W. T. Schaller of the U. S. Geological Survey has made an extensive series of measurements of the angles of the quartz "cores" found in some of the cavities, and he kindly lent his notes to the writer for comparison; complete agreement with the artificial casts was shown.

[6] In a subsequent paper this new orientation of the mineral will be fully discussed by Dr. Schaller.

[7] Ann. N. Y. Acad. Sci. **20**: 93–187. 1910.

[8] Bergeat. Zeit. prakt. Geol. **7**: 43. 1899.

on the island of Vulcano, in fumarole deposits, which are genetically related to these "zeolite-veins." There is also a quite analogous occurrence of this mineral at Rosenegg, Württemberg, the igneous rock being in that case a phonolite tuff, while the glauberite has been replaced by both calcite and quartz.[9]

Summary: The lozenge-shaped, prismatic, monoclinic cavities which occur in Triassic shales and especially in the First Watchung Mountain zeolite deposits are believed to represent the mineral glauberite, the crystallographic, geological, and genetic evidence all pointing in the same direction. A full report on this subject, with descriptions of the geologic occurrences, the crystallographic measurements, figures of specimens, etc., is in preparation.

[9] LEUZE. Jahresh. Ver. vaterl. Naturk. Württemberg 1886, 62; 1889, 305; abstracted in Zeit. Kryst. Min. **14**: 408. 1888; **20**: 303. 1892.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*The colorimetric determination of acetylene and its application to the determination of water.* E. R. WEAVER. Bureau of Standards Scientific Paper No. 267. Pp. 39. 1916.

A colorimetric method for the detection of small amounts of acetylene has been developed in the course of an investigation upon the determination of small amounts of water by the use of calcium carbide. The results upon the quantitative determination of water have not been satisfactory, but a simple and very sensitive qualitative test for water is easily made.

The method for the determination of acetylene has been worked out successfully. The determination is made by conducting the gas to be investigated into an ammoniacal solution of cuprous chloride containing gelatine and alcohol, and comparing the red colloidal solution so obtained with a suitable standard, which may be either a solution of red dye or a piece of ruby glass.

The method is very sensitive. Amounts of acetylene as small as 0.03 mg. may be detected and amounts up to 2 mg. may be determined with an accuracy of better than 0.05 mg.

Hydrogen sulphide and large amounts of oxygen and carbon dioxide interfere with the test, but all of these may be removed by passing the gas to be tested through a hot alkaline solution of pyrogallol without loss of acetylene.

A qualitative test for water, sensitive to less than 0.1 mg., may be very easily and quickly made by bringing the substance to be tested into contact with calcium carbide in the presence of a solvent for acetylene, which is then decanted or distilled into an ammoniacal solution of cuprous chloride. E. R. W.

PALEONTOLOGY.—*Bibliographic index of American Ordovician and Silurian fossils.* Ray S. Bassler. U. S. National Museum Bulletin 92. Pp. 1521, 4 pls. (tables). 1915.

This work gives the entire bibliography and synonomy of the hundreds of genera and thousands of species found in North America in the rocks of the Ordovician and Silurian periods. In addition, the genotypes of the genera are given, and also the formation, the type locality, and the known wider distribution of the species. In cases where the U. S. National Museum has type material, this is noted and the Museum catalog numbers are cited. At the end of the bibliography proper is given an index of specific names and their generic combinations (pages 1342–1406), a bibliographic classification and index of genera (1407–1440), faunal lists of American Ozarkian to lowest Helderbergian species (1441–1509), and a list of American Ordovician and Silurian formations showing their place in the geologic column (1511–1521). Finally at the end of the work are four very important correlation tables of the geologic divisions and their occurrence in the various basins of deposit. R. S. B.

ANTHROPOLOGY.—*Kickapoo tales.* William Jones and Truman Michelson. Publications of the American Ethnological Society, **9**: 1–143. 1915.

The texts of these tales were collected by the late William Jones in 1903; the translations are nearly all by Truman Michelson, as are all the comparative notes. The notes on Kickapoo grammar are based mainly on the materials left by William Jones, edited by Truman Michelson, though some observations by the latter have also been incorporated. The notes on the conditions of the texts are likewise by the latter.

The tales are, so far as is known, the first extended publication of Kickapoo folk-lore. They are eleven in number: three Culture Hero tales, three Animal tales, and five miscellaneous tales. A comparative study shows that both woodland and plains elements occur. The question as to which predominates cannot be answered until more material is available. That European elements also occur is clear. Tentatively we may say that Kickapoo folk-tales and mythology are closest to Fox, which is in accordance with the linguistic facts. T. M.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 768th meeting was held on February 19, 1916, at the Cosmos Club; President Briggs in the chair, 41 persons present. The minutes of the 767th meeting were read in abstract and approved.

Mr. William Bowie presented an illustrated paper on *Determination of the intensity of gravity on land in the United States.* Numerous attempts have been made to determine accurately the absolute gravity by the reversible pendulum, but the results were not very satisfactory for there were a number of errors which entered into the determination. The principal ones were probably in the determination of the distances between the two knife edges on the pendulum, the flexure of the pendulum support, and the temperature changes. Later attempts were made by using the invariable pendulums which were swung only in the direct position, the period being determined at the base station and then at the new station. Since the length of the pendulum is invariable, the difference in gravity at the two stations could be obtained by a simple formula involving only the two periods. Because of the great length of the second pendulum used at first, great accuracy was not obtained from the observations. A great step forward was made when Baron von Sterneck of Vienna designed and constructed the half-second invariable pendulum which he swung in a closed case from which the air had been almost entirely exhausted. These pendulums give a high degree of accuracy in the determination of the relative intensity of gravity at any two stations. All the gravity determinations in the United States during the last 25 years have been made with the Mendenhall pendulum, which is a modification of the von Sterneck pendulum, and the results have been most satisfactory. The value of the intensity of gravity at each station in the United States has been corrected for topography and isostatic compensation, as well as for elevation above sea level. The resulting anomalies (the differences between the observed and computed values) are small in comparison with the anomalies obtained by the older methods which are not based upon the theory of isostacy.

Discussion: Mr. Swann asked whether the proposed use of invar in the construction of the pendulum would not require correction for magnetization. Mr. Humphreys stated that some invars were practically non-magnetic. Mr. Abbot asked how much time was required to make a satisfactory determination. Mr. C. A. Briggs thought that the transfer of the knife edges from the pendulum to the support would introduce inaccuracies. Mr. Bowie stated that, on the average, 4 stations were occupied per month; the transfer of knife edges from the pendulum to the support causes no sensible error.

Vice-President HUMPHREYS took the chair and Mr. L. J. BRIGGS then presented an illustrated communication on *Measurement of the acceleration of gravity at sea.* The different methods which have been proposed and used in the measurement of the acceleration of gravity were first discussed. Two other methods, the first based on the current-balance and the second on the viscosimeter, were suggested. The speaker then presented a series of gravity measurements at sea from New York to San Francisco via Panama with instruments of the type already used in trans-Pacific measurements; in this type the pressure of an inclosed mass of gas is balanced by a column of mercury of variable height. The apparatus is so designed that the volume of gas is constant at the time of making the observations and, since the temperature is maintained constant by a bath of melting ice, the heights of the mercury column at two stations are theoretically inversely proportional to g at the two stations. The average probable error of the mean of the readings of 3 instruments at base stations on the voyage from New York to San Francisco was 1 part in 60,000. Apparent anomalies were observed at sea on both sides of the Isthmus, off the coast of Lower California, and off the California coast near San Francisco.

Discussion: Mr. SWANN stated that one should expect systematic differences for observations during rough weather because of the effect of centrifugal action on the mercury column and called attention to a possible method for compensation. Mr. BOWIE thought that the results presented indicated a decided improvement in the accuracy of determination at sea over previous work; along the shallow waters near the coast the errors doubtless would be greater than those due to topography, but over the deep-sea areas the data obtained should be valuable. Mr. ABBOT asked how much time was required for observations at base stations. Mr. CURTIS referred to the difficulties experienced with reference to designation of units for gravity work. Mr. WHITE referred to possible improvements in details of contruction of the apparatus. Mr. BRIGGS stated that he thought further improvement could be effected by exercising greater precaution with reference to the cleaning of the mercury and the apparatus before sealing.

The 769th meeting was held on March 4, 1916, at the Cosmos Club: President BRIGGS in the chair, 68 persons present.

The evening was devoted to the address of the retiring President, Mr. W. S. EICHELBERGER, *The distances of the heavenly bodies.* (This Journal, pp. 161–175).

J. A. FLEMING, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 302d meeting was held in the lecture room of the Cosmos Club on January 12, 1916.

INFORMAL COMMUNICATIONS

Max W. Ball exhibited photographs of the results of an earthquake which occurred about 50 miles south of Winnemucca, Nevada. The pictures were taken by S. L. Gillan, Mineral Inspector, General Land Office.

REGULAR PROGRAM

T. Wayland Vaughan: *Some littoral and sub-littoral physiographic features of the Virgin and Leeward Islands. A discussion of submarine terraces, their significance, the criteria for determining their relative age, and their relation to the development of coral reefs.* Illustrated. (Published in full in Journ. Wash. Acad. Sci. **6**: 53–66. 1916.)

O. E. Meinzer: *Physical features of Guantanamo Bay and adjacent areas in Cuba.* The rocks in the region comprise: (1) a basal complex of metamorphic and igneous rocks; (2) a sedimentary series, several thousand feet thick, consisting chiefly of conglomerate, limestone, and shale resting unconformably on the basal complex and in general dipping away from its outcrops; (3) horizontal beds of conglomerate and coralline limestone underlying a series of terraces and resting unconformably on the basal complex and on the tilted beds of conglomerate, limestone, and shale; (4) stream gravels; and (5) recent marine and delta deposits. Fossils collected in 20 localities have not yet reached Washington. Four marine terraces are well developed—in most of the region at altitudes of about 40, 200, 500, and 750 feet. They consist largely of benches cut into the older rocks (Series 1 and 2) and mantled with coralline limestone (Series 3). Their development in the interior valleys indicates that the present major topographic features were in existence prior to the terraces. They rank in age according to their altitudes. All bear evidences of geologic youth and were apparently formed in the Quaternary period. After the 40-foot terrace was formed the region stood higher than at present, as is indicated by innumerable small bays and estuaries which were created through the dissection of the 40-foot terrace limestone, and by a submerged bench (or series of benches) 100 feet or less below present sea level. That the shore line has for a long time been stationary is shown by the existence of a well-developed bench at present sea level.

G. S. Rogers: *Oil field waters and their chemical relations to oil; particularly the conversion of sulphates into carbonates by hydrocarbons.* It has long been known that oil and gas are commonly associated with water, but of the chemical relations between the two we know little, and scientific literature contains only a few references to the chemical composition of the waters themselves. The study of several hundred analyses of water from the oil fields of the San Joaquin Valley, California, discloses the following facts. (a) Some of the deepest waters are as salty as sea water, while in others chlorides are practically lacking. The distribution of the chlorides is apparently a function of the freedom of the underground circulation, which is controlled largely by geologic structure. (b) Sulphates, which are the predominating salts in the normal ground water on the west side of the San Joaquin Valley, diminish rather regularly in amount as the oil zone is approached and finally disappear, but outside of the oil fields their quantity remains constant to great depths or even increases. (c) Carbonates increase as the oil zone is approached, and if no chlorides are present constitute the only dissolved salts in the waters associated with the oil.

These marked variations in the character of the waters are presumably due to reaction between them and the hydrocarbons, by which the sulphate is reduced to H_2S and the hydrocarbons oxidized to carbonate and CO_2. Carbon dioxide, doubtless derived in this way, is present in the hydrocarbon gas in these fields and usually occurs in greatest quantity (up to 35 per cent) nearest the outcrop, where the sulphate waters enter the strata and where the reaction would be most vigorous. It is probable also that part of the H_2S formed is oxidized to sulphur, which would react with the oil and make it heavier and more asphaltic. In general, the heaviest oil is that nearest the outcrop and that in the zone of "tar sands" above the main oil zone, where the sulphate water would exercise its greatest effect. The occurrence of the heavier oil nearest the surface has hitherto been ascribed to oxidation, but the action of sulphur derived from the sulphate waters is believed to have been more important.

The 303d meeting was held in the lecture room of the Cosmos Club on January 26, 1916.

REGULAR PROGRAM

G. F. Loughlin: *Faulting in the Tintic Mining District, Utah.* Five periods of faulting are recognized: (a) faulting during the later stages of the period of folding; (b) faulting during the subsequent period of recoil; (c) faulting due to igneous intrusions, especially that of the main monzonite stock; (d) fissuring and faulting just after igneous intrusion, providing channels for the ore-forming solutions; (e) post-mineral fissuring and faulting. The largest faults in the mining district proper are included in groups (a) and (c). They had only minor influence in determining the locations of ore bodies.

A detailed discussion of the faulting will be included in a forthcoming report of the United States Geological Survey on the geology and ore deposits of the Tintic District.

Philip S. Smith: *Notes on the geology of the Lake Clark-Iditarod region, Alaska.* The speaker described the areal geology of the Lake Clark-Iditarod region, Alaska. This region is located in southwestern Alaska, extending from the Pacific Mountains to the central part of the Yukon Plateau province. The rocks are dominantly sedimentary strata of Mesozoic age, but some Paleozoic limestones are also exposed. Igneous rocks both of intrusive and effusive origin occur at a number of places and certain of them seem to have been closely associated with the deposits of commercial value such as gold and quicksilver. Unconsolidated deposits are widespread and throughout much of the region mantle and hide the underlying bedrock. These deposits are mainly of glacial and glacio-fluviatile origin, though lacustrine, fluviatile, and volcanic ash deposits are also described.

F. W. Clarke: *The inorganic constituents of marine invertebrates.* Two hundred analyses of hard parts of corals, mollusks, echinoderms, worm tubes, algae, etc., throw much light on the origin of magnesian limestone and phosphatic rock. (No abstract; the complete paper will be published as a Professional Paper of the U. S. Geological Survey).

Carroll H. Wegemann, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 111th regular meeting of the Botanical Society of Washington was held in the Crystal Dining Room of the New Ebbitt Hotel, Wednesday evening, March 8, 1916. Eighty-two members and 117 guests were present. Mr. A. S. Hitchcock, president of the Society, presided. Dr. Rodney H. True, as retiring president, delivered an address, an abstract of which is given below. A dinner preceded the address, after which there was dancing.

Relation of Thomas Jefferson to Botany: Rodney H. True. It is not generally known that Thomas Jefferson, who was perhaps the center of a more intense partisan activity than any other man of his time, was at the same time a great lover of outdoor life and took a keen interest in an amateur way in botany. Throughout his life he maintained a correspondence with many of the prominent botanists of his time and exchanged garden plants with William Hamilton, Bernard McMahon, John Bartram, and other gardening botanists. Like many of his planter neighbors, Jefferson accumulated a rather extensive collection of rare and interesting plants and built up what was perhaps one of the best botanical libraries in the United States. He wrote only one book dealing chiefly with matters of science, his *Notes on Virginia*, printed while he was in France in 1784. This book dealt with the State of Virginia in all its aspects and in proper chapters discussed the botany and natural history of the state. This book was translated into the French and German languages and ran through many editions during the first fifty years of our country's history. While in France he kept in close touch with the various developments of European science and wrote long letters to various American correspondents, including friends at Harvard, Yale, and other institutions, summarizing the most important results coming to his attention. His belief that the future of the United States was closely connected with the country beyond the Mississippi led him to endeavor to secure the exploration of that country soon after the close of the Revolution.

But it was not until he received authority to launch the Lewis and Clark expedition that he was able to achieve his object. He planned the expedition with the greatest of care, appointed chief officers, gave them very detailed instructions concerning what they should attempt to do, and after the return of the expedition was finally successful in getting the results collected for publication. After his retirement to Monticello he maintained an active correspondence with many botanists and other scientists on the important scientific questions then under consideration. In his old age he was the means of securing the appropriation making possible the University of Virginia. He was made head of the institution, planned its buildings, supervised their construction, chose the faculty, and determined the policy of this great state institution. It seems clear that, notwithstanding the prominent position which Jefferson attained in the political life of his country, he was also an important figure in the American scientific world of his time.

William E. Safford, *Corresponding Secretary.*

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PHYSICS.—*A misconception of the criterion for gray body radiation.* PAUL D. FOOTE and C. O. FAIRCHILD, Bureau of Standards.

Some 15 years ago Lummer and Pringsheim[1] investigated spectrophotometrically the radiation of carbon and platinum by comparison with a black body at various known temperatures. It was found, when the carbon was maintained at a constant temperature and the temperature of the black body was altered, that the graph of the logarithm of the ratio of the intensities of the two sources at any given wave length plotted against the reciprocal of the absolute temperature of the black body was a straight line, and further that these linear graphs for various wave lengths in the visible spectrum intersected at one common point. The fact that such a common point of intersection existed was casually suggested as a possible proof of the "grayness" of carbon where the term gray is understood to denote that the material has an emissivity independent of the wave length. Consequently the value of the temperature coordinate corresponding to this point of intersection would be the true temperature of the gray radiating material.

Recently an extensive paper on this subject has been published by Elisabeth Benedict[2] working under the direction of Lummer and Pringsheim in which the following questions among others proposed by Dr. Lummer are considered.

[1] LUMMER and PRINGSHEIM. Verh. d. Deut. Phys. Ges. **3**: 36–42. 1901.
[2] BENEDICT. Ann. d. Phys. **47**: 641–678. 1915.

1. Are there materials which show true intersections of the logarithmic isochromatics?

2. Do these intersections furnish an exact measure of the true temperature?

Carbon was found to show the intersections referred to. The conclusion was accordingly made that carbon is gray and that the temperature corresponding to the point of the intersection is the true temperature of the carbon.

It is the purpose of this note to point out that these conclusions can not be drawn from the experimental data. It will be shown that even though the logarithmic isochromatics of various wave lengths do intersect in one common point, this point of intersection is *no immediate indication whatever of the true temperature of the non-black radiator, and is no proof that the radiator is even approximately gray.*

The radiation of a black body is compared spectrophotometrically with that of a non-black body.

J_1 = intensity of radiation of wave length λ from black body.

J_2 = intensity of radiation of wave length λ from non-black body.

θ = absolute temperature of black body.

T = absolute true temperature of non-black body.

A = emissivity coefficient of non-black body which in general is a function of both T and λ.

The question of A as a function of T is not considered in the present note. We shall accordingly assume A to be a function of λ only.

(1) .... $J_1 = c_1\lambda^{-5} e^{-\frac{c_2}{\lambda\theta}}$

(Wien's law for black body.)

(2) .... $J_2 = c_1\lambda^{-5} A e^{-\frac{c_2}{\lambda T}}$

(Analogous law for non-black body.)

Whence

(3) .... $\log_e \frac{J_2}{J_1} = \log_e A + \frac{c_2}{\lambda}\left(\frac{1}{T} - \frac{1}{\theta}\right)$

Suppose that A can be represented, within observational errors, by a function of the following form, where p and A' are constants

$$(4) \ldots\ldots\ldots\ldots \begin{cases} A = A' e^{\frac{c_2 p}{\lambda}} \\ \log_e A = \log_e A' + \dfrac{c_2 p}{\lambda} \end{cases}$$

Substituting in (3)

$$(5) \ldots\ldots \log_e \frac{J_2}{J_1} - \log_e A' = \frac{c_2}{\lambda}\left(\frac{1}{T} + p - \frac{1}{\theta}\right)$$

Since by the method in question T is maintained constant, the only variables being J_2/J_1, λ and θ, the above equation is of the form

$$(6) \ldots\ldots\ldots\ldots (y - a) = m\,(b - x)$$

i.e. a family of straight lines with the variable parameter c_2/λ. The common point of intersection has the coordinates $\log_e A'$ and $\dfrac{1}{T} + p$.

We have accordingly shown that the intersection may occur when the material is not gray and that the temperature corresponding to the point of intersection T' is not the true temperature T but related to it by the reciprocal expression $\dfrac{1}{T'} = \dfrac{1}{T} + p$, where p is a constant which requires an entirely different mode of experimentation for its determination. It is of course recognized that only a few functions of the type represented by equation (4) will satisfy the condition that intersections of the isochromatics occur, and that there is probably no physical reason why the true emissivity relation should take this one peculiar form, which invalidates the conclusion that the emissivity must be independent of the wave length. But it may be remarked that the intersections are never perfect, that the straight lines at best are only a smoothed mean of the observed points, that there are only a few radiating materials which do show intersections, and finally that within the observational errors involved in work upon radiation the proper choice of A' and p of equation (4) will satisfactorily determine almost any function desired.

As a particular illustration of the possible erroneous conclusions which may be drawn from the intersection of isochromatics, viz. that the radiating material is gray and that the temperature corresponding to the intersection is the true temperature of the radiator, the following example may be cited, in which the radiation from a black body at various temperatures is compared with that from a non-black and non-gray body. There can be no question that this particular radiator is not gray. We have purposely made it as far from gray as conveniently possible.

Temperature of non-black radiator = 1400° *abs.*

WAVE LENGTH	EMISSIVITY
0.4μ	0.102
0.5	0.280
0.6	0.549
0.7	0.889

The logarithmic isochromatics obtained by (theoretically) comparing this radiator with a black body at temperatures 1200°, 1300°, 1500°, and 1600° absolute are shown in figure 1. A per-

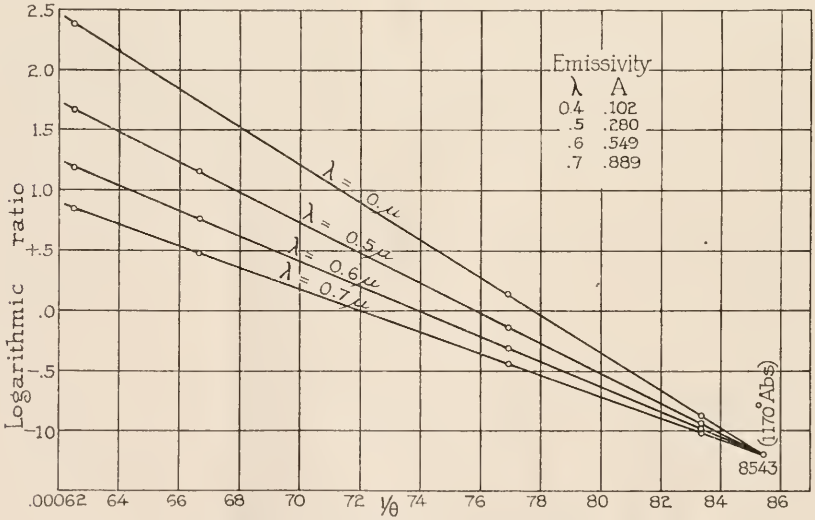

Fig. 1

fect intersection occurs at the temperature 1170° absolute. Following the criterion of Lummer and Pringsheim as applied by Benedict we would conclude that this radiator is gray and is at the temperature 1170° absolute. Actually this radiator is very far from gray and has the temperature 1400° absolute.

Using the valuable method of isochromatics and considering the constant p of equation (4) the writers hope to present later experimental data on the emissivity of carbon. It may be remarked that the intersections used directly give simply the temperature at which a color match is obtained. It is also interesting to note that a non-black material may show the energy distribution of a gray body and still not be gray. That is, it is theoretically possible to obtain a color match against a black body with *certain* materials which have an emissivity coefficient varying greatly with the wave length. It is theoretically possible to have two radiators at different temperatures, one gray and the other far from gray, giving an exact color match, and an exact intensity match at every wave length.

BOTANY.—*Rolliniopsis, a new genus of Annonaceae from Brazil.* W. E. SAFFORD, Bureau of Plant Industry.[1]

Among the plants collected by Messrs. Dorsett, Shamel, and Popenoe while on their mission of agricultural exploration in Brazil, in 1914, there is one of peculiar interest, belonging to the Annonaceae, with 3-winged flowers resembling those of a Rollinia but with clusters of small, one-seeded, orange-colored fruits very much like those of a Guatteria or Aberemoa. A photograph of the flower and fruit was taken in the field, and plants propagated from the seeds were distributed by the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, bearing the label "Guatteria sp., S. P. I. No. 37902."

A second species having the same botanical features was brought back from Brazil more recently by Dr. J. N. Rose and Mr. P. G. Russell, who collected it in the state of Bahia, in the summer of 1915, while carrying on botanical exploration under the auspices of the Carnegie Institution of Washington.

For these and two allied plants hitherto assigned to the genus Rollinia (*R. parviflora* St. Hil. and *R. leptopetala* R. E. Fries) must be created a new genus, for which I here propose the name Rolliniopsis.

[1] Published with the permission of the Secretary of Agriculture.

Rolliniopsis Safford, gen. nov.

Flowers resembling those of Rollinia, solitary or in clusters of 2 or 3. Calyx gamosepalous, 3-lobed. Corolla gamopetalous, the lobes corresponding to the outer petals of other Annonaceae produced into three spreading obtuse spurs or compressed rounded wings, the three alternate inner lobes connivent in such a way as to leave only a very small opening above the gynœcium. Stamens minute, numerous, closely crowded on the torus, the connective produced into a thin transverse shield above the pollen sacs, these linear, parallel, and contiguous, opening extrorsely by a longitudinal fissure. Carpels several to many, forming a cluster (gynœcium) in the center of the mass of stamens just below the opening of the corolla; ovaries 1-ovuled. Receptacle (torus) at length indurated and bearing a cluster of distinct fruits, these closely crowded but not concrescent nor compressed into prisms or angular pyramids. Fruits small, pyriform or ovoid, containing a single seed surrounded by a thin layer of aromatic pulp (mesocarp), very much as in the genus Guatteria. Seeds pyriform, obovoid, or ovoid, the thin testa somewhat wrinkled by the inclosed ruminate endosperm and marked by a longitudinal line from the small basal hilum to the rounded apex.

Type species: *Rolliniopsis discreta* Safford.

Geographical range: Brazil, from the State of Bahia to Minas Geraës.

This genus is separated sharply from Guatteria by its 3-winged flowers. From Rollinia[2] it differs chiefly in its fruits, which consist of a cluster of separate, or discrete, carpels instead of a fleshy Annona-like syncarpium. Its relation to Rollinia is very much the same as that of Aberemoa or Duguetia to the genus Annona. The seeds differ from those of a typical Rollinia in their minute hilum; and the fruits, instead of having a sugary, juicy pulp like that of the commercial custard-apples, possess a thin aromatic mesocarp surrounding the seed, very much like that of certain species of Xylopia known in Brazil as "monkey peppers" and in Panama as "*malaguetas*," suggesting also the flavor of the Mexican *xochinacaztli*, or "ear-flower" (*Cymbopetalum penduliflorum*), whose petals were used by the Aztecs as an ingredient of their chocolate.

KEY TO THE SPECIES

Leaf blades oblong-elliptical or oblong-lanceolate.
Nerves 7 to 9 on each side........................1. *R. discreta*.
Nerves 9 to 13 on each side......................2. *R. simiarum*.

[2] Prantl, in an analytical key of the section Xylopieae, briefly distinguishes the genus Rollinia as follows: "Kronenb. über dem holen Grunde seitlich zusammengedrückt; Fr. verschmolzen." Nat. Pflanzenfam. **3**²: 35. 1891.

Leaf blades broadly elliptical
Flowers minute; young branches ferruginous-tomentose; leaf blades acute . . . . .3. *R. parviflora.*
Flowers medium-sized (winged petals about 1 cm. long); young branches fulvous-tomentose; leaf blades round-tipped . . . . .4. *R. leptopetala.*

1. **Rolliniopsis discreta** Safford, sp. nov.

A small tree, 6 to 9 meters high. Vegetative branches not observed; flowering branches slender, grayish brown, thickly dotted with gray lenticels and bearing prominent leaf scars. Leaf blades oblong-elliptical, rounded or obtuse at the base, usually rounded or obtuse or sometimes slightly retuse at the apex, variable in size, when normal 7 to 8 cm. long, 2.5 to 3 cm. broad, with 7 to 9 nerves on each side; smaller blades near extremities of branchlets 5 cm. long, 1.5 cm. broad; petioles 5 to 7 mm. long, often recurved, broadly grooved above, clothed with fine grayish tomentum; blades membranaceous but firm, minutely tomentose with short whitish hairs on both surfaces, more densely so beneath; midrib impressed above, prominent beneath and tomentose like the petiole. Flowers (fig. 1) solitary or in 2's or 3's; peduncles extra-axillary or opposite a leaf, straight or curved and wirelike, 10 to 17 mm. long, clothed with minute reddish brown tomentum, subtended at the base by a small sessile tomentose bracteole and usually bearing a second minute clasping bracteole at or below the middle; calyx 3-lobed, clothed outside with reddish tomentum like that of the peduncle, the divisions broadly triangular, 5 mm. broad, 3 mm. high; corolla reddish brown, the 3 lobes corresponding to outer petals compressed laterally into thin orbicular vertical wings 11 to 12 mm. in diameter, minutely tomentellous (as seen under the microscope), the 3 lobes corresponding to inner petals minute, grayish-puberulent, connivent. Stamens numerous, minute (0.6 mm. long, 0.2 mm. broad), with the reddish brown connective expanded above the two straw-colored parallel pollen sacs. Gynœcium composed of about 50 carpels, these remaining distinct and developing into a cluster of small drupes. Mature fruit cluster 4 cm. in diameter; indurated receptacle 8 to 12 mm. in diameter; drupes pyriform, sessile, often somewhat oblique, 12 to 14 mm. long, 7 to 8 mm. in diameter, rounded at the apex and terminating in a short oblique point, gradually narrowing toward the base; pericarp bright orange, turning dark brown in drying; seeds pyriform or obovoid, enveloped in a thin layer of aromatic pulp, 9 to 10 mm. long, 4 to 5 mm. in diameter, the testa light brown, slightly wrinkled by

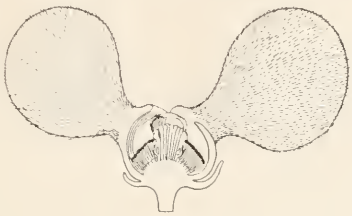

Fig. 1. Flower of *Rolliniopsis discreta*, with portion removed to show crowded stamens surrounding the central gynœcium. Scale about 1.5.

Fig. 2. *Rolliniopsis discreta* Safford.

the corrugations of the enclosed ruminate endosperm, marked on one side by a longitudinal line extending from the small basal hilum to the rounded apex.

Type in the U. S. National Herbarium, No. 865593, collected and photographed at Januaria, State of Minas Geraës, Brazil, February 15, 1914, by Messrs. Dorsett, Shamel, and Popenoe (No. 371 b; photograph, Field No. 1855, File No. 15508; seeds, No. 125a). "A small tree 20 to 25 feet high, common between Januaria and Brejo, 4 miles back from the river. Fruits bright orange; called '*fruta de macaco*' [monkey-fruit]."

EXPLANATION OF FIG. 2.

The type specimen of *Rolliniopsis discreta*, showing flowering branches with leaves, flower, and fruits both immature and mature; *a*, stamen, dorsal view; *b*, stamen, ventral view; *c*, two mature carpels which have fallen from the receptacle; *d*, seed. Branches with flower and fruits, and detached carpels and seed, *c*, *d*, natural size; *a*, *b*, scale 10.

2. **Rolliniopsis simiarum** Safford, sp. nov.

A small irregularly branching tree with small narrow round-pointed leaf blades, 3-winged flowers, and dense clusters of small yellow aromatic berries. Young growth grayish-tomentulose, the branchlets soon becoming glabrous, those of the vegetative growth slender, zigzag, with reddish brown bark sparsely dotted with lenticels, those terminating the limbs often irregular, with grayish bark, short internodes, and prominent leaf scars. Leaf blades variable in shape, those at the base of the branchlets smaller and relatively broader than the succeeding ones; normal leaf blades oblong-lanceolate, rounded or very slightly retuse at the apex, rounded at the base, 8 to 10 cm. long, 2.8 to 3.5 cm. broad, with 9 to 13 nerves on each side, membranaceous, deep green above, paler beneath, yellowish green or olivaceous when dry, apparently glabrous on both faces but as seen under the microscope clothed with scattered minute curved whitish hairs; midrib impressed above, prominent beneath, reddish brown, sparsely clothed with grayish hairs; parenchyma between the lateral nerves divided into polygonal areoles by fine reticulating veins; petioles broadly grooved above, clothed at first with grayish tomentellum, those of the normal leaves 6 to 8 mm. long, of the smaller leaves 3 to 5 mm. long. Flowers (only the detached petals of one flower observed) reddish brown when dry; petals laterally compressed, winglike, suborbicular, abruptly contracted at the base, 11 mm. long, 9 mm. broad; calyx persistent (observed only on dry fruits), 3-lobed, the divisions rounded or obtuse at the apex, 2 mm. broad, 1.8 mm. high; peduncles (only those of fruit observed) at length woody, 12 to 21 mm. long. Fruit a cluster of small distinct sessile carpels borne on the indurated receptacle; mature carpels aromatic, pyriform or obovoid, 8 to 12 mm. long, 5 to 6 mm. in diameter, rounded or abruptly beaked at the apex, gradually narrowed at the base; pericarp glabrous, yellow when fresh, dark brown or blackish when dry; seed solitary, obovoid or pyriform, sometimes slightly compressed, 7 to 10 mm. long, 4 to 5 mm. in diameter, the testa light brown, slightly wrinkled by the corrugations of the inclosed ruminate endosperm, the hilum basal, small, and inconspicuous.

Type in the U. S. National Herbarium, No. 762291, collected in the vicinity of Machado Portella, State of Bahia, Brazil, June 19–23, 1915, by J. N. Rose and P. G. Russell (No. 19963).

The specific name chosen for this plant was suggested by its Portuguese vernacular name, *fruta de macaco* [monkey fruit].

3. **Rolliniopsis parviflora** (St. Hil.) Safford.

Rollinia parviflora St. Hil. Fl. Bras. Merid. **1**: 30. 1825.

A small tree with rufous-pubescent branchlets. Leaf blades 4 to 6.4 cm. long, 1.8 to 2.5 cm. broad, oblong, acuminate at the apex, acute at the base, glabrous above, puberulous beneath, the midrib prominent, ferruginous-pubescent, the lateral nerves parallel; petioles about 4 mm. long, nearly terete, ferruginous-pubescent. Flowers small, the peduncles solitary, 4 to 6 mm. long, recurved, slightly thickened at the apex, ferruginous-villous. Calyx ferruginous-villous, 3-lobed, the divisions broadly ovate, acute. Corolla 3 to 5 mm. long and broad, villous, green to rufescent, 6-lobed; lobes thick and obtuse, horizontally spreading, those corresponding to the inner petals of other Annonaceae a little narrower than the others, nearly orbicular. Torus convex on top, bearing a cluster of about 15 carpels at its apex and below these a mass of minute, closely crowded stamens (about 1 mm. long). Fruit a cluster of small oblong-ovoid sessile drupes, these 1 cm. long, 5 mm. in diameter, closely crowded on the indurated receptacle, but quite distinct and falling off separately when mature, like those of Guatteria.

Type collected by Augustin St. Hilaire "in sylvis primaevis montis *Tejuca* propè Sebastianopolim [Rio de Janeiro]. Florebat Novembre."

Rolliniopsis parviflora can readily be distinguished from the two preceding species as well as from *R. leptopetala* by the minute size of its flowers and the relatively short and thick lobes of the corolla.

In the type material collected and described by St. Hilaire there were no specimens of fruit and the fruit remained unknown until 1905, when R. E. Fries described it from specimens collected by Riedel in the vicinity of Rio de Janeiro.[3] In the amended description of this

[3] "Die Früchte, die für diese Art bisher nicht bekannt sind, bieten ein sehr eigenthümliches Aussehen dar. Die Einzelfrüchte sind nicht in einem Syncarpium vereint; sie sind länglich eiförmig . . . und sitzen ungestielt auf dem Receptaculum dicht zusammen, unter einander jedoch frei; sie fallen auch von einander getrennt ab, wie z. B. bei den Guatterien. Hierin weicht *R. parviflora* von den allermeisten übrigen *Rollinia*-Arten ab, von denen man Früchte kennt; nur *R. leptopetala* R. E. Fr. hat die Frucht auf ähnliche Weise gebaut."—R. E. Fries, in Arkiv för Botanik, **5**[4]: 20. 1905.

species by Martius[4] the leaves are described as "ovate, ovate-lanceolate, or lanceolate," and two varieties are indicated: var. *α latifolia* and var. *β angustifolia*. Whatever varieties may be established, that which corresponds with the original description of the species must be regarded as the type form ("Rollinia foliis oblongis, acuminatis, basi acutis"). A specimen in the U. S. National Herbarium (No. 703471), collected by Riedel "in sylvis montosis propè Rio Janeiro, 1829," with most of the leaf blades broadly elliptical or oval and acuminate, belongs undoubtedly to the variety *latifolia*. The blades of the smaller leaves at the base of the flowering branchlets of this specimen are orbicular. It is quite possible that the leaves of vegetative branches would be relatively narrower, like those of the type described by St. Hilaire.

Distribution: Known only from Brazil. Primeval forests of Mount Tejuca, vicinity of Rio de Janeiro, *St. Hilaire* (type, as cited above); *Glaziou* 6077; Mount Gabia and neighboring hills, *Martius*, *Sellow*, and *Lhotzky;* Serra Tinguá, *Schott;* Rio de Janeiro, without definite locality, *Sellow*, *Riedel;* "Versant de Copacabana," January 26, 1870, *Glaziou* 3859; without definite locality, *Glaziou* 2120.

4. **Rolliniopsis leptopetala** (R. E. Fries) Safford.
Rollinia leptopetala R. E. Fries, Kongl. Sv. Vet. Handl. **34**[5]: 50. *pl. 7, f. 3, 4.* 1900.

A tree or shrub, with gray to blackish gray bark, that of the young branches dotted with numerous light-colored lenticels; young branchlets, petioles, and peduncles tomentose with projecting yellowish hairs. Leaf blades broadly elliptical, rounded at the base and rounded or subemarginate at the apex, variable in size, reaching the dimensions of 8 cm. in length and 4.5 cm. in breadth, membranaceous, clothed on the upper surface more or less densely with short white hairs, at length glossy though still bearing scattered hairs; on the lower surface clothed with a uniform tomentellum of yellowish white hairs; midrib impressed above, beneath prominent, reddish brown like the principal lateral nerves (6 to 8 on each side); petioles 5 to 8 mm. long, narrowly grooved above. Peduncles 1 to 1.5 cm. long, bearing at the base and at the middle two small acute hairy bracteoles (1 mm. long). Flowers red, fragrant. Calyx lobes 2 mm. long, 2.5 mm. broad, rounded and abruptly acuminate at the apex, united at the base, clothed outside with reddish hairs, glabrous within. Outer petals obtuse, each bearing a thin ferruginous-pilose, rounded or cuneate wing 8 to 11 mm. long and, near the rounded apex, 6 to 8 mm. broad; inner petals (corolla lobes) 2.5 mm. long, 3 mm. broad, suborbicular, obtuse, clothed outside with minute grayish hairs, glabrous within. Stamens scarcely 1 mm. in length. Fruit (observed only on 1 specimen) spheroidal, 1.5 cm. in

[4] Fl. Bras. **13**[1]: 19. 1872.

diameter, composed of a few smooth ovoid carpels 8 mm. by 6 mm. in size, borne on the indurated receptacle. Seeds oval, 7 mm. long, 5 mm. in diameter, light yellow, smooth.

Type in the Berlin Botanical Museum, collected in the state of Piauhy, Brazil, in 1840, by George Gardner (No. 2033).

Fries compares the leaves of this species to those of *Rollinia longifolia*, which, however, are relatively narrower and are not rounded at the apex. He says that the flowers and fruit are more like those of *Rollinia emarginata*, but specimens of the latter in the U. S. National Herbarium show its fruit to be a solid syncarpium. To this species he assigns as a variety, *angustifolia*, a plant in the Berlin Botanical Museum collected at Rio de Janeiro by Glaziou, No. 13508, but of this he figures only a single leaf and gives no account of the flower or fruit. In his figure of the type[5] the wings of the corolla are shown as different from those of *Rolliniopsis discreta* in size and form, and the mature carpels as ovoid instead of pyriform as in the latter species; moreover he describes *R. leptopetala* as a tree or shrub with "ramulis, petiolis, pedunculisque fulvo-tomentosis" . . . . and its "jüngsten Sprosse von abstehenden gelblichen Haaren wollig." These characters readily serve to disinguish his species from both *R. discreta* and *R. simiarum*, as well as from the ferruginous-tomentose *R. parvifolia*.

PLANT PHYSIOLOGY.—*A field auxanometer*. G. N. Collins and J. H. Kempton, Bureau of Plant Industry.

In studying the effect of different environmental factors, such as light, temperature, and water supply, on the rate of growth of maize varieties, the lack of some means of measuring the elongation of plants growing naturally in the field has for several years been recognized as a serious obstacle. There are two principal requirements in securing satisfactory measurements: (1) In order to ascribe any observed difference in the behavior of two varieties to its environmental cause it is necessary to make the measurements at short intervals; (2) that due allowance may be made for individual diversity, it is essential to make simultaneous measurements of a number of plants. These conditions have been met by devising a form of auxanometer well adapted to

[5] Op. cit. *pl. 7, f. 3, 4*.

field conditions and sufficiently simple and inexpensive to permit the use of a number of instruments at one time. The following description is published in the belief that the instrument may be found useful in other fields.

The instrument is illustrated diagrammatically in figure 1. It consists of a light wooden box, *a*, 4 inches square and 12 inches in height constructed of $\frac{1}{2}$ inch material. Passing entirely through the box is a glass rod or tube, *b*, about $\frac{1}{8}$-inch in diameter and about 20 inches long. The lower end of this rod is attached to the growing plant by means of a copper wire and a light clip or wire hook. The rod is supported by a cord attached to a close fitting cork, *e*, through which the rod is passed. The cord leads over a pulley, *c*, to a counterpoise, *d*. The recording pen, *f*, is made of thin sheet copper bent into a shallow trough and attached to a light wooden arm supported on the cork. The driving mechanism consists of an ordinary alarm clock, *g*, placed face down. The milled head used in setting the hands is removed and replaced by a $\frac{1}{8}$-inch brass rod, 7 inches long, drilled and slotted at the lower end in the same manner as the discarded milled head. A shallow groove also is cut in the upper end of the rod. The drum, *h*, for carrying the record paper is made of a section of a pasteboard mailing tube filled at either end with a perforated cork, through which the brass rod passes. A pin passed through the cork at the upper end rests in the shallow groove in the top of the brass rod. The counterpoise string for lifting the glass rod is attached near the edge of the cork, *e*, and the pressure of the pen on the drum can be regulated by a slight turning of this cork.

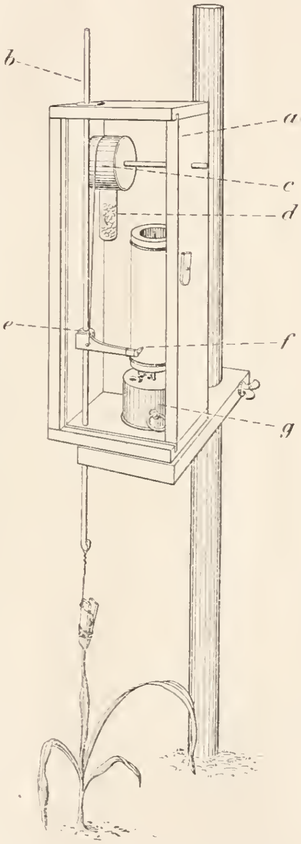

Fig. 1. Field auxanometer.

A convenient method of supporting the machine is to drive a round wooden stake by the side of the plant to be measured, on which a

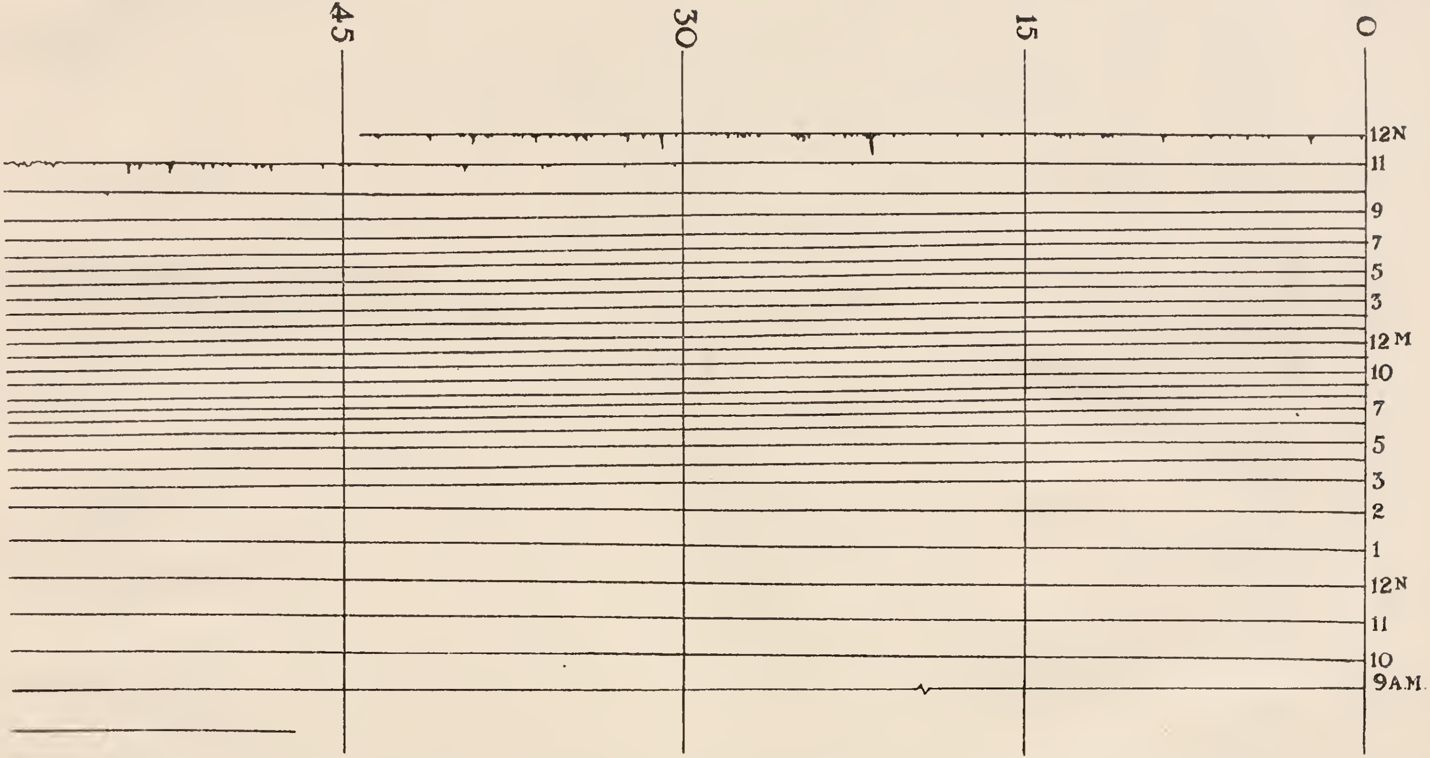

Fig. 2. Sample record of field auxanometer made on the seventh leaf of a Boone County white maize plant, Chula Vista, California, September 26, 1915. The irregularities during the last two hours show the effect of wind. Natural size.

wooden shelf is supported. A narrow slot is cut from one end of the shelf to within an inch or two of the other, and near the open end the slot is enlarged to pass over the stake. A bolt provided with a wing nut is passed edgewise through the board behind the opening for the stake, permitting the shelf to be fastened at the desired height. The auxanometer is attached to the shelf by means of a wood screw or bolt which passes through the slot and into the bottom of the box. This arrangement permits movement in either direction, and allows the instrument to be brought directly over the plant to be measured.

Satisfactory clocks can be had for $5.35 per dozen. The value of all other materials is trifling and the cost of the finished machines, including the labor, need not exceed $15.00 per dozen.

Since the recording pen is attached directly to the growing part of the plant by an inelastic rod, the accuracy of the measurements is not affected by lack of precision in the construction of the instrument. The only essential is that the parts move freely and with a minimum of friction. If the axis of the recording drum and the glass rod are not parallel, there will be a slight error in the absolute elongation recorded, but this error will be constant throughout the record and will not affect the comparative elongation of different periods. In this particular this simple auxanometer may claim advantages in accuracy over the more elaborate and expensive forms, in which the motion is transmitted by a flexible thread and the direction of the motion is changed by passing the thread over a revolving drum. With such instruments it is difficult to eliminate slight errors due to hygroscopic changes in the thread, and any inaccuracies in the curvature or centering of the drum are reflected in the measurements.

In the making of continuous measurements of plants in the open, the movement of the plant due to wind is always a disturbing element. With the instrument here described the displacement of the plant, of course, depresses the pen; but as the highest point that the pen can reach at any given time is the position of rest, the effect of wind is to cause a series of almost vertical lines always below the horizontal line that marks the true elongation. In very gusty weather, when the plants are unprotected, this may result in the formation of an almost continuous band, but even then the upper margin of this band records the correct elongation. The effect of a moderate wind is shown in the last two hours of the record reproduced in figure 2.

It is believed that the relatively high cost of the auxanometers that are on the market, together with the fact that they are not adapted for use in the open, has seriously retarded the accumulation of information regarding individual and varietal diversity in the reaction of crop plants to changes in environment. In designing the present instrument, therefore, an effort was made to use only the cheapest material and the simplest form of construction, so that the cost might be kept down to a point that would permit the use of the instrument in sufficient numbers to acquire extensive data for statistical treatment.

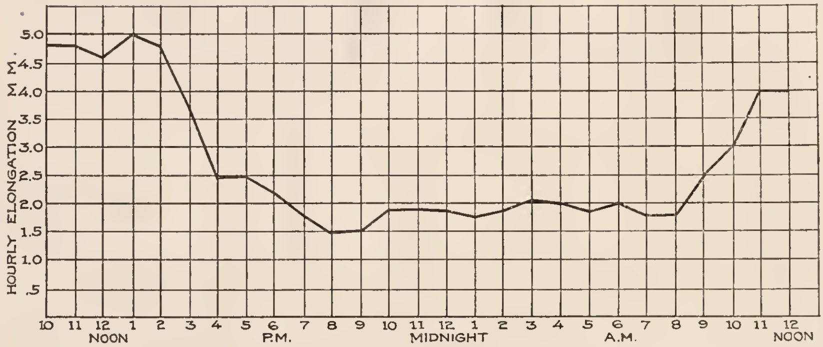

Fig. 3. Graph of hourly elongation, taken from record shown in figure 2.

Our observations on the rate of elongation in maize plants have led to the belief that in many of the investigations of periodicity in growth individual variation in the plants has not been adequately considered. For example, it was found that some plants showed a definite reduction in the rate of elongation between the hours of 8 and 10 a.m., while other plants of the same variety showed no such reduction. To detect differences of this kind it is necessary to secure records from a number of plants simultaneously, for if the records were taken on different days it would be difficult to exclude the possibility that differences in behavior were due to differences in the climatic conditions.

In many investigations it is equally important that measurements should be made on plants growing naturally in the field. With maize, at least, results obtained under greenhouse or laboratory conditions are quite at variance with results obtained in the open. In our experiments the only maize plants to exhibit a greater rate of elongation at night than in the day have been greenhouse individuals. The question naturally arises, then, as to what extent the accepted belief that elongation is generally more rapid at night than in the day may be due to the fact that most experments on periodicity have been conducted under greenhouse or laboratory conditions.

ANTHROPOLOGY.—*Ritualistic origin myths of the Fox Indians.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

The Fox Indians of Iowa, who are probably the most primitive of all Algonkins within the borders of the United States, have an extremely extensive folk-lore and mythology. Their long systematic myths accounting for existing ceremonies are especially noteworthy, and it should be mentioned that the particular type of these myths is thus far unique.

To go into some details: The plots are all of one type. The hero is usually poor and sometimes ill-treated, but fasts and in a vision sees his supernatural helper or helpers. Ordinarily he has a vision of them four times and receives a little instruction each time. He then goes home, informs the people, and holds the ceremony in which he has been instructed. The ceremony is the one in actual use today. The songs are the existing ones, as are some of the set speeches. Usually the people subsequently are attacked by their enemies or there is a famine. In any case the hero always succors them.

Such topics as taboos, facial paintings, localizations in clan-feasts, descriptions of drums, positions in dancing, the number of ceremonial attendants and the gentes to which they belong, songs, set speeches, contents of sacred packs, and instruction regarding exogamy of gentes come up incidentally in these ritualistic origin myths. In so far as the actual ceremonies can rarely, if ever be witnessed in their entirety, owing to the conservative character of the Fox Indians, these myths are extremely valuable for strictly ethnological studies.

[1] Summary of an address delivered before the Anthropological Society of Washington, February 15, 1916. Published with the permission of the Secretary of the Smithsonian Institution.

It is the profusion of information contained in the Fox ritualistic origin myths that gives them their unique character in primitive literature. This applies especially to the incorporation of existing songs and set speeches.

Among the Piegans, as Wissler has pointed out, myths occurring in many other tribes in certain cases have been utilized for ritualistic myths. Thus it is patent that they are secondarily adapted for such uses. Among the Menomini (Skinner) such is not the case; the myths do not occur elsewhere out of their ritualistic setting. But the ritualistic myths of both these tribes are not comparable with those of the Foxes in the details given. Yet there is one point in which the Fox ritualistic origin myths resemble those of the Menomini; that is, that the elements do not occur elsewhere outside their setting.

Some of the songs of the Fox ritualistic origin myths occur among the Kickapoo, which shows that they must be rather ancient. Unfortunately the Kickapoo as well as the Sauk ritualistic origin myth is at present unknown. In so far as Kickapoo folk-lore and mythology are extremely close to Fox (as I have recently shown), and as Fox, Sauk, and Kickapoo are extremely closely related linguistically, it is the more to be regretted, for it might prove that not only the same type of ritualistic origin myths occurs in all three, but also the same myths, which in this case would go back to a hoary antiquity unless they have spread by dissemination. In this connection it must be stated that our knowledge of Sauk folk-lore and mythology is too scanty to permit us to determine how close it is to Fox.

In so far as Fox origin myths are all of one type, it is clear that literary systematization has taken place. In other words we cannot regard the Fox ritualistic origin myths as the actual history of how certain ceremonies were introduced among the Fox Indians. This is somewhat confirmed by the fact that the Ojibwa have some of the ceremonies that the Fox ritualistic origin myths account for, but apparently lack the origin myths. It is, however, possible that they have simply not been thus far recorded. Yet today there is a large amount of Ojibwa mythology published, and Dr. Jones' unpublished material (which I am editing for publication) is very bulky; nevertheless in both the systematic origin myth of the Fox type is absent. Only a single Ojibwa myth in Dr. Jones' collection shows a resemblance to the Fox type of ritualistic origin myth. Both the Potawatomi and Cree to my own knowledge also possess certain ceremonies which Fox ritualistic origin myths account for, but unfortunately our knowledge of their folk-lore and mythology is too limited to compare these with those of the Foxes. Summing up, we must say that at present we cannot prove that the Fox ritualistic origin myths were invented to account for the existing ceremonies, though this may have been the case. On the other hand it is entirely possible that certain individuals did have religious experiences and did initiate ceremonies which subsequently were utilized in ritualistic origin myths. Unfortunately there is too little comparative material from closely cognate Algonkin tribes at present available to settle these problems.

As to the language employed in the Fox ritualistic origin myths: The words are unusual and archaic. The set speeches are interspersed with variations of a mystic word *no tti* (so written in the current syllabary), the exact translation of which is difficult. Words are considerably mutiliated in the songs and would rarely be intelligible in themselves. They must be explained in full by informants, to make their meaning at all clear. Padding by mere vocables also occurs in considerable profusion. Though these are blemishes from our point of view, from the native standpoint they are not. A single word or phrase will recall to the Fox Indian the entire thought, which is all that is desirable from their point of view.

In closing, I may say that the genuineness of these ritualistic origin myths is attested by the facts (1) that some of the songs contained in them occur among the Kickapoo; (2) that I have heard some of the songs in the appropriate existing Fox ceremony; (3) that in other cases the informant has been gauged by his other stories—if this latter material checks up well, there being reason to doubt his honesty in regard to the ritualistic origin myths; and (4) that Indians are quite incapable of inventing long, sustained, origin myths without internal evidence of fraud.

ARCHEOLOGY.—*The relation of Sun Temple, a new type of ruin lately excavated in the Mesa Verde National Park, to prehistoric "towers."*[1] J. WALTER FEWKES, Bureau of American Ethnology.

During the summer of 1915, under the direction of the Secretary of the Interior I carried on excavation and repair of ruins in the Mesa Verde National Park. This work was a continuation of that already accomplished on these cliff-dwellings: Cliff Palace, Spruce-tree House, and Balcony House. The general plan was to bring to light any types of ruins existing in the Park different from those already known, in order to enlarge our knowledge of the character or culture of prehistoric man on this reservation.

Cliff Palace, which lies in one of the canyons of the Mesa Verde, was excavated and repaired in 1909, and at that time a pile of stones was discovered on the point of Chapin Mesa, across Cliff Canyon. The artificial character of marking found on stones on the surface of this mound and the great quantity of debris suggested the former existence of a building of large size. A small fragment of wall projected above the surface of the mound on which grew many old trees and bushes, giving evidence that the place had long been deserted by human beings.

The government work on this mound extended from August 10 to the close of October, 1915, and a report on the more popular phases of this work has already been transmitted to the Secretary of the Interior,[2] to be followed by a more extended account for the Secretary of the Smithsonian Institution. The following account gives a summary of the work thus far accomplished and a brief description of the ruin.

There was brought to light a type of ruin hitherto unknown in the park, and the building excavated shows the best masonry and is the most mysterious structure yet discovered in a region rich in so many prehistoric remains. Although at first there was some doubt as to the use of this building, it was early recognized that it was not con-

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] See, Excavation and Repair of Sun Temple, Mesa Verde National Park. Dept. of Interior, 1916. Also, newspaper bulletin released January 16, 1916.

structed for habitation, and it is now believed that it was intended for the performance of rites and ceremonies; the first of its type yet recognized in the Southwest.

The ruin was purposely constructed in a commanding situation in the neighborhood of large inhabited cliff houses. It sets somewhat back from the edge of the canyon, but near enough to present a marked object from all sides, especially the neighboring mesas. It must have presented an imposing appearance, rising on top of a point above inaccessible, vertical cliffs. No better place could have been chosen for a religious building in which the inhabitants of many cliff dwellings could gather and together perform their great ceremonial dramas (see fig. 1).

The ruin was found to have the form of the large letter D, as shown in the accompanying illustration (fig. 2). It was composed of two sections, one of which may be called the original building, and the other the Annex. The side wall, which was situated on the south side, is 121.7 feet long. The whole building is 64 feet wide. The walls, including the central core of rock and adobe, average four feet in thickness. The entire outer facing of the wall is composed of well cut stones, some of which were smoothed by rubbing. There are about 1000 feet or more, containing 28,000 cubic feet of masonry. It is estimated that the building was once several feet higher than it is at the present time.

The rooms in this building vary in form and type, one kind being circular, the other rectangular. The circular rooms are identified as kivas, or sacred rooms; the purpose of the rectangular rooms is unknown. There are two circular rooms, or kivas, of about equal size in the original building, and a third occupies the center of the Annex.

There are 23 other rooms; 14 of these are in the original building, and have parallel walls; several have curved walls, others straight. Of the rooms with curved walls three had entrances from the roofs, four had lateral doors into the plaza, and the remainder are arranged in two series, the members of which communicate with each other.

Not a single room, either circular or rectangular, shows any signs of plastering, but all joints between stones from the bottom to the top were carefully pointed with adobe and generally chinked with stones, the impressions of human fingers and palms of small hands of the workmen, probably women, still showing in the clay mortar.

The principle of the arch was unknown, but the corners were practically vertical, implying the use of a plumb bob. The curved walls are among the best in the ruin. Outside the main building is a circular building with walls four feet thick, which closely resembles the base of a tower. This was probably intended for ceremonial rites. One of the most interesting features is the embellishment of the walls by geometrical figures cut in their surfaces—a rare form of decoration. Several stones bearing incised figures were set in the walls. Generally the designs are geometric, but there are others, including the figure

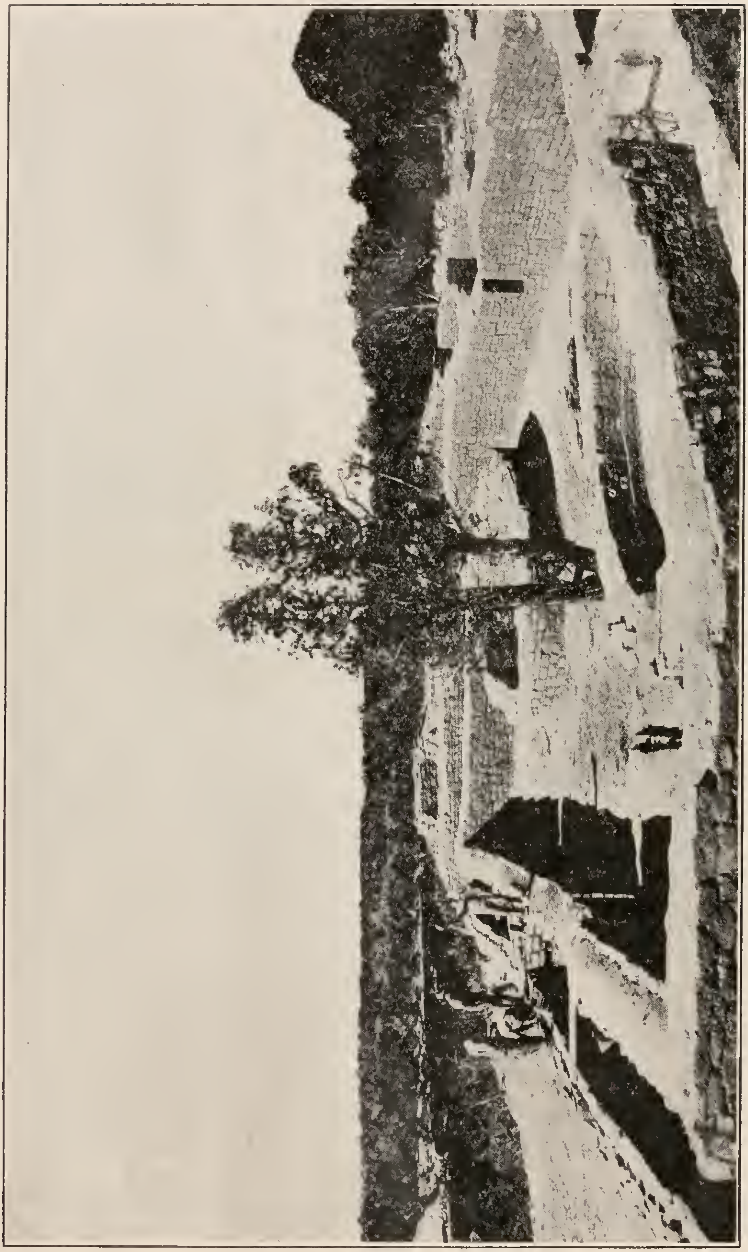

Fig. 1. View of Sun Temple from the southeast.

of a ladder leaning against a wall, turkey tracks, and the conventional sign for flowing water.

The importance of these incised figures on stones set in walls lies in the fact that they seem to indicate an advance in architectural decoration not represented in other prehistoric buildings in the Southwest. They may be regarded as first steps in mural sculpture, a form of decoration that reached such an advanced stage in old ruins in Mexico and Central America. Each figure may have had a special meaning or symbolic significance connected with the room in which it was placed, but these figures seem to me to have been introduced rather for ornament or decorative effect.

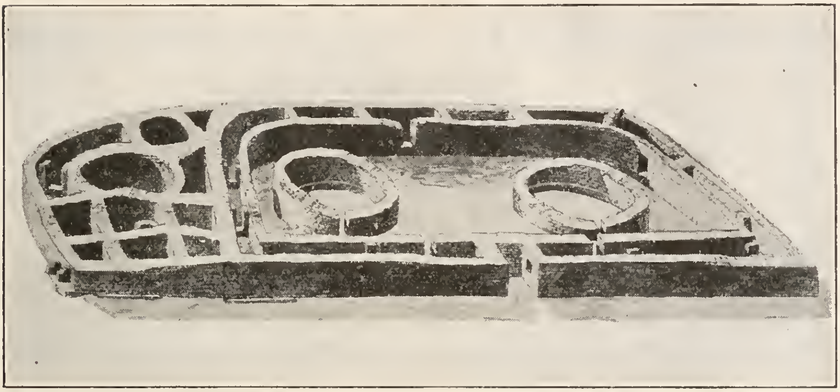

Fig. 2. Perspective view of Sun Temple from the southwest.

The argument that appeals most strongly to my mind as supporting the theory that Sun Temple was a ceremonial building is the unity shown in its construction. A preconceived plan existed in the minds of the builders before they began work on the main building. Sun Temple was not constructed haphazard, nor was its form due to addition of one clan after another, each adding rooms to an existing nucleus. There is no indication of patching one building to another, so evident at Cliff Palace and other large cliff dwellings. The construction of the recess of the south wall, situated exactly, to an inch, midway in its length, shows it was planned from the beginning.

We can hardly believe that one clan could have been numerous enough to construct a house so large and massive: its walls are too extensive; the work of dressing the stones too great. Those who made it must have belonged to several clans fused together; and if they united for this common work, they were in a higher state of sociological development than the loosely connected population of a cliff dwelling.

In primitive society only one purpose could have united the several clans who built such a structure, and this purpose must have been a religious one. This building was constructed for worship, and its size is such that we may practically call it a temple.

The fine masonry, the decorated stones found in it, and the unity of the plan stamp Sun Temple as the highest example of Mesa Verde architecture. The walls were constructed of the sandstone of the neighborhood. Many stone hammers and pecking stones were found in the neighborhood.

One of the most remarkable features of the structure is a fossil set in the outer wall near the southwest corner. Mr. F. H. Knowlton of the U. S. Geological Survey has identified this as the fossil leaf of a palm tree of the Cretaceous epoch. The point is that the rayed leaf resembles the sun, and that the ancient races were sun worshipers. A natural object resembling the sun would powerfully affect a primitive mind. At all events they partially inclosed their emblem with walls in such a way that the figure is surrounded on three sides, leaving the opening on the fourth, or west side. There can be no doubt that the walled inclosure was a shrine, and the figure in it may be a key to the purpose of the building. The shape of the fossil on the rock suggests a symbol of the sun, and if this suggestion be correct, there can hardly be a doubt that solar rites were performed about it.

It is impossible to tell when Sun Temple was begun, how long it was building, or when it was deserted. There are indications that its walls were never completed; and from the amount of fallen stones there can hardly be a doubt that when it was abandoned they had been carried up in some places at least six feet above their present level. The top of the wall has been worn down at any rate six feet in the interval between the time it was abandoned and the date of my excavation of the mound. No one can tell the length of this interval in years.

We have, however, some knowledge of the lapse of time, because the mound had accumulated enough soil on its surface to support the growth of large trees. In the Annex, near the summit of the highest wall, there grew a juniper or red cedar of great antiquity, alive and vigorous when I began work. This tree undoubtedly sprouted after the desertion of the building and grew after a mound had developed from fallen walls. Its roots penetrated into the adjacent rooms and derived nourishment from the soil filling them. It is not improbable that this tree began to grow on the top of the Sun Temple mound shortly after the year 1540, when Coronado first entered New Mexico, but how great an interval elapsed during which the walls fell to form the mound in which it grew and how much earlier the foundations of the ruined walls were laid no one can tell. A conservative guess of 250 years is allowable for the interval between construction and the time the cedar began to sprout, thus carrying the antiquity of Sun Temple back to about 1300 A.D.

From absence of data the relative age of Sun Temple and Cliff Palace is equally obscure, but it is my firm conviction that Sun Temple is the younger, mainly because it shows unmistakable evidences of a higher sociological condition of the builders; but here again we enter a realm of speculation which merely adds to the mystery of the building.

Comment has been made on the fact that practically no household implements were found in the rooms, which has been interpreted to mean that the building was never finished. It also signifies that the workmen did not live in or near it during construction. On the theory that this building was erected by people from several neighboring cliff dwellings for ceremonies held in common, we may suppose that the builders came daily from their dwellings in Cliff Palace and other houses and returned at night, after they had finished work, to their homes. The trails down the sides of the cliffs, which the workmen used, are still to be seen. The place was frequented by many people, but there is no evidence that any one clan dwelt near this mysterious building during its construction.

Perhaps the most important result of my explorations at the Mesa Verde National Park last summer was the unearthing for the first time of this large, mysterious building bearing evidence that it was constructed solely for religious purposes. This interpretation is very important, if correct; and in order to test the theory by reference to other ruins I have studied in a comparative way related structures that have certain architectural features in common with Sun Temple. Among the most striking of these are the problematical buildings known as "towers," represented by a number of examples in southwestern Colorado and southeastern Utah.

The existence along the Lower Mancos, on the San Juan, and in the canyons of the McElmo, of a type of ruins hitherto unrecorded in the Southwest, designated as "towers," was made known in 1876 and 1879 by Mr. W. H. Jackson[3] and Mr. W. H. Holmes.[4] Since that date, now almost 40 years ago, the figures they published have been frequently reprinted,[5] but the buildings themselves still await systematic excavation and study. Work

[3] Ancient Ruins in Southwestern Colorado. Rept. U. S. Geol. & Geog. Surv. 1876.

[4] Report on the Ancient Ruins of Southwestern Colorado examined during the Summers of 1875 and 1876. 10th Ann. Rept. U. S. Geol. & Geog. Surv. 1879.

[5] In *Search for a lost race*, Illustrated American, May, 1892. In this article Mr. Gunckel adds a few new observations of interest, mainly regarding distribution of towers; no excavations were made. See also, PEET, STEPHEN DENISON: *The Cliff Dwellers and Pueblos*. American Antiquarian, Chicago, 1899.

at Sun Temple has stimulated my desire to know more of architectural details and especially the use to which these towers were formerly put. So far as the question of use is concerned their resemblances to ceremonial rooms called kivas would appear conclusive. Let us consider some of the known architectural features of these towers, on the theory that they are ceremonial in character.

Fig. 3. Tower ruin in Ruin Canyon, Utah.

The central room of one of these towers is circular in form, suggesting a kiva, but its inner walls show no evidences of the former presence of pedestals, or pilasters, or supports of a roof. Evidently if a roof once covered the central room, it was not vaulted as in the majority of circular kivas, but flat, the beams supporting it having been laid parallel, with ends resting on top of the walls. One of the characteristic features of a typical tower is the double wall with intervening rooms separated by partitions.[6] Unfortunately we do not know the character of the floors of these towers, as they still await the spade of the arche-

[6] I am inclined to doubt the existence of triple walled towers.

ologist; but so far as I am aware, evidence is strong that they belong to the second type of circular kivas, those with flat roofs and destitute of columns for support of the roof beams.

One of the so-called towers described by Professor Holmes is said by him to be 140 (138) feet in diameter, this dimension suggesting a large ceremonial building like Sun Temple rather than a tower or kiva. I suspect that, if the architecture of the building containing the tower referred to by Professor Holmes were better known, it would be found to have a straight wall on the side above the cliff and a D-shaped, rather than a circular, wall about it.

Another "tower" described by the same author as set in the midst of secular rooms is evidently a kiva with two encircling walls, surrounded by rooms separated by partitions. The strong resemblence of the Annex, or western end of Sun Temple, to such a tower leaves little doubt that both were identical in use, being sacred enclosures. In a comparison of the Annex with one of the McElmo towers we find in the middle a circular room around which are arranged other rooms, irregularly placed in the former, and modified on one side by confluence with an attachment to the original (main) building. Both have, in the center, ceremonial rooms known as kivas which belong, however, to a type different from the subterranean kivas of Cliff Palace.[7]

As has been elsewhere pointed out, we have in the Mesa Verde culture area circular kivas belonging to two types, one of which, the more common, is subterranean, with vaulted roofs supported on pilasters attached to the inner walls, characteristic ventilators and deflectors, and (generally) a ceremonial opening in the floor styled the *sipapu*. These may be designated vaulted-roofed kivas. The second, or flat-roofed type, to which, *en passant*, it may be said the towers above considered are related, apparently had no pilasters to support the low vaulted roof; consequently the roofs are flat, the ends of the supporting beams extending across the chamber with their extremities resting on the walls of the room, not from one pilaster to another. Some

[7] Semicircular, or D-shaped, Sun temples occur also in Peruvian ruins.

kivas of the flat-roofed type are so surrounded by other rooms that their walls have a sunken appearance, but the chambers are not subterranean. When isolated from the room groups, as are certain modern kivas, they suggest the towers found in the Mesa Verde culture area.[8] The tower kiva is more closely allied to kivas of the second type, represented in Cliff Palace by O and R, and possibly by W (see my account of the excavation and repair of that ruin). I do not regard this type as a transition form connecting circular and rectangular kivas, as suggested by Nordenskiöld, for I find they have distinct origins, but a circular subterranean kiva with pedestals and an arched roof may be related to a round kiva of the second type.[9]

The comparisons that have been made above between the ceremonial rooms in cliff dwellings, towers, and the ruin called Sun Temple have led me to believe that certain of the structures, known as towers, were in reality not lookouts, as commonly believed, but were constructed solely for religious purposes as suggested by the discoverers. On the other hand, some of the towers cannot be regarded as places of worship. Some served probably as lookouts, while many were built for storage, defense, or other purposes. All our theories about their use are tentative, awaiting the time when we shall have more exact knowledge of details, which can be discovered only by scientific excavation of the debris that has fallen around their foundations, obscuring the floors and the connections with other buildings in the immediate neighborhood.

In closing this comparison of Sun Temple or its kivas with San Juan tower kivas, a word may be said in explanation of the term "type ruin." Our Southwest is dotted with prehistoric habitations of several distinct forms, indicating different culture areas, so far as it is possible to determine them in the light of

[8] The circular kivas without pilasters are common lower down the San Juan in the Navaho National Monument. The modern circular kivas belong to the group without vaulted roofs, which includes also towers. A D-shaped kiva of the second type, suggesting D-shaped tower kivas of Ruin Canyon, is found in Oak Tree House.

[9] Antiquities of the Mesa Verde National Park: Cliff Palace. Bull. 51, Bur. Amer. Ethn. 1911.

architecture. Manifestly it is not necessary to excavate carefully and repair all these ruins, even if money were available for that purpose. We need to determine, however, how many kinds of ruins there are, and to get clearly in mind the essential features of each kind, in order to discover culture groups of the prehistoric Southwest. The problem is not unlike that with which the biologist has to deal, and which he has so well worked out in biological textbooks. An intimate knowledge of the anatomy of the starfish, crayfish, frog, cat, and other animals representative of the groups to which they belong, respectively, makes it possible for the zoological student to get a good idea of the anatomy of other members of these groups, the knowledge being gained largely through dissection or through study of "preparations" made by others. These animals serve as types. The same method, with modifications, may be applied in the study of Southwestern archeology, although from the nature of the case preparations of types should be made, for beginners or even for advanced students, by experts.

A few of these type ruins already have been prepared for inspection and for study. The famous Casa Grande in the Gila valley is a good example of a type ruin of the great house ruins of that valley, while Cliff Palace and Spruce-tree House are excellent type ruins of cliff dwellings. Sun Temple seemingly represents a type of ruined buildings of a well defined prehistoric culture area, and as a type will afford the student information bearing on the architecture of other members of a group of ruins one of the main features of which is a specialized building constructed for religious ceremonies.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The illumination from a radiating disk.* Paul D. Foote. Bureau of Standards Scientific Paper No. 263, pp. 583–586. 1916.

A knowledge of the illumination from a radiating disk is of practical value to engineers, but certain solutions of this problem which have appeared in technical journals have been in error. In this paper is given the correct expression for the illumination produced by a diffusely and uniformly radiating circular disk, at any point on any surface parallel to the disk. P. D. F.

PHYSICS.—*Inclusions in the silver voltameter deposits.* G. W. Vinal and W. M. Bovard. Bureau of Standards Scientific Paper No. 271, pp. 147–172. 1916.

For the purpose of determining the absolute value of the electrochemical equivalent of silver and the absolute value of the faraday it is necessary to learn the amount of "inclusions" in the silver voltameter deposits. Lord Rayleigh[1] advocated heating the platinum cups with deposits to incipient redness as the simplest method of expelling the inclusions, which are chiefly water and silver nitrate. Richards and Anderegg[2] have recently used this method also, finding the inclusions to be large and variable in amount.

When silver deposits are heated in the platinum cups alloying of the two metals takes place, and on removing the silver the platinum cup shows stains which are brownish or black.

We have found that these stains are platinum black and that they render the weight of the empty platinum crucible very uncertain unless the precaution is taken to heat the cups to incandescence, or to remove

[1] Phil. Trans. A. **175**: 411. 1884.

[2] J. Am. Chem. Soc. **36**: 15. 1915.

the stains by aqua regia before making further deposits. This heating process transforms the platinum black to platinum gray and the loss in weight apparently suffered by the cups may be anything from 0.1 mg. to 5.0 mg., depending on the amount of material adsorbed by the platinum black. The presence of either platinum black or platinum grey in the cup renders the cup unfit for use in measuring the electric current since they exercise a catalytic action on the hydrogen ions present in the solution and therefore the amount of silver deposited is too small to represent all of the electricity which actually passed through the voltameters.

Taking these sources of error into consideration we have made determinations of the losses in weight of deposits from pure electrolyte and find, as the mean of 25 determinations, that it amounts to 0.0040 per cent.

The Bureau of Standards published some time ago an absolute value[3] for the electrochemical equivalent of silver which was obtained by the silver voltameters containing especially pure electrolyte and an absolute current balance of the Rayleigh type. The value found was 1.11805 mg. per coulomb which may be now corrected by subtracting 0.0040 per cent. It thus appears that the value 1.11800 mg. per coulomb which was adopted by the International Electrical Conference in 1908 is in reality within one part in one hundred thousand of the best value which we can now assign to this constant. On this basis, and using the present value for the atomic weight of silver (107.88), we find the farady to be 96,494 coulombs. G. W. V.

PHYSICS.—*A study of instruments for measuring radiant energy in absolute value: an absolute thermopile.* W. W. Coblentz and W. B. Emerson. Bureau of Standards Scientific Paper No. 261. Pp. 49. 1916. *The present status of the determination of the constant of total radiation of a black body.* W. W. Coblentz. Bureau of Standards Scientific Paper No. 262. Pp. 30. 1916.

The first paper gives the results of an investigation of an instrument for measuring radiant energy in absolute value. The instrument consisted of a thin blackened strip of metal with a thermopile back of it. The strip of metal functions (1) as a receiver for absorbing radiant energy, (2) as a source of radiation (by heating it electrically) which can be evaluated in absolute measure and (3) as a standard source of radia-

[3] Bulletin Bureau of Standards **10**: 477. 1914.

tion for calibrating the radiometer which includes the galvanometer and the thermopile.

Various widths and thicknesses of metal were used in the receiver which was covered with various kinds of absorbing surfaces of lamp black and platinum black. The instrument was found satisfactory for refined radiometric measurements.

The second paper gives the results of an inquiry into the probable value of the coefficient of total radiation of a uniformly heated enclosure or so-called black body. Experimental data are given on the lack of blackness of the radiator, on the absorption caused by atmospheric water vapor, on the reflecting power of lamp black, etc.

W. W. C.

GEOLOGY.—*Ground water in Lasalle and McMullen counties, Texas.* Alexander Deussen and R. B. Dole. U. S. Geological Survey Water-Supply Paper No. 375–G, pp. 142–181, with geologic and artesian water maps and sections. 1916.

Lasalle and McMullen counties lie in the Coastal Plain of southwest Texas, where irrigation supplies are valuable. Physiographically they consist of uplands and valleys, the uplands being divided into several parallel belts trending northeast, the valley lands including two groups of Pleistocene terraces. On the uplands are remnants of a late Pliocene plain now nearly destroyed by erosion. The sediments exposed comprise several formations belonging to two systems, the Tertiary and the Quaternary. Deep wells encounter also formations belonging to the underlying Cretaceous system. The beds older than the Quaternary have been elevated and tilted toward the Gulf. The upland gravels and valley deposits were laid down after some tilting and erosion had taken place. An important feature is a difference in the direction in which the formations dip on the opposite sides of a line extending diagonally across the area from the northwest corner of Lasalle County, as suggested by the structure contours. A normal fault having a vertical displacement of probably 40 feet is inferred on the evidence of well sections and the quality of the water. There are several extensive sandy beds separated by beds of impervious clay or shale. The sandy beds are artesian reservoirs and supply flowing wells. Numerous analyses given in the report indicate that almost all the waters exceed 500 parts per million in total mineral content, and nearly two-thirds of them exceed 2000 parts. Sulphate and chloride waters predominate and more than half contain notable amounts of black alkali. The best water is found in the northwestern part of the area, in the deepest formations. Irrigation on a small scale is practicable west of the fault line. O. E. M.

ENGINEERING.—*Water powers of the Cascade Range, Part III, Yakima River basin.* GLENN L. PARKER and FRANK B. STOREY. U. S. Geological Survey Water-Supply Paper No. 369. Pp. 1–169, with text figures and illustrations. 1916.

This is the third of a series entitled "Water powers of the Cascade Range," prepared by the United States Geological Survey and the Washington State Board of Geological Survey. Part I, containing data on the drainage basins of Klickitat, White Salmon, Little White Salmon, Lewis, and Toutle rivers, in southwestern Washington, was prepared by John C. Stevens and was published in 1910 as Water-Supply Paper 253. Part II, relating to the drainage basins of Cowlitz (except the Toutle), Nisqually, Puyallup, White, Green, and Cedar rivers, on the west side of the Cascade Range, was prepared by Fred F. Henshaw and Glenn L. Parker and was published in 1913 as Water-Supply Paper 313. The Yakima River basin described in this report lies east of the Cascade Range.

The data on which this report and the others are based consist of stream-flow records, river plans and profiles, reservoir surveys, and field reconnaissances of the rivers and the various tributaries. The physical characteristics, economic conditions, and industrial development of the region are described rather fully in order that the limitations to the development of power may be more clearly understood.

G. L. P.

TECHNOLOGY.—*Determination of carbon in steels and irons by direct combustion in oxygen at high temperatures.* J. R. CAIN and H. E. CLEAVES. Bureau of Standards Technologic Paper No. 69. Pp. 10. 1916.

A method has been devised for the determination of carbon in steels and irons by direct combustion in oxygen at 950° to 1100° C., finishing above 1450°, so that the oxides of iron are kept fused for several minutes, in order to give the best possible chance for liberating all the carbon. This method was tested by analyzing various types of plain carbon and alloy steel standards of the Bureau and some of the pig iron standards, and the results obtained for carbon in this way were in the mean about 0.01 per cent carbon above the certificate averages.

J. R. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 104th meeting of the Washington Academy of Sciences, the 17th annual meeting, was held in the lecture room of the Cosmos Club, the evening of January 13, 1916, with Vice-President W. S. Eichelberger in the chair and about 75 persons present.

The Corresponding Secretary reported a total membership of 486, 179 nonresident, 297 resident, 1 life, 6 honorary, and 4 patrons (1 of whom is also a regular member). This is a net gain of 72 over the membership at the time of the last preceding annual meeting. During the year the Academy lost by death several of its most noted members: Charles E. Bessey, Lincoln, Nebraska; Karl E. Guthe, Ann Arbor, Michigan; Joseph H. Holmes, Washington, D. C.; Morris Longstreet, Cambridge, Massachusetts; F. W. Putnam, Cambridge, Massachusetts; Frank A. Sherman, Hanover, New Hampshire; Geo. M. Sternberg, Washington, D. C.; and Mrs. Matilda Coxe Stevenson, Washington, D. C.

The Recording Secretary reported the previous annual meeting and the 7 subsequent meetings at which scientific papers were presented.

The report of the Treasurer, confirmed by the report of the auditors, showed:

Cash balance, January 1, 1915	$1,597.31
Total receipts during 1915	3,991.31
	$5,588.62
Disbursements, 1915	$3,560.55
Investments, 1915	500.00
Balance, December 31, 1915	1,528.07
	$5,588.62

The Academy's total investments are: $13,090.00.

The following were elected officers for the ensuing year: *President*, L. O. Howard; *Corresponding Secretary*, F. E. Wright; *Recording Secretary*, W. J. Humphreys; *Treasurer*, William Bowie; *Vice-Presidents*, representing the: Anthropological Society, J. Walter Fewkes; Archeological Society, Mitchell Carroll; Biological Society, W. P. Hay; Botanical Society, R. H. True; Chemical Society, R. B. Sosman; Electrical Engineers Society, C. B. Mirick; Engineers Society, J. C. Hoyt; Entomological Society, W. D. Hunter; Foresters Society, Geo. B. Sudworth; Geographical Society, O. H. Tittmann;

Geological Society, T. W. Vaughan; Historical Society, J. D. Morgan; Medical Society, E. Y. Davidson; Philosophical Society, L. J. Briggs; *Non-Resident Vice-Presidents,* A. G. Mayer and E. C. Pickering; *Managers, Class of 1919,* G. K. Burgess and C. L. Alsberg.

After the election of officers the Academy continued its meeting jointly with the Chemical Society to hear the address of Dr. Carl L. Alsberg on *The chemical analysis of animal nutrition,*—an instructive survey of the beginning, development, present status, and immediate problems of this exceptionally difficult yet all-important branch of chemistry.

The 105th meeting of the Academy was held in the auditorium of the New National Museum on Thursday evening, March 2, 1916, with President L. O. Howard in the chair. Dr. Douglas W. Johnson, Professor of Physiography in Columbia University, gave an illustrated lecture on the *Surface features of Europe as a factor in the war.*

The geologic history of Europe was briefly outlined and the resulting present physiographic features explained and illustrated in some detail. It is these features, especially the steep walls on the eastern margin of the "Paris basin," and the lakes, rivers, and swamps of western Russia, that throughout the war have largely determined the routes of advance and retreat, the lines of defense, and the points of attack.

The 106th meeting of the Academy was held in the auditorium of the New National Museum on Tuesday evening, March 23, 1916, with President L. O. Howard in the chair and a large audience present. Dr. L. H. Baekeland, Member of the Naval Consulting Board, gave an address on *Chemistry in relation to war.* Early experiments were described that led to the chemical discovery and commercial development of dynamite, gun cotton, "T. N. T.," and the various other modern high-power explosives, and the processes of their manufacture outlined. It was explained that in the manufacture of these substances nitric acid is indispensable. The only large-scale sources of this acid, as now manufactured, are "Chili saltpeter" and the nitrogen of the air. Three methods of "fixing" the nitrogen of the air are now in use, two of which were first developed commercially in the United States, though subsequently abandoned owing to the high cost of the necessary power. Both processes are now extensively used abroad, especially in Norway and Germany.

Whether nitrogen shall be "fixed" in America, and aniline dyes and other chemicals manufactured on a large scale, is merely a question of business and dividends, the speaker pointed out, and in no sense a question of scientific ability and chemical knowledge, both of which of high order exist in this country.

W. J. Humphreys, *Recording Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 551st regular meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, February 26, 1916; called to order at 8 p.m. by President W. P. Hay. Fifty persons were present.

The first paper of the program was by D. E. Lantz, *An Early Seventeenth Century mammalogist.* This was a review of Edward Topsell's *History of Foure-footed Beastes*, published in London in 1607. Topsell was born about 1538 and at the completion of this, the first general work on mammals published in the English language, was chaplain of the church of St. Botolph, Aldergate, under Richard Neile, Dean of Westminster, to whom the book is dedicated. The work, including illustrations, is largely translated from Conrad Gesner's *Historia Animalium*, published in 1551; but the author quotes also from the works of over 250 other writers—Hebrew, Greek, Latin, German, Italian, and French authorities—including 76 medical treatises. The speaker gave many curious extracts from Topsell, illustrating them with lantern pictures of the animals under discussion, taken from the old wood cuts in the book. The pictures included those of the antelope, an ape monster, the American sloth, the beaver, various kinds of hyenas, the unicorn, the riverhorse, and the Su, an untamable and ferocious animal that has been identified with the American opossum.

The second and last paper of the program was by J. W. Gidley, *A talk on the extinct animal life of North America.* Mr. Gidley defined the terms fossil and petrifaction, explained how fossils were formed under various conditions, and how they are discovered by the collector. He discussed the evolution of certain animals as shown by their fossil remains, and as particularly exemplified by horses, elephants, and dinosaurs. He emphasized in especial the unfortunate tendency on the part of paleontologists to try to see in fossil remains ancestral forms of later fossils or of existing animals. The speaker thought that many fossils represented highly specialized types of their kind, some extinct animals being more highly specialized than their present day representatives; in fact in many cases their extreme specialization led to their extinction. In a general way fossil forms represent the evolution of certain groups, but the immediate connecting forms are for the most part lacking.

Mr. Gidley's communication was profusely illustrated with lantern views of fossil-bearing localities, of fossils, and of certain artists' restorations of fossils. It was discussed by Dr. L. O. Howard.

M. W. Lyon, Jr., *Recording Secretary.*

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PHYSICS.—*Polarized skylight and the petrographic microscope.*[1] W. S. Tangier Smith. (Communicated by F. L. Ransome.)

When skylight is used with the petrographic microscope, there is often a notable loss of available light owing to its partial polarization. This polarization, like the blue color of the sky, is due to the effect of light waves on particles of matter in the atmosphere, the diameter of which is small compared with the wave-length of light, so that the light which strikes them, instead of being reflected, sets up harmonic vibrations in the particles or the surrounding ether, these vibrations in turn giving rise to light waves and resulting in what is commonly referred to as "scattered light." This scattered light, composed mainly of blue and violet rays, is polarized to a greater or less extent, since at any one point the vibrations which give rise to it are confined to a single plane transverse to the direction of transmission of the original beam of light.

The more numerous the minute particles which scatter light, and the fewer the larger reflecting particles which mask the scattered light, the bluer is the sky and the greater the polarization of its light when viewed in certain directions.

The blueness of the sky and the polarization of its light being due to the same cause, they vary for the most part together, and the polarization is therefore greatest under those circum-

[1] Read before the Cordilleran Section of the Geological Society of America. April 11, 1913.

stances which give the bluest skies. Hence it is that the polarization of the skylight and the resulting loss of light in the microscope are most evident on the brightest days, with the clearest, bluest skies, and from those parts of the sky which are the deepest blue; moreover it is especially noticeable in the more arid parts of the country and at considerable altitudes.

The polarized skylight, reflected from the mirror of the microscope, enters the lower nicol vibrating in a plane which may or may not coincide with the plane of vibration of the nicol. If the two coincide, there is of course no loss of light. When they do not, however, there is always more or less loss, sometimes amounting to one-half or more of the total illumination received by the microscope.

Any remedy for the difficulty must involve either some change in the illumination, or else a shifting of the microscope or a modification of its optical parts. Among the possible devices which would reduce or prevent the loss of light are the following:

(1) Artificial light may be used as the source of illumination, or a translucent screen may be interposed between the microscope and direct sunlight. A cloudy or foggy sky has the same effect as an interposed screen, the light from clouds being non-polarized.

(2) The microscope may be so placed that the light will come from a favorable part of the sky. As already noted, the degree of polarization of the skylight varies in different parts of the sky, being greatest in those portions from which lines to the sun and the microscope make an angle approximating 90° with each other, and decreasing rapidly on either side of this zone, more especially with approach toward the sun (fig. 1). It also decreases close to the horizon, on account of the large number of reflecting particles present in this portion of the sky. The horizon belt, however, is generally too narrow and often too low to be of much practical use; while near the sun the intensity of the light becomes too great. Thus, while the selection of favorable parts of the sky may somewhat decrease the polarization effects, it is not always a satisfactory remedy, especially when the choice is restricted to those parts visible from a single window.

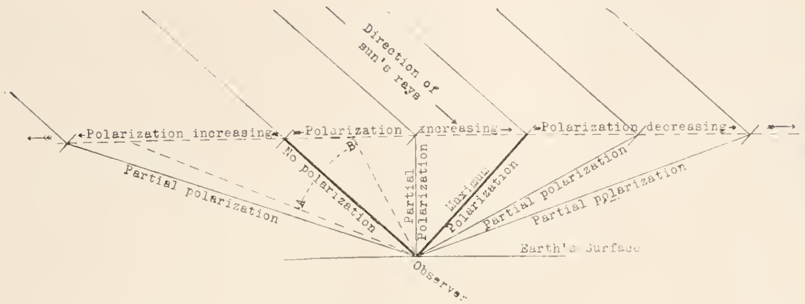

Fig. 1. Diagram to illustrate the variation in the polarization of scattered light from different parts of the sky. The short lines perpendicular to the lines representing the sun's rays are the traces of planes of vibration of harmonic motions which give rise to scattered light. *A–B* marks the approximate maximum limits of the sun's diffraction glow, the circle of intense illumination close to the sun, within which the effects of scattering are more or less masked and polarization is at a minimum.

(3) The microscope may be rotated on its base until the plane of vibration of the reflected polarized skylight coincides with that of the lower nicol of the instrument. This is a simple expedient, applicable at all times, and when the observer can move with the microscope it is entirely satisfactory. When he cannot, however, it necessitates his becoming familiar with the use of the micropscope and its accessories in varied positions, and even with such familiarity it is likely to lead to some confusion.

In this connection it may be noted that the orientation of the plane of vibration in the polarizer of the microscope may have some effect in increasing or decreasing the difficulties with polarized skylight. The plane of vibration of the lower nicol is differently oriented in different instruments, even of the same make. In the common type of the Bausch and Lomb petrographic microscope, for example, this plane of vibration is square with the instrument, in some cases running from front to rear, in others from right to left. In the "Larson Model" the plane of vibration is diagonal, sometimes in one direction, sometimes in the other. The difficulties with polarized skylight are met with in all four of these types, and in this respect there is little to choose between them; what slight preference there may be for one type or the other will depend on the sky facing which one adopts—or often must adopt; on the time of day when the microscope is most used; and on the importance of sky polarization as a factor at noonday. F. E. Wright,[2] in a recent paper, has concluded that for Washington, D. C., where "at noon time there is always an abundance of light from a clear sky" (so that the polarized scattered light may be disregarded), and for a northern facing, and a use of the microscope at any hour of the day, "there is a slight advantage in having the plane of vibration parallel to the vertical cross-hair."

(4) A suitable compensator introduced below the polarizer of the microscope, and capable of independent rotation about the axis of the instrument, may effect practically complete correction of the polarization of the skylight and at the same time give a whiter and more favorable light. A simple type of such compensator is a thin, parallel-faced plate of some transparent, birefringent material—as quartz or muscovite—cut so as to give, theoretically, with monochromatic light of 518 $\mu\mu$ wave length (the value which yields, with the petrographic microscope, results most nearly in accord with the conditions of ordinary white light), a phasal difference of a half wave length between the entering and emerging rays of light. Practically, it is cut so as to give with ordinary light and between crossed nicols pure white of the first order as an interference color. This compensator or half-wave plate, mounted in a movable ring, should be free to rotate about the axis of the microscope through an angle of not less than 90°, and in use should be so turned that, theoretically, its planes of vibration, for light with normal incidence, bisect the angles between the planes of vibration of the reflected polarized skylight and the polarizer of the microscope (see fig. 2); practically, so as to obtain the maximum illumination. If the compensator is tested between the nicols of a microscope—the most severe test which can be applied—there is no observable

[2] Journ. Wash. Acad. Sci., **5**: 641–644. 1915.

loss of light, even when the nicols are crossed. The writer has used such a compensator in his own work and finds it entirely satisfactory.

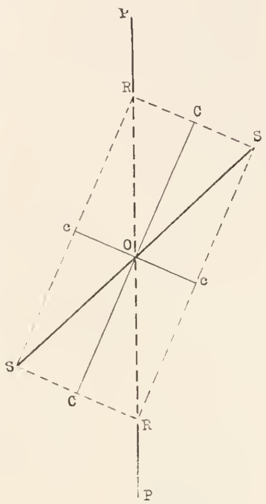

Fig. 2. Diagram to illustrate the action of the polarized-skylight compensator or half-wave plate. *S–S* is the trace of the plane of vibration of polarized skylight. *P–P* is the trace of the plane of vibration of the polarizer of the microscope. *C–C* and *c–c* are the traces of the planes of vibration in the compensator. They bisect the angles between *S–S* and *P–P*. The polarized skylight which enters the compensator, vibrating in the direction *S–S* and with amplitude *OS*, is resolved into two plane polarized rays, *C–C* and *c–c*, with amplitudes *OC* and *Oc*, respectively, and with no phasal difference. Emerging with a phasal difference of one-half wave length, these rays combine to form a single plane polarized ray, *R–R*, whose direction of vibration coincides with that of the polarizer, *P–P*, and whose amplitude, *OR*, equals that of the original ray, *OS*. Theoretically, therefore, there is no loss in the light entering the polarizer.

The compensator just described can be used, of course, only with a stationary polarizer. In order to use it with the type of microscope in which both nicols can be rotated simultaneously, it is necessary to connect the mounting of the compensator with that of the polarizer in such a way that, when the polarizer is turned through any angle, the compensator will be rotated, automatically, through half that angle, the movements of both being in the same direction. This rotation of the mounting, however, is independent of that of the compensator itself, already referred to. When both nicols are rotated simultaneously without the compensator, the intensity of the light transmitted by the polarizer may vary considerably, while with the compensator the illumination is uniform during rotation.

It may happen, during the middle of the day, that the full skylight, even from the zone of maximum polarization (which, it may be noted, is also the zone of minimum illumination), is too intense for the most satisfactory work with the petrographic microscope. At such times, when using light from this zone or near it, the compensator may be used, not only to correct the loss of light resulting from a lack of correspondence between the planes of vibration of skylight and polarizer, but also to adjust the light to the needs of the worker, either by an incomplete correction of the light loss or, where there is already essentially complete correspondence between the vibration planes, by a reduction of the illumination through a reverse movement of the compensator.

PALEONTOLOGY.—*The uropods of* Acanthotelson stimpsoni.

T. D. A. Cockerell, University of Colorado.

Among some fossils kindly presented by Mr. L. E. Daniels to the University of Colorado Museum is a specimen of *Acanthotelson stimpsoni* Meek & Worthen in a nodule from the Carboniferous of Mazon Creek, Illinois. I have examined many examples of this species, but the present one is remarkable for the perfect preservation of the uropodal rami, permitting a more exact interpretation of their structure than was possible to Meek and Worthen, or to Packard.[1] The rami are about 9.5 mm. long, hard and perfectly spiniform, and strongly longitudinally grooved. The outer one is straight, the inner gently curved. Stiff spinelike bristles occur at intervals of somewhat less than a millimeter on both sides of the inner ramus; and also on the outer side of the outer ramus, where they are more closely set. There are in addition many very fine, soft setae fringing the rami, forming an especially long fringe on the inner side of the outer ramus. Packard's figure is, therefore, in error in showing numerous quite closely set bristles of one sort only.

Fig. 1. Uropodal rami of *Acanthotelson stimpsoni*. About scale 4.

Acanthotelson is an animal of more than ordinary interest. It belongs to a group of Crustacea which Packard named Syncarida, peculiar freshwater Malacostraca in which there is no carapace whatever. In the Carboniferous and Permian strata of the

[1] Mem. Nat. Acad. Sci., **3**: 15th Memoir, pl. 1, fig. 1d. 1886.

northern hemisphere there is evidence of the existence of several genera. Formerly it was supposed that the group became extinct in later Paleozoic times, but in 1893 a living representative (*Anaspides* Thomson) was discovered in deep pools in the mountains of Tasmania. Still more recently two other living genera have been found: *Paranaspides* G. Smith in Tasmania and *Koonunga* Sayce in the vicinity of Melbourne, Australia. As early as the Mazon Creek Carboniferous, the appendages known as uropods had become greatly modified from a strictly primitive type. In *Palaeocaris typus* Meek & Worthen, of which an example from Mazon Creek is before me, the rami are flattened and expanded, approaching the form usual in Malacostraca, and evidently used for swimming, i.e., for propulsion in water. In *Acanthotelson,* on the other hand, the rami are of a very different nature, slender and spinelike, apparently suited for executing springing movements (comparable to those of the Collembola) in the soft sand or mud at the bottom of the water. Thus two types of modification were present; one became nearly universal, while the other, that of *Acanthotelson,* died out. *Acanthotelson* must be regarded as the type of a distinct family, Acanthotelsonidae, and the groups of Syncarida may be tabulated thus:

Rami of uropods spinelike.................... ACANTHOTELSONIDAE.
(*Acanthotelson* Meek & Worthen. Mazon Creek Carboniferous.)
Rami of uropods flattened swimming organs...................... 1.
1. First thoracic somite quite distinct, though short.... URONECTIDAE.[2]
(Permian of Europe; Carboniferous of Europe and America.)
1. First thoracic somite fused with head, the point of junction more or less indicated by a groove (living forms).................. 2.
2. Eyes sessile........................ KOONUNGIDAE (*Koonunga*.)
2. Eyes stalked.................................. ANASPIDIDAE.
No dorsal hump; mandible with three-jointed uniramous palpus. Anaspidinae (*Anaspides*).
With a dorsal hump; mandible with four-jointed biramous palpus. Paranaspidinae (*Paranaspides*).

[2] Packard called this family Gampsonychidae, basing it on *Gampsonyx* Jordan & V. Meyer. It appears, however, that this generic name was earlier used for a genus of birds; so the next available name, *Uronectes* Bronn, has to be used. This is the Permian form; the Carboniferous one is *Palaeocaris* Meek & Worthen (*Praeanaspides* H. Woodward). *Palaeocaris typus* has a more or less distinct dorsal hump, though Packard's figure does not show it.

The fact that the three living genera are extremely distinct from one another, and are monotypic, indicates that they are ancient forms, the group having apparently lost all tendency to produce new species. The curiously restricted geological and recent distribution of the whole series shows how little we know of some types of life, which must have had a long evolutionary history now hidden from us.

I take this opportunity to note that the Arachnid family Holotergidae Petrunkevitch,[3] which occurs at Mazon Creek, must be called Curculioididae, as "Holotergidae" is not based on a generic name.

BOTANY.—*Comparative notes on the floras of New Mexico and Argentina.* PAUL C. STANDLEY, National Museum.[1]

That there exists a marked relationship between the flora of the southwestern United States and that of central and southern Argentina is a fact fairly well known to botanists. The closeness of this relationship is scarcely realized, perhaps, except by one familiar with the flora of either region when he inspects a collection of plants or goes over a list of species characteristic of the corresponding area. About three years ago Mr. Walter Fischer, at that time director of the Escuela Experimental de Agricultura at Río Negro, in the Department of Río Negro, southern Argentina, secured some three hundred numbers of plants in that vicinity. His collections were studied and named by Dr. Cristóbal M. Hicken, Professor of Botany in the University of Buenos Aires. Dr. Hicken has published recently[2] an extended report upon these specimens. The collection, although not a large one, is interesting to the student of the Argentine flora because of the considerable number of new species and of species previously unknown in Argentina which it contains.

A set of Mr. Fischer's plants was received recently by the U. S. National Museum. When the writer had occasion to inspect the specimens, he was impressed at once by the strong resem-

[3] Trans. Connecticut Acad. Arts & Sciences, **18**: 81. 1913.

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] Physis, **2**: 1–18, 101–122. 1915–16.

blance of many of the species to others of the same genera with which he is familiar in New Mexico. A comparison of the flora of this limited area with that of the Rio Grande Valley of New Mexico may be of some general interest. It is not certain that the flora of this particular region of the southwestern United States is the one with which that of the Río Negro might best be compared; but the writer, being more familiar with the vegetation of the Rio Grande Valley, is better able to use it as a basis of comparison, than some similar area in Arizona or southern California with whose flora, also, that of the Argentine region shows an equally close or possibly even closer alliance.

Río Negro is situated in southern Argentina, in about latitude 39°, upon the Río Negro, one of the larger streams of the region. The Mesilla Valley of New Mexico, with which it is proposed to compare its flora, lies along the Rio Grande in southern New Mexico, in latitude about 32° North. Judging from the data available from Mr. Fischer's notes, the two regions must bear a strong resemblance topographically: a wide river valley with large areas of heavy clay soil under irrigation, broken by stretches of sand dunes, the valley bordered by elevated sandy mesas or low hills. In the Argentine region part of the uplands appears to consist of clay soil, but in New Mexico all the mesa land is sandy, at least until the foothills of the mountains are reached. From the information at hand it is not possible to compare the composition of the corresponding zones of vegetation; consequently it seems more practicable to compare the related specific elements which constitute each flora as a whole.

It is remarkable to find that several species of plants are actually common to these two regions. These are as follows:

Agrostis verticillata Vill.
Andropogon saccharoides Swartz
Echinochloa zelayensis (H. B. K.) Schult.
Eragrostis cilianensis (All.) Link
Festuca octoflora Walt.
Paspalum distichum L.
Phragmites phragmites (L.) Karst.
Polypogon monspeliensis (L.) Desf.
Cyperus inflexus Muhl.
Eleocharis palustris (L.) R. Br.
Juncus mexicanus Willd.
Rumex persicarioides L.
Monolepis nuttalliana (Roem. & Schult.) Greene
Silene antirrhina L.
Halerpestes cymbalaria (Pursh) Greene
Daucus pusillus Michx.
Heliotropium curassavicum L.
Petunia parviflora Juss.
Solanum elaeagnifolium Cav.
Linaria canadensis (L.) Dum.

Most of these are species of wide distribution, some of them, like *Phragmites phragmites*, *Polypogon monspeliensis*, and *Eleocharis palustris*, extending to the Old World. *Polypogon monspeliensis* may even be adventive in the Western Hemisphere. Others of the list, like *Paspalum distichum*, *Juncus mexicanus*, *Heliotropium curassavicum*, and *Petunia parviflora*, have an extended range in the warmer parts of North and South America. Several of the other species, however, are not continuous in their ranges, being restricted to the temperate parts of the two American continents. Among them are *Festuca octoflora*, *Monolepis nuttalliana*, *Silene antirrhina*, *Halerpestes cymbalaria*, *Daucus pusillus*, *Solanum elaeagnifolium*, and *Linaria canadensis*. Some of these are plants which range widely in the United States, but the *Monolepis*, *Halerpestes*, *Daucus*, and *Solanum* are typically southwestern plants. *Solanum elaeagnifolium* is a characteristic plant of southern New Mexico and Arizona and of western Texas.

In addition to the species listed which are common to the two regions, certain others occurring in the Argentine area appear elsewhere in the southwestern United States. *Veronica anagallis-aquatica* L. occurs in New Mexico and Arizona, and *Lythrum hyssopifolium* L. and *Scirpus riparius* Presl in California. *Panicum urvilleanum* Kunth is known only from Arizona, California, Chile, and Argentina. *Malacothrix coulteri* Gray is common to southern California and Argentina. *Chenopodium ambrosioides* L., *Potamogeton filiformis* Pers., and *Hordeum pusillum* Nutt. are widely diffused in North America.

More interesting and suggestive is the following list of paired species. The species listed in the lefthand column are Argentine, while those in the righthand column are certain New Mexican ones which bear a close resemblance to them. A few of those cited from New Mexico do not actually occur in the Mesilla Valley but they are found at New Mexican points not far distant.

Argentine Species	New Mexican Analogues
Azolla filiculoides Lam.	*Azolla caroliniana* Willd.
Ephedra ochreata Miers	*Ephedra trifurca* Torr.

Setaria[3] *villiglumis* Hicken	*Chaetochloa composita* (H. B. K.) Scribn.
Salix chilensis Mol.	*Salix exigua* Nutt.
Parietaria debilis Forst.	*Parietaria obtusa* Rydb.
Atriplex ameghinoi Speg.	*Atriplex argentea* Nutt.
Chenopodium hircinum Schrad.	*Chenopodium incanum* (S. Wats.) Heller
Dondia divaricata (Moq.) Standley[4]	*Dondia intermedia* (S. Wats.) Heller
Clematis dioica campestris (St. Hil.) Kuntze	*Clematis ligusticifolia* Nutt.
Draba australis ameghinoi Speg.	*Draba cuneifolia* Nutt.
Radicula philippiana (Speg.) Standley[5]	*Radicula obtusa* (Nutt.) Greene
Hoffmanseggia falcaria Cav.	*Hoffmanseggia densiflora* Benth.[6]
Prosopis juliflora DC.	*Prosopis glandulosa* Torr.[7]
Strombocarpa strombulifera (Benth.) Gray	*Strombocarpa pubescens* (Benth.) Gray
Lupinus microcarpus Sims	*Lupinus pusillus* Pursh
Vicia graminea Sims	*Vicia exigua* Nutt.
Covillea cuneifolia (Cav.) Vail.	
Covillea divaricata (Cav.) Vail.	*Covillea glutinosa* (Engelm.) Rydb.
Covillea nitida (Cav.) Vail.	
Euphorbia ovalifolia argentosa Muell. Arg.	*Chamaesyce serpyllifolia* (Pers.) Small
Tithymalus portulacoides (L.) Standley[8]	*Tithymalus montanus* (Engelm.) Small
Condalia lineata Gray	*Condalia spathulata* Gray
Sida leprosa (Orb.) Schum.	*Sida hederacea* (Dougl.) Torr.
Sphaeralcea miniata (Cav.) Spach	*Sphaeralcea lobata* Wooton.
Nuttallia albescens (Gill. & Arn.) Standley[9]	*Nuttallia multiflora* (Nutt.) Greene
Menodora integrifolia (Cham. & Schlecht.) Steud.	*Menodora scabra* Gray
Androsace salasii Kurtz	*Androsace occidentalis* Pursh

[3] The names *Setaria* and *Chaetochloa* apply to the same genus.

[4] *Suaeda divaricata* Moq. Chenop. Enum. 123. 1840.

[5] *Nasturtium philippianum* Speg. Bol. Agr. Buenos Aires, **1**: 200. 1901.

[6] It is doubtful whether this is distinct from *H. falcaria*. It ranges from western Texas to southern Arizona and adjacent Mexico. *H. falcaria* is found in southern South America.

[7] The relationship of this to *P. juliflora*, and the range of the latter species are very uncertain. The Argentine plant may not be *P. juliflora*, but on the other hand, *P. glandulosa* may not be sufficiently distinct from *P. juliflora*. The same species, or else two closely related ones, occurs in Argentina and New Mexico.

[8] *Euphorbia portulacoides* L. Sp. Pl. 456. 1753.

[9] *Bartonia albescens* Gill. & Arn. Edinb. Phil. Journ. **2**: 273. 1831.

Cressa australis petiolata Meissn.	*Cressa truxillensis* H. B. K.
Gilia valdiviensis Griseb.	*Gilia inconspicua* (Smith) Dougl.
Lappula redowskii (Lehm.) Greene[10]	*Lappula occidentalis* (S. Wats.) Greene
Phyla nodiflora (Michx.) Greene[11]	*Phyla incisa* Small
Verbena gracilescens Cham. & Schlecht.	*Verbena neomexicana* (Gray) Small
Lycium floribundum Dunal *Lycium pubescens* Miers	*Lycium parviflorum* Gray
Lycium wilkesii Ball	*Lycium torreyi* Gray
Nicotiana monticola Dunal	*Nicotiana trigonophylla* Dunal
Plantago patagonica Jacq.	*Plantago purshii* Roem. & Schult.
Plantago rocae Lorentz	*Plantago major* L.
Ambrosia tenuifolia Spreng.	*Ambrosia artemisiaefolia* L.
Aster squamatus (Spreng.) Hieron.	*Aster exilis* Ell.
Baccharis juncea Desf.	*Baccharis wrightii* Gray
Baccharis salicifolia Pers.	*Baccharis glutinosa* Pers.
Flaveria bidentis (L.) Kuntze	*Flaveria campestris* Johnston
Gaillardia megapotamica scabiosoides Baker	*Gaillardia pinnatifida* Torr.
Gnaphalium cheiranthifolium Lam.[12]	*Gnaphalium chilense* Spreng.
Solidago microglossa DC.	*Solidago arizonica* (Gray) Woot. & Standl.
Tessaria absinthioides DC.	*Tessaria borealis* Torr. & Gray
Thelesperma scabiosoides Less.	*Thelesperma gracile* (Torr.) Gray

In some of the cases cited the resemblance is very striking, for example, in the instance of *Ephedra, Atriplex, Draba, Lupinus, Vicia, Sida, Nuttallia, Androsace, Solidago,* and *Thelesperma.* The two Sidas belong to a small group which, in the United States, is chiefly southwestern. Other instances of representatives of genera or groups of species which with us are typical of the arid southwest, are found in species of *Ephedra, Hoffmanseggia, Strombocarpa, Covillea, Condalia, Sphaeralcea, Menodora, Cressa, Gilia, Lycium, Baccharis, Flaveria, Tessaria,* and *Thelesperma.* It is interesting to note that in Argentina the cresote bush, *Covillea,* is represented by three species, while in the southwest

[10] The determination of this species is doubtfully correct. At any rate, the plant is very close to *L. occidentalis.*

[11] The plant so determined may not really be *P. nodiflora,* but it is very like *P. incisa.*

[12] The specimens so determined are different from the plant of western South America found in herbaria under this name.

we have but a single one. *Strombocarpa strombulifera* is in many respects similar to *S. pubescens,* the well-known screw-pod mesquite or *tornillo* of the Southwest, especially in its fruits, which are almost identical. But the Argentine plant can scarcely, like its New Mexican ally, be an important source of firewood, for it is only two or three decimeters high.

Besides the instances just mentioned, certain Argentine species of *Persicaria, Gutierrezia, Grindelia, Astragalus, Glycyrrhiza, Lepidium, Pappophorum, Monnina, Phacelia, Polygala, Ximenesia, Senecio, Distichlis, Stipa, Poa, Sophia,* and *Heliotropium* bear a general resemblance to New Mexican species of the same genera. There are also represented in the collection such genera as *Myriophyllum, Tissa, Allocarya, Amsinckia, Bowlesia, Pectocarya, Buddleia,* and *Hydrocotyle,* which are not represented in the Mesilla Valley, although they occur in regions not far distant. Most of these genera, also, consist in the United States of characteristically southwestern plants. It is significant to find about Río Negro a curious xerophytic shrub belonging to the Caper Family, *Atamisquea emarginata* Miers, a species found also in Lower California but unknown in the intervening countries. Several genera which occur in the Southwest are represented in Argentina by species very unlike the North American ones. Some of these are *Lippia, Elymus, Frankenia, Verbena, Menodora, Prosopis, Atriplex, Sida, Eupatorium, Eryngium,* and *Sporobolus.* The Verbenas are specially interesting; species of this genus are very numerous in southern South America, but many of them are strikingly different from our North American ones, all of which fall into two groups, each composed of similar plants. Some of those of Argentina are shrubs, often with curious leaf form, and some of them have yellow flowers.

Of course, there are represented in this Argentine locality genera of which no species are found in the southwestern United States. Among them are *Mulinum* and *Asteriscium* (Apiaceae), *Chuquiragua* and *Cyclolepis* (Mutisiaceae), *Adesmia* (Fabaceae), *Fabiana* and *Trechonaetes* (Solanaceae), *Facelis* and *Hysterionica* (Asteraceae), *Turrigera* and *Oxystelma* (Asclepiadaceae), *Schinus*

(Anacardiaceae), *Cristaria* (Malvaceae), *Hippeastrum* (Amaryllidaceae), *Margyricarpus* (Rosaceae), *Bougainvillea* (Allioniaceae), *Arjona* (Santalaceae), and *Hypochaeris* (Cichoriaceae). Most of these have no obvious analogues in the United States, although *Oxystelma* and *Turrigera* may correspond to our *Philibertella,* and *Adesmia* in a manner take the place of *Astragalus* or perhaps *Lotus.* The family Mutisiaceae reaches its greatest development in the arid regions of western and southern South America. In North America it is represented in Mexico and the southwestern United States chiefly by the genera *Trixis* and *Perezia.*

Many of our characteristic New Mexican genera, on the other hand, are not found in Argentina. Among them may be mentioned *Tridens, Sitanion, Yucca, Eriogonum, Abronia, Dithyraea, Koeberlinia, Fouquieria, Oreocarya, Hymenopappus, Townsendia,* and *Chrysothamnus.*

From all the analogies of the two floras that have been cited it is evident that the relationship between the vegetation of southern Argentina and that of New Mexico is strongly marked. The limited size of Mr. Fischer's collection affords, of course, an insufficient basis for an extensive comparison of the vegetation of these areas, but the data afforded by other collections only accentuate the closeness of the relationship. It is evident that students of the flora of the southwestern United States would do well to devote more attention to the flora of the corresponding regions of South America. No doubt many of our United States species find their closest allies in those regions, and it may well be that in some cases identical forms common to the two areas have been described independently by botanists who relied too much upon geographic isolation in establishing their species. Probably, however, such instances are few. The botanists of California long have been aware of the relationship of their xerophytic flora to that of Chile, and have profited by this knowledge. Unfortunately the plants of southern and western South America are too poorly represented in United States herbaria at present to furnish an adequate basis for comparative studies of the flora.

Before finishing his comparison of these floral areas, the writer feels it desirable to make some mention of the adventive and naturalized plants of the Río Negro Valley represented among Mr. Fischer's collections. Of the native Argentine species two are of interest to United States botanists because they have become more or less naturalized in this country. *Poinciana gilliesii* Hook., the bird-of-paradise bush, is one of the commonest cultivated plants of the arid southwestern United States and of Mexico, and is often found as an escape from cultivation. *Amaranthus crispus* (Lesp. & Thév.) A. Br. has been collected at Albany and New York City, New York, at Wilmington, North Carolina, and at Mobile, Alabama. It was described originally from plants adventive in France, and only in very recent years has it been ascertained that its native habitat is Argentina. A list of the more noteworthy plants adventive in Argentina, as shown by the present collection, is as follows:

Agrostis alba L.
Dactylis glomerata L.
Holcus halepensis L.
Hordeum murinum L.
Phleum pratense L.
Poa annua L.
Polygonum aviculare L.
Rumex crispus L.
Atriplex rosea L.
Atriplex semibaccata R. Br.
Salsola pestifer A. Nels.
Portulaca oleracea L.
Bursa bursa-pastoris (L.) Web.
Sisymbrium altissimum L.
Medicago lupulina L.
Medicago sativa L.
Melilotus alba Desr.
Melilotus indica (L.) All.
Trifolium repens L.
Trifolium pratense L.
Erodium cicutarium (L.) L'Hér.
Convolvulus arvensis L.
Marrubium vulgare L.
Plantago lanceolata L.
Cichorium intybus L.
Sonchus asper (L.) Hill
Sonchus oleraceus L.
Taraxacum taraxacum (L.) Karst.
Xanthium spinosum L.
Anthemis cotula L.
Senecio vulgaris L.

All of the above are Old World plants which occur in New Mexico, and many of them are common in the irrigated lands of the Mesilla Valley. In addition, the following species may be mentioned which have become established in the Río Negro Valley but are not known from New Mexico, although they have become established elsewhere in the United States, most of them in the Southwest:

Lolium italicum A. Br.	*Medicago orbicularis* All.
Notholcus lanatus (L.) Nash	*Conium maculatum* L.
Atriplex hortensis L.	*Daucus carota* L.
Amaranthus deflexus L.	*Veronica peregrina* L.[13]
Brassica napus L.	*Dipsacus fullonum* L.
Brassica nigra L.	*Lactuca scariola* L.[14]
Cerastium vulgatum L.	*Centaurea melitensis* L.
Medicago denticulata Willd.	*Cirsium lanceolatum* (L.) Scop.

Several of these European plants, notably *Dipsacus fullonum*, *Centaurea melitensis*, *Hordeum murinum*, *Medicago sativa* and *M. denticulata*, *Melilotus indica*, *Marrubium vulgare*, *Erodium cicutarium*, and *Sonchus asper*, are either confined in the United States to the Southwest or else are particularly abundant there, and are known to have occurred in that region at an early date. It is probable that they reached the United States through the same agency by which they were transported to Argentina—the early Spanish settlers.

While some of the European plants cited have become widely scattered with the development of international commerce, many thrive only in temperate regions, and several of them, like the *Salsola*, *Erodium*, *Hordeum*, and *Centaurea*, seem to thrive best in arid or subarid regions. These adventive plants, combined with the more than slightly familiar aspect of the native flora, would make a botanist accustomed to our Southwestern vegetation feel very much at home when he first made the acquaintance of the Río Negro Valley of Argentina.

[13] In New Mexico we have *V. xalapensis* H.B.K. as a native species. While all botanists may not consider it specifically distinct from *V. peregrina*, it certainly is distinguished readily from the naturalized European plant.

[14] In New Mexico only *L. integrata* (Gren. & Godr.) A. Nels. is known. It is often considered a subspecies of *L. scariola*.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 304th meeting assembled in the lecture room of the Cosmos Club on February 9, 1916, and immediately adjourned out of respect to the memory of Dr. C. Willard Hayes, past President.

The 305th meeting was held in the lecture room of the Cosmos Club on February 23, 1916.

REGULAR PROGRAM

Charles Butts: *Faults of unusual character in central Pennsylvania* (Illustrated). In the vicinity of Henrietta, in the southeast corner of the Hollidaysburg quadrangle, Pennsylvania, a wedge-shaped block 8 to 10 miles long and 2 miles wide at base is thrust up between younger rocks. The maximum throw is at the point of the wedge at the north end where the Waynesboro formation, of Middle Cambrian age, is in contact with dolomite of Beekmantown age. The relations resulting from the converging faults are abnormal for the Appalachian valley. The fault block is overthrust along the west fault and relatively downthrown along the east fault. The west fault is the major one and seems to extend northward for a long distance. It, or one in the same line of disturbance, is revealed in a cut of the Pennsylvania Railroad at Birmingham, Pennsylvania, where the fault plane dips eastward about 15°

Several possible explanations were given for the abnormal relations along the fault on the west side of the wedge: First, that it is a normal fault downthrown on the east; second, that it was formed long subsequent to the west fault and after deep erosion, the movement being along the bedding plane of the base of the Beekmantown limestone; and third, that it took place along a second original fissure east of that along which the main overthrust occurred, at a time when the arch was completely overturned in such a way as to bring the second fissure into line with the direction of the maximum pressure of the overthrusting force.

Laurence LaForge: *Résumé of the geology of southeastern New England in the light of field work since 1908* (Illustrated). No abstract.

Alfred H. Brooks: *The physiographic provinces of Alaska* (Illustrated).

Five principal physiographic provinces, each divisible into subprovinces, are recognizable in Alaska. These are (1) Pacific Mountain system, (2) Central Plateau region, (3) Rocky Mountain system, (4) Arctic Mountain system, and (5) Arctic Slope region.

The Pacific Mountain system is made up of a number of parallel ranges forming a rugged highland of crescentic outline sweeping around the Gulf of Alaska. Its central part is upwards of two hundred miles in width, but the system narrows to the southeast and to the southwest. It is continued to the southeast by the Coast Range of British Columbia and to the southwest by the rugged Aleutian Islands. Several subprovinces of lesser relief are included within the Pacific Mountain system. In most places the inland slope of this system falls off abruptly to the Central Plateau region, though the line of demarcation between the two provinces is not everywhere well defined.

The Central Plateau region is characterized by flat-topped interstream areas separated by broad valleys and lowlands and broken by minor ranges and peaks that rise above the general level. The plateau feature is best developed in the upper Yukon basin, for it loses its definition on approaching Bering Sea. Here the characteristic topography consists of low rounded highlands rising island-like from broad lowlands.

The Rocky Mountain system maintains its northwesterly trend through western Canada to within about 400 miles of the Arctic Ocean and then bends to the west and enters Alaska as a single range (Ogilvie Mountains). Crossing the boundary just south of the 66th parallel it loses its definition and soon merges with the flat summits of the Central Plateau region. The Crazy and White Mountains of the Yukon-Tanana region that stand above the plateau level lie in the continuation of the Rocky Mountain axis.

A new name, Arctic Mountain system, is proposed for the east and west trending mountain system of northern Alaska formerly regarded as part of the Rocky Mountain system. Recent investigations by Canadian and American geologists have shown that this is a distinct system from the Rocky Mountains, although they are connected by the flat-topped Richardson Mountains forming the Mackenzie-Porcupine divide. The Arctic Mountain system stretches westward from the International Boundary to the Arctic Ocean north of Kotzebue Sound. It is not everywhere sharply differentiated from the plateau region to the south, for in many places the dissected plateau remnants merge with the foothills of the ranges. In its western part the northern limit of the lowland of the Kobuk Valley affords a definite line of demarcation. On the north the mountains, so far as known, everywhere fall off abruptly to the Arctic Slope. This scarp affords a definite boundary line between the two provinces. The system is made up throughout its extent of two or more parallel ranges and includes some broad lowlands. These lowlands are specially striking topographic features in the western half of the chain. The Arctic Mountain system is continued east of the boundary by some mountains of lesser altitude. These end in a scarp at the Mackenzie delta, east of which they have not been recognized.

The Arctic Slope region has two subdivisions, the Anaktuvuk Plateau and the Coastal Plain. The first forms a piedmont plateau sloping northward from the base of the range. Along the Colville River it has a width of about 50 miles, but it narrows to the east. At the boundary it appears to be entirely absent, for here only a narrow coastal plain intervenes between the mountains and the sea. The westward extension of Anaktuvuk Plateau is unexplored. On the north the plateau is bounded by a scarp which separates it from the Coastal Plain. This plain varies from a width of less than 10 miles at the bounary to over 150 south of Point Barrow.

All of the features described, except those of the Arctic Slope region, form a part of the North American cordillera. Tectonically, however, the Arctic Mountain system is a discordant element in this cordillera. Its structures parallel the Arctic Ocean, and its folding was probably caused by movements from the Polar Sea. Tectonically and possibly physiographically it is to be correlated with the Werojanski Range and its northeastward extension of Siberia.

The 306th meeting was held in the lecture room of the Cosmos Club on March 8, 1916.

REGULAR PROGRAM

C. F. Bowen: *Review of the stratigraphy and structure of the Hanna Basin, Wyoming.*

In the early Territorial surveys under King, Hayden, and Powell the 20,000 feet of coal-bearing rocks overlying the uppermost marine sediments of the Hanna Basin—the Lewis shale—were grouped in a single formation, for which the name Laramie was adopted.

In 1907, A. C. Veatch (U. S. Geol. Survey Bull. 316, p. 246. 1907.) subdivided this group into two formations which he designated as "Upper and Lower Laramie." Correlating a conglomerate at the base of the "Upper Laramie" on the west side of the basin with a conglomerate that marked a pronounced unconformity on the east side of the basin, he announced that the "Upper and Lower Laramie" were separated by an unconformity that involved the removal of 20,000 feet of strata. Veatch's upper division became the type of the "Upper Laramie" formation, and the flora which it yielded was adopted as a standard for comparison in other fields.

Recent detailed work over three quadrangles in the Hanna Basin has demonstrated that the unconformity which Veatch assigned to the base of the "Upper Laramie" is really near the middle of that formation or 6,500 feet above the position to which he assigned it. The "Upper Laramie" of Veatch is thus divisible into two formations separated by a marked unconformity which permits the upper part of that formation to transgress across all of the older formations exposed.

There are no structural evidences of the supposed unconformity between the "Upper and Lower Laramie" as defined by Veatch. No angular or erosional discordance or apparent evidence of overlap between the two formations was noted. Furthermore both seem to have been equally affected by diastrophic disturbances. The only apparent evidence in support of an unconformity at this horizon is the presence of a conglomeratic zone, the base of which has been taken as the boundary between the two formations. Recent petrographic studies seem, however, to indicate that this conglomerate was not derived from the surrounding mountains but was obtained from a more remote source—apparently that which furnished the sediments of the "Lower Laramie." The conglomerate seems to have been deposited before the orogenic disturbances which gave rise to the present mountain ranges surrounding the Hanna Basin and without any great physical break between it and the underlying formation.

These observations seem to indicate that the great post-Cretaceous orogenic disturbance and resultant unconformity occurred about the middle of the so-called "Upper Laramie" epoch rather than preceding it; that is, it is pre-Wasatch instead of pre-Fort Union.

Carroll H. Wegemann: *The discovery of Wasatch fossils in so-called Fort Union beds of Powder River Basin, Wyoming, and its bearing on the stratigraphy of the region.*

The rocks overlying the Fox Hills in the region southeast of the Bighorn Mountains of Wyoming have been divided by most writers into two formations,—the Lance or Triceratops beds below and the Fort Union above. The Fort Union is separable, on lithologic grounds, into two divisions; the lower carries abundant fossil leaves and consists of shale and fine-grained bluish-white sandstone, together with numerous thin beds of highly ferruginous sandstone; the upper is composed of gray shale and rather coarse-grained yellow and buff sandstone (the color of the whole formation being predominantly yellow), ferruginous beds are lacking, and fossil leaves are not abundant. During the past season specimens were obtained, by R. W. Howell and the writer, of teeth of *Coryphodon molestus* from beds near the top of the upper disvision of the Fort Union as exposed in the Pumpkin Buttes, and from beds near the middle of the formation. *Coryphodon molestus* is known only from the Wasatch, and the finding of its remains in the upper division of the Fort Union appears sufficient evidence for the correlation of that division with the true Wasatch. Former collections, near the base of the upper division of the so-called Fort Union, of small mammal teeth resembling species collected from the Torrejon of New Mexico and the Silberling Quarry of Montana are not considered by Dr. J. W. Gidley as necessarily establishing the correlation of the beds in which they were found with the Fort Union, since recent discoveries in the Clark Fork and Sand Coulee beds of Wyoming and in the Ignacio beds of Colorado have proved that these primitive mammals are not confined to the Fort Union but are present also in the Wasatch beds.

The fresh-water formations above the marine Fox Hills appear, therefore, to belong to three formations: The Lance at the base, bearing Triceratops; the Fort Union in the middle, bearing abundant leaves; and the Wasatch at the top, containing remains of Coryphodon. The Kingsbury conglomerate in the vicinity of Buffalo is probably basal Wasatch, and the great erosional unconformity on which it rests represents the one which is present at many localities between the Fort Union and Wasatch formations.

C. J. HARES: *Stratigraphic relations of some of the Cretaceous and Tertiary formations of the Hanna and Powder River basins with those of the Wind River Basin.*

Mountains did not exist or were very small between Hanna, Wind River, Big Horn, and Powder River basins until the lower group of the Upper Laramie of Hanna Basin, the Great Pine Ridge beds of Powder River Basin, and the beds mapped as Fort Union in Wind River Basin were deposited. Only in the Bighorn Basin has an unconformity been demonstrated below a formation correlated with these beds. The position of the so-called Fort Union beds, only 250 feet above the Lewis Shale at Alkali Butte, is now believed to be due to extraordinary thinning of the Lance formation. These widely separated so-called Fort Union beds contain the same cherty conglomerate, but contain, so far as satisfactorily shown, no pebbles of Upper Cretaceous age, except possibly west of Rawlins and at Alkali Butte. Should the pebbles at these localities prove to be Mowry shale, then it is still necessary to prove that the containing beds are pre-Wind River in age. These formations contain no dinosaur bones, but many Fort Union leaves. Succeeding their deposition orogenic movements were pronounced between the present intermontane basins; in the Granite Mountains relative uplift amounting to nearly 20,000 feet took place, but in the middle of the basins the algebraic sum of the movements was nearly zero.

Succeeding these greatly deformed so-called Fort Union beds occurs the only profound, angular, and overlapping unconformity in the Cretaceous-Eocene series of Wyoming. This occurs at the base of the Wind River formation and is believed to be obvious at all places except in the middle of the basins of deposition. The Wind River formation rests on upturned Cambrian to Fort Union strata, and the relief of this old surface even in short distances is certainly 1000 feet and may have amounted to 5000 feet. The Wind River formation contains fragments of all underlying formations including Madison limestone pebbles with Niobrara fossils and ferruginous material containing Fort Union leaves, all derived from the adjacent mountains. Strata below the unconformity contain no recognizable local material. Thin sections of Mesaverde, Lower Laramie, lower group of the Upper Laramie, Lance, and so-called Fort Union show no marked differences. The Wind River formation contains much arkosic material and granite bowlders up to 5 by 10 by 20 feet, which are now found 8 miles or more from the nearest granite outcrop. They were probably transported by sapping and water. The type Wind River is like the "Wasatch" at Whiskey Peak, which can be traced southward to the U. P. Railway, and is of the same age as the beds above the angular unconformity in the Hanna Basin. It is like the Wasatch of Bighorn Basin and the Coryphodon bearing beds of Powder River Basin, which include the Kingsbury conglomerate resting on upturned formations including Madison limestone and the Great Pine Ridge beds. The unconformity below the Kingsbury is of more than local importance and corresponds to the pronounced angular unconformity in the other basins. The formations above this unconformity in each basin except the Hanna Basin contain a Coryphodon fauna that varies somewhat from basin to basin, more because of incompleteness of collections than of difference in age.

Two alternatives appear to be possible; first, the terms Fort Union, Wind River, and Wasatch may apply to the same group of strata or, second, the type Fort Union of North Dakota may include at the top beds of Wind River age and should therefore be separable into Fort Union below and Wind River above. The first alternative appears the more probable.

The Wind River is unconformably overlain by the White River formation, which is highly arkosic, volcanic, clayey, and conglomeratic, and contains pebbles of lava and andesitic porphyry, the latter derived from the intrusives in the Rattlesnake Mountains. The porphyry pebbles are not found in the Wind River, and hence are post-Wind River and pre-White River in age. The North Park formation of Hanna Basin and possibly the Browns Park formation of Colorado, which are of like composition and position, are of the same age.

Carroll H. Wegemann, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 552d regular meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, March 11, 1916, at 8:00 p.m.; called to order by President Hay, with 28 persons present.

On recommendation of the Council the following persons were elected to active membership: Dr. Molyneux L. Turner, R. T. Jackson, H. L. Viereck.

Under the heading Brief Notes and Exhibition of Specimens, Dr. Shufeldt exhibited lantern slide views of some of the aquatic and terrestial vertebrates of the District of Columbia and vicinity.

Under the same heading Mr. Wm. Palmer made remarks on, and exhibited, the bones of a hitherto unknown cetacean lately collected by him at Chesapeake Beach, Maryland.

The first paper of the regular program was by M. W. Lyon, Jr.: *Hemolysis and complement fixation.* Dr. Lyon outlined the steps in the discovery of hemolysis by normal and immune serums from the early observation following transfusion by Landois in 1875, through Pfeiffer's phenomenon of bacteriolysis in 1899, Bordet's discovery of of complement in 1899, and Bordet and Gengou's discovery of complement fixation in 1901 to the practical application of the latter phenomenon as utilized by Wassermann in 1905 and by later workers in the diagnosis of syphilis, glanders, Malta fever, dourine, tuberculosis, infectious abortion, etc. The graphic conceptions of amboceptor, complement, antigen, and fixation as understood by Ehrlich, and as understood by Bordet, were illustrated by movable models. The action of hemolytic amboceptors and complement on blood cells of the ox and of the sheep was demonstrated by test tube mixtures, and some positive and negative results in complement fixation were exhibited.

The last paper of the regular program was by D. L. Van Dine: *A study of malarial mosquitoes in their relation to agriculture.* Mr. Van Dine said that the Bureau of Entomology is making a study of the relation of malaria to agriculture and of the malaria-bearing mosquitoes, on a plantation in the lower Mississippi valley where typical conditions as regards malaria and plantation operations occur. The object is to devise measures for prevention of malaria which will apply practically to farming conditions. Lines of work include determination of the manner in which malaria operates in reducing farm profits, of the relative efficiency of *Anopheles* to act as transmitting agent and their distribution, of behavior of each species under known conditions of environment, and consideration of preventative measures which involve control of mosquito hosts. Solution centers around prevention of malaria among tenants, since it has been shown that the direct loss to planters occurs through lost time and reduced efficiency in labor. Detailed study was made of tenants, their relation to the plantation, their habits, and the prevalence of malaria among them, the conclusion being that it will be more practical to control the mosquito than the human host.

One measure of prevention consists in the favorable location of tenants' houses, requiring information on habits of flight, food, and breeding of the mosquitoes. Where drainage is impracticable, surface water must be rendered unsuitable for *Anopheles* development. Food requirements and natural checks to larval development are being studied, the Bureau of Fisheries coöperating in the study of the relation of fish to mosquito development.

Anopheles quadrimaculatus, A. punctipennis, and *A. crucians* were the species studied. *A. quadrimaculatus* is the common house-frequenting species of that region, *A. crucians* occurs in very limited numbers, and *A. punctipennis* is more restricted in its house habits but is common in nature. The work thus far has dealt almost entirely with *A. quadrimaculatus,* but following the demonstration of tertian and estivo-autumnal malaria in *A. punctipennis* by King in coöperation with Bass it will be expanded to include this species. The study includes the habits of mosquitoes under low temperature conditions; also the resistance of malaria organisms to low temperatures in the body of the mosquito host.

Mr. Van Dine's paper was illustrated with lantern slide views of the various conditions on the plantation. Messrs. WILLIAM PALMER, DOOLITTLE, and KNAB took part in the discussion.

The 553d regular meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, March 25, 1916, at 8 p.m.; called to order by President W. P. HAY, with 40 persons present.

The President called attention to the recent death of Henry Talbott, a member of the Society.

Under the heading Brief Notes and Exhibition of Specimens, General WHEELER showed lantern slide views of the country along the Mexican border of the United States. Mr. A. A. DOOLITTLE exhibited a specimen of *Amblystoma puncta um* from the District of Columbia. Dr. O. P. HAY exhibited the mutilated braincase of an elk which had caused much difficulty in identification; he showed also a remarkably well preserved skull of an extinct horse. President HAY exhibited a number of lantern slides of biological interest, chiefly of aquatic animals in the vicinity of Beaufort, North Carolina. Medical Inspector AMES asked if any member present had positive knowledge as to the ability of camels to swim; this question was discussed by several members. He also inquired as to the possible existence of a South American animal with dorsally placed mammae.

The regular program was as follows:

W. P. HAY: *Notes on the growth of the loggerhead turtle* (Illustrated by lantern slides and chart). Mr. Hay gave an account of two young loggerhead turtles now under observation at the U. S. Fisheries Biological Station at Beaufort, North Carolina. They are the survivors of a lot of 77 hatched September 9 to 11, 1912, from eggs obtained from a nest on Bogue Bank about six weeks earlier. When first hatched the average size and weight of the young were: Total length 77.3 mm.; length of carapace, 46.2 mm.; weight, 20.1 gram. At the age of three years the survivors measure 493 and 515 mm. in total length and 343.75 and 365 mm. in length of carapace, and weigh 6690 and 7967 grams, respectively. The increase in size and weight has been steady and the measurements, which have been taken twice a year, can be plotted as points on a curve. This curve continued indicates that the maximum size of this species, about 1000 mm. in length of carapace, may possibly be obtained in the tenth or eleventh year and that sexual maturity is probably reached in the sixth or seventh year. This is considerably more rapid growth than has usually been attributed to animals of this kind.

The paper was discussed by Dr. R. W. SHUFELDT, Dr. O. P. HAY, Medical Inspector AMES, and Mr. DOOLITTLE.

R. W. SHUFELDT: *The restoration of the dinosaur, Podokesaurus holyokensis.* Dr. Shufeldt gave an historical account of a discussion upon the restoration of the dinosaur *Podokesaurus holyokensis* of Talbot, which took place in the autumn of 1915. This discussion was carried on in correspondence and participated in by Dr. Richard S. Lull, Dr. Mignon Talbot, Dr. Gerhard Heilmann, and the speaker. Lantern slide illustration and blackboard demonstration were employed to point out what were held to be inconsistencies in the restoration of this animal, as figured in Dr. Lull's *Triassic Life of the Connecticut Valley* (fig. 31). Lull and Talbot contend that the pubic element in the matrix of *Podokesaurus holyokensis* occupies the position in relation to the other bones of the skeleton that obtained in life. Shufeldt and Heilman controvert this decision by pointing out that all the bones in the slab containing the remains of this dinosaur are far removed from their normal articulations and that if the pubic element were articulated as Lull has figured it, it would have come, in life, forcibly in contact, anteriorly, with the sternal ribs and been a constant menace to the abdominal viscera in various movements of the animal.

R. E. Coker: *A biological and fish cultural experiment station* (Illustrated by lantern slides). Mr. Coker said that since biologists, at least, are generally familiar with the functions of the Fairport Biological Station in the propagation and study of the fresh-water mussels, particular attention would be given to the purposes of that station in experimental work relating to the rearing of fishes. As in horticulture the problems of the nurseryman and those of the fruit grower are distinct, so in fish-culture and in fish-culture experimental work there is the phase of the hatchery, with its product of fry and fingerling, and that of the fish farm where it is intended to rear fish to adult size in commerical quantities. The Fairport station is concerned with problems of rearing rather than of hatching. The grower of fish has problems similar to those of the stock farmer or the poultry raiser, while in addition he must take thought of conditions affecting the respiration of fish. He cannot always regulate the numbers of fishes in his ponds by direct means, but may have to accomplish this end by proper association of species. It may even be necessary to group together species which are to an extent "incompatible." The problem of the fish pond has its mechanical, physical, chemical, and zoological aspects; more especially, however, it is a problem of appropriate vegetation, promotion of food supply, and proper association of species of fish.

Following the adjournment of the Society several members examined a microscopic preparation of a living embryo of *Filaria bancrofti* obtained by Dr. M. W. Lyon from a former inhabitant of British Guiana, for several years resident in the District of Columbia.

M. W. Lyon, Jr., *Recording Secretary.*

THE CELEBRATION OF THE ONE HUNDREDTH ANNIVERSARY OF THE ORGANIZATION OF THE U. S. COAST AND GEODETIC SURVEY

In 1816 the U. S. Coast Survey was organized under Mr. Ferdinand Rudolph Hassler as Superintendent and field work was begun. This event was fittingly celebrated in Washington on the 5th and 6th of April last by meetings to which the public was invited in the auditorium of the New National Museum. At these meetings papers were presented by representative men in the fields of Science, Engineering, Commerce, the Federal Government, and Military Affairs. The celebration closed with a banquet at the New Willard hotel on the evening of the sixth, at which the President of the United States was the principal speaker. The present Superintendent of the Coast and Geodetic Survey, Mr. E. Lester Jones, presided at the banquet and at the three public sessions at the Museum. Abstracts of the addresses delivered at the Museum and at the banquet are given below.

AFTERNOON OF APRIL 5TH

Dr. Hugh M. Smith, Commissioner of Fisheries: *The Bureau of Fisheries and its relation to the United States Coast and Geodetic Survey.* Dr. Smith said that early in the history of the Bureau of Fisheries there began close coöperative relations with the Coast and Geodetic Survey. The former has always depended upon the latter for its basic triangulation whenever a biological survey of any kind has been undertaken in a region in which the Coast and Geodetic Survey has operated, which of course means anywhere on the coast of the United States. On the other hand, the hydrographic and topographic results of this biological work have always been made available to the Survey. On both the Atlantic and the Pacific coasts a considerable part of the offshore soundings found on the charts was made by the steamers *Fish Hawk* and *Albatross* in pursuance of their fishery investigations, and some of the inshore data of certain of the earlier charts came from reconnaissances by the *Albatross.* While much of the latter has been superseded by more accurate work, as the Coast Survey was able to extend its operations, it served a good purpose for some years.

Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington: *The work done by the United States Coast and Geodetic Survey in the field of terrestrial magnetism.* From the earliest days of the Coast Survey magnetic observations have been considered a legitimate and useful part of its work, but it was not until 1899 that an increased appropriation made it possible to undertake a systematic magnetic survey of the United States. The first chart issued by the Survey (in 1855) showing the lines of equal magnetic declination was based on only about 150 values distributed very irregularly near the seacoast. At the close of 1915 the number of stations was about 5000, distributed over the whole country with a fair degree of uniformity, and observations had been made at about 500 stations in our outlying possessions. Meridian lines for the use of surveyors had been established at many county seats, magnetic data at sea had been obtained by vessels of the Survey, and magnetic observatories (5 since 1903) had been maintained for recording continuously the countless fluctuations of the earth's magnetism. An extensive compilation of the available data relating to the change of the compass direction with lapse of time, combined with the systematic reoccupation of old magnetic stations, has made it possible for the Survey to furnish promptly information of great value in the settlement of disputed land boundaries, established by compass as much as 100 or 150 years ago. It may be said, without fear of contradiction, that the contributions of the Coast and Geodetic Survey to the advancement of our knowledge in terrestrial magnetism have not been excelled by those of any other national organization.

Dr. S. W. Stratton, Director of the United States Bureau of Standards: *The Bureau of Standards and its relation to the United States Coast and Geodetic Survey.* The speaker sketched the history of the various standards which have been used in this country and paid a high tribute to Mr. Hassler for creating the division of weights and measures of the Survey. This division became in 1904 the present Bureau of Standards, a separate organization. He spoke of the close coöperation which has always obtained between the Bureau of Standards and the Coast and Geodetic Survey.

Rear Admiral J. E. Pillsbury, United States Navy (Retired): *Ocean currents and deep sea explorations of the United States Coast and Geodetic Survey.* After mentioning the early voyagers who came in contact with and noticed the Gulf Stream, the speaker gave a brief description of the first American investigation, that of Benjamin Franklin. It was not until 1845, under the administration of A. D. Bache, that the Coast Survey began a systematic study of the Gulf Stream. From that year until 1853 many vessels were engaged in the work under the most comprehensive orders. In 1867 Prof. Henry Mitchell of the Coast Survey began an investigation of the Gulf Stream by a new method. He sounded between Key West and Havana and observed currents to 600 fathoms by means of cans floating or suspended from a floating can. In 1883 the first attempt was made to investigate the actual flow of the Gulf Stream by a vessel at anchor, when the Schooner *Drift,* under Lieutenant Fremont, anchored with wire rope and observed the currents between Jupiter Inlet, Florida, and Memory Rock, Bahama. The results were of so great value that the Superintendent decided to continue the work. The *Blake*, under Lieutenant Pillsbury, was the vessel chosen, and during the following five years she was engaged in Gulf Stream work each winter season and several summers. As to results, it was found that the velocity of the Gulf Stream varied daily, according to the moon's transit, and monthly, following its declination, and that these variations could be predicted with fair accuracy. A calculation as to its volume, deduced from many hundreds of observations in the narrowest part of the Straits of Florida, was 90,000,000,000 tons per hour.

Dr. George Otis Smith, Director of the United States Geological Survey: *The United States Geological Survey and its relation to the United States Coast and Geodetic Survey.* The Coast and Geodetic Survey and the Geological Survey have much in common. The field of endeavor for each is nation-wide; they are scientific in spirit and civil in organization; both are primarily field services; and the product of most of the work of each reaches the public in the form of maps. With full opportunity to overlap their fields of operation, to duplicate work, and thus to waste public money, there has been economical coördination rather than wasteful competition. In these days when, as American citizens, we have such deep concern in the question of public regulation of private business, it may be opportune for some of us as public officials to pause and consider the question of regulation of public business. In making the informal comparison of the actual and ideal in the administration of the scientific bureaus of the Government, the speaker had ever in mind the existence of a real basis for optimism in the splendid record of the Coast and Geodetic Survey and the Geological Survey in absolutely coördinating their endeavors in the public service.

EVENING OF APRIL 5TH

Hon. J. Hampton Moore, Member of the United States House of Representatives: *The United States Coast and Geodetic Survey's part in the development of commerce.* Mr. Moore spoke of the relation of the Coast and Geodetic Survey to Commerce and, after paying high tribute to the perseverance and loyalty of the men of the Service, said that commerce itself did not fully appreciate the importance of the work. He spoke in particular of the needs of extending the surveys along the Atlantic coast. Along the coasts of Florida there are 172,000 square miles of water area which should be charted accurately for the use of ships engaged in commerce and in national defense. He also called attention to the changes made by the waves and currents on the North Carolina, Virginia, and New Jersey coasts. He stated that inlets close and open according to the whims of nature and that it is an interesting historical fact that no living man is now able to locate the inlet through which passed the expedition of Sir Walter Raleigh which made the first English settlement on Roanoke Island in 1584. That the vessels of Amadis and Barlow entered Croatan Sound is well established, but the channel through which they came has long since disappeared.

Brigadier General W. M. Black, Chief of Engineers, United States Army: *The United States Corps of Engineers and its relation to the United States Coast and Geodetic Survey.* The speaker said that the association in work of the Corps of Engineers and the United States Coast and Geodetic Survey began with the organization of the Survey. In 1802 the Corps of Engineers was organized as a separate body, of which the U. S. Military Academy formed a part. The first Superintendent of the Coast and Geodetic Survey, Ferdinand R. Hassler, was appointed from the Corps of Instructors of the Academy, having served there as Acting Professor of Mathematics from 1807 until 1810. From 1843 through a period of many years officers of both the Army and Navy served by detail with the Coast Survey Bureau. When a harbor is to be improved the first recourse of the Army Engineer is to the charts of the Coast and Geodetic Survey. The triangulation points established by the Survey are used, when available, as a basis for the work of the Engineers. Free interchange of information is made between the two organizations, and the work of one supplements that of the other. In yet another way the work of the Coast and Geodetic Survey is useful to and is utilized by the Corps of Engineers, namely, in the preparation of projects for national defense; for this purpose the charts of the Survey are at once available. The work of the Survey and that of the U. S. Engineers touch at many points, but their respective spheres of duty are well defined and separate. The great work done by the Coast and Geodetic Survey in its hundred years of existence and the traditions of faithful labor well performed will always be an inspiration for further effort.

Hon. George R. Putnam, Commissioner of Lighthouses: *The Lighthouse Service and its relation to the United States Coast and Geodetic Survey.* The speaker said that all progressive countries recognize their obligations to survey, light, and mark their coasts, and that when a country builds a lighthouse or publishes a chart, it aids the whole family of nations. An accurate survey of the coast is a necessary preliminary to the location of aids to navigation; without an accurate chart an aid may be so stationed as to lead a vessel on to some hidden danger. The two bureaus under discussion have the important common object of protecting the mariner and keeping him out of danger. One gives him the chart showing where the course is safe; the other gives him aids to guide him over the course. The Coast and Geodetic Survey has made special surveys for choosing sites of lighthouses, and accurately determines their positions. The Lighthouse Service marks new dangers located by surveys, and moves aids as new surveys show the need. Much work is required in keeping charts corrected for changes in aids, and in this work there must be close coöperation. On a single chart, that of New York Harbor, there are shown 299 aids. As both nature and the works of man are ever changing the coast line, channels, and harbors, and as the needs of commerce are continually varying, both charts and beacons must ever be corrected and modified; therefore, the coöperation in these two important works must always be continued.

Mr. George Washington Littlehales, Hydrographic Engineer, United States Hydrographic Office: *Hydrography and charts with special reference to the work of the United States Coast and Geodetic Survey.* The speaker pointed out that a century ago the United States instituted a survey of its coasts and authorized as an aid large drafts from the Army in earlier years and yet larger ones from the Navy as long as they could be spared from the battle fleet. It is the province of marine hydrography to chart the features of the submerged border to the land, thereby indicating the hidden dangers to be avoided and the safe channels, for the guidance of shipping to and from our ports, not only at home but also in the distant countries under our jurisdiction. It must be with no small degree of pride that men should feel that their calling has made the coast of the United States its best known geographical feature, a calling so enriched with the heroisms of the sea and so unexcelled for the aggregate of its influence in promoting the security of shipping and in safeguarding the lives of seamen.

AFTERNOON OF APRIL 6TH

Prof. William Henry Burger, College of Engineering, Northwestern University: *The contribution of the United States Coast and and Geodetic Survey to geodesy.* Previous to 1843 the geodetic function was little in evidence in the work of the Coast Survey; but upon the reorganization in that year, the broad and far-reaching plans advocated by Superintendent Hassler were adopted and the corner stone was laid for that fine system of geodetic operations which the Survey has at present. A further impetus was given when the geodetic connection between the Atlantic and Pacific coasts of the United States was authorized, the result of which was the great arc of triangulation along the 39th parallel. Another arc of note is the Eastern Oblique Arc from the Bay of Fundy to New Orleans, which binds together the surveys of the harbors on the Atlantic coast. Many other arcs have been measured by the Survey, until now the length of the combined arcs is more than three-sevenths of the circuit of the globe. The precise leveling work by the Survey stands without a rival in the world, as judged by the very magnitude of its operations, by the instruments employed, and in the speed and cost. The formation of the great telegraphic longitude net of the Coast and Geodetic Survey is a geodetic feat worthy of special notice. The problem of determining the shape and size of the earth may be said to be the climax in geodetic work, from a scientific point of view, and in this the Coast and Geodetic Survey has contributed much to the field of geodesy.

Rear Admiral Richard Wainwright, United States Navy (Retired): *The Civil War record of the United States Coast and Geodetic Survey and what the Survey is doing towards preparedness.* Mentioning his acquaintance with the Coast and Geodetic Survey for over 60 years as warrant for attempting to give the record of the field force of the

Survey during the Civil War, the speaker referred to the officers of the Survey as early volunteers of their services to the country and to their assistance, which was eagerly sought by generals in the field and admirals afloat. They gave valuable military service during the Civil War, and afterward returned to their regular duties without any of the rewards of rank or pay or pension for themselves or families so freely distributed at this time for military services. In a future war the field force of the Coast and Geodetic Survey will be needed as it was during the Civil War. The Army and Navy are both very short of officers and there is little likelihood of its being otherwise for many years. A trained topographer will always be of value on the staff of a general. In modern war with long-range guns the general must visualize his work by close reference to the map, and a topographer from the Coast Survey would find little training necessary to keep the new features and movements of the troops plotted ready for the commanding general. In the Navy a skilled hydrographer would prove a most valuable addition to the staff of an admiral. His power of quickly locating his position on a chart would be of assistance in bombardment, blockading, mining, and countermining. On the practical side, the work of the Survey has been done well and with economy. The Coast and Geodetic Survey charts stand at the head of all others for accuracy of execution and in general usefulness.

Dr. Otto Hilgard Tittmann, President of the National Geographic Society. *The international work of the United States Coast and Geodetic Survey.* Speaking of the international work of the Coast and Geodetic Survey done in direct coöperation with other countries, Mr. Tittmann said that it may justly give satisfaction to the members of the Survey that the results of its work are nearly all international in their scope. The hydrographic and tidal surveys are obviously for the benefit of all mankind, because they safeguard the commercial intercourse of nations. Its geodetic work contributes to the knowledge of the Earth's dimensions and constitution. The world's knowledge of terrestrial magnetism would be incomplete without the record of the observation of magnetic phenomena as they occur in the vast territory inhabited by us, and so with those relating to tides. Thus, in the prosecution of its tasks the Survey adds to our knowledge of the planet which we inhabit and thereby furthers the ultimate aim of all civilization, the intellectual development of mankind.

After reviewing briefly the delimitation by the Survey of the Alaska boundary, extending over a length of about 1800 miles, Dr. Tittmann described the part taken by the Survey in the delimitation and remonumenting of our Canadian and Mexican boundaries, an undertaking which he considered the most striking of the Survey's international accomplishments. He then spoke of the relation of the Survey to the International Geodetic Association and described the Survey's share in the scientific work leading to the establishment of the International Bureau of Weights and Measures.

Dr. Charles Lane Poor, Professor of Celestial Mechanics, Columbia University: *Oceanic tides, with special reference to the work of the United States Coast and Geodetic Survey.* The mathematical theory of the tides first assumes a solid Earth surrounded by a shallow, frictionless ocean, in which the moon would cause waves to travel around the earth from east to west. While this is apparently a simple problem, conditions which actually exist, with the ocean varying in depth and broken up by continents, present a most complex one. Yet scientists for years considered the tides as an ideally simple wave, modified and broken up by the continental barriers and the varying depths of the ocean. This world wave theory, based on a study of European tides, which are exceptionally simple, became the basis of all tidal work and theories. Later the tides of the Pacific were studied; and although they differed greatly from those of Europe, the discrepancy was explained away as a modification of the theory, due to some local condition.

The Coast and Geodetic Survey has for a century collected and discussed an enormous amount of tidal data in the Pacific and Atlantic Oceans. These data revealed so many departures of the observed tides from those predicated upon the world wave theory, that the accepted general tidal wave would have to be so radically modified, in order to represent the observed phenomena, as to lose all semblance to a single uniform progressive wave. Gradually a feeling was evolved that the tides were not a world phenomenon, but were strictly local in character; that the tides of the Atlantic were due to oscillations in the waters of the Atlantic, independent of what might be happening in the Pacific. This idea has been developed by the Coast and Geodetic Survey into a thoroughly consistent theory, and stands out as the great scientific contribution of the survey to the theories of oceanic tides.

Dr. Douglas Wilson Johnson, Associate Professor of Physiography, Columbia University: *The contribution of the United States Coast and Geodetic Survey to physical geography.* Every division of physical geography has been enriched by the contributions of the Coast and Geodetic Survey during the century of its existence. We are indebted to this Bureau for notable additions to our knowledge of the size and form of the Earth and associated phenomena as developed in its work in latitude, variation of latitude, longitude, azimuth, triangulation, gravity, and terrestrial magnetism. To the physical hydrography of the ocean it has supplied data for detailed study of material and relief of the bottom. Its studies of the Gulf Stream and other currents have produced notable results. The Survey's treatment of the subject of the tides and tidal currents has been exhaustive, culminating in a monumental expansion of the equilibrium theory of tides. Its charts record the changes in coastal topography and exemplify the laws which govern the action of wave and current. To the physical geography of the atmosphere this organization has contributed a study of the winds and related phenomena.

EVENING OF APRIL 6TH

Dr. Paul Ritter, Minister of Switzerland: *Hassler, the organizer of the United States Coast and Geodetic Survey.*

The Minister of Switzerland said that he owed his presence at the banquet to the circumstance that the first Superintendent of the Coast and Geodetic Survey was the Swiss engineer, Ferdinand R. Hassler. He sketched the life and career of Mr. Hassler in Switzerland, his native land, and also in the United States, to which country he migrated in order to satisfy his desire for wider fields of activity. In 1807 Hassler submitted a plan to Congress for the survey of the coasts, which was adopted. In 1816 he was appointed Superintendent of the Coast Survey, and in that year field work was begun.

Hon. Josephus Daniels, Secretary of the Navy: *The coöperation of the United States Coast and Geodetic Survey with the Navy.*

The Secretary of the Navy spoke of the coöperation between the Coast and Geodetic Survey and the Navy and called particular attention to the fact that for a number of years naval officers were detailed for duty in the Survey, where they had charge of the vessels engaged upon the hydrographic work. When the Spanish war began, the naval officers returned to the regular naval duties on the fleets. Since that time all of the work of the Survey has been done by civilians.

Hon. William C. Redfield, Secretary of Commerce: *The scope and needs of the United States Coast and Geodetic Survey.*

The address of the Secretary of Commerce was a tribute to the members of the Survey and a plea for support for the Survey by the public and by Congress, in order that it might be able to render still greater usefulness to the nation in the safeguarding of ships and lives on the oceans and in assisting in the development of the country.

Dr. T. C. Mendenhall, former Superintendent of the Coast and Geodetic Survey: *The superintendents of the United States Coast and Geodetic Survey.*

Dr. Mendenhall took as his theme the salient features of the careers of the various superintendents of the Survey, starting with Hassler. He sketched the development and progress of the Survey during its one hundred years of existence and expressed the hope that its work during the next century might compare in character with that of the first one.

The President of the United States: *The scientific spirit of the United States Coast and Geodetic Survey.*

During the course of his address, in referring to the Coast and Geodetic Survey, the President said:

"This is one of the few branches of the public service in which the motives of those who are engaged cannot be questioned. There is something very intensely appealing to the imagination in the intellectual ardor which men bestow upon scientific inquiry. No social advantage can be gained by it. No pecuniary advantage can be gained by it. In most cases no personal distinction can be gained by it. It is one of the few pursuits in life which gets all its momentum from pure intellectual ardor, from a love of finding out what the truth is, regardless of all human circumstances, as if the mind wished to put itself into intimate communication with the mind of the Almighty itself. There is something in scientific inquiry which is eminently spiritual in its nature. It is the spirit of man wishing to square himself accurately with his environment not only, but also wishing to get at the intimate interpretations of his relationship to his environment; and when you think of what the Geodetic Survey has been attempting to do—to make a sort of profile picture, a sort of profile sketch, of the life of a nation, so far as that life is physically sustained,—you can see that what we have been doing has been, so to say, to test and outline the whole underpinning of a great civilization; and just as the finding of all the outlines of the earth's surface that underlie the sea is a process of making the pathways for the great intercourse which has bound nations together, so the work that we do upon the continent itself is the work of interpreting and outlining the conditions which surround the life of a great nation."

E. Lester Jones,
Superintendent, U. S. Coast and Geodetic Survey.

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BIOCHEMISTRY.—*The biochemical analysis of nutrition.*[1]

Carl L. Alsberg, Bureau of Chemistry.

There are a number of ways in which nutrition may be studied. By the statistical method the effect of diet upon definite social or geographical groups of individuals or upon inmates of hospitals, asylums, or barracks is determined. The physical method determines the energy income and outgo of the individual. The physiological method determines the rôle in nutrition of individual organs. Nutrition may, furthermore, be studied by the method of biochemical analysis. This method seeks to follow each one of the many chemical complexes that enter into the composition of food in its course through the animal organism. Therefore, for the purposes of this method the component chemical radicals of the food must be known. This information can be obtained only by resolving the food elements into their component parts, that is, by analyzing them biochemically. This paper, therefore, presents a discussion of some of the component parts of the food elements and of the fate in the metabolism of some of the individual chemical complexes that are found free or combined in food, in so far as their fate is understood or surmised.

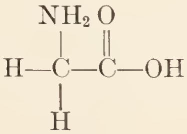
My reason for selecting this particular subject is that during recent years perhaps the most interesting contributions to knowledge made by biochemists have been in this field. Among

[1] The address of the retiring President of the Chemical Society of Washington, given at a joint meeting of that Society with the Washington Academy of Sciences, January 13, 1916.

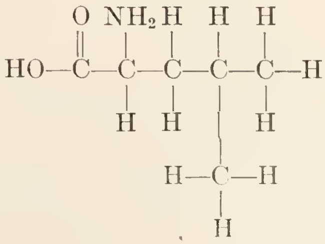
the most important contributions of recent years to the study of nutrition are investigations upon the rôle of the proteins and of the nitrogenous constituents of the food in the animal organism. You know, no doubt, that in Liebig's time proteins were regarded as that element of the food which supplied the material for growth, tissue maintenance, and repair, as well as for most of the energy. Though it was soon demonstrated that while proteins did and could furnish energy, under ordinary conditions this was supplied in the main by sugar and other carbohydrates and by catabolized fats. The proteins were, however, still regarded as all of about equal value, and their value was estimated as proportional to the amount of nitrogen they supplied to the animal organism. One protein was regarded as of about as much dietary value as another. This was, however, soon found to be an erroneous notion. It was learned that with certain proteins, gelatine for example, as the sole source of nitrogen in the diet, life could not be supported. The proteins then came to be divided into two classes, the true proteins and the albuminoids. Gelatine was classed as an albuminoid. The fact that it and some other proteins were found to be incapable of supporting life was regarded as corroborative evidence that they were not true proteins. Why they are incapable of supporting life was not known. It was known that animals could not live without proteins in the diet, but it was believed that relatively few of the proteins were incapable of supplying all the nitrogenous needs of the animal organism.

That is about where matters rested for a long time. Then in 1901 Loewi published a most startling investigation, so startling in fact that it received scant attention. He subjected the pancreatic gland, which all of you know as sweet-bread, to self-digestion, the process that is technically known as autolysis. As you know, practically all cells and tissues contain many enzymes or ferments, some of them similar to those secreted in the stomach and intestines for the purpose of digesting proteins. Therefore, under suitable conditions tissues can be made to digest themselves. Loewi caused the self-digestion of the pancreas to proceed until the digestion of the proteins in the gland was so complete that no trace of any reaction for protein could be obtained. This predigested material as the sole nitrogenous element of the diet was then fed to dogs and it was found that upon such a diet the animals maintained their weight. These results were remarkable because they tended to show that it was not absolutely necessary to life that protein be an element of the diet. For a time these findings were ignored, but it has since been shown that life can be supported for a time at least upon a diet containing no complexes known as protein, but instead a suitable mixture of amino-acids.

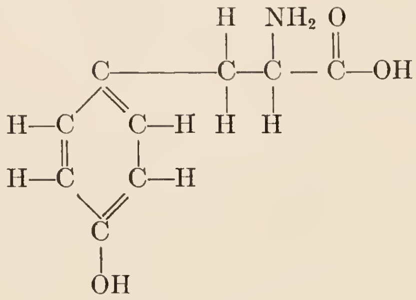
For the information of those of you who have not followed the chemistry of the proteins during recent years I may say that the proteins are combinations of the amino-acids, by which we mean ordinary organic acids in which one or two hydrogen atoms have been replaced by the amino group, NH_2. The simplest amino-acid found in protein is glycine which, as you see, is derived from acetic acid.



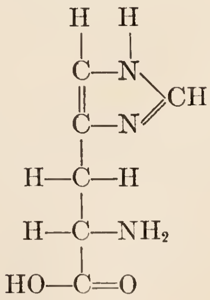
There are seventeen of these amino-acids commonly found in proteins. Several others have been reported more or less definitely. Perhaps the commonest one is leucine, which has six carbon atoms.



As you see, in all these substances the amino group is associated with the carbon atom adjacent to a carboxyl, COOH, group, the alpha position, as it is known technically. When two amino groups are present one is in the alpha position; the other is associated with the terminal carbon atom at the other end of the chain, the omega position. Lysine is such a diamino-acid, as you can observe from the formula $CH_2(NH_2)(CH_2)_3 . CH(NH_2)COOH$. In these acids the atoms are arranged in a chain. However, the protein molecule may contain amino-acids in which the arrangement is such that a ring is found. Tyrosine, a benzol derivative, is a good example.



Histidine is another ring compound:



Tryptophane, which is related to indigo, is still another. The proteins are combinations of a number of these amino-acids with one another. Most of the seventeen or eighteen amino-acids are found in each protein. In all probability each molecule of protein contains a number of molecules of a given amino-acid, so that the protein molecule may be very large. The union of the amino-acids with one another is, so far as now known, always of the same kind; the amino group of one acid is united with the carboyxl group of another. One of the simplest compounds of this type is glycylleucine:

$$\underset{\text{Glycyl}}{NH_2CH_2\text{—}CO} \;\vdots\; \underset{\text{Leucine}}{NH\cdot\underset{\textstyle C_4H_9}{\underset{|}{CH}}\cdot COOH}$$

These compounds are known as peptides and were first made artificially. They were later discovered among the decomposition products of proteins. A peptide with a molecular weight of more than one thousand, composed of eighteen molecules of amino-acids, has been made. Substances with still larger molecular weights could be made, were it worth while. Thus substances which are believed to have a structure similar to that of proteins, and which have a molecule approaching in size that of some proteins, have actually been made.

After this digression in explanation of the chemical structure of proteins let us return to the problem of the nutrition of animals with amino-acids. Loewi found that animals could be kept for a time without loss in weight upon a mixture of completely digested protein. It was not at that time known that such mixtures contained peptides, which, as I have explained, have certain resemblances to proteins. It was therefore a most important discovery when it was later determined that an animal could be maintained for a time upon an artificial mixture of the pure crystalline seventeen or eighteen amino-acids found in proteins free from peptides. If these observations are correct, it is theoretically possible to supply the so-called protein needs of animals by wholly artificial substances.

Certain investigators have very recently gone still further by endeavoring to show that some of the nitrogenous needs of the animal organism can be supplied by simple salts of ammonia such as are used in fertilizers. It has hitherto been believed that only plants are capable of utilizing ammonia. The matter has not been settled; but there is good reason to believe, as will appear later, that even if it be shown that animals can utilize ammonia, it is impossible to support animal life upon ammonia as the sole source of nitrogen.

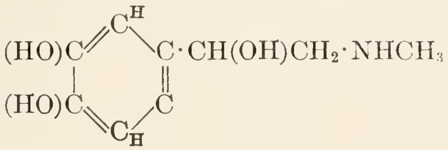
Whatever may be the ultimate practical significance of the observations that animals can supply themselves with most or all of their nitrogen needs by means of synthetic amino-acids, these experiments have led to investigations that have explained much that has been obscure in the physiology of nutrition. Formerly it was believed that proteins when ingested were digested by the enzymes of the intestinal tract and converted into simpler substances, in the main albumoses and peptones, which were absorbed. These albumoses and peptones, while simpler than most food proteins, are, nevertheless, still very complex substances. It was believed that they are absorbed and then converted by the animal into the protein characteristic of that particular animal. How that conversion was accomplished was not understood. Now every species of animal and plant has its own characteristic proteins. The proteins of even closely related species are different. The proteins of the food supply are quite different from those of the animal taking that food. Much work was done to explain how the proteins of the food were converted into the proteins of the body and where this conversion took place. At first it was believed to occur in the blood. Later a difference of opinion arose as to whether it took place in the tissues or in the intestinal wall. As food proteins could be demonstrated in neither place, the matter remained unsettled. We know today that neither hypothesis is tenable. Proteins are not ordinarily absorbed as such. They are completed dismembered within the intestinal canal into their component amino-acids and these are absorbed. As long as it was not known that an animal can be maintained upon pure synthetic amino-acids, no one had any reason to believe that proteins were completely digested before absorption.

Now what happens to these amino-acids after they are absorbed? As ordinary diets may contain more nitrogenous material than is needed by the organism, a part of the amino-acids is changed within the walls of the intestinal canal by the removal of the amino group to form ammonia. As this takes place in the presence of carbonic acid, ammonium carbonate and ammonium carbamate are formed. It has recently been found that there is an equilibrium between these two substances, so that where one is present in solution there is also found a definite amount of the other. It is an easy step from ammonium carbamate to urea. Thus the amino group split off from the amino-acid in the intestinal wall or elsewhere is ultimately converted into urea and excreted. There are probably other methods of the formation of urea, as, for example, by cleavage from arginine which contains a guanidine grouping closely related to urea. After the removal of the amino group from the amino-acids there is left a carbonaceous residue which may be burned to furnish energy, perhaps directly, perhaps after conversion into sugar. A portion of the amino-acids absorbed by the intestines is not, however, deprived of its nitrogen, but passes into the blood stream from which it is absorbed by each individual cell according to that cell's particular needs. The cell then reconstructs from these amino-acids its own characteristic protein. Thus it is possible to explain in a comparatively simple manner how, for example, wheat protein when fed to an animal is converted into the characteristic proteins of that animal. It is done by the cells of the tissues from amino-acids supplied to the cells by the blood, the blood receiving the amino-acids from the intestinal wall.

This theory concerning the fate of food proteins in the animal body is supported by certain very interesting feeding experiments. In these experiments animals, usually white rats, were fed upon definite mixtures containing only a few pure food substances. These mixtures consisted of sugar, fat, mineral salts, and a single pure protein. In each set of experiments a different pure protein was used in each series, all other factors remaining constant. It is in this way possible to determine the nutritive value of individual proteins. The results of this work indicate that many proteins are incapable either of supporting life or of producing growth. On the whole it may be said that many more vegetables than animal proteins are defective in this way. Now, when the composition of such defective proteins is compared with that of proteins that are not defective in this respect, it is found that the defective proteins lack one or more of the amino-acids which are found in the proteins that are not defective. This is very much oftener true for the vegetable proteins than for the animal proteins. Some lack lysine, others tryptophane or histidine, or cystine. The latter is an amino-acid containing sulphur, the usual form in which sulphur is contained in proteins. Some proteins lack more than one amino-acid. Gelatine, for example, contains no cystine, tyrosine, or tryptophane. Now it has been shown in certain cases that if to a diet of the kind just described, containing a single defective protein, there be added the amino-acids which that protein lacks, the value of the diet is greatly increased; in certain instances it may even become entirely capable of supporting life and growth. We have here a direct proof that the animal organism is capable of utilizing amino-acids and incapable of manufacturing for itself certain amino-acids. Herein it differs from the plant organism which is capable of making all the amino-acids necessary to support its life. The animal organism is, however, capable of making certain amino-acids. It can, for example, make glycine. It has not as yet been finally determined exactly which amino-acids can be made by animals and which can not.

There are a number of ways in which the lack of certain amino-acids may affect the functioning of the animal organism. Their lack may, of course, make it impossible for the animal to manufacture its own tissue protein. It suffers a kind of starvation. There are, however, more indirect ways in which the absence from the diet of a necessary amino-acid may be important. It has recently been found that the iodine compound of the thyroid gland, the gland that you feel in the neck about the Adam's apple, is a derivative of the amino-acid tryptophane. It has long been known that the normal functioning of the thyroid gland is essential to life and health. It has been found that the normally functioning gland contains the iodine compound now believed to be formed from tryptophane. It is therefore possible that when there is no tryptophane in the diet, difficulty in the formation of the iodine compound necessary for the thyroid gland results with corresponding disturbance of the gland's function.

The iodine compound of the thyroid gland is physiologically active; that is to say, it is poisonous. It is not, however, the only physiologically active substance produced from amino-acids in the animal metabolism. Adrenaline



is another such substance probably derived from an amino-acid. As you may see by comparing the formulae, it is related to the amino-acid tyrosine. It is formed in the adrenal glands, two small glands found in the kidney fat just above the kidneys. Hence their name, which was given to them before it was known that they have no direct relation to the kidneys. They apparently furnish adrenaline to the blood. Adrenaline when injected into the blood causes the small blood vessels to contract and therefore the blood pressure to rise, since the heart then pumps against the increased resistance of the contracted vessels. When the adrenal glands do not function normally, as for example when they are tuberculous, Addison's disease develops, which is characterized among other symptoms by a low blood pressure. The substance adrenaline is probably known to you, since it is used therapeutically in a number of ways, for instance, to constrict capillary blood vessels to stop bleeding from the capillaries on wound surfaces. If there is an absence from the diet of the material necessary to form adrenaline, it is conceivable that symptoms other than those of starvation might result.

There is a small gland at the base of the brain known as the pituitary gland, which is apparently necessary to life and which manufactures a physiologically active substance, probably derived from the amino-acid histidine. Disease of this gland seems to occur in certain giants and in the disease akromegaly, in which among other symptoms is found enlargement of the bones of the face and the extremities.

A very interesting physiologically active substance, paraoxyphenylethylamine, is formed in the self-digestion of the pancreas from tyrosine, as shown by Emerson. It is tyrosine from which carbonic acid has been removed. This is of great interest, since it was at one time believed that carbonic acid was formed in living organisms solely by oxidation. This observation shows that it can also be formed by enzymatic cleavage. This is of profound biological interest, since in all probability the energy which is required by organisms living in an environment free from oxygen is obtained by reactions of this type. Ordinarily we think of such organisms as being limited to the fungi, but there are quite highly organized animals which live in this way; for example, parasitic intestinal worms. The gases of the intestines are practically free from oxygen. In all probability these worms obtain the energy necessary for the maintenance of life by cleavages, rather than by direct oxidation. Finally, it is interesting to note that most of these physiologically active substances are amines, probably derived from amino-acids by removal of carbonic acid, that is, by the elimination of the carboxyl, COOH. This method of the formation of amines is probably quite common in plants and leads to the formation of various poisonous plant bases. It has been suggested that the active principle of ergot is formed in this way.

In making this digression to explain that physiologically active substances may be formed from amino-acids, it was my purpose to suggest that the defective or incomplete proteins, when the main or sole nitrogenous element of the diet, may not merely produce a form of starvation, but that they may also have an indirect action through failure to supply the raw materials which are needed by certain glands to elaborate their specific products.

It should not be inferred from what has been said that these incomplete or defective proteins are without food value. On the contrary they may be of great food value. They are merely not of themselves sufficient, but they can be made sufficient if supplemented in relatively small amounts by other proteins that contain the lacking elements. This is a matter of the greatest practical importance in the feeding of farm animals.

Animal feeds consist in the main of vegetable proteins which are often incomplete. Obviously such a feed can be used most economically if it is supplemented by small amounts of proteins which supply the missing elements. To do this it is necessary to know what amino-acids are contained in the different vegetable foods. Agricultural chemists are now engaged in studying this problem. In this connection it must be pointed out that there is a distinction between maintenance and growth. It is perfectly possible to maintain an animal in good health upon a diet which will not permit it to grow. It is possible to stop the growth of an animal by putting it upon such a diet. When the diet is changed growth may be resumed. The capacity for growth has not been destroyed. Furthermore, it has been shown that it is not safe to conclude that a given diet is sufficient if it permits an animal to develop to adult life. It is necessary to show that it will also permit it to reproduce. There are diets that apparently permit perfect development but do not permit reproduction. It has also been found that more growth will take place upon a diet containing a mixture of incomplete proteins than upon a diet containing only one or two of them. Thus growing pigs will utilize for growth only about 24 per cent of the proteins of corn or wheat, whereas upon a mixture of the two grains they will utilize for growth about 33 per cent. It may be stated by way of comparison that pigs will utilize for growth about 60 per cent of the milk proteins fed.

Some of the investigators who put animals upon these restricted diets found that the animals throve a great deal better if small quantities of certain substances were added to the diet. The presence of so small a quantity of milk that its protein was a negligible factor kept animals growing or in good condition upon diets that would not otherwise permit the animals to remain in good health. A diet which does not permit normal growth will do so if a small quantity of butter is added. Apparently there are present in certain foods small quantities of substances of unknown nature which are necessary to growth and life. What this substance in butter is is not known. It seems to contain neither nitrogen nor phosphorus. This is of importance, since it proves that the substance is not a lipoid. Lipoids are complex fat-like substances containing both nitrogen and phosphorus. It has been claimed that a diet without lipoids will not support life. The absence of nitrogen from the growth-promoting substance of butter indicates that it is not related to the vitamine of rice which is almost certainly a nitrogenous base. The vitamines are substances of unknown composition, found in certain foods and essential to life. In the polishing of rice the vitamine is removed. An individual living upon a diet of polished rice will develop a disease known as beri-beri, frequently found among rice eaters. There is apparently a whole series of substances found in foods which are necessary to life. The absence of certain of them is believed to produce scurvy. A similar hypothesis has been advanced concerning the disease pellagra.

Little is known as yet concerning the chemical nature of these substances. They are very unstable, being decomposed by heating, especially by sterilizing under pressure. Lime juice has been used for many years as an antiscorbutic. It is not particularly rich in these substances, but in lime juice they seem unusually stable. It has been suggested that the free organic acid present in the lime juice protects the antiscorbutic substances.

It is therefore quite evident that the last decade has brought forward many contributions of the greatest hygienic and economic importance. It is quite certain that more important discoveries are still to come. It is therefore well to look askance at popular prophecies concerning the approaching inadequacy of the world's food supply. When our viewpoint has changed so radically in a few years, it is idle to speculate about the future. If I have been able tonight to present this point to you clearly, I have accomplished my purpose.

PHYTOGEOGRAPHY.—*The eastern and the western migrations of Smilax into North America.* J. B. NORTON, Bureau of Plant Industry.

It is generally recognized by students of that group that Smilax and its allies must have spread over the earth from a point somewhere in southeastern Asia. This conclusion is borne out by several facts, particularly by the presence in that region of all the related genera with their subgenera, and by the breaking down there of certain group characters separating sections of the large genus Smilax, the last circumstance indicating a survival of the links that are often mourned as missing in other groups of organisms, but which are a source of trouble to a key maker when present. The evidence offered by paleontology likewise leads to the above conclusion.

In addition to these reasons for considering the region east of the Himalaya as the home of this group, the distribution of the species of Smilax in North America has a very distinct bearing on the question. *Smilax hispida* Michx. and *S. rotundifolia* L. are often confused by collectors, so closely do they resemble each other in some characters. *S. rotundifolia* and the related *S. Walteri* Chapm. have their nearest relatives in the Azores, the Canary Isles, the Mediterranean region, Asia Minor, Turkestan, and western India This chain is broken in a few places from the complex group of spieces in northern India including *S. ferox* Wall., through *S. excelsa* L. and *S. canariensis* Willd. to *S. Walteri* and *S. rotundifolia* in America. The trail across the Atlantic is partly hidden, as the Bermudian species, *S. Bonanox* L., is apparently connected with the other European species, *S. aspera* L. But the relationship of *S. roiundifolia* to *S. excelsa* from the Azores is too striking to overlook. Throughout this group the stems have few large spines, which are never at the nodes. In *S. hispida* and its allies, on the other hand, the spines are slender and needle-like and numerous, at least below, where they often make a definite ring at the node. In *S. hispida* and its allies the berries are always greenish-black without a glaucous bloom, while in the *rotundifolia* group the berries are red or blue, with a distinct glaucous coat.

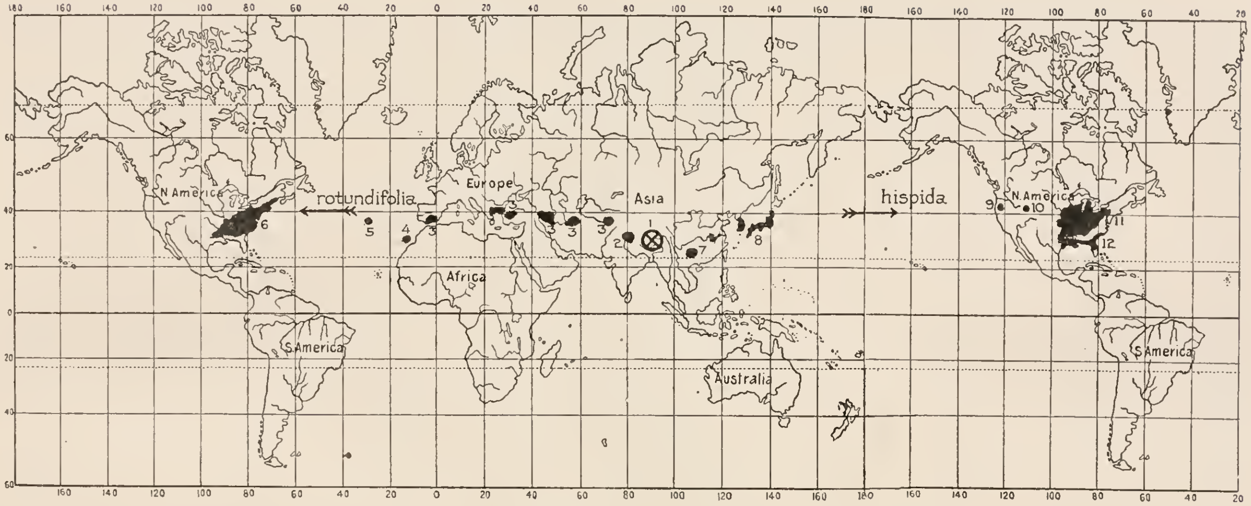


FIG. 1. Map showing the distribution of *Smilax rotundifolia* and *S. hispida*, with their allies, in relation to the supposed original home and distribution center of the genus at (1), in southeastern Asia; at (2), the region occupied by *S. ferox* and several other species which show a blending of group characters, but suggest a relationship to *S. rotundifolia;* at (3, 3, . . .), reported localities for *S. excelsa;* at (4) the related *S. canariensis*, which occurs on Teneriffe and in a varietal form extends to (5), the Azores, where also occurs a plant that is apparently true *S. excelsa*, while (6) shows the present distribution of *S. rotundifolia* in America. The eastern extension of Smilax, culminating in *S. hispida*, begins at (7), *S. scobinicaulis*, the south China species nearest the primitive type. In Japan and Korea, (8), is found *S. Sieboldi*, which shows a decided advance toward *S. hispida.* At (9) this group reappears in California and Oregon in *S. californica*, the nearest living relative of *S. hispida;* but a fossil form, *S. lamarensis*, which is apparently intermediate between its living American relatives, is found in Wyoming at (10). Finally, at (11) is indicated the region occupied by typical *S. hispida*, and at (12) that of its formal variety which splits away from the type in Texas and extends eastward in the coastal plain.

Smilax hispida has no European relatives but can, however, be traced back to India in another direction. *S. californica* Gray, a closely allied form, is found in a small area in northern California and southern Oregon, where it was apparently stranded when its connection with the rest of the world was destroyed by some disturbance in the past. The next species in point of relationship is *S. Sieboldi* Miq. of Japan and Korea. South of Korea we find no near relatives until we reach Yunnan, where *S. scobinicaulis* Wright fills in a space in the trail, both geographically and phylogenetically. *S. scobinicaulis* links up closely with the imaginary primitive types that can be constructed from the maze of inter-related species in the home area of the genus. In this migration we have a fine case of simple orthogenetic progression, with each successive step set off from the last by a barrier and with its nearest relatives in their proper places in the sequence.

Smilax herbacea L. and its relatives have followed the same path taken by *S. hispida* but have spread further, both in area and in differentiation of characters. While the other American groups have not left so plainly the tracks of their migrations from their Asiatic home, there can be little doubt that careful research will connect them all with the original stem.

The eastern and western migrations of Smilax have met and overlapped in the eastern United States, but it is probable that both waves are still moving. *S. hispida* has not as yet reached the Atlantic ocean, while *S. rotundifolia* is plainly stretching west through Texas to the Pacific. Eventually it is to be supposed that the waves will meet again in China. When this has occurred in any group the geologic record is necessary in tracing the course of the migration. In this connection it is interesting to note that the type of the fosssil *S. lamarensis* Knowlton, from the Yellowstone, has been examined and found to show an undoubted intermediacy between *S. californica* and *S. hispida*. To complete the geographic trail it is only necessary to find a fossil form from the North Pacific coast. In the accompanying chart (fig. 1), based on Mercator's projection of the globe, the longitudinal separation of the successive steps in the northern zones is greatly exaggerated.

BOTANY.—*Agriculture and native vegetation in Peru.* O. F. Cook, Bureau of Plant Industry.

Alternation of forests with open grass lands or sparse desert vegetation is one of the most striking of the biological phenomena of tropical countries. Since the time of Humboldt many travelers in tropical America have sought to explain the presence or absence of the different types of vegetation by reference to differences of geological formations, altitudes, prevailing winds, or other natural features. More recent observations in Central America have led to the opinion that the chief factors governing the distribution of the forest vegetation are the agricultural occupation of the land and the continued action of fire on lands abandoned from cultivation.

There are reasons for believing that most of the forests of Central America do not represent original or virgin growth, but different stages of reforestation. Likewise most of the open grass lands and deserts appear to be consequences of the native system of farming—to be interpreted as artificial conditions rather than as natural features. The climatic, geologic, or topographic factors, though not without influence in determining the rate of reforestration, seem in general to have very little importance in comparison with human activities and exposure to fire. The complete reforestation of fireswept grass lands is a long and gradual process, but the successive stages can be recognized by taking account of the habits of the different kinds of trees.[1]

Opportunities of studying the relations of agriculture to forest vegetation under a different combination of natural conditions have been afforded during four months (April to July, 1915) spent in southern Peru and Bolivia as a member of the Expedition conducted by Professor Hiram Bingham, under the auspices of Yale University and the National Geographic Society, with the cooperation of the United States Department of Agriculture. Most of the time was spent in the region traversed by the Urubamba River and its tributaries, from the Pass of

[1] Cook, O. F. Vegetation Affected by Agriculture in Central America. Bull. 145, Bureau of Plant Industry, U. S. Dept. of Agriculture. 1909.

La Raya, at an elevation of 14,000 feet, down to Santa Ana, at an elevation of 3000 feet, including a visit to the Panticalla Pass and the Lucumayo Valley. The region includes Cuzco, Pisac, Ollantaytambo, and Machu Picchu, the chief centers of the Inca and pre-Inca or Megalithic civilizations, and is of great agricultural and ethnological interest as the original home or place of domestication of numerous species of cultivated plants.

In this part of Peru, as in Central America, it apears that the present distribution of the principal types of vegetation is not a natural effect of altitudes, climates, or soils, but an artificial result of an intensive agricultural occupation of the land, extending through a long period of time. If we wish to think of an original condition, a biological background, so to speak, of the primitive agricultural civilization that occupied this region, we must imagine a country well covered with forests. The destruction of forests appears to have been carried much further than in Central America, in many localities to the complete extermination of all forms of arboreal vegetation. The chief considerations that seem to support these conclusions are stated in the following paragraphs.

BIOLOGICAL CONDITIONS FAVORABLE TO FOREST GROWTH

Though many districts are now entirely treeless and true forests are found in only a few localities, there appear to be no natural conditions that are definitely unfavorable to arboreal vegetation. Light, heat, and moisture are sufficient to support the growth of trees and there is ample fertility of soil, at the higher elevations as well as in the lower and more tropical valleys. In other words, there seems to be no climatic or biological factor to preclude the growth of trees on any part of the land surface except the bare rocks and snow fields at the summits of the high cordilleras.

From the positions of the moraine deposits and the lack of soil accumulations above them it may be inferred that the glaciers have receded in comparatively recent times, perhaps following the destruction of the forests. Some of the moraines

Fig. 1. Native agriculture in a branch of the Ushcopata Valley above Sicuani, Peru, at an altitude of nearly 13,000 feet, with fields of potatoes, barley, and broad beans, and remnants of the native forest flora—the white trees *quishuar*, the others mostly *queñuar* and *capuli*.

are as low as 9000 feet, with the present glaciers ending from 2000 to 4000 feet above. Under the Peruvian conditions it does not seem unreasonable to believe that the removal of a forest covering might tend to bring about a recession of the glaciers. Greater exposure of the rocky slopes would bring increased heat and dryness of atmosphere. Less snow would fall and the accumulations on the high summits would be exposed to longer periods of melting under direct sunlight.

As trees are often found above the moraines, there is no reason to doubt that the ancient forest covering extended up to the glaciers, as forests are known to do in other glacial regions. Several isolated tracts of forests have been found by Professor Bingham at very high elevations, even up to 15,000 feet. These high-altitude forests are of interest as affording the most definite demonstration of the fact that tree growth is not limited by elevation alone.

ANDINE FOREST FLORA

The possibility of a forest covering for all of the inhabited areas of this region is shown not only by the fact that trees grow when planted, but also by the presence of an indigenous forest flora whose different components are well adapted to the various natural conditions afforded by different exposures and elevations, up to the line of glaciers.

Two of the high-altitude trees, *queñuar* (Polylepis) and *quisuar* (Buddleia), have been noted frequently by travelers because they are often planted in villages or allowed to grow among the fields. (See fig. 1) Other members of the Andine forest flora of southern Peru are *lambran* (Alnus), *chachacoma* (Escallonia), *unca* (Eugenia), *lengli* (Hesperomeles), *quisca* (Berberis), *mulli* (Schinus), *chicjlluromay* (Vallea), and numerous other trees, including various arboreal Compositae. Several of the genera are represented by two or more species. Some of these, such as the species of Escallonia, are reported by botanical writers only as shrubs, but under favorable conditions they attain true arboreal proportions. especially at altitudes of 10,000 to 12,000 feet.

REFORESTATION OF TERRACED VALLEYS

Though no original or virgin forests are now known to exist in this part of Peru on any lands that could be cultivated, reforestation with native trees is in progress in many places, notably in the valley above Ollantaytambo, and in the next valley to the west, leading up to the Panticalla Pass. In both valleys the growth of the native trees has progressed so far that

Fig. 2. Valley above Ollantaytambo, Peru, at an altitude of about 10,000 feet, showing terraced slopes partly overgrown with forests of native trees, including *quishuar*, *queñuar*, *lambran*, *unca*, and *lengli*.

genuine forest conditions have been restored, in the Ollantaytambo Valley covering several hundred acres, in the Panticalla Valley thousands of acres. Reforestation is demonstrated by the fact that the trees stand on ancient agricultural terraces supported by skilfully constructed stone walls. (See fig. 2.)

The survival of native trees in these valleys may be ascribed to the presence of lateral ravines too deep, narrow, and precipitous for cultivation. Such places may well have escaped the otherwise complete clearing of the land for agricultural purposes. Hardy types of woody vegetation, growing in the ravines and on the rocky slopes above, might survive even long perods of agricultural occupation of the terraced lands below. The neighboring areas might be seeded easily from the old trees. Such a ravine, leading up from the other side of the spur shown in the figure, is now heavily wooded and contains many well matured trees of the same species that now cover the terraces, although very few of the trees appear to be very old or to have reached the stage of natural decay. Some of the terraces in the Panticalla Valley are covered with much older trees than any found in the valley above Ollantaytambo.

HABITS OF SURVIVING NATIVE TREES

Although the genera of native trees, as mentioned above, belong to as many different families, there is a general similarity in habits of growth, in that all of them sprout readily from the stumps and endure repeated cutting. Seed is produced in a few years, if the sprouts are allowed to grow. The limitation of the present forests to such trees may be taken to indicate that persistent vitality was necessary to pass through the periods when these valleys were occupied by large agricultural populations, as shown by the extensive terracing of the slopes. A period of complete denudation of a valley would mean the extermination of all kinds of trees that were unable to sprout from the stumps, but trees like Escallonia, Eugenia, and Schinus might survive centuries of pollarding. The last is familiar as the "pepper-tree," now grown by thousands in southern California for shade and ornamental purposes. Other members of the Andine tree flora are even more attractive in appearance and promising for introduction into the United States.

DENUDATION OF UNCULTIVATED LANDS

The former presence of large agricultural populations accounts not only for the clearing of all the lands that could be cultivated, but also for the denudation of lands that were not capable of cultivation. The growth of each native community means that supplies of fire-wood have to be sought farther and farther away. A large Indian town is usually surrounded by a broad belt of denuded lands, no forest being allowed to remain within two or three leagues. Judging the past by the present, a period of denudation of all the neighboring slopes must have followed the building of the extensive systems of terraces in the valleys about Ollantaytambo, Torontoy, and Machu Picchu. The country around these centers must have reached the same treeless state as the districts that now have large agricultural populations, such as the Vilcanota Valley and the slopes around Lake Titicaca.

REFORESTATION PREVENTED BY FIRE

In many localities cultivation is confined to the bottoms of the valleys or to the lower slopes, while the higher slopes have only a sparse covering of grass or low bushes. This gives the impression that the interior of the country is naturally treeless, like the desert regions along the coast. But the coast deserts are explained by the rainless climate, whereas in the interior the rainfall is sufficient to support forest growth.

The former cultivation of many of the higher slopes is indicated by the ridges and terraces that still remain. These show in turn the previous existence of forests, since forests must have preceded cultivation in order to accumulate soil and make it possible to clear the land by the primitive method of burning. This method is ineffective on grass lands, which have to be reforested before they can be re-occupied by a primitive agricultural people. At the higher altitudes grassy slopes are cultivated by spading, but this method is used only where turf is formed.

When treeless slopes are seen in tropical valleys meeting the tropical forest vegetation, it is plain that some active enemy of forest growth must be at hand, and this is fire. The fires that are set to clear land for cultivation commonly escape and overrun the slopes above. As the grass-covered slopes are used only for grazing, no effort is made to protect them from fire.

FORESTS IN INACCESSIBLE PLACES

Trees are often found growing under very unfavorable natural conditions, in places that are too steep, rocky, or isolated to be cleared for cultivation or for providing fuel. In the lower Urubamba Valley it was observed that the driest and rockiest hillsides in the vicinity of Santa Ana are covered with forests of *huillca* (Piptadenia) and other tropical trees, while the smoother and more fertile lands on either side have no trees, but a heavier growth of grass.

Tree seedlings often appear in grass lands, but are killed when fires sweep over them. Hence, the forests are confined to the rocky slopes as long as the adjacent grass lands are visited by fire. Grazing reduces the danger of fire, and this assists in reforestation; but the forests themselves may burn after sufficiently long periods of drought. In the lower Urubamba Valley, at altitudes of from 4000 to 8000 feet, the forests have been burned on many slopes altogether too steep for cultivation. This not only kills the trees but often has the effect of loosening the soil and rocks, causing destructive landslides.

PAUCITY OF THE HUMUS FAUNA

Another indication of the more complete denudation of this region in former times is the paucity of the humus fauna, comprising the insects, millipeds, centipeds, and other small animals that live normally in the upper layers of the soil. These creatures become very abundant under conditions that afford permanent moisture in the soil, but are killed when the land is burned over or parched by severe drought. In southern Peru the humus-inhabiting animals are everywhere extremely scarce, and often lacking altogether. The number of species is very small, as well as the number of individuals. Of millipeds only three orders are represented, Merocheta, Anocheta, and Diplocheta; in many localities only Merocheta, and most of these of Antarctic types rather than tropical. The three orders of very primitive arthropods, Symphyla, Rhabdura, and Dicellura, are present, but were nowhere found in abundance, even in places where reforestation has advanced so far that ample deposits of humus have accumulated. Humus-inhabiting insects of other orders, including the Thysanura and Collembola, are also few.

ABSENCE OF PALMS IN TROPICAL FORESTS

The flora of the valley between San Miguel at 6000 feet and Santa Ana at 3000 feet is distinctly tropical, and large areas are forested, but not with original or virgin growth. That reforestation is still far from complete is shown by the general scarcity and often complete absence of palms. Instead of a normal palm flora, no locality in the Urubamba Valley was found to have more than two species, a large Geonoma and a small Chamaedorea.

This deficiency seems the more significant because the natural conditions are extremely favorable and the palm flora of the adjacent regions of South America is one of the richest in the world. The original palm flora of this district can not be estimated at less than a dozen species, and may have included two or three times that number. But denudation would involve a complete extermination of the palms, and these plants are very slow to return, even after forest conditions have been reestablished.

RECONSTRUCTION OF THE FLORA AND FAUNA

In view of these indications of prolonged interference with the original conditions of plant and animal life it does not seem reasonable to ascribe the present distribution of the native vegetation entirely to differences of soil, temperature, altitude, or rainfall. An ecological account of the Peruvian flora that ignores the factor of human activity, as in the treatise by Weberbauer, does not convince. To present an adequate conception of the native flora and its relations with the external conditions would require a process of reconstruction, a careful collecting and piecing together of the parts of the flora and fauna that are left. Then there would need to be a careful comparison with the floras and faunas of neighboring regions that were not occupied and denuded by the ancient civilizations, if such regions can be found. This would give a better appreciation of the extent to which the presence of man has modified the original conditions of the environment along the eastern slopes of the Andes.

AGRICULTURE AT HIGH ALTITUDES

Corresponding with the wide range of altitude there is great diversity in the forms and habits of the wild vegetation and in the agricultural arts of the native inhabitants. In the lower valleys where corn is the principal crop the method of clearing the land and the relation of agriculture to the native vegetation are much as in Central America.

The high plateaus of Peru, where the native agricultural population is now chiefly centered, are unlike any part of Central America, the nearest approach being found in the tablelands of Guatemala. In Central America cultivation is hardly carried above 8000 feet; whereas in Peru potatoes and other Andine crops are commonly grown at 13,000 feet and in some places at 14,000 feet. Moreover, it is in these elevated districts that the native system of agriculture attained its highest development and was least disturbed by the Spanish conquest.

CONCLUSIONS

The native agriculture of southern Peru is self-limiting. Cultivation may be maintained for longer periods on the tablelands and higher slopes, but when the soil is once exhausted and removed by erosion there is less prospect of renewal through reforestation than at the lower elevations. Although under the high altitude conditions the accumulation of soil goes on to a certain extent in open grass lands, without the aid of forests, such gains evidently do not make good the losses incidental to cultivation. Large areas of the higher slopes that appear to have been cultivated intensively in former times are now completely sterile and abandoned.

Thus Peru may be said to afford even more striking evidence than Central America of the fact that the primitive agricultural civilizations were not permanent, but of limited duration. Eventually the soil became unsuited to cultivation by the native methods.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Lavas of Hawaii and their relations.* WHITMAN CROSS. U. S. Geological Survey Professional Paper No. 88. Pp. 93, 4 plates. 1915.

The Hawaiian Islands have been built up by a long continued series of volcanic eruptions beginning at a point far west of the principal islands of today. While basalt of a common type is the predominant rock of the islands, there is much greater variety among the rocks than has heretofore been recognized. As indicated by the work of Cohen, E. S. Dana, Lyons, and Silvestri, the rocks range chiefly between normal basalts rich in olivine, augite, and highly calcic plagioclase to pyroxene andesites either free from or poor in olivine and containing andesine or more richly sodic plagioclase. There are, however, more basic rocks such as limburgite, nephelite and melilite basalt, and picritic basalt, while xenoliths of peridotite are reported from several islands. A soda trachyte is the most feldspathic rock so far collected.

The chemical characters are discussed on the basis of 43 existing analyses showing many rocks of the so-called alkaline type. These analyses evidently do not cover the entire range of rock types but, classifying the analyzed rocks in the "quantitative system," all but the three most salic rocks come within the range of two classes, that is, in Class III or the adjacent halves of Classes II and IV.

The Hawaiian archipelago forms a simple petrographic province whose rocks are clearly comagmatic and consanguineous. The region is especially suited to furnish the means of testing several broad generalizations of the day regarding the genetic relations of igneous rocks.

Each of the larger islands contains several kinds of rocks showing important differences in both chemical and mineral composition and conversely several kinds of rocks are known in all or nearly all the larger islands. In view of the meagerness of our knowledge concerning all the centers of eruption it is believed that nearly all the varieties described and perhaps some others occur on each of the principal islands. Nephelite-melilite basalts are known on three islands—Kauai, Oahu, and Maui. Strongly feldspathic andesites occur on Hawaii; and the lavas of Kilauea, the youngest volcano of the islands, are predominantly olivine-poor basalts.

The relations of the magmas as differentiation products are compared with those of other island groups of the Pacific Ocean, and the distribution of the Hawaiian types in other parts of the world is considered. Their chemical characters and the circumstances of their association demonstrate that the so-called alkalic and calcic magmas may and do occur together as derivatives from a common source. The current generalization that this distinction between alkalic and calcic series ("Atlantic and Pacific branches") of igneous rocks is of fundamental importance in petrogenesis and may serve as a factor in a natural system of classification is held to be fallacious and to lead to endless confusion.

The series of Hawaiian lavas are concluded to have been derived from a general magma of nearly the same character in all parts of the province. It does not seem probable that there has been any noteworthy differentiation in the main reservoir beneath the Hawaiian district. During the active growth of each volcano the lavas presented a moderate variability in composition, but definite system in this variation was not detected. With decreasing eruptive activity and possibly attendant contraction and limitation of lava chambers a higher degree of differentiation was accomplished and is shown by more salic and correspondingly more femic lavas than those of earlier date. In the long period of parasitic or subsidiary eruptions conditions were favorable to extensive differentiation. The processes of differentiation are still problems for investigation. Movement under gravity of crystal particles may have played a part. J. Fred. Hunter.

BOTANY.—*On the characters and relationships of the genus Monopteryx Spruce.* Henry Pittier. Bulletin of the Torrey Botanical Club, **42**: 623-627. 1915.

The genus Monopteryx (Fabaceae) was based upon flowering specimens of a tree collected by Spruce on the upper Río Negro, Brazil. Because of the fact that the fruits were unknown, the genus has been erroneously placed among the Sophoreae. Complete specimens of a new Venezuelan species, *Monopteryx jahnii,* show that the genus is closely related to Pterocarpus. H. P.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 107th meeting of the Washington Academy of Sciences was held in the auditorium of the New National Museum at 4.45 p.m., April 7, 1916, with President L. O. Howard in the chair and a large audience present. Dr. Eugene F. DuBois, Medical Director of the Russel Sage institute of Pathology, New York, gave an illustrated lecture on *The basal food requirement of man.*

The lecture dealt chiefly with the amount of heat generated by the body as affected by such factors as age, sex, size, labor, and disease. It was shown that the metabolism, or sum-total of chemical changes within the body, as manifested by the quantity of heat generated per unit area of surface, is very low in the infant, rises to a maximum (1.5 that of the adult) at the age of 4 to 6 years, and then falls rapidly to the metabolism of the normal adult, except at the age of puberty when it rises slightly. From 20 to 30 it remains constant, after which it slowly decreases.

Metabolism is somewhat greater in man than woman, increases practically in direct proportion to the total skin area, varies enormously—even more than 5 fold—with different degrees of exertion, and in disease varies widely with the nature of the malady. In typhoid, for instance it is roughly 50 per cent greater than in health, demonstrating that the typhoid patient needs to be *fed,* rather than starved. Equally interesting and valuable results have been gained from the studies of other diseases, so that scientific human feeding may soon be expected, at least in hospitals.

The 108th meeting of the Academy was held in the auditorium of the New National Museum, Friday afternoon, April 14, 1916, with Dr. Carl L. Alsberg in the chair and a large audience present. Dr. Graham Lusk, Professor of Physiology, Cornell Medical College, gave an illustrated lecture on *Nutrition and food economics.*

An extremely interesting exhibit was shown of different kinds of food,—hominy, oat meal, rice, flour, potatoes, etc.—each sufficient in amount for an adult, if inactive, for 24 hours. At present prices the cheapest food appears to be corn meal, or hominy, costing, if one lived on this alone, about $4\frac{1}{2}$ cts. per day. Tables were shown that gave the quantities and the costs of many kinds of food, assuming one to live on each alone. Hominy, oat meal, and rice are the cheapest, while of ordinary foods meat is the most expensive. Other tables were presented that gave the actual quantities and kinds of food used at certain schools, some of which strikingly confirmed the general belief that one eats more during his "teens" that at any other time of life.

The 109th meeting of the Academy was held in the Auditorium of the New National Museum, Friday afternoon, April 21, 1916, with President L. O. Howard in the chair and an appreciative audience present. Dr. E. B. Forbes, Chief of the Department of Nutrition of the Ohio Agricultural Experiment Station, gave an illustrated lecture on *Investigations in the mineral metabolism of animals.*

Careful investigations, especially with cattle and hogs, have shown the importance of having sufficient amounts of certain mineral substances in their food. Of these calcium in some assimilable form is needed in greatest abundance, particularly during the period of rapid growth. Hence blue grass, which is rich in calcium salts, is an excellent food for growing stock, while an all-grain food, poor in such substances, is inadequate. Among the interesting developments of the work was the fact that good milch cows secrete more mineral matter during the period of full lactation than they assimilate from even the best food, and thereby suffer a kind of mineral exhaustion.

The 110th meeting of the Academy was held jointly with the Geological Society of Washington in the lecture room of the Cosmos Club, Wednesday evening, April 26, 1916, with Dr. A. C. Spencer presiding and about 60 persons present.

Dr. K. F. Kellerman spoke of *Bacteria as agents in the precipitation of calcium carbonate.* Illustrations were shown of spherulites formed through bacterial agency from solutions of calcium sulphate, calcium acetate, and artificial sea water, which are practically indistinguishable from those formed in nature.

Dr. J. Johnston discussed *Some factors which influence the deposition of calcium carbonate.* The fundamental importance of the solubility-product in relation to saturation was explained, and the different methods of producing precipitation or inducing solution discussed. The greater solubility of calcium carbonate in cold water obviously must lead to its depletion in the higher latitudes and its accumulation in equatorial regions, a process which appears to be in full operation.

Dr. H. E. Merwin described *The forms of calcium carbonate and their occurrence.* There are at least three easily distinguishable crystallized forms of calcium carbonate and a number of doubtful forms. The form deposited from a solution depends very largely upon temperature, though there may also be other contributing causes.

In the discussion that followed Dr. T. Wayland Vaughan spoke of the oölitic deposits of Florida and their problems, and Dr. Chas. D. Walcott described the similar silicious deposits of the Yellowstone Park.

The 111th meeting of the Academy was held in the Auditorium of the New National Museum, Friday afternoon April 28, 1916, with President L. O. Howard in the chair and about 200 persons present. Dr. Carl Voegtlin, of the U. S. Public Health Service, Washington, D. C., gave an illustrated lecture on *The relation of the vitamines to nutrition in health and disease.* It formerly was supposed that any diet was sufficient if it contained enough proteins, fats, carbohydrates, and salts; but it is now known that under certain circumstances, even with an abundance of food, nutrition diseases such as scurvy and beri-beri are apt to develop. Beri-beri, for instance, is likely to develop when polished rice forms the exclusive diet, but does not occur when the rice is unpolished and even disappears when the patient is given rice-bran or certain bran extracts. It follows that the bran contains something essential to health which the rice-grain proper does not. Such products are found in many grains and plants and are known as vitamines, that is, basic organic compounds essential to life. These compounds are produced by plants only, but very unequally. In the animal body they are found most abundantly in the spinal cord and other nerve tissue.

W. J. Humphreys, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 770th meeting was held on March 18, 1916, at the Cosmos Club; President Briggs in the chair, 46 persons present. The minutes of the 768th and 769th meetings were read in abstract and approved. The Secretary reported the action of the General Committee adopting an amendment to Article V of the By-laws to class as life members all who have maintained an active membership in the Society for 40 years. Messrs. Abbe, Clarke, Dall, and Gilbert have been designated life members under this amendment. The treasurer read a communication from the Secretary General of the Committee of the International Association of Academies in charge of the publication of the *Annual Tables of Constants and Numerical Data* expressing thanks for the continued financial aid received from the Society.

Mr. H. C. Dickinson presented an illustrated communication giving the results of an investigation in collaboration with Mr. M. S. Van Dusen on *Heat transmission through air layers.* Measurements were made of the heat transmission in unit time per unit area and unit temperature difference through vertical air layers inclosed between plane nickel-plated copper plates, for heights (h) of from 3 to 60 cm., for distances (D) between the plates of from 1 to 60 mm., and for differences of temperature (Δ) of from 5° to 30° centigrade. The effect of direct radiation was determined and all observations were corrected to include only transmission due to gas conduction, quiet convection, and turbulent convection. Transmission decreases to a minimum for increasing D and for greater widths becomes nearly constant, the position of minimum depending upon h. Transmission decreases with increasing

h, and increases with increasing Δ. Applications of the results to calorimetric problems in the laboratory as well as to many industrial problems were suggested. An approximate mathematical expression for the results obtained was presented.

By invitation Mr. L. H. ADAMS presented an illustrated paper on *The thermoelectric power of pure metals.* Thermoelectric force and the closely allied thermal and electrical effects have an important bearing on many aspects of the behavior of metals and an extended knowledge of these quantities would go far toward a solution of the problems of metallic conduction. The results enable one to calculate 4 other quantities, viz. $\frac{dE}{dT}$, $\frac{d^2E}{dT^2}$, Peltier effect, and Thomson effect. The last named, although extremely difficult to measure calorimetrically, can be determined by the electrical method with considerable accuracy. Curves illustrating the course of $\frac{dE}{dT}$ and of the Thomson effect from absolute zero to very high temperatures show that the relations involved are much more complicated than has hitherto been supposed, and explain the difficulty of obtaining a suitable equation for representing the thermoelectric force as a function of the temperature. It is of interest to note the extraordinary sensitiveness of the thermoelectric force to slight impurities in the metal.

The communication was discussed by Messrs. SWANN, BURGESS, and WHITE. The Chair expressed to the speaker the Society's thanks for his very suggestive paper.

Mr. A. HALL then spoke on *The equatorial micrometers of the Naval Observatory,* illustrating his communication with lantern slides. The micrometers constructed by Clark, Saegmüller, Warner and Swasey, and Repsold were compared. The last is a large instrument, made of iron and steel, with a platinum-iridium position circle, purchased by the Naval Observatory in 1913. An eye-piece microscope is provided for the examination on the telescope of the micrometer screw. The readings of the screw can be made in the usual manner or can be printed on a Morse fillet, on two type-metal wheels which carry raised figures. Great care is taken to have the illumination of the threads symmetrical, and in every way provision is made to eliminate systematic errors.

The Secretary read an invitation from the Washington Academy of Sciences inviting members of the Society to attend a lecture by Dr. L. H. BAEKELAND at the New National Museum on March 23 at 8.30 p.m.

The 771st meeting was held on April 1, 1916, at the Cosmos Club; President BRIGGS in the chair, 44 persons present. The minutes of the 770th meeting were read in abstract and approved.

Mr. R. S. WOODWARD presented a communication on *The extraction of square roots of numbers.* Referring to a previous communication to the Society by the author on the same subject some further applications were explained of the formula

$$\sqrt{m} = \sqrt{(ab)} = \tfrac{1}{2}(a+b)\left\{1 - \frac{(a-b)^2}{(a+b)^2}\right\}^{\frac{1}{2}} \quad \ldots\ldots \quad (1)$$

In this m is any number and a and b are any two numbers whose product is m. Attention was called to the rapid approximation which may be secured by successive applications of the arithmetic mean $\frac{1}{2}(a + b)$. Special emphasis was given to the use of formula (1) when m is an integer and not a square. In this case the square root of m is involved in the two equations

$$y^2 - mx^2 = \mu$$
$$y^2 + mx^2 = \nu$$

in which every symbol represents an integer. These equations give[1]

$$\sqrt{m} = \frac{\nu}{2xy} - \frac{\mu^2}{4\,xy\nu} - \frac{\mu^4}{16\,xy\nu^3} - \quad \ldots\ldots\ldots \quad (2)$$

The number μ is arbitrary within certain limits. For the present purpose it is obviously most advantageous to have $\mu = +1$, and it is known from Fermat's theorem that $\mu = +1$ is always possible. Moreover, an infinite series of sets of values of x and y exists, each set satisfying the equation $y^2 - mx^2 = +1$. Hence an infinite series of increasingly rapid approximations to the $\sqrt{m}$ is furnished by equation (2).

The paper was discussed by Messrs. Wead, Farquhar, Van Ostrand, and Harris, particularly with reference to earlier methods.

Mr. W. W. Fraser then presented a communication on *Vectors and quaternions; what has been done and what can be done.* Among his definitions we find that Hamilton has defined the quaternion as the quotient of two vectors α, β, as $q = \frac{\beta}{\alpha}$; and as a set of four, or $q = x + iy_1 + jy_2 + ky_3$ where i, j, and k are algebraic extraordinaries such that $i^2 = j^2 = k^2 = -1$, $ij = k = -ji$, etc., making the quaternion analysis an algebra of sets in which the commutative law for the multiplication of the extraordinaries is thrown out. Grassmann's Ausdehnungslehr differs chiefly from the quaternions in his definition of the product of two vectors, being defined (inner), $A.B = |A||B| \cos(A,B)$; and (outer) $A \times B = n\,|A||B|\sin(A,B)$ (after Gibbs). The Borali-Forti assumption that $i\times(\quad) \equiv i$ (of Hamilton) $\equiv \sqrt{-1}$ affords a means of uniting the systems of Grassmann, Gibbs, and Hamilton, since we can effect translations from scalars, rotations with complexes or quaternions, and projective transformations with the dyadic of Gibbs. If Ohm's law for alternating currents is expressed with Grassmann vectors instead of complexes, as used by Dr. Steinmetz, the difficulties of the latter's symbolic method are avoided.

Mr. W. J. Spillman then presented the results of an investigation in collaboration with Messrs. H. R. Tolley, and W. G. Reed on *A gra-*

[1] Equation (2) may be derived from (1) by writing $a = \frac{y}{x}$ and $b = \frac{mx}{y}$.

phic method for the determination of the average interval between departures from the mean greater than a given departure. In determining the absolute winter minimum below which the winter temperature would not fall on the average oftener than once in thirty years, a problem which arose in connection with the investigations of the methods and cost of heating greenhouses, a curve was constructed for which the abscissas are departures from the mean expressed in terms of the standard deviation, and the ordinates represent the reciprocals of the probability of departures greater than a given amount. Thus if the departure in question is an annual event, the ordinates of the curve represent the average interval, in years, between successive occurrences of the event. Periods of observations of meteorological phenomena are too brief to give very reliable results from the method outlined. The method is also applicable only to variables represented by normal frequency curves. In the case of 569 stations the actual number of spring frosts after the calculated date beyond which frost should occur on the average only one year in ten gave no unexpected frosts in 73 per cent of the stations and only one unexpected frost in 21 per cent of the stations. Thus in 94 per cent of the stations there was either no unexpected frost or only one. The mean of the standard deviation for these stations was calculated from an average of about 23 observations.

The paper was discussed by Messrs. WOODWARD and HUMPHREYS.

The 772d meeting was held on Thursday, April 20, 1916, at the Cosmos Club; President BRIGGS in the chair, 130 persons present.

The evening was devoted to an address by Dr. R. A. MILLIKAN on *Some recent aspects of the radiation problem.* Partly as the result of an experimental situation and partly because of a theory, Planck's h first made its appearance in 1900 in connection with the development of the laws of black-body radiation. Since then it has unexpectedly revealed itself (2) in the domain of specific heats, (3) in that of corpuscular emission under the influence of light and X-rays, (4) in the domain of spectroscopy, both of light and of X-rays, and (5) in the general radiation which is stimulated by the impact of corpuscles against the atoms of matter.

This is an extraordinary experimental situation which has not yet been interpreted in the light of any consistent theory. After the presentation of the facts which have recently come to light in connection with the last three of the foregoing fields, it was pointed out that the work of Duane, Hunt, and Hull seems to permit of a real advance in theory in that it appears to show that the h which is found in connection with the general X-ray radiation, and presumably in connection with black-body radiation has nothing to do with the *natural periods* of the atomic constituents of the radiating bodies as heretofore assumed, since it is quite independent of the *nature* of these bodies. It appears to be rather a property of the ether pulse which is generated by the stopping of an electron.

The inverse problem, namely, that of obtaining any satisfactory conception of the way in which a train of ether waves of frequency ν can eject an electron from an atom with an energy $h\nu$ is as yet quite unsolved. Yet the direction in which a solution must be found seems to be indicated. For the conception of localized bundles of energy traveling out through space from the radiating body is untenable in view of the oil-drop experiment, while energy considerations preclude the possibility that the ejected electron receives its energy from a single spreading ether pulse. It seems therefore necessary to assume with Planck and Bohr that the atom possesses such a structure that it can absorb energy without radiating at all until a critical energy content is reached when an explosion takes place and the electron is ejected with the energy $h\nu$. How it can do this we do not yet know, but experiments are presented which show that in any case this type of absorption is not a phenomenon of resonance. With Bohr's atom, however, which is shown to have had notable success very recently in explaining the relations between the lines of fluorescent X-radiations, it is not surprising that absorption is unlike anything which we have observed in the region of low frequency vibrations where the cause of absorption is, in general, resonance.

The communication was discussed at length by Messrs. Duane, Hull, Bateman, and Swann. Mr. Hull gave some additional experimental data extending Bohr's theory.

A vote of thanks was unanimously extended to Dr. Millikan and the other speakers for their kindness in addressing the Society.

J. A. Fleming, *Secretary.*

THE CHEMICAL SOCIETY

The 251st meeting of the society was held at the Bieber Building on October 14, 1915, the society being the guests of the members of the Bureau of Chemistry. Several reels of motion pictures showing various activities of the Department of Agriculture were shown. President Alsberg, as Chief of the Bureau of Chemistry, gave a short address of welcome, outlining the various phases of the work of the Bureau. The laboratories of the Bureau were opened for inspection and a very profitable and enjoyable evening was spent by the two hundred members and guests attending.

The 252d meeting was held at the Cosmos Club on November 11, 1915, for the annual election of officers. President C. H. Herty of the American Chemical Society was present as a guest of the local section and gave a brief address, especially emphasizing the important rôle the American chemist is to play in the important matters now before the American public.

The following were elected officers for the year 1916:

President: R. B. Sosman, Geophysical Laboratory.

First Vice-President: H. M. Loomis, Bureau of Chemistry.

Second Vice-President: A. Seidell, Hygienic Laboratory.

Secretary: E. C. McKelvy, Bureau of Standards.

Treasurer: F. P. Dewey, Bureau of the Mint.

Councilors: J. Johnston, Geophysical Laboratory; R. C. Wells, Geological Survey; C. S. Hudson, Bureau of Chemistry.

Executive Committee: J. C. Hostetter, Geophysical Laboratory; E. C. Schorey, Bureau of Soils; A. N. Finn, Bureau of Standards; M. J. Ingle, Bureau of Chemistry.

It was the sentiment of the meeting that the previous custom of having a presidential address by the retiring president be revived for the January meeting and for the following years.

The 253d meeting, a special meeting of the society held jointly with visiting members of the Association of Official Agricultural Chemists, was held through the courtesy of the Borden Condensed Milk Company of New York City at the Circle Theatre, November 16, 1915. The program consisted of motion pictures, illustrating the production and testing of certified milk, ably explained by Mr. W. E. B. Kirk, a representative of the company. After the pictures were shown the members adjourned to the research laboratories of the National Canner's Association, 1739 H Street, N.W., for inspection of the laboratories and a social hour.

The 254th meeting (special) was held at the New Willard Hotel on December 8, 1915, the society being guest of the National Rivers and Harbors Congress. The part of the program of especial interest to the members consisted of motion pictures provided by the National Tube Co., showing the manufacture of steel tubing from the ore to the finished product. Explanatory remarks and a short history of the use and manufacture of steel pipes were given by a representative of the company.

The 255th meeting was held at the Cosmos Club on December 16, 1915. R. B. Sosman was elected to represent the society as a vice president of the Washington Academy of Sciences during the year 1916. The president appointed the following committee of three to consider the arguments pro and con and present a report to the society regarding the bill H. R. 528, introduced by Representative Albert Johnson of Washington State, to discontinue the use of the Fahrenheit scale of temperature in government publications: W. F. Hillebrand, J. Johnston and E. B. Sosman. The following were appointed as auditing committee: A. B. Adams, J. A. LeClerc, and R. C. Wells. The following papers were presented.

R. B. Dole, Geological Survey: *The action of natural waters on boilers.*

B. McCollum and K. H. Logan, Bureau of Standards (given by Mr. Logan): *Chemical factors affecting electrolytic corrosion in soils and reinforced concrete.*

Experiments on corrosion in soils from various sources show a wide variation in the coefficient of corrosion. The rates of electrolytic corrosion were not materially different for Ingot iron, wrought iron, cast iron, and machine steel.

A series of tests in which nitrates, carbonates, sulphates, chlorides, and chromates were added to the soil showed that only the chromates retarded the electrolytic corrosion. The character of the corroded surface depends upon the chemical in the soil. Pitting is not due entirely to the non-homogeneity of the anode.

The coefficient of corrosion in normal concrete is usually about 1 per cent. High current density, temperatures above 50°C., the addition of salt to the cement, and the exposure of small green specimens to CO_2 greatly accelerate the corrosion.

Electrolytic corrosions with alternating currents show low coefficients of corrosion, unless the length of the cycle or the character of the soil is such as to prevent the corroded iron from plating back on the reversal of the current. The coefficient of corrosion is usually low, even when the period of a complete cycle is several hours.

On account of the reversing polarity of the underground structures throughout a large part of the areas affected by stray currents from street railways, electrolytic damage will usually be much less than might be expected.

Coefficients of corrosion greater than 100 per cent are only found when the current density is low, and are probably due to accelerated self-corrosion. (Author's abstract.)

G. K. Burgess and P. D. Merica, Bureau of Standards (given by Mr. Merica): *Some examples of metal failures.* The talk was illustrated by many slides of great interest.

The question of metal failures is a very comprehensive one and may indeed be said to embrace all cases in which a metal does not fulfill, as well as may be, the use or uses to which it is put. Whether or not a metal is a failure under given conditions may therefore be a relative matter and there cannot usually be an ideal standard of service.

Metal failures may evidently be classified as to type or cause, whether due to inherent chemical or physical imperfections or to some incorrect treatment (thermal, mechanical or chemical) which it may have received either in manufacture or subsequently.

It is often necessary, in considering metal failures, to fix the responsibility for failure, and it may be necessary at times to decide whether the fault lay in the metal or in the specifications which may have been so incorrectly or inadequately drawn as to be entirely unsuited to the metal in question.

Examples of metal failures and of imperfections in metals were given with illustrations, the same being taken from the experience at the Bureau of Standards.

The effect of pipe, segregation, and blowholes in ingots of steel can be readily traced in the properties of articles manufactured from these ingots. Steel rails, for instance, will contain longitudinal seams, due to cavities in the ingot, and will be found to be unduly brittle in the web, due to the segregation of the impurities and carbon in the original ingot.

The effect of wrong heat treatment of otherwise good material, such, for instance, as overheating, was illustrated in the case of steel and of naval brass.

Other cases of failure of a typical sort are the oxidation of the tin fillings of fusible tin boiler plugs, due to the presence in the tin of a small content of zinc, the selective corrosion of Muntz metal sheet exposed to action of sea water, and the season-cracking of brass, particularly manganese bronze, which is due to the presence in the material, particularly when in the wrought condition, of high initial stresses. (Author's abstract.)

The 256th meeting, a joint meeting with the Washington Academy was held at the Cosmos Club, January 13, 1916, The retiring president, C. L. Alsberg of the Bureau of Chemistry presented as his presidential address, *The chemical analysis of nutrition*, which consisted of a brief survey of the advance during the last decade in our knowledge regarding the chemical substances involved in animal nutrition and metabolism. Particular reference was made to the advance in our knowledge of the chemical nature of the active constituents of the ductless gland secretions. The effect of vitamines and small quantities of other materials upon the assimilation of foods was considered. The address called forth considerable interesting discussion. A. Seidell spoke of his success in concentrating vitamines by means of Lloyd's reagent, that is, by absorbing with hydrated aluminium silicate.

The reports of the officers for the year 1915 were read and approved. The following committees were appointed by the president for the year 1916: *Communications:* E. B. Phelps, H. S. Bailey, W. H. Keen, R. S. McBride and A. Seidell; *Entertainment:* F. A. Wertz, H. R. McMillin, G. W. Morey, H. J. Morgan, E. E. Smith.

The following resolution regarding H. R. Bill 528 to discontinue the use of the Fahrenheit thermometer scale in government publications, presented by the committee appointed to prepare an expression of the feeling of the society, was approved:

Resolved, That the Chemical Society of Washington favors unqualifiedly the purpose of Bill 528, now before the House of Representatives and in charge of the Committee on Coinage, Weights and Measures, and endorses said bill, provided it shall appear that its provisions are such as will lead to the desired end with the least determinable inconvenience to the public and to the Government service.

The 257th meeting of the society was held at the Cosmos Club, February 18, 1916. Mr. H. C. Fuller presented a memorandum in relation to the Sheppard bill (S 1082) now pending before the Senate. The substance of the memorandum was adopted with the proviso that a committee of three be appointed by the President to shorten the memorandum in order to make it more effective. Messrs. JOHNSTON, MUNROE and FULLER were appointed members of the Committee. The resolution in its final form reads;

Whereas the bill now before the Senate, known as S 1082, introduced by Senator Sheppard, which is concerned with the manufacture and sale of alcoholic liquors within the District of Columbia, in its present form contains provisicns which would prohibit absolutely the use of grain alcohol for all chemical and technical purposes in all the many laboratories, connected with Government departments or with educational or private institutions, now established in the District of Columbia, and would also prohibit the delivery, for analysis or other purposes, of samples and specimens containing alcohol;

And whereas the important work, highly beneficial to the public welfare, carried on by these several laboratories would be very seriously crippled, and much of it would be stopped altogether, by the prohibition of the delivery of alcohol to these laboratories, or of its use therein; for in many chemical operations pure alcohol is an absolute necessity and irreplaceable;

And whereas Congress itself has specifically provided in the Food and Drugs Act and in the Insecticide Act that the degree of purity of food and drug products should be determined by certain prescribed tests, few of which could be made if the use of alcohol be prohibited;

And whereas it is unreasonable to suppose that Congress would enact a law which would effectually prevent the making of tests prescribed in previous acts, work which moreover can not be interrupted without detriment to public welfare; and it is the belief of this Society that it is not the intent of Congress to prevent legitimate and necessary scientific work in any laboratory, private or public, or to hinder the advancement of science, or to interfere in any way with the training of technically skilled men, especially at this time when the advantage—nay, the necessity—of proper technical training and advice has been brought home to all of us;

Therefore be it resolved by the Washington Section of the American Chemical Society, that the foregoing summary statement of facts be brought to the attention of those in charge of this bill, with the plea that they modify those provisions which, if the bill S 1082 were enacted in its present form, would be highly prejudicial to the laboratory work, scientific, technical, and educational, now carried on within the District of Columbia, a work which is absolutely essential to the continued progress of the country.

The program of the evening consisted of a lecture on *Radium* by C. L. PARSONS, of the Bureau of Mines. A concise survey of the recent methods developed by this Bureau for the extraction of radium from carnotite ores was accompanied by lantern slides and motion pictures showing the entire range of operations from the mining of the ore to the crystallization of the radium bromide. By means of the new methods it is thought that 90 per cent of the radium is actually recovered; by previous methods about 70 per cent was considered a very good yield. An interesting discussion ensued, partaken in by many members of the society.

The 258th meeting of the society was held in the Assembly Hall of the Y. M. C. A. on March 9, 1916. The following program was presented:

H. H. Custis, Bureau of Animal Industry: *The action of light on chlorine, with special reference to the formation of chloracetic acid.*

The reactions between chlorine and other substances in the presence of light were all classed with those reactions in which the light only gives an impulse to the activity of chemical change. Several examples of such reactions were cited. A brief outline of the history of the study of phenomena accompanying reaction between hydrogen and chlorine in the presence of light and a résumé of the work previously reported on the reaction between chlorine and acetic acid were given.

The speaker then reported that after unsuccessful attempts to chlorinate acetic acid, benzene, and toluene under the influence of light from a projection lantern he was able to make mono-chloracetic acid by the action of chlorine on acetic acid at the temperature of the steam bath under the influence of the rays from an iron arc. The reaction was accelerated by the use of red phosphorus as catalyzer. He was also able to chlorinate benzene and toluene at room temperature, using an iron arc. In these experiments no catalyzers were used. Though benzene was not chlorinated by chlorine subjected to the rays from a quartz mercury arc while passing through a quartz tube, toluene was chlorinated. (Author's abstract.)

Atherton Seidell, Hygienic Laboratory: *The isolation of vitamine from brewer's yeast.*

Vitamine is the name which has been given to a recently recognized essential food element necessary for normal metabolism. Although vitamine (vitamines?) is undoubtedly widely distributed in food stuffs, the amount actually present in any one is probably very minute. Attempts which have so far been made to concentrate vitamine or isolate it have been only partially successful. The material appears to be destroyed or seriously altered by the manipulations involved in the processes of isolation. It has therefore not been possible to make extensive studies of the physiological action of vitamine uninfluenced by accompanying substances.

Brewer's yeast has been shown to be comparatively rich in vitamine. While attempting to concentrate the vitamine present in this product it was ascertained that hydrous aluminium silicate (fuller's earth) selectively adsorbs vitamine from the complex, aqueous, autolyzed yeast solution. Experiments on pigeons receiving a deficient diet of polished rice showed that the separation of the vitamine by means of the adsorbent was complete. The yeast solution filtered from the solid was free of vitamine, whereas the solid adsorbent retained all that was originally present in the yeast solution. The solid combination of fuller's earth and vitamine appears to be stable and shows unimpaired vitamine activity even after several months. Since the inorganic solid adsorbent is an inert substance, from the standpoint of its action on the organism, the combination serves as a convenient source of vitamine for nutritional experiments and possibly as a therapeutic agent in the treatment of beri-beri and other nutritional deficiency diseases. Experiments upon the separation of vitamine from its solid combination with fuller's earth are under way and a crystalline product possessing the vitamine action has already been prepared. (Author's abstract.)

R. R. Williams, Bureau of Chemistry: *The chemical nature of the vitamines.*

Alpha-hydroxypyridine exists in three isomeric forms. Two of these forms can be isolated as needle and prism crystals respectively, while the third enolic form is present only in the metallic salts of the compound. Prism crystals may be converted into needles by dry heat. The needles on standing in the air at ordinary temperatures are transformed again into prisms. Water solutions of the needles produce rapid cures of avian beri-beri when administered within five or six days after the solution is made. The prism crystals have no curative power. The enolic or metallic salt form probably possesses no therapeutic value. A similar isomerism and physiological effect appears to be common to all hydroxypyridines, suggesting that the natural vitamines possess a similar chemical structure. (Author's abstract.)

The 259th meeting (special) of the society was held in the Chemical Lecture Hall of George Washington Medical School on March 21, 1916. The speaker of the evening, John Uri Lloyd, of Cincinnati, presented a *Practical demonstration of some of the principles of colloidal chemistry.* An experimental demonstration was given of the selective absorption of alkaloids by what is now known as Lloyd's reagent, a selected fuller's earth (hydrated aluminium silicate) especially treated to give extreme fineness of grain and great absorptive power. The absorption is carried out in acid solution and presents a distinct advance in the technique of alkaloid separation and manufacture. The action is extremely rapid and applies to practically all alkaloids. However, though the application of the reagent as an absorbent for alkaloids used in the therapeutics looks promising, its application as a remedy in alkaloid poisoning has so far been unsuccessful, owing to the liberation of the alkaloid in the alkaline parts of the alimentary tract. A considerable number of slides were presented showing micrographs of the reagent and its absorption compounds.

E. C. McKelvy, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 307th meeting was held in the lecture room of the Cosmos Club on March 22, 1916.

INFORMAL COMMUNICATIONS

E. T. Wherry presented a communication on the cavities in vein fillings of the basalt near Paterson, New Jersey. He showed that the lozenge-shaped cavities from a shale in eastern Pennsylvania were like those in the basalt. These cavities correspond to glauberite crystals. (Published in full in Journ. Wash. Acad. Sci. **6**: 181–184. 1916.)

REGULAR PROGRAM

R. B. Sosman and J. C. Hostetter: *Zonal growth in hematite and its bearing on the origin of certain iron ores.*

In studying the natural oxides of iron, the authors have observed that some of these can be separated magnetically into fractions. They have also shown (Journ. Amer. Chem. Soc., April, 1916) that ferric oxide (Fe_2O_3) and magnetite (Fe_3O_4) form a series of solid solutions in which the percentage of FeO increases continuously from zero to 31.03, which is the percentage in magnetite. The oxides become increasingly magnetic as the percentage of FeO increases.

The powdered oxide from certain crystals of hematite from Elba contains considerable FeO and can also be fractionated magnetically. It is therefore not homogeneous, as would be the case if the crystal were a uniform solid solution throughout. Analyses and magnetic measurements on a cross-section of an Elba crystal showed that the magnetic susceptibility and percentage of FeO vary, not irregularly, but continuously, being highest at the base and lowest at the free-growing tip of the crystal. The crystal is therefore zoned with respect to its FeO content. The physico-chemical conditions which could bring about such a zonal growth were discussed.

R. W. Pack: *Structural features of the San Joaquin Valley oil fields, California.* (Illustrated.)

The general features governing the occurrence of oil in the San Joaquin Valley are (1) the presence of material in which the oil originated; (2) an avenue affording an easy escape for the oil from this material in which it originated; (3) lithologic and structural features that together form a reservoir favorable for the accumulation of this oil.

The first condition is satisfied by the presence of thick formations of shale composed largely of the remains of minute organisms—diatoms and foraminifers—and it appears certain that it is in these formations and from these organisms that the petroleum originated. The escape of the petroleum from these shales is rendered easy by the unconformable relation at the top of the shales. Adequate reservoirs are afforded by the sandy beds that rest upon the truncated edges of the shale. Numerous anticlines heading in the central part of the ranges on the west side of San Joaquin Valley, running out into and plunging beneath that valley, form traps in which the oil has accumulated and is now retained. Each of the productive fields on the west side of the San Joaquin Valley shows all the features listed and the intervening non-productive areas lack one or more of them.

The sandy beds that form the reservoirs for the oil outcrop in or near the fields. Escape of the oil is prevented by a sealing of these beds by tar. This tar is the result either of the fractional distillation of the oil and removal of the lighter constituents or of interaction of oil and mineral waters, both probably being effective. Oil moving upward through the sandy beds overlying the shales, being prevented by this tarry seal from further movement, moves outward down the dip through sandy beds lying stratigraphically above the bed resting unconformably upon the shale. Oil moves through these upper beds away from the plane of unconformity until its further movement is prevented by a sealing of these upper beds by tar. The tarry seal in this case may be formed, as in the case with the outcrop, by natural fractionation of the oil, but in the deeper sands it is evidently caused chiefly by the action of "edge water" on the oil. The tarrification of oil in the presence of water is well recognized in the fields, and this knowledge is of practical value in drilling for the deeper sands, since it furnishes a guide as to the proximity of water.

The productive sands, although occurring in a definite zone in the lower part of the formation that rests upon the shale, are not continuous sands, but lie rather in a step-like arrangement, one small oil sand above another, all of them abutting against the diatomaceous shale on the flanks of the anticline, but diverging more and more widely from the shale toward the axis of the syncline.

Charles T. Lupton: *Notes on the stratigraphic and structural relations in southern and eastern Bighorn Basin, Wyoming.*

Bighorn Basin is a large topographic and structural depression in northwest Wyoming nearly surrounded by Bighorn, Bridger, Owl Creek, and Shoshone Mountains. It is drained by Bighorn River, which flows through deep canyons in the mountain rim at the south (Wind River Canyon) and at the northeast (Bighorn Canyon).

The rocks exposed in the basin range from Cambrian to Quarternary in age. Only those formations between the Morrison and the base of the Wasatch were considered in detail. Leaves of Cretaceous age were found during the field season of 1915 in the upper part of the Morrison formation near Ten Sleep. The overlying Cloverly formation, Thermopolis and Mowry shale, Frontier formation, Cody shale, Mesaverde formation, Bearpaw (?) shale, Lance (?) and Fort Union formations were described in considerable detail. Of these, the Cloverly, Mowry, and Frontier produce a light, high grade oil and some gas. The Cody shale is equivalent to the upper part of the Colorado and the lower part of the Montana groups. The Mesaverde on the south and east sides of the basin is believed to correspond to the Gebo on the west side, Bearpaw (?) to part or all of the Meeteetse, and the Lance (?) to the Ilo. No evidence has been obtained in Bighorn Basin to prove that the beds designated Bearpaw (?) or Meeteetse are marine.

Two unconformities are recognized in Bighorn Basin—one at the base of the Fort Union and the other at its top. Discordance in dip and lenses of conglomerate mark the unconformities.

Structurally Bighorn Basin is a vast geosyncline with minor folds developed on its flanks. Its axis trends northwest-southeast. The axes of the minor folds trend in the same general direction but more nearly parallel to the adjacent mountains. The upfolds are characterized by narrow flanks and steep dips on the mountainward sides and broad flanks and gentle dips on the basinward sides.

The anticlines and domes that produce most of the oil and gas are nearest the major axis of the basin. Many of the anticlines plunge into the basin and are of little value as oil and gas reservoirs.

Most of the anticlines are developed in rocks older than Wasatch, but in a few places that formation is deformed. Such a condition suggests a greater deformation of the beds on which the Wasatch rests.

Only a few faults are present. The greater number of them extend parallel to the strike of the beds. An unusual condition obtains at Greybull, where dip faults throw out the middle of the oil and gas field.

Carroll H. Wegemann, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 554th regular meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, April 8, 1916, at 8 p.m.; called to order by President Hay, with 65 persons present.

The President called attention to the recent death of Wells W. Cooke, Treasurer of the Society, and announced the appointment of Messrs. Hollister, Gidley, and Wetmore to draw up appropriate resolutions. The President also announced the election of Dr. Ned Dearborn to the office of Treasurer, made vacant by Mr. Cooke's death, also the appointment of Dr. Dearborn to the committee on publications.

On recommendation of the Council the following persons were elected to active membership: Robert M. Libbey, Washington, D.C.; G. K. Noble, Museum of Comparative Zoology, Cambridge, Massachusetts; and Dr. Howard B. Ames, U. S. Navy (Retired).

The following informal communications were made:

Dr. R. W. Shufeldt commented upon and exhibited specimens of a Japanese salamander, *Diemictylus pyrrhogaster,* obtained from a local dealer in live animals.

Dr. Paul Bartsch called attention to the introduction of the European agate snail, *Rumina decollata,* in certain parts of the southern states and to the recent publication by J. B. Henderson of a book entitled, *The cruise of the Tomas Barrera*, the narrative of a scientific expedition to western Cuba and the Colorados Reefs, with observations on the geology, fauna, and flora of the region.

Dr. M. W. Lyon, Jr., made remarks on the history of the *Filaria bancrofti* embryos exhibited at the previous meeting of the Society.

Mr. F. Knab discussed the mosquito host of *Filaria bancrofti*, saying that an appropriate species of Culex is found in Washington in the late summer.

The regular program was an illustrated lecture by Mr. Edmund Heller entitled, *Hunting in the Peruvian Andes*. Mr. Heller gave an account of a recent collecting trip made by him from the west coast of Peru up into the high Andes and down to the head waters of the Amazon. He described the animals collected, mainly mammals, but also birds and reptiles, including the rare spectacled bear, wild llamas, etc. He also commented on the habits and customs of the natives, and showed photographic lantern slides not only of the wild life, the inhabitants, and physiographic features, but also of many points of archeologic interest.

M. W. Lyon, Jr., *Recording Secretary*.

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 492d meeting, held December 21, 1915, Dr. J. Walter Fewkes, of the Bureau of American Ethnology, gave an illustrated lecture on his archeological investigations in the Mesa Verde National Park during the preceding summer. The substance of the address has since been given in this Journal (**6**: 212–221. April 19, 1916), although with a special view to a comparison between the "Sun Temple" excavated by him on the Mesa Verde and the so-called prehistoric "towers."

At the 493d meeting of the Society, held January 18, 1916, Dr. Tom A. Williams read a paper on *The origin of superstitions*. He stated that the forms which superstitions assume are imposed by traditional survival, but that superstitious feeling occurs when extraneous support is desired in too difficult situations. It is a reaction to inadequacy, especially prone to occur when the brain is numb with drugs, infections, body poisons, or fatigue. An attitude of mind may also induce it. Other refuges from the feeling of inadequacy or discomfort are drug-taking, wine-bibbing, tobacco-smoking, wandering about, various amusements, and even intemperate work. The fantastic personalities of our dreams, of which so-called psychic phenomena are merely a variety, give support to occultistic beliefs.

It is in the feelings themselves, however, that the origin must be sought, belief being merely an attempted rationalization of these, as when a person deduces from the exceptional character of his feelings during the experience a supernatural quality of the force that must have caused it. Such inferences need have no religious color. For instance, one patient with intact perceptions and intelligence declares, "It is black all around; there is no world there; but you can not understand, and I can not explain it." The root of this condition is a disturbance of the internal feelings, the cause of which is usually a physical disorder, a perverted body chemistry. However, as the feelings may be incited psychogenetically, and as the superstitious belief may persist even when the body chemistry is restored, it is necessary in dealing with them to understand the facts of human psychology, more especially of morbid psychology. The comfort brought by the feeling of support and the sense of refuge found in reliance upon a supernatural agent make their appeal very strong to inadequate persons. That is why the superstitious aspect of so many religions is clung to so fervently; for, not differentiating this from the essence of the religion, the devotee fears that the destruction of the superstition will entail the loss of the comfort brought by his religion, which is, of course, an improper inference.

That the religious aspect of these, however, is not that which makes belief in them so strong is proved by what so often happens during anaesthesia. For instance, Humphry Davy, on waking from nitrous oxide narcosis, had so grandiose a feeling of having made wonderful discoveries that he showed his contempt for those round him by walking about calling, "Nothing exists but thought; the universe is composed of impressions, pleasure, and pain;" and it took him some time to overcome his belief in the validity of this experience. Again, a young man, who, during anaesthesia for an operation, had the awful feeling of a world reverting to nothingness, could not shake off the belief in the terribleness of this, so that special measures had to be used to bring his mind into normal touch with the real world.

The color of the superstition depends upon the *zeitgeist;* but its fundamentals are psychopathological facts, and the study of their origin demands an extensive knowledge of the cognate phenomena revealed by persons with disturbed minds. Even in the case of amputated limbs a patient may declare himself "more sure of the lost limb than of the one he has." Like these instances the inexpressible wonderfulness of the mystic's experience is pure illusion and its origin is in feelings of similar kind.

The portion of the address on *The craving for the supernatural* appeared in the Medical Record for February 12, 1916.

At the 494th meeting of the society, held February 1, 1916, two papers were read. The first, by Dr. TRUMAN MICHELSON, of the Bureau of American Ethnology, was on *Ritualistic origin myths of the Fox Indians.* This has appeared in the Journal of the Washington Academy of Sciences (**6**: 209–211. April 19, 1916). In the discussion, a visitor, Mr. STEWART, who said that he had grown up among the Kickapoo, insisted that scientists should get behind the form of the myth to its meaning and that, although the solar explanation of myths, for example, had been overworked by Max Müller, there is a real esoteric meaning of the ritual in certain American tribes. Mr. LaFlesche agreed, from his knowledge of the Osage ritual, that all has a meaning and that nothing is nonsensical. Every bodily movement even has a symbolic significance; the prayers which the ritual contains are for safety, for health, and to secure offspring, that is, for the welfare of the tribe. Mr. Hewitt cited, in this connection, the Iroquois ritual for the installation of the chief, which recounted the history of the tribe and the formation of the League. Dr. Michelson replied that it is necessary to study the forms of rituals of different tribes in order to determine their origins, because it is evident that the interpretations now placed upon them are in nearly all cases secondary. Dr. Swanton, referring to the old question as to whether myth or ritual were prior, stated as the essential fact that myth and ritual are in association and that these associations as they exist should be the object of our study.

The second paper, by Mr. William H. Babcock, was entitled *Certain pre-Columbian notices of American aborigines.* It dealt mainly with records found in early Norse writings. Four regions were taken up in geographical order: The eastern coast of Greenland; the western coast of Greenland; Markland (probably Newfoundland), and Wineland and the neighboring regions. For the first he quoted from the Floamanna Saga the account of the attack of Thorgisl on the two "giant women" gathering driftwood; for the second, the statement of Islendingabok concerning the Skrelling relics found by the first Norse settlers, the mention in *Historia Norwegiae* of meetings between Norse hunters and Skrellings in the districts north of the settlements, the narrative of the far northward exploration of 1266 contained in a priest's letter (on which voyage no Eskimo were discovered, only the sites of their habitations), and the account of the two trolls who became servants of a shipmaster visiting Greenland. The account of the Markland captives was given from the Hauksbok version of Eric the Red; both of the accounts of the killing of Thorvald, as they present different views of the natives on the southeastern border of the Gulf of St. Lawrence; and both versions of the intercourse of Karlsefni and his people with the more southerly Wineland natives and the hostilities, which ended both it and the Norse scheme of colonization.

In answer to questions by Dr. Anderson, Mr. Stewart, Miss Breton, Dr. Folkmar, and others, Mr. Babcock said that he considered it probable that Irish monks reached America before the Norsemen. While some of the Celtic theories are fantastical, it is certain that Irish relics were found by the Norse in Iceland; that Disnil tells of a voyage made by them far beyond that island until they were stopped by the ice; that on such voyages they may have touched America; and that the western region which the Norsemen called Great Ireland, or White Man's Land, was probably a part of our coast. The evidence for a Chinese discovery of America was not considered sufficient to warrant quotations in the paper of the evening. "Fusang" may have been Korea, Japan, or at most the Aleutian Islands, although some of the products reported resemble those of Mexico. There is no positive evidence for priority of discovery by Basque or Breton fishermen. Corte-Real's voyage to Newfoundland occurred in 1500 A.D. The name Bacalaos applied to this land first appears on maps of a later date. On being asked what degree of reliance is to be placed on the Norse narratives, since they were handed down for a time by oral tradition before they were written down, Mr. Babcock said that the earliest dates of the writings are unknown; that the Erlendsson copy of the Eric the Red manuscript was made before 1334, perhaps about 1320; that the narrative which it contains bears evidence of having been composed in the eleventh century; and that a brief log of Karlsefni's voyage seems to be the kernel of part of the sagas. Certainly all of the details are not to be relied on.

At the 495th meeting, held February 15, 1916, Mr. Paul Popenoe addressed the Society on *Progress in the study of human heredity.* He said that man offers by far the most difficult material for the study of heredity and that the number of students who have undertaken to work upon it is small. The Eugenics Record Office, at Cold Spring Harbor, Long Island, New York, is the principal American agency; Dr. Alexander Graham Bell has founded a Genealogical Record Office in Washington for the study of longevity; many anthropologists are contributing to the knowledge of heredity in man; and various physicians and geneticists in colleges are also making contributions. The Galton Laboratory of National Eugenics at the University of London, directed by Karl Pearson, is the principal agency in England. On the continent of Europe the work is scattered among medical men and anthropologists.

It is now regarded as established that physical and mental traits are inherited with the same intensity and in the same manner. Most of the physical traits thus far studied have been abnormalities and are therefore not of great significance to race betterment; but the study of longevity and disease resistance points the way to important progress in eugenics. The study of mental traits has also dealt largely with abnormal or pathological conditions—feeble-mindedness, insanity, epilepsy, and the like. At present students are showing a tendency to take up the study of positive characters that are of more significance to the progress of the race.

In many cases an attempt has been made to show exactly how a given trait is inherited. Probably a hundred traits have been classed, at one time or another, as "known," but this list is greatly exaggerated. If the evidence for them were critically sifted, the traits of the exact mode of inheritance of which there could be no doubt would be reduced to a group not much larger than the following: Huntington's chorea, brachydactyly, and a white blaze in the hair (dominants); albinism and various rare diseases or pathological conditions (recessives). Some sexlinked characters are also definitely worked out, as one kind of color-blindness, one kind of night-blindness, haemophilia, and a few defects of the eye.

Concerning the heredity of many other traits, such as feeble-mindedness, we have enough knowledge to be of great social value. Most of our knowledge of the general principles of heredity will have to be learned through experimentation with plants and lower animals. Work with them has resulted in the elaboration of the "factorial hypothesis" of heredity, which is accepted by most advanced workers today; it assumes that every transmission of traits is due to the transmission of hypothetical "factors" in the germ-plasm and that each one of these factors influences an indefinitely large number of factors. These hypothetical factors are perhaps to be looked on as chemical reactions, one of which gives rise to another and so on in an unbroken chain during the development and differentiation of the embryo.

The present knowledge of heredity in man is sufficiently ample to form the basis for much sociological action—to guide a program of national eugenics; but it will be a long time before we can confidently give very much advice as to individual marriage matings.

Several speakers in discussing the paper maintained that environment is of more weight than heredity, notwithstanding the geneticists' claim to the contrary. Dr. Folkmar suggested that the evolution of man would be more rapid in the distant future than in the past, because it will be the result, in part, of artificial and not, as in the past, merely of natural selection. In the future, "evolution per saltum" will be possible, although it cannot explain the appearance of the Java man or the Neanderthal, or any other race that has evolved in the past.

Following the suggestion that alcoholic drinks hasten the survival of the fit by killing off the unfit, and that Indians are killed off faster than the whites by the use of alcoholic liquors because their race has not been weeded out through centuries of drinking, Dr. Anderson and others stated that many American tribes did have alcoholic drinks before the Discovery. Mescal was found in the Southwest, and the chicha, made from corn or bananas, still farther south. Dr. Michelson said, however, that alcoholic beverages were known but slightly north of Mexico prior to the Discovery.

Daniel Folkmar, *Secretary.*

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PHYSICS.—*The relation between color temperature, apparent temperature, true temperature, and monochromatic emissivity of radiating materials.* Paul D. Foote, Bureau of Standards.

In an earlier note[1] the relation between color temperature and true temperature was discussed. The present paper interrelates the color temperature, apparent temperature, true temperature, and monochromatic emissivity coefficient of a radiating material. A new method of determining the temperature coefficient of monochromatic emissivity is also considered.

Most metals are supposed to have practically zero temperature coefficient of monochromatic emissivity in the visible spectrum, a region of resonance where the well known Maxwell relations for emission coefficient do not apply. This supposition is not thoroughly warranted by experimental data, since the accuracy of many of the data is not sufficient to detect a 10 per cent change in emissivity over a temperature range of several hundred degrees. For some metals, moreoever, a small temperature coefficient of monochromatic emissivity has been observed. The following empirical equation may represent the emissivity for wave lengths in the visible spectrum and a moderate temperature range where A', c_2, p and q are constants, A the emissivity coefficient, T the absolute true temperature, and λ the wave length in microns.

[1] Foote and Fairchild, J. Wash. Acad. Sci. **6**: 193–197. 1916. In this paper the following corrections were overlooked in the manuscript. Eq. (3), change $+\frac{c_2}{\lambda}$ to $-\frac{c_2}{\lambda}$, page 195, Eq (5) and lines 10 and 14, change $+p$ to $-p$.

$$A = A' e^{\frac{c_2 p}{\lambda}} e^{\frac{q}{T}} \tag{1}$$

By proper choice of A', p, and q, the above equation can be adjusted to fit almost any curve of emissivity which is likely to be found experimentally. A type of dispersion of emissivity which it can not represent is that in which the emissivity possesses a very decided maximum in the middle of the visible spectrum. There is no experimental evidence of such a form of emissivity as a function of the wave length for metals, possibly excepting gold and copper. Over the small range of wave lengths comprised by the visible spectrum the emissivity of most metals is, within experimental observations, either increasing or decreasing linearly or exponentially with the wave length. All such variations are accounted for by adjusting the constant p. If the emissivity is constant with wave length, as in the case of a gray body, $p = 0$. Similarly, all probable variations in the emissivity with temperature over a reasonable temperature range are accounted for by adjusting the constant q. The only serious restriction to equation (1) is that it assumes all wave lengths of the visible spectrum have the same temperature coefficient of emissivity. This assumption is probably practically correct—there is no satisfactory experimental evidence bearing directly upon this point.

If a material having an emissivity coefficient given by equation (1) is compared spectrophotometrically with a black body at various temperatures, and the logarithmic isochromatics are plotted for various wave lengths (viz., logarithm of the ratio, at a definite wave length, of the intensity of radiation of the non-black body at true absolute temperature T to that of a black body at absolute temperature θ, versus $1/\theta$) these isochromatics will show the following form. (Natural logarithms throughout.)

$$\log \frac{J_2}{J_1} - \left(\log A' + \frac{q}{T}\right) = \frac{c_2}{\lambda}\left\{\frac{1}{\theta} - \left(\frac{1}{T} - p\right)\right\} \tag{2}$$

where

$$J_1 = c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\theta}} \quad \text{for black body}$$

$$J_2 = c_1 A \lambda^{-5} e^{-\frac{c_2}{\lambda T}} \quad \text{for non-black body}$$

Equation (2) represents a family of straight lines of variable parameter $\frac{c_2}{\lambda}$ intersecting at $\log A' + \frac{q}{T}$ and $\frac{1}{T} - p$. At the point of intersection the ratio of the intensity of the non-black body to the intensity of the black body is the same for every color. This by definition is a "color match" and the temperature of the black body when the condition of color match exists is the "color temperature" of the non-black body. Denote the color temperature by T', then

$$\frac{1}{T'} = \frac{1}{T} - p \tag{3}$$

If S denotes the apparent temperature of the non-black material for a wave length λ, equation (4) follows immediately from Wien's law,

$$\frac{1}{S} + \frac{\lambda \log A}{c_2} = \frac{1}{T} \tag{4}$$

and from equations (1), (3) and (4)

$$\frac{1}{S} - \frac{1}{T'} = -\frac{\lambda q}{c_2}\left(\frac{\log A'}{q} + p + \frac{1}{T'}\right) \tag{5}$$

which is a straight line of slope $-\frac{\lambda q}{C_2}$ when $\left(\frac{1}{S} - \frac{1}{T'}\right)$ is plotted against $\frac{1}{T'}$. The apparent temperature S and the color temperature T', easily measured quantities, may therefore be used to determine the constant q, and thus give the temperature coefficient of monochromatic emissivity.

Color temperature of carbon. From the work of Elisabeth Benedict[2] and also from some unpublished work of the writer it appears that the logarithmic isochromatics for a carbon lamp

[2] Ann. d. Physik, **47**: 641. 1915.

intersect at a point for any temperature of the lamp. That is, a perfect color match against a black body is possible at all temperatures. Hyde, Cady, and Forsythe[3] have published a table of color temperature versus apparent temperature ($\lambda = 0.665\mu$) for an untreated carbon filament lamp. If $\left(\frac{1}{S} - \frac{1}{T'}\right)$ is plotted against $\frac{1}{T'}$ using their observations, the relation is found to be linear within observational errors, in accordance with equation (5). From the slope of the line, q is found to be $+462$. Putting this value of q in equation (1) the monochromatic emissivity is seen to decrease with increasing temperature as follows.

TABLE I

TEMPERATURE ABSOLUTE	RELATIVE MONOCHROMATIC EMISSIVITY
1500	1.00
2000	0.92
2400	0.89

Mendenhall and Forsythe[4] experimentally found the emissivity at 1300 and 2300° absolute to be 0.86 and 0.79 respectively. This is in qualitative agreement with the above table.

Color temperature of tungsten. A more interesting verification of the correctness of the above equations is obtained by a consideration of Hyde, Cady, and Forsythe's[5] data on tungsten. In this paper a table is given of the observed color temperatures, true temperatures, and apparent temperatures ($\lambda = 0.665\mu$) for a tungsten lamp. From the values of the apparent temperature and true temperature the emissivity for $\lambda = 0.665\mu$ may be computed according to equation (4). Taking the value of $c_2 = 14350$ it was found that $e^{\frac{322}{T}}$ represents the temperature coefficient exactly. The coefficient p of equation (1) was found to be $+0.0000104$ and the general equation for emissivity of tungsten is as follows.

[3] J. Frank. Inst. **181**: 420. 1916.

[4] Astrophys. J. **37**: 389. 1913.

[5] Loc. cit. p. 419. Also Worthing, idem, p. 417.

(6) $$A = 0.304\, e^{\frac{0.1492}{\lambda}}\, e^{\frac{322}{T}}$$

Where λ = wave length in microns and T = true absolute temperature. The relation between the color temperature and true temperature follows from equation (3) viz. $1/T' = 1/T - 0.0000104$. The agreement between the computed and observed values illustrated in the following table is surprisingly good, and proves at once that the above theoretical relations have a sound physical significance.

TABLE II

OBSERVED VALUES				COMPUTED VALUES		
$S_{0.665\,\mu}$	T	T′	$A_{0.665\,\mu}$	$A \propto e^{\frac{322}{T}}$	T′	$T'_{obs} - T'_{comp}$
1627	1729	1763	0.458	0.458	1761	+2
1753	1875	1917	0.448	0.451	1912	+5
1840	1976	2025	0.446	0.447	2017	+8
1909	2056	2109	0.448	0.445	2101	+8
1967	2125	2179	0.442	0.442	2173	+6
2017	2184	2237	0.441	0.440	2235	+2
2062	2238	2290	0.439	0.439	2291	−1
2102	2286	2338	0.438	0.438	2342	−4
2113	2299	2350	0.438	0.437	2355	−5
2140	2332	2383	0.436	0.436	2390	−7
2174	2373	2425	0.435	0.435	2433	−8
Average deviation				±0.0008		±5°

As seen from columns 6 and 7, the color temperature, computed by equation (3) where $p = 0.0000104$, agrees far within experimental errors with the observed color temperature, the difference between the computed and observed values showing an average deviation of only 5°.

Using equation (6) one can predict what the emissivity at any wave length will be. Table III gives the emissivity of tungsten for several wave lengths. Whether equation (6), obtained indirectly from the color temperatures, can be used as far out as $\lambda = 0.4\mu$ is of course questionable. It is not likely however that the values are in great error.

TABLE III

T	Emissivity (c_2 = 14350)				
	0.7 μ	0.665 μ	0.6 μ	0.5 μ	0.4 μ
1700	0.455	0.460	0.471	0.50	0.53
1800	0.450	0.455	0.466	0.49	0.53
1900	0.446	0.451	0.462	0.49	0.52
2000	0.442	0.447	0.458	0.48	0.52
2100	0.439	0.444	0.454	0.48	0.51
2200	0.436	0.440	0.451	0.47	0.51
2300	0.433	0.438	0.448	0.47	0.51
2400	0.431	0.435	0.446	0.47	0.50

Color temperature of platinum. Koenigsberger has determined[6] the emissivity for various wave lengths in the visible spectrum for platinum at room temperature. If the logarithm of the emissivity is plotted against $1/\lambda$ the slope of the straight line is c_2p, whence p of equation (1) is directly determined. This computation gives p = 0.0000287. Waidner and Burgess[7] determined the emissivity of platinum at its melting point (assuming melting point = 1755°C.) for three different wave lengths. Their values give p = 0.0000185. It is quite possible that this latter value of p is too low because of the difficulty in obtaining accurate measurements of emissivity at high temperatures. If both values of p are correct platinum must have a temperature coefficient of emissivity and the temperature coefficient must be a function of the wave length. The following table shows the relation between the color temperature and the true temperature of platinum, based on both values of p.

TABLE IV

p = 0.0000287			p = 0.0000185	
T	T′	T′ − T	T′	T′ − T
1000	1030	30	1019	19
1500	1567	67	1543	43
2000	2122	122	2077	77

[6] Ann. d. Physik, **43**: 1205–22.
[7] Bur. Stds. Sci. Paper No. 11, p. 244. 1905.

The interesting point is that the color temperature of platinum at the melting point must be 80° and possibly 120° higher than the true temperature. This is at variance with the conclusions drawn by Paterson and Dudding,[8] who claim that platinum is practically gray thus requiring that $p = 0$ and $T = T'$.

Conclusion. The various relations between color temperature, apparent temperature, and true temperature are pointed out for the first time. These relations are checked by observations of Hyde, Cady, and Forsythe on tungsten and are found to agree excellently with experiment. Color temperatures open a new field in the subject of optical pyrometry which is certain to prove highly interesting. Color temperature may be measured by the spectrophotometer using the method of logarithmic isochromatics, or by an ordinary photometer if the observer is skilled in color matching. A still better means perhaps of studying the color temperatures of various materials is by use of a suitable form of colorimeter. Measurement of the dominant hue of a black body and of metals at various temperatures is a field of investigation as yet untouched.

PHYSICS.—*Luminosity and temperature of metals.* PAUL D. FOOTE, Bureau of Standards.

Recently Mr. Fairchild and the writer published a paper on the relation between the luminosity and temperature of a black body.[1] In the present note this work is extended to apply to the case of radiation from metals, and from oxides for which the emissivity coefficient can be represented by equation (4) below. Luminosity of a black body is defined as the integral from 0 to ∞ in respect to $d\lambda$ of the product of visibility (V) and energy (J) of the radiating source thus:

(1) $$L = \int_0^\infty VJd\lambda$$

where $V = f(\lambda)$ and $J = c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\theta}}$ = Wien's law.

[8] Proc. Phys. Soc. London, **27**: 253. 1915.

[1] Bureau of Standards Sci. Paper No. 270. 1916.

The integral of equation (1) obtained graphically using the data of Ives, Nutting, and Hyde and Forsythe for visibility was found to have the following form.

$$L = P\left(\frac{\theta + B}{\theta + C}\right)^D \tag{2}$$

where, for

$$c_2 = 14450$$

$$\begin{aligned} B &= -\ 105.92 \\ C &= +\ 265.46 \\ D &= +\ \ 72.166 \end{aligned}$$

The luminosity of a non-black body, such as a metal, is defined by equation (3) where A is the emissivity coefficient of the non-black material.

$$L' = \int_0^\infty AVJd\lambda \tag{3}$$

The writer has shown[2] that for most metals the emissivity coefficient can be accurately represented by equation (4) where A', p, and q, are constants, λ the wave length in microns, θ the true absolute temperature.

$$A = A' e^{\frac{pc_2}{\lambda}} e^{\frac{q}{\theta}} \tag{4}$$

If equation (4) is substituted in (3) one obtains the following:

$$L' = A' e^{\frac{q}{\theta}} \int_0^\infty c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\theta}} e^{\frac{pc_2}{\lambda}} V(\lambda)\, d\lambda \tag{5}$$

(6) Let

$$\frac{1}{\theta'} = \frac{1}{\theta} - p$$

(7) then

$$L' = A' e^{\frac{q}{\theta}} \int_0^\infty c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\theta'}} V(\lambda)\, d\lambda$$

The integral in equation (7) is identical with that of (1) hence from (2):

$$L' = A' e^{\frac{q}{\theta}} P\left(\frac{\theta' + B}{\theta' + C}\right)^D \tag{8}$$

[2] This Journal, **6**: 317–323. 1916.

which represents the luminosity of a non-black body at temperature θ where θ' is given by equation (6). It is well known that θ' is the color temperature[3] of the non-black body.

Application of equation (8) to the determination of the melting point of tungsten. Langmuir[4] found the luminosity of tungsten to be 6994 candles per square centimeter at its melting point. Equation (8) may be used to determine the temperature corresponding to this value of the luminosity after the constants P, A' p, and q have been evaluated. The constant P is obtained by equation (2) from the work of Hyde, Cady, and Forsythe[5] upon the brightness of a black body at various temperatures. The result of this computation is shown in the following table.

TABLE I

θ	candles/cm^2	$P \times 10^{-7}$
1700	5.3	1.94
1800	11.3	1.84
1900	24.4	1.92
2000	45.0	1.84
2100	80.0	1.80
2200	146.0	1.91
2300	248.0	1.97
2400	382.0	1.93
2500	600.0	1.98
2600	880.0	1.97

Mean $P = 1.91 \pm 0.05 \times 10^7$

The constants p and q, on the basis of Hyde, Cady, and Forsythe's[6] data for color temperature, true temperature and apparent temperature of tungsten were found[7] to have the values $p = +0.0000104$ and $q = +322$. On the basis of $c_2 = 14450$ and these data $A' = 0.303$. From equation (6) θ' is found, whence from equation (8) L', the luminosity for various values

[3] FOOTE and FAIRCHILD, J. Wash. Acad. Sci. **6**: 195. 1916. FOOTE, this JOURNAL, **6**: 317–323. 1916.

[4] Phys. Rev. **6**: 141. 1915.

[5] J. Frank. Inst. **181**: 421. 1916.

[6] J. Frank. Inst. **181**: 419. 1916. Also WORTHING, idem, p. 417.

[7] FOOTE, this JOURNAL, **6**: 317–323. 1916.

of the true temperature θ may be computed. From a curve of L' versus θ the temperature corresponding to a luminosity of 6994 candles per square centimeter is found to be 3712° absolute. If one uses Langmuir's values of the emissivity, the constants A', p, and q have the values: $A' = 0.388$, $p = + 0.0000079$, and $q = 0$. This gives a temperature of 3660° absolute for the melting point of tungsten.

Summary. An equation has been derived giving the relation between luminosity and temperature of a non-black body, more especially a metal. This has been applied for the computation of the melting point of tungsten from Langmuir's determinations of the luminosity of tungsten at its melting point. The value of 3712° absolute is obtained on the basis of Hyde, Cady, and Forsythe's and Worthing's measurements on the color temperature, true temperature, and apparent temperature of tungsten. If Langmuir's values for the emissivity are used, the melting point is found to be 3660° absolute. Both of these values are computed on the basis of $c_2 = 14450$ and upon Hyde, Cady, and Forsythe's values of the luminosity of a black body at various temperatures.

CRYSTALLOGRAPHY.—*Crystals and crystal forces.*[1] F. E. WRIGHT, Geophysical Laboratory.

The object of this paper is to state a problem, namely, that of the measurement of crystal forces, and to discuss briefly some of the more important phenomena which result from the action of these forces and which may possibly be of value in the solution of the general problem.

A crystal is a body whose component atoms are arranged in definite space lattices; this arrangement is probably the result of the vectorial action of interatomic forces and, as a rule, finds outward expression in the development of flat crystal faces. In this definition no reference is made to the state of cohesion of the body, whether solid or liquid; nor to its homogeneity. Ordinarily these attributes are essential and are included in the definition; but the discovery of liquid crystals by Lehmann has

[1] Read before the Geological Society of America on December 29, 1915.

rendered rigidity in a crystal a less fundamental characteristic than it was formerly supposed to be; while the common occurrence of zonal growth in natural mix-crystals has taken away some of the emphasis which used to be placed on chemical and physical homogeneity. In general, crystals are rigid and show a high degree of homogeneity and are bounded by flat faces; but the fact that these characteristics are lacking in certain individual units has an important bearing on the theory of crystal growth and crystal forces.

In crystals there is a regular periodic arrangement in space of the component atoms. All theories of crystal structure are based on this postulate which in recent years has been confirmed by the brilliant investigations, especially, of Professor W. H. Bragg and his son, W. L. Bragg, on the phenomena of diffraction and reflection of characteristic X-rays from oriented crystal plates. From this it may be inferred that the orderly arrangement of the atoms in interpenetrating space lattices is the result of the action of interatomic forces which are spacially vectorial in character. Little is known, however, of the order of magnitude of these forces and of the law of their variation with distance. The problem of measuring these forces and of ascertaining the laws describing their behavior may be treated from different viewpoints.

Development of crystal forms. The development of crystal forms as it has been stated by Victor Goldschmidt[2] in his law of complication is a remarkable expression of the action of crystal forces; this law may, in a given crystal substance, enable us to ascertain the directions of the primary poles of attraction in the crystal structure.

Crystal growth. Studies on the rate and character of crystal growth have added much to our knowledge of the individuality of a particular crystal group and also of the mechanism of crystal growth. The importance of diffusion and adsorption in crystal growth is now clearly recognized; Marc[3] and others have shown

[2] Uber Entwickelung der Kristallformen. Zeitschrift für Kristallographire, **28**: 1. 1897.

[3] Zeitschrift für Physikalische Chemie, **67**: 470. 1909; **67**: 640. 1909; **68**: 104. 1909; **73**: 685. 1910; **75**: 710. 1911; **79**: 71. 1912; **81**: 641. 1912.

that the presence, in the solution, of minute quantities of certain colloids or semicolloids may influence profoundly the rate and character of crystal growth, these colloids probably entering into the surficial adsorbed layer and changing greatly the rate at which the molecules diffuse through the adsorbed film to the growing crystal. Gibbs concluded from thermodynamical relations that, because of the vectorial character of crystals, the surface tension on different crystal faces is different and that, therefore, a difference in the solubility of these faces must exist; Curie inferred that in a growing crystal the tendency exists, by virtue of surface tensional forces, to develop in such form that the total surface energy is a minimum. Ritzel and Marc[4] concluded further that because of the differences in solubility of the different faces the tendency also exists for the less soluble forms to develop at the expense of the more soluble and that, therefore, the final crystal form represents the equilibrium adjustment between these two tendencies, namely, toward total minimum surface energy and toward faces of minimum solubility. The same relations should, of course, obtain for vapor pressures over different faces, since vapor pressure may be looked upon as solubility in a vacuum. Experimentally these relations are very difficult to test satisfactorily, partly because of the formation of etch figures. It is probable that accurate vapor pressure measurements will furnish results least open to criticism.

Field of atomic forces. The distances through which atomic and molecular forces act effectively have been shown by different methods to be of the order of magnitude of 5 $\mu\mu$. Lehmann observed that small acicular liquid crystals of ammonium oleate on precipitation from solution exert, if sufficiently close together, a mutual orienting influence; and that, finally, after having attained strict parallelism, they coalesce. Certain liquid crystals are susceptible, moreover, to the orienting influences of a magnetic field. The analogy between a magnetic field and the field of the atoms and molecules in a crystal is more significant than may appear at first sight. In modern theories on the

[4] Zeitschrift für Physikalische Chemie, **76**: 584. 1911.

constitution of matter the atom is considered to consist of an electrically positive nucleus surrounded by negative electrons. The fields surrounding the atoms in a crystal may be electromagnetic in nature.

Influence of a crystal system of forces on other systems of forces, especially light waves. Crystals exert a profound influence on transmitted light waves. The effects which are thereby produced constitute the subject matter of crystal optics, in which light waves are commonly treated from the viewpoint of the electromagnetic theory. It is known that with change in pressure or in temperature the distances between the component atoms of a crystal are changed slightly and that these slight changes induce corresponding changes in the optical constants of the crystal. Under these conditions we are dealing with two distinct systems of forces, the crystal system and the light wave system; by measuring quantitatively the differential shifts which these slight changes in the crystal system of forces produce in the light wave system of forces we obtain a relation between the differential changes in the two systems of forces; in short, a differential equation which, if we can integrate it and determine the constants in terms of absolute elastic units, will enable us to determine the form of the force-function of the crystal system and thus to obtain a measure of atomic forces. This problem is now under attack at the Geophysical Laboratory. Apparatus has either been built or is under construction for measuring accurately the changes in the crystallographical and optical constants of crystals for temperatures ranging from $-190°$ to $+1600°$C. and for hydrostatic pressures ranging from 1 to 2000 atmospheres.

The fact that in a crystal each of the component atoms is restricted largely to minute translational oscillations about a point, in other words is limited in its degrees of freedom, is exceedingly important from a thermodynamical standpoint. Thermodynamics is a general system of statistical mechanics applied to the energy relations involved in heat and work; because of its generality thermodynamics is applicable to a great variety of problems, but the mode of its application requires nice discrimination in problems which are essentially vectorial in character, as are problems involving differences in directional crystal forces. A large number of the minerals which occur in nature are of the monotropic type and many of the reactions are examples of thermodynamically false equilibria and yet these may exist for geologic ages without change. In applying thermodynamical reasoning to problems of equilibria between crystals, it is essential that the individuality of the crystals be considered, especially as this introduces factors which may be superior in magnitude to the thermodynamical tendencies toward equilibrium, i.e. a configuration for which at the given temperature the total energy content is a minimum. Thus, to speak of the lack of crystallization in a volcanic obsidian because of an exceedingly slow rate of reaction, does not describe the situation adequately, because in the volcanic glass the internal friction at ordinary temperatures is so high that it is superior to the crystal forces and completely inhibits effective action on their part; the viscosity serves as a brake and may bring the crystallizing tendencies to a stop. Similar conclusions apply to the general application of thermodynamical equations to problems involving the elastic properties of crystals, especially to the deformation of a crystal under load.

In the treatment of problems of this nature which involve crystallization it is important to realize that the influence of certain forces which are grouped under the term "individuality" of the crystal may exceed in importance the thermodynamical tendencies toward equilibrium. In crystal as in other systems thermodynamical relations are fundamental, but equally fundamental are the vectorial and polar force-relations which heretofore have been little regarded because of the difficulty of defining and of measuring them satisfactorily. Many of the problems of crystal equilibria are of such a nature that in order to effect a complete solution neither thermodynamics alone is adequate, because of its inherent inability to treat vectorial and polar properties properly, nor is crystallography alone adequate, because it considers chiefly the single crystal. Progress can best be made by bringing to bear on the problem both thermodynamics and crystallography. The recognition and delineation of the fields of application of thermodynamics and of crystallography in problems of crystal equilibria is an essential step in the solution of such problems; but before this can be done satisfactorily more quantitative data on interatomic crystal forces are required.

The rock-making minerals. As a good example of the kind of problem in which crystal configurations of certain types persist over a great range of conditions of formation, the rock-making minerals may be cited. The most remarkable fact in petrology is the relatively few rock-making mineral species, especially in igneous rocks. These few minerals persist the world over and constitute the major part of the rocks of the earth's crust; and yet their number can be counted on the fingers of the two hands—thus quartz, the feldspars, micas, amphiboles, pyroxenes, nephelite, and calcite predominate; magnetite, zircon, apatite are also common, but their total amount is small. This persistency of a few mineral species, notwithstanding great diversity in conditions of formation and in chemical composition, is fundamental. In magma solutions such factors as temperature, pressure, solubility relations, rates of reaction, change in composition by virtue of escape of volatile components, and crystal nucleation enter the problem; but it appears that, in spite of the great diversity possible in such complex chemical systems, the crystal groupings of the chemical elements, which do result, are exceedingly few in number. These groupings represent, of course, the resultant of all the forces involved; the problem is in part to ascertain the relative importance of these several factors. It may be inferred that possibly the dominating factor in the crystallization of a magma is the stability of certain crystal types or configurations and that these assert themselves notwithstanding tendencies toward other groupings which thermodynamically are more stable. Of crystallographic interatomic forces we know but little. The facts of observation are, however, too patent to be disregarded in any consideration of rock genesis, and are here cited as the kind of problem in which a better understanding of crystal forces and of crystals is essential to an adequate solution. The study of crystals from the viewpoint of crystal forces is an integral part of geophysical and geochemical research.

MINERALOGY.—*Xanthophyllite in crystalline limestone.* ARTHUR S. EAKLE, University of California, Berkeley, California. (Communicated by EDSON S. BASTIN.)

The rare brittle mica xanthophyllite has not been reported from any localities other than those in the district of Slatoust in the Ural Mountains, where it, and its variety waluewite, were found.

The xanthophyllite described and named by Gustav Rose[1] was a wax-yellow mineral in scales and plates, occurring as a constituent of a talc-schist in the Shiskimskaya Mountains, in the Urals, and this yellow color was probably exceptional.

Many years later the green variety was found, and named waluewite by Kohscharof.[2] The waluewite occurred as a constituent of chlorite schist in the Nicolai-Maximilian Mine, near Slatoust. Small veins of calcite which occurred in the schist also contained flakes of the mineral, merely as inclusions, however. The original yellow xanthophyllite and green waluewite were schist minerals; so it may be of value to note the occurrence of the green waluewite in another locality, and as a contact metamorphic mineral in crystalline limestone, in association with monticellite.

The isolated hill of crystalline limestone and granodiorite situated at Crestmore, about eight miles west of Riverside, California, is one of the best studies in contact metamorphism that exists anywhere, and upwards of fifty mineral species, among them the recently described new mineral, wilkeite,[3] have been found in the same quarry. The white marbleized limestone rests as a capping upon a base of granodiorite, and the general metamorphism of the original limestone beds has probably been

[1] Pogg. Ann. d. Phys. u. Chem. **50**: 654. 1840. Also in his "Reise nach dem Ural," **2**: 120, 514, 527. 1842.

[2] Zeits. fur Kryst. **2**: 51. 1877. Also in his Mineral d. Russ. **7**: 346.

[3] EAKLE, A. S., and ROGERS, A. F. Amer. Jour. Sci. **39**: 262. 1914.

due to intrusion of, and contact with, this igneous mass. Metamorphism has been repeated, however, in portions of the rock mass by later injection of dikes and hot solutions, and in consequence parts of the hill have been mineralogically enriched by further development of lime-magnesia-silica minerals. The Crestmore waluewite was thickly disseminated in some of the sky-blue calcite of the Commercial quarry on the northeast side of the hill, as indicated by the specimens saved from destruction. It is said that tons of the sky-blue calcite containing the waluewite were quarried and used for road-making, for sugar refining, and for cement, and in consequence, all of it has disappeared.

The waluewite occurs mainly as isolated, hexagon-shaped, basal plates of a deep grass-green color. The sizes of the plates vary greatly, some measuring 3 to 4 cm. in diameter and 2 to 3 cm. thick. The average size of the crystals is about 5 mm. in breadth and 4 mm. in thickness. The plates are transparent with a brilliant and somewhat pearly luster, but the edges are dull, rounded and grooved, and the measured angles did not approximate any of the forms given by Kohscharof. The plates are very brittle with a hardness of 4–5. The thicker crystals show polysynthetic twinning like the micas, and under the microscope they extinguish in striated sectors and give a confused axial figure. The thinner crystals and cleavage plates give a good biaxial figure with an apparent optic angle of about 20°. Measurements of the optic angle in sodium light showed a variation from 12° to 18°. The optic axial plane is (100) and the mineral is optically negative. The refractive indices β and γ which lie in the basal section are practically the same and were determined as 1.660.

Several analyses of the xanthophyllite and waluewite from the Urals have been published and the analysis of the Crestmore mineral agrees with them.

The associated monticellite is scattered through the calcite as small masses and grains. It appears to be more segregated along the cleavage planes of the calcite rhombohedrons, and is often in close association with the flakes of waluewite and occasionally includes the waluewite. One large specimen shows a wide band of massive monticellite, indicating that it was an abundant mineral. The color is pale brown and luster somewhat greasy. There are no crystal faces visible. The analysis gave: SiO_2, 36.02; FeO, 2.82; CaO, 34.36; MgO, 24.74; Ign., 1.25; total, 99.19.

TABLE I

ANALYSES OF WALUEWITE FROM CRESTMORE AND SLATOUST

	1	2	3
SiO_2	16.74	16.39	16.85
TiO_2			tr.
Al_2O_3	42.70	43.40	42.33
Fe_2O_3	2.85	1.57	2.35
FeO	0.41	0.10	0.20
CaO	13.09	13.04	13.30
MgO	20.03	20.38	20.77
Ign	4.49	4.39	4.60
	100.31	99.27	100.40

1. Average composition of waluewite from Crestmore, California. Sp. gr. 3.081.
2. Analysis by Nikolajen of waluewite from Nikolai-Maximilian Mine, District of Slatoust, Urals. Zeit. für Krys. **9**: 579. (Abstract).
3. Analysis by Clarke and Schneider of waluewite from Nikolai-Maximilian Mine, District of Slatoust, Urals. Amer. Jour. Sci. **43**: 379. 1892.

The association of the two minerals is of particular interest, because waluewite may be viewed as having the composition of monticellite with the spinel and alumina hydrate molecules. In the discussion by Clarke and Schneider of the constitution of the members of the clintonite group it was suggested that waluewite may have the monticellite molecule in addition to its spinel and olivine molecules, although no direct association of the two was then known.

The two Crestmore minerals are products of hydrothermal metamorphism of the limestone, and the waluewite has crystallized in a lime carbonate solution in which the monticellite molecule was the predominating component of the silicate mixture and presumably governed the formation of the waluewite, the small excess of silica and all of the alumina entering into the waluewite which formed somewhat prior to the monticellite.

Monticellite occurred in large masses, while the waluewite was quite subordinate in amount. The composition of waluewite suggests a mineral mixture of monticellite + olivine + spinal + diaspore in the respective approximate ratio of 6 : 1 : 5 : 6.

The recrystallization of the limestone produced a pure blue calcite with coarse rhombohedral texture. Cleavage rhombohedrons several centimeters in diameter can be broken from the mass.

The source of the magnesia, alumina and silica is somewhat problematical. The original limestone was not especially dolomitic or argillaceous as the main limestone capping averages about 2 per cent magnesia and about the same in insolubles. The blue calcite with its monticellite, waluewite, vesuvianite, diopside, wilkeite, etc., is very localized in its development, occurring in patches and bands or zones. It suggests an occurrence near the contact with former dikes or apophyses of igneous rock, and it appears highly probable that the assimilation of the magnesian-felspathic constituents of these intrusions with the lime carbonate by the action of hot magmatic solutions had produced these localized occurrences of hydrometamorphic minerals.

BOTANY.—*Pamburus, a new genus related to Citrus, from India.*

Walter T. Swingle, Bureau of Plant Industry.

In 1833 Dr. Robert Wight described as a new species *Limonia missionis,* a small, spiny tree from the sandy coastal regions of southern India. In 1861 this species was referred to the genus Atalantia by Oliver, who notes, however, that it is "rather isolated in its general *facies* as well as by precise characters."[1] Subsequent botanical writers have followed Oliver in referring this plant to Atalantia.

[1] Oliver, D. *Nat. order Aurantiaceae.* Journ. Linn. Soc. **5** (suppl. 2): 12. 1861.

In the course of a revision of the plants related to Citrus it has been possible for the writer to examine much material referred to the genus Atalantia and it has become evident that decidedly diverse plants have been put into this genus. The true Atalantias congeneric with the type species, *A. monophylla* (Roxb.) DC., have fruit resembling miniature oranges, with pulp vesicles somewhat like those of other citrous fruits. *Atalantia missionis*, on the contrary, has, as noted by Wight in the original description, a small fruit with cells "containing a very glutinous mucilaginous fluid." Besides this very significant distinction, *A. missionis* differs from *A. monophylla* and its congeners in having the anthers linear-oblong instead of broadly ovoid, and in having a tall, narrow disk supporting the ovary, instead of a very short, thick one. The leaves differ widely from those of the true Atalantias in texture and venation, being thick, glabrous, with both faces nearly alike, and velvety gray-green when dry, showing only a very few obscure lateral veins and no reticulate veinlets.

Because of these numerous points of difference, some of them of much taxonomic value in this group, it seems necessary to create a new genus, Pamburus,[2] to include this remarkable species.

Pamburus Swingle, gen. nov.[3]

Much-branched thorny shrubs or small trees; young branches angled, becoming rounded when older, with single stout sharp straight thorns at one side of the bud in the axils of the leaves. Leaves unifoliolate,

[2] From the Singhalese name *pamburu*.

[3] **Pamburus** Swingle, gen. nov., *Paramignyae* affinis, sed frutex vel arbuscula, foliis crassis, coriaceis, utrinque similibus, venis inconspicuis, petiolis brevibus, rectis, pulvinis carentibus, ovario disco magno innixo.

Folia unifoliolata, petiolis brevibus apteris; laminae crassae, siccitate cinereovirides, superficiebus superioribus et inferioribus similibus, venis secondariis inconspicuis, tertiis carentibus; spinae singulae, rectae, axillares. Flores magnitudine mediocres, odoratae; petala alba, obovata, caduca; stamina libera, filamentis tenuibus, subulatis; stylus tenuis; stigma subglobosum diametro stylo multo majus; ovarium 5–4-loculare, ovulis in loculo binis. Fructus subglobosus, cortice ut in *Citro* carnosa, loculis 1–2-spermis, liquoris glutinosi plenis. Semina subglobosa.

Arbusculae vel frutices ramosi, spinosi, ramulis junioribus angulosis. Species typica, **Pamburus missionis** (*Limonia missionis* Wight). Habitat in India.

thick; lateral veins inconspicuous, not visibly connected by reticulate veinlets; petioles short, more or less margined but not winged, not articulated with the lamina. Flowers small, 5- or 4-merous, borne in short racemes in the axils of the leaves on rather long pedicels. Calyx small, 4–5-lobed; sepals acute. Flower buds globose when young. Petals 5 or 4, white, obovate. Stamens free, 8–10 (twice as many as the petals); filaments free, slender, glabrous; anthers large, erect, linear-oblong. Pistil stipitate, seated on the prominent cylindric disk; style slender, short, ending in the much thicker subglobose stigma; ovary subglobose 5- or 4-celled, with 2 ovules in each cell. Fruits globose, like a small orange in appearance, with the cells usually containing a single seed surrounded by a glutinous mucilaginous fluid (lacking true pulp vesicles). Peel rather thick, firm, with numerous oil glands. Seeds subglobose. Germination unknown.

Type species, **P. missionis** (*Limonia missionis* Wight), native to India.

The genus Pamburus differs from Paramignya in having short petioles, lacking the pulvini characteristic of the latter genus, and in the very different character of the leaves which are nearly veinless and very similar on both faces. The spines of Pamburus are straight or nearly so, not recurved as in Paramignya. Pamburus is a tree or shrub, not a perennial woody liane like Paramignya. Pamburus differs widely from Merope in the character of the fruit and seeds, and from Lavanga in having unifoliolate leaves. Hesperethusa, Triphasia, and Severina differ widely in leaf and fruit characters.

Pamburus belongs with the genera mentioned above in a group characterized by small soft-rinded fruits having the segments filled with a sticky fluid. The true citrous fruits differ from this group in having soft-rinded fruits, but the segments filled with pulp vesicles. The hard-shelled citrous fruits are again different and have large fruits with a hard, usually woody rind, though likewise cells filled with a sticky fluid.

In the peculiar structure of its leaves Pamburus is unique in the tribe Citreae, though possibly showing some analogy with the xerophytic Eremocitrus[4] of Australia.

Only one species of Pamburus is known:[5]

[4] SWINGLE, WALTER T. *Eremocitrus, a new genus of hardy drouth-resistant citrous fruits from Australia.* Journ. Agric. Research, **2**: 86. 1914.

[5] *Chilocalyx ellipticus* Turcz., cited in Index Kewensis and Hook. Fl. Brit. Ind. (**1**: 513.) as a synonym of *Atalantia missionis*, is probably based on *Atalantia monophylla*. It certainly is not synonymous with the present species.

Pamburus missionis (Wight) Swingle, comb. nov.

Limonia (?) *missionis* Wall. Cat. No. 6358. 1832 (*nomen nudum*).

Limonia missionis Wight in Hook. Bot. Misc. **3**: 291, *pl. 33*. 1833.

Atalantia missionis Oliv. Journ. Linn. Soc. **5** (suppl. 2): 25. 1861.

A much-branched shrub or small tree, armed with stout straight spines, these 2–3 cm. long, arising singly (or rarely in pairs?) on the side of the bud in the axils of the leaves. Leaves oval, oblong-obovate or elliptical, 6–10 cm. long, 2–4 cm. broad, very thick, coriaceous, glandular-punctate, the tip rounded, sometimes slightly emarginate, the base narrowed rather abruptly into the petiole, the margin entire, becoming gray and apparently crenate in drying; lateral veins inconspicuous, tertiary ones not apparent, the two faces very similar in appearance, drying to velvety gray-green unlike those of any other member of the subfamily Citratae. Flowers 12–20 mm. in diameter, fragrant, with small pointed sepals and 5 or 4 white obovate caducous petals about 1 cm. long. Pistil about 1 cm. long. Fruit about 2.5 cm. in diameter, orange-colored when ripe, with a thick peel dotted with oil-glands, 5–4-celled, the cells containing 1 or 2 seeds surrounded by a sticky gum.

Type locality: Tanjore District, Madras Presidency, Southern India.

Distribution: Southern India and Ceylon, in low flat country near the coast.

The writer has had opportunity to study authentic cotypes, collected by Dr. Wight, in the Kew Herbarium, as well as other material from India and Ceylon.

POSSIBLE UTILIZATION OF PAMBURUS

It is possible that Pamburus is closely enough related to the true citrous fruits to serve as a stock upon which they can be grafted. The peculiar leaves of this species, unlike those of any other member of the orange subfamily, make it probable that it will be found to possess climatic or soil requirements different from those of related genera. This species has not yet been introduced into the United States, but it is hoped that it may be secured soon. It is native to southern India and Ceylon and, according to Trimen,[6] is rather common in the low country, chiefly in the dry region of Ceylon.

[6] Trimen, H. Handbook Fl. Ceylon, **1**: 228. 1893.

ETHNOBOTANY.—*Polynesian names of sweet potatoes.* O. F. Cook, Bureau of Plant Industry, and Robert Carter Cook.

The same word, *cumara* or *kumara,* serves as a name for the sweet potato (*Ipomoea batatas*) among the Quichua or Inca people of Peru and in the Polynesian islands. The fact was recognized over half a century ago when Seemann recorded the use of the word in Ecuador. In the Urubamba valley of southern Peru, on the eastern slope of the Andes below Cuzco, there are two native names for different classes of sweet potatoes, *apichu* for the sweet varieties and *cumara* for those that are merely starchy.[1]

That an important crop plant should have the same name among the Polynesians as in the interior of Peru might be taken as proof of a recent introduction, just as the Polynesian name *poaka* was taken at first to demonstrate that pigs were brought by Europeans. Later it was pointed out that the Polynesian pigs could not have come from Europe because they belonged to an Asiatic or Malayan species. The name *poaka,* in spite of its obvious likeness to the Spanish *puerco* or the English *porker,* is accepted by the best authorities as a genuine Polynesian word.

To insist that *kumara* can not be a Polynesian word because it appears in the Quichua language of Peru would be like saying that *puaka* could not be Polynesian because the Greeks and Romans had *porcus.* If *kumara, poaka,* or other words for particular animals or plants reappear in different languages, the fact needs to be recognized and taken into account in tracing the origins of the domesticated species and their relation to the extension of agriculture in prehistoric times.

Thus far the word *kumara* seems not to have been challenged as a foreign element by any student of the Polynesian language. Certainly it does not appear un-Polynesian, in view of the frequent occurrence of the sounds and syllables of which it is composed. Among such words as *kakara* (odor), *kapura* (fire), *karoro* (sea-gull), *korora* (mussel), *mamara* (charcoal), *marara* (fly-

[1] Cook, O. F. *Quichua names of the sweet potato.* Journ. Wash. Acad. Sci. 6: 86. 1916.

ing-fish), *tauama* (outrigger canoe), and *tamara* (palm leaves), *kumara* seems fairly at home. It is also very widely distributed, with only slight modifications, conforming with the changes of consonant sounds in some of the dialects. The following variations of the word are brought together by Tregear: *kumaa* (Marquesas), *kumala* (Tonga), *uala* (Hawaii), *umala* (Samoa), *umara* (Tahiti), *uwala* (Hawaii), with *kumara* recorded for New Zealand, Rarotonga, Easter Island, Mangareva, and Paumotu. *Hooarra* was recorded as the Hawaiian name of the sweet potato in 1778, by Captain Cook's expedition.

Possible cognates or derivatives of *kumara* are numerous in the Maori language, including *kumanu*, to tend carefully; *kumore*, cape or headland; *kumete*, dish, bowl, or trough; *kume*, to pull out; *kumu*, to draw back. *Whakakumu* is the name of one of the New Zealand varieties of sweet potato, and *kumu* also means fist, or portions of food squeezed out with the hand. The growing sweet potato crop was called *maara* in New Zealand, reminding of *malla*, the Quichua word for a young plant. *Kamala* is a word for thatch in Hawaii, where *kumara* vines were often used for this purpose. *Kalau* is another Hawaiian word which means either a thatch of leaves or vines of sweet potatoes, or to work inefficiently, the sweet potato materials being but poorly adapted to the purpose. *Kalina* is defined by Andrews as "old potato vines that have done bearing," or "a garden of potatoes where the old refuse potatoes only remain." *Kalina* and *ilina*, the latter meaning burial-place in Hawaii, are suggestive of the Quichua word *illuni*, meaning to dig for roots. Other Quichua words are *cullquini*, meaning "to dig with a stick," and *culluna*, a silo or subterranean storehouse.

In New Zealand the words *kapuka* and *kepura* are both said to mean "a handful of potatoes." Two native New Zealand plants, *Pomaderris elliptica* and *Quintonia serrata*, are called *kumarahou*, but the relation to *kumara* is not indicated. *Hau* is a general name for *Paritium tiliaceum*, a shrub widely cultivated among the Polynesians for the sake of its fibrous bark.

In Hawaii, where the name of the sweet potato is softened into *uala*, the same word is applied to the large muscles of the upper arm, by an analogy easily understood. In Easter Island, where the full form of the word *kumara* is used, there is a word, *komari*, also applied to parts of the human body. *Komala* means pleasant in Hawaii.

Dried sweet potatoes are called *kao* in New Zealand and *ao* in Hawaii, where the same is applied to dried *taro* or to Alocasia. *Koiri*, in New Zealand, means "to plant potatoes," and a variety of sweet potatoes is called *koiwi*. Other meanings of *kao* are rib, core, shoot, or terminal bud of a plant. The Hawaiians called the sea-bread or hardtack of the English ships *ao* when they first saw it. *Kao* suggests *kaya*, the Quichua name for dried *ocas* (Oxalis). *Kauno*, in Quichua, means withered or dried in the sun; *kauñu*, dried cane or corn stalks; potatoes after freezing, *chuño* or *chuñu;* potatoes left behind in the field, *koyo*. *Kauñu* and *chuñu* are obviously related, like the German *kauen* and the English *chew*.

According to Martius the sweet potato is called *coundi* by two tribes of Indians in Brazil, while in Florida *kunti* is the native name of the edible cycad Zamia. In the Lucumayo valley of southern Peru the rootstocks of Xanthosoma, an aroid closely similar to the taro of the Polynesians, are dried "to make *chuños*." In the vicinity of Ollantaytambo, Peru, a native medicinal plant with thickened roots, somewhat resembling the dried *ocas*, is called *kayakaya*.

The Hawaiians had two words, *haaweawee* and *pahulu* for second-growth sweet potatoes, or those that spring up from roots left behind at the harvest, just as the Quichuas have *koyo, acacha, cachu*, and *ihua* (eewa) for potatoes left in the ground or growing in the old fields. In New Zealand gleanings of root crops are called *wairan*, but the word *kaunga* is applied to sweet potatoes that will not grow when planted. Another meaning of *kaunga* is "smelling unpleasantly," which would be a natural connection if the word related to stored potatoes that had begun to decay.

In some of the Polynesian islands *kao* is not defined as relating to dried sweet potatoes, but is used in the sense of "grabbling," taking a few of the roots from the hill without disturbing the plant. In explaining the connection Tregear states that the immature roots are used to make *kao*, presumably because they dry better while the flesh is still starchy, before much sugar is formed.

Related perhaps, to *kao* and *kaunga*, are *kauahi*, *kauati*, *kauhure*, *kaunaki*, and *kaunoti*, which are Maori names relating to the sticks that are used for making fire by friction, the wood for this purpose being kept, of course, very dry. *Kauati*, in the Paumotu islands, means to make fire; *auwaki* are fire-sticks in Hawaii, and *kahu* is fire or to burn. In New Zealand again, *kauhuri* means "to dig; to turn over the soil." *Huri*, in some of the islands, means to dig, but in others seed, suckers, or offshoots used for planting. The Quichua name for a green corn-stalk or sugar-cane is *huiro*.

That *kao* and *kahu* may be related words is further suggested by the fact that one of the Hawaiian varieties is called *kahe* and one of the New Zealand varieties *pokerekahu*. The Maori name of the yam is *uwhikaho*. Although in the Maori language *kahu* is not reckoned as a name of fire, it is the name of the hawk, the god of fire, reckoned as a child of the fire-goddess Mahuika. Moreover, *Kahukura* was the name of the rainbow-god of the Maoris, and also the name of the man who, according to one tradition, brought the *kumara* to New Zealand, together with the taro, the bottle-gourd, and the yam. The traditions indicate that the dried sweet potatoes had great importance in former times among the Maoris, perhaps as affording their only supplies of food that could be kept over from one season to another.

In addition to the drying of sweet potatoes to make *kao*, the leaves of the plant were eaten, as they are by the Quichuas in South America. The Hawaiian word *palula* is defined as the leaf of the sweet potato, and as a dish made by roasting sweet potato leaves on hot stones. The word resembles *pahulu*, defined as "potatoes of a second growth," and *ponalo*, "the dying or drying up of potato tops.'"

The status of sweet potato varieties among the Polynesians affords the most definite evidence of long-standing possession and familiarity. While almost nothing in the way of detailed information regarding the Polynesian varieties seems to have been placed on record, the facts that have been noted incidentally by writers on ethnology and language are sufficient to show that numerous varieties of sweet potatoes are recognized and distinguished by native names, in the same way that large numbers of potato and other root crop varieties are named among the Quichuas in Peru, although very few of these names have been recorded in the published vocabularies of the Quichua language.

Although domesticated plants afford significant data for the study of the contacts and relations of primitive peoples, plant names have seldom received much attention from philologists and ethnologists. From New Zealand, however, about 40 native names of varieties of sweet potato have been published, from different districts, the largest list, containing 25 names, supposed to represent nearly as many different sorts.[2]

A similar diversity of varieties might be found in other islands, but from most of the groups no varietal names have been recorded, while in others a few names have been noted incidentally, such as Manana, "the name of a kind of sweet potato," in Hawaii. In the same group "very small potatoes with red veins"

[2] Three lists of native varieties of sweet potato have appeared in the Journal of the Polynesian Society (**2**: 102, **3**: 144, and **3**: 237). Arranged in alphabetical order to facilitate comparison, the names are as follows:

List 1. (Locality not given.) Kaihaka, Kaipo, Kanawa, Kaoto, Korehe, Kotepo, Maomao, Taurapunga, Toroamahoe, Tukau, Waina, Waniwani, Whakakumu. The variety called Waina is noted as having been introduced early in the nineteenth century.

List 2. East Cape district: Anutipoki, Huiupoko, Kawakawa, Kerikaraka, Kokorangi, Koreherehe, Makakauere (Makakauri or Matakauri), Makutu, Matawaiwai, Moii, Monehu, Ngakaukuri, Paea, Papahaoa, Para-karaka (same as Makutu), Paretaua, Patea, Pokere-kahu, Puatahoe (said to produce flowers), Punuiarata, Tanehurangi, Taratamata, Taurapunga, Toroamahoe, Waiha (or Waniwani) (same as Huiupoko), Wini. All of these varieties are said to have been cultivated in New Zealand before the arrival of Europeans.

List 3. West Coast of the North Island: Anurangi, Aorangi, Arikaka, Kahutoto, Kopuanganga, Kotipu, Monenehu, Pehu, Pokere-kahu, Rangiora, Taputini, Toroamahoe.

Other New Zealand varieties mentioned by Tregear are Koiwi, Ruamataki, and Torowhenua, the last name said to be used also in the Marquesas group, where Maori is also the name of a sweet potato variety.

and "water-soaked potatoes" are called *kokokooha, koko* being the name of the fibers of the leaf-bases of the coconut palm, or a net of braided strings to hold a calabash. One of the Hawaiian varieties is called Apo, while *apoapo* means a hill of sweet potatoes, reappearing in New Zealand as *apuapu*. Other Hawaiian names for varieties of sweet potatoes mentioned in Andrews' *Dictionary* are Kahe, Kipawale, and Koloaha. The variety called Kihi is said to be "the ancient potato of Hawaii."

Some writers have thought that the sweet potato must be a recent acquisition among the Polynesians, because of the many myths and traditions relating to its introduction. But such evidence appears to have a different signification when we consider how much the Polynesians were given to family pride and genealogies. To say that one's forefathers came in the canoe that brought the *kumara* certainly did not mean that the family was recent, but was the Maori way of claiming a Mayflower ancestry. White has given us a detailed account showing how acutely the subject was debated by the Maoris, and the intensity of feeling is reflected in the care taken by that author to report the controversy in such a way as to avoid the appearance of taking sides and thus offending some of his native neighbors.

If weight is to be given to traditions of the introduction of sweet potatoes, account must also be taken of the myths and cosmographies that represent the sweet potato as one of the primeval possessions of the human race, the first plant to be recognized among the heavenly gifts. Thus the Maori pantheon began with Void (Kore) and Darkness (Po) as the parents of Heaven (Rangi) and Earth (Papa). In the third generation of deities came Tane, god of trees, forests, and birds; Tangotango, god of day and night; and Wai-nui, the goddess of water. Tane figures as the grandfather of sweet potatoes and the bottle-gourd, the former by his oldest child, the latter by his youngest. The passage treating of the sweet potato is as follows:

Tane took to wife Hine-rau-a-moa and begat Rongo-ma-Tane, who was the parent, origin, or personification of the *kumara* (sweet potatoe) and of cultivation and the arts of peace; and Hine-te-iwaiwa, the guardian of motherhood; and Tangaroa, the Polynesian Neptune, who stands in the same relation to the ocean and the fish thereof as does Tane to forests and birds.[3]

In this, as in many other myths and traditions of the Maoris, the sweet potato has precedence over all other crops and plants, and it may be significant that the bottle-gourd, another plant that the Polynesians shared with the natives of South America, is in this case the second in order of consideration, before the taro or other plants cultivated by the Maoris.

Tregear has made a careful study of the ancient religious myths of the Polynesians and finds many that are closely parallel to those of the Mediterranean countries. He compares the god Maui of New Zealand with the Egyptian Osiris, and his wife Hina or Pani with Isis, Ceres, Diana, and other goddesses of agriculture and fecundity among the Asiatic and Mediterranean peoples. Maui is associated with the sun and Hina with the moon. *Kura-a-Maui* is recorded as a poetic name of the sweet potato among the New Zealanders, *kura* meaning red or royal, or a wreath of red flowers, as worn by the ancient heroes, according to the traditions. There was also a sacred or priestly name of the sweet potato, *kurawhiti*. Maui was invoked in planting *kumaras*, but the formal incantation was addressed to

[3] Best, E. *Notes on Maori mythology.* Journal of the Polynesian Society, **8**: 95.

The *kumara* figures in many of the myths of this collection, including several that have to do with the sun and stars, as in the following passages:

"The sun has two wives. One wife lives in the south; her work is the cultivation of food, and her name is Aroaro-a-manu or Raumati (Warmth or Summer). The other wife is Hine-takurua (Winter); she dwells on the ocean, and her task is the taking of fish. In the winter the Sun goes to the ocean and dwells with Hine-takurua. In the month O-toru [of the Maori year] the sun returns to land to his wife Raumati, who cultivates the *kumara*. It is then summer."

"Hoko-kumara is a name for Matariki (Pleiades). When Matariki rises in the east the *kumara* is sown."

"When Whanui [the star Vega] is seen flashing above the eastern horizon as autumn approaches, then the cry resounds: '*Ko Whanui E-E! Ko Wahnui!*' For that is the sign for taking up the *kumara* crop. If the *kumara* [sweet potato] be not dug then, the crop will be spoilt and will not keep. Such *kumara* as are left in the ground become *houhunga*, good to eat but will not keep. Potatoes are dug in the month Pou-tu-te-rangi. If left too late they will be spoilt, in which state they are termed *tauhere* or *puakiweu*."

Pani. Large sweet potatoes of a special form were sacred to Pani and were not eaten. They were called "Pani's canoe" and the finding of them was considered a special omen from the goddess, presaging fertility. Boats were among the symbols of Isis, and one of her names was Pania.[4]

In New Zealand, elaborate ceremonies were performed when the *kumara* crop was planted, the seed tubers being selected with the greatest care by a priest, as was also the place in which they were planted. Over each tuber a special incantation was chanted and it was placed in the ground with the head slightly raised and pointed toward the east. One of the legends dealing with the introduction of the *kumara* tells how those who went to get them traveled toward the rising sun, and how their canoe was kept by enchantment for many days in the same place in the ocean, meaning, perhaps, that no land was sighted for many days.

Several times during the growth of the *kumara* crop religious rites were observed, and when the roots were harvested still another series of ceremonies was enacted, the first fruits of the crop being given to the gods of *kumara*.[5] The extent to which the religious precautions were carried is indicated by Tregear's definition of the word *whakamahunga:* "The ceremony of making sacred those who planted or dug up the *kumara*. After the first-fruits had been offered to Pani, the cultivators became common (*noa*), or no longer under restriction."

To judge from the facts noted in this brief review of the subject, the word *kumara* must still be accepted as the Polynesian name of the sweet potato, notwithstanding that the same word is applied to the same crop among the Quichuas of the eastern valleys of the Andes, below Cuzco. In view of the general distribution of the plant and its name among the Polynesians, the use of the leaves and the dried roots, and their special names, the development and naming of numerous varieties, and finally the many myths and traditions connected with the sweet potato,

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[4] Tregear, E. *Asiatic gods in the Pacific.* Journal of the Polynesian Society, **2:** 145. 1893.

[5] White. *Ancient History of the Maori,* vol. 3, preface.

it does not seem reasonable to believe that the introduction of the plant occurred within the period of exploration of the Pacific by Europeans. Nothing need be said of the reports of the early explorers who found sweet potatoes already in the islands.

If the sweet potato had come to the Polynesians in recent times from an outside source it is practically inconceivable that the same name should have been distributed and adopted in so many islands. In this respect there is a notable contrast with the many distinct names for sweet potatoes among the native tribes of the American continent. The many traditions or myths regarding the *kumara* in the Pacific may mean nothing to which any definite significance can be attached, but at least they show how deeply the *kumara* was embedded in the existence of the islanders. The sweet potato, like the coconut palm, had relatively greater importance among the Polynesians than in other parts of the world.

PHYSIOLOGY.—*The basal energy requirement of man.*[1] EUGENE F. DU BOIS, M.D.

It is not too much to say that the science of nutrition is founded on the study of the basal energy requirement. Therefore it seems advisable to spend our time today on this aspect of the subject as an introduction to the subsequent lectures of the series. First we shall consider the definition of the term, basal energy requirement, next the manner in which it is studied, and finally the factors by which it is influenced in health and disease.

The energy requirement of a man is represented by the number of food calories, or heat units, required to balance the calories of his heat production. The two are equal, because food oxidized in the body gives off just as much heat as food burned outside the body. The basal requirenent is the minimal requirement or lowest heat production, and this condition is found only when an individual is lying down, at complete rest in the morning,

[1] A lecture delivered before the Washington Academy of Sciences, April 7, 1916. From the Russell Sage Institute of Pathology, in affiliation with the Second Medical Division of Bellevue Hospital, New York.

fourteen hours or more after his last meal. There are many synonyms for the term basal energy requirement, and it has seemed advisable to group them in a list so as to straighten out misunderstandings.

SYNONYMS OF BASAL ENERGY REQUIREMENT

Basal metabolism	"Nüchtern" metabolism
Basal caloric requirement	Post-absorptive metabolism
Basal caloric production	Total energy exchange
Basal heat production	Total gaseous exchange
Minimal metabolism	Total respiratory exchange
Total metabolism	

Of all of these synonyms the term basal metabolism is perhaps the best and most scientific. Metabolism includes the absorption of foods, their oxidations and transformations into body constituents, and also the later oxidations of these tissues. Such are the energy exchanges of the body, taking place with the consumption of oxygen and the formation of carbon dioxid, these gases being carried to and from the blood by means of the respiratory apparatus.

On looking over this formidable list of synonyms one gets the impression that scientists have spent much time in coining phrases and have tried to make two words grow where one grew before. Still we can have the recompense of knowing that when we have understood the term basal metabolism we have mastered a considerable portion of the dictionary.

Lavoisier was the first to make experiments on the respiratory metabolism and to grasp their significance. A long time afterwards Pettenkofer and Voit constructed the famous respiration chamber in Munich that gave Voit the data on which he founded our modern science of nutrition. His pupil Rubner with his own hands constructed a respiration chamber which was at the same time a calorimeter. By means of this Rubner was able to prove that foods are oxidized in the animal body in very much the same way that they are oxidized in the bomb calorimeter or the Liebig combustion furnace. The process is slower but just as complete, except for the urea portion of the protein molecule. No heat is lost, for the law of the conservation of energy applies to the animal organism.

Meanwhile Zuntz and his pupils were making very important contributions to the science, using an apparatus which collected the expired air during periods ten to twenty minutes long. They were the first to grasp the importance of the modern standard conditions used in determining the basal metabolism. Their subjects were studied in the morning before breakfast, lying relaxed on a couch. Magnus-Levy examined a large number of patients in this manner and made great advances in our knowledge of the metabolism in disease. Zuntz, Loewy, and Durig used a portable apparatus in the study of the physiology of walking and other forms of muscular exercise.

America's greatest contribution to the science of nutrition was the Atwater-Rosa calorimeter, devised in Middletown, Connecticut. This was a small chamber about the size of a ship's state-room, equipped with a folding bed, a chair, a table, and a stationary bicycle. In it a man could live for a week or two, comfortably, but perhaps monotonously. His heat production was measured in two different ways. First, by the method of direct calorimetry, which determined by physical methods the heat of vaporization and of radiation and conduction; second, by analysis of the oxygen consumption and carbon dioxid production the grams of protein, fat, and carbohydrate oxidized each hour, this being the method of indirect calorimetry. Results obtained by these entirely different methods agreed perfectly. Atwater and his associates, Rosa and Benedict, established the fact that the law of the conservaton of energy applied to man. They also made important contributions to our knowledge of the utilization of foods, and of the dietary requirements under various circumstances. After the retirement of Atwater two groups of his assistants carried on his work. Langworthy and Milner moved with the famous calorimeter to the Department of Agriculture in Washington. Benedict and Carpenter built several new calorimeters and established in Boston the Nutrition Laboratory of the Carnegie Institution of Washington. Here they have not only made great advances in technique but have also

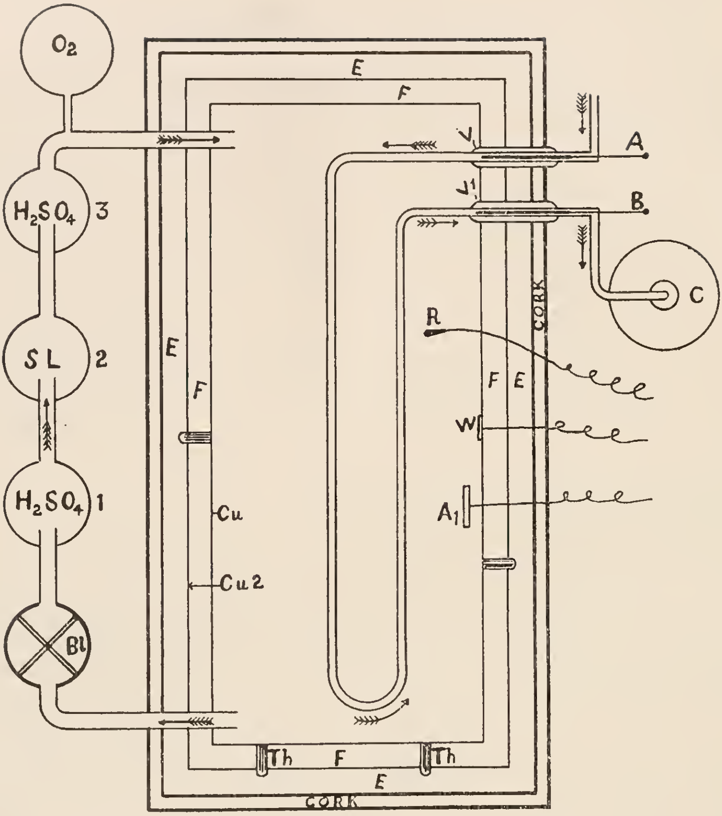

Fig. 1.—Schematic diagram of the Atwater-Rosa-Benedict respiration calorimeter.

Ventilating System:
- O_2, Oxygen introduced as consumed by subject.
- 3, H_2SO_4, to catch moisture given off by soda lime.
- 2, Soda lime to remove CO_2.
- 1, H_2SO_4 to remove moisture given off by patient.
- Bl., Blower to keep air in circulation.

Indirect Calorimetry:
- Increase in weight of H_2SO_4 (1) = water elimination of subject.
- Increase in weight of soda lime (2) + increase in weight of H_2SO_4 (3) = CO_2 elimination.
- Decrease in weight of oxygen tank = oxygen consumption of subject.

Heat-Absorbing System:
- A, Thermometer to record temperature of ingoing water.
- B, Thermometer to record temperature of outgoing water.

V, Vacuum jacket.
- C, Tank for weighing water which has passed through calorimeter each hour.
- W, Thermometer for measuring temperature of wall.
- A1, Thermometer for measuring temperature of the air.
- R, Rectal thermometer for measuring temperature of subject.

Direct Calorimetry:
- Average difference of A and B $\times$ liters of water + (gm. water eliminated $\times$ 0.586) $\pm$ (change in temperature of wall $\times$ hydrothermal equivalent of box) $\pm$ (change of temperature of body $\times$ hydrothermal equivalent of body) = total calories produced.

Th, thermocouple; *Cu*, inner copper wall; Cu_2, outer copper wall; *E*, *F*, dead air spaces.

made experiments on many individuals under a great variety of conditions. Their bed calorimeter in particular has been of great service in the study of the basal metabolism.

The most ingenious apparatus constructed for the study of metabolism is the small calorimeter of Langworthy and Milner. In this the temperature control is automatic and small electrical instruments day after day perform work that exhausts an experienced man after a few hours. Most calorimeters require two or three men in constant attendance, but theirs will run accurately all by itself.

The small calorimeter constructed by Dr. H. B. Williams for Lusk at the Cornell University Medical College in New York City has given results which are technically perfect even in short experimental periods. Only those who have worked in the subject can appreciate the brilliant planning of Lusk's experiments on dogs and their profound significance in the study of the fundamental laws of metabolism. As a result of this work on animals and some work on patients with the small "unit" respiration apparatus devised by Benedict, it seemed advisable to construct a calorimeter for the study of disease. This was made possible by the trustees of the Russell Sage Institute of Pathology, who supplied funds to Dr. Lusk sufficient for the construction and maintainence of a calorimeter and metabolism ward in Bellevue Hospital, New York.[2]

This apparatus, which was built by Riche and Soderstrom, is the latest development of the apparatus of Atwater and Rosa as improved by Benedict, Milner, Williams, and others. It is about the size of the lower berth of a sleeping car and is provided with a comfortable bed, a shelf and a couple of windows. The subject of the experiment lies quietly for three or four hours in the well ventilated box at a comfortable temperature. During this time his heat production is being measured by the independent methods of direct and indirect calorimetry.

The direct method depends on the physical measurement of the heat of radiation and conduction and also of vaporization, about one quarter of the total heat produced being eliminated by evaporation of water from skin and lungs. The indirect

[2] Archives of Internal Medicine, **15**: 793. 1915.

method is purely chemical. The carbon dioxid production of each hour is measured, also the oxygen consumption. Knowing these and the nitrogen elimination in the urine, we can calculate out the grams of carbohydrate, fat, and protein metabolized each hour, and from their well known caloric values can determine the total heat production. In normal controls the two methods agree very closely, if we take the averages of all the experiments made. Even in periods as short as one hour the agreement is usually within 5 per cent.

This calorimeter in Bellevue is particularly well adapted to observations on patients. It is situated in a room next to a small metabolism ward where the food can be weighed out accurately and complete twenty-four hour specimens of urine collected. The experimental period within the chamber is only three hours, as contrasted with the long periods of one to ten days needed in the old Atwater-Rosa chamber in Middletown. The patient lies on a comfortable bed, breathing pure air at a uniform temperature. Even patients who are seriously ill can serve as subjects of the observation without the slightest harm being done. As a matter of fact they are greatly benefited, because their diets can be arranged scientifically as a result of the information obtained in the calorimeter.

In order to understand the results obtained in disease we must first consider the basal metabolism of normal men. With most individuals this is surprisingly uniform from day to day and from year to year. Of course the heat production of a man depends largely on his size, but it is by no means proportional to the body weight. A large man gives off more heat than a small man but for each kilogram of weight the small person has the higher metabolism. On the other hand the metabolism of men of various sizes and shapes is rather closely proportional to the surface area of the body. Many years ago Rubner established this law of surface area and was able to show that mice, rabbits, dogs, men, and horses had almost the same metabolism per square meter of skin.

Up to the last few years we were obliged to estimate the surface area of men by Meeh's formula which was simple but, unfortunately, not accurate. Recently a better method was devised by Mr. Delafield Du Bois. This so-called height-weight formula can be expressed in a chart which enables one to find the approximate surface area if the height and weight of the individual be known. Using it to recalculate the results obtained upon normal persons, we find that the average heat production of men between the ages of twenty and fifty is about 40 calories per square meter per hour. There is a normal range of variation amounting to plus or minus 10 per cent from the average, and a few apparently normal individuals may depart as much as 15 per cent from the mean. Curiously enough very fat people and very thin ones have almost exactly the same heat production, measured in this way, while there may be a difference of 30 or 40 per cent between the two groups if we base the calculations on kilograms of body weight.

The level of the metabolism varies greatly with age. During the first few days of life it is very low, then rises rapidly during infancy, and reaches its highest level in the almost unexplored period between the ages of two and six years. After this it falls rapidly until about the eighteenth year when the curve flattens out. Between the ages of twenty and forty there is comparatively little change, but after this a slight fall, so that by the eightieth year the line is about 10 per cent below the average level for the ages of twenty to forty. There seems to be a stimulation to the basal metabolism during the period of growth.

Women show an average basal metabolism about 7 per cent lower than that of men of the same age. Athletes are about 7 per cent higher than men of sedentary habits. Confinement indoors or in bed reduces the metabolism, as does cage life for a previously active dog. Prolonged undernutrition can reduce the metabolism 30 or 40 per cent. Benedict's subject Levanzin, who fasted for thirty-one days, showed a marked reduction in basal metabolism, amounting to about 23 per cent after three weeks starvation.

The basal metabolism is always measured fourteen hours or more after the last meal, because food stimulates the heat production. A meal containing 60 grams of protein can increase the metabolism 10 or 12 per cent for six or seven hours. One hundred grams of glucose may cause as great a rise, but for a shorter period. The stimulation from fat takes place much more slowly and does not reach its maximum until six hours after the meal. This stimulation caused by food is the specific dynamic action described by Rubner and studied in detail in the last few years by Lusk at the Cornell Medical College, New York City.

Muscular work affects metabolism to far greater extent than all other factors combined. Even walking at a moderate gait may increase the energy consumption threefold, and riding on a bicycle ergostat may increase it sixfold. Work of this type is done with an efficiency of 22 per cent. Only 78 per cent of the energy consumed is wasted, the rest being transformed into mechanical work. This is better utilization of fuel values than is found in machines that use coal. The body works more economically than a steam engine, but we can see why a lumberman in the Maine woods needs 9000 calories of food a day, which is three times as much as most of us consume and six times as much as our requirement would be were we to maintain it at its basal level by staying motionless in bed all day without food.

BASAL METABOLISM IN DISEASE

It has been possible at Bellevue Hospital to study in detail a large number of patients with typhoid fever. During the active stage of this disease, when the temperature maintains itself at 104° Fahrenheit, there is an increase in the basal heat production amounting to 40 or 50 per cent above the normal. The significance of this is appreciated if we remember that most doctors keep their typhoid patients on very small diet for weeks at a time. The result of such underfeeding is a profound wasting away of the patients own tissues, with great loss of weight and the addition of the symptoms of starvation to those of typhoid fever. Shaffer and Coleman, on the basis of studies of the nitrogen of metabolism, advocated a high calory diet in this disease. Dr. Coleman and the writer have studied the effects of such liberal feeding by means of the small Benedict apparatus and of the Sage calorimeter. Curiously enough the taking of food does not stimulate the heat production nearly so much in typhold fever as in health, and patients on the high calory diet have no greater caloric production than those on the starvation diet. This shows how groundless was the old dread of fanning the fever by giving food. It seems to be well established that there is a toxic destruction of protein in typhoid fever. Even if we give the patient plenty of protein and enough calories in food to meet his caloric output, he will show a steady negative nitrogen balance. This phenomenon indicates that protein is broken down faster than it can be reconstructed. If we wish to maintain a typhoid patient in nitrogen equilibrium we must give him 4000 or 5000 calories a day, whereas his calculated output seldoms exceeds 3000 or 3500 calories. Patients do very well on these large diets if they be carefully administered; and at the end of the fever they are well nourished, instead of starved. The proper food in large amounts does not increase the intestinal symptoms.

The disease which has the greatest effect on metabolism is exopthalmic goiter, sometimes called Graves' disease. This is due to an overactivity of the thyroid gland, situated in the neck. Patients who suffer from this hyperthyroidism usually show some swelling of the gland, protrusion of the eyes, nervousness, large appetite, and warm, moist skin. In severe cases of the disease the resting metabolism may be increased 75 to 100 per cent above the normal level. This explains the great demand for food and the marked loss in weight if the diet be not liberal. It also explains the warmth of the skin, since each square meter of surface has to eliminate 75 to 100 per cent more heat than normal. There is also a disease called myxoedema in which the secretion of the thyroid gland is diminished. Patients with myxoedema are lethargic and have small appetities and cool dry skin. Their heat production is much below the normal, but if extract of thyroid gland be given them the normal level is attained once more and their symptoms disappear.

There are several other diseases in which the metabolism is increased 20 to 40 per cent. Among these may be included severe anaemias, cancer, severe cases of heart or kidney disease, high fevers, and perhaps other conditions that have not yet been studied. Patients who are not very ill show little change from the normal in their basal metabolism, and their food requirements are those of normal men under similar conditions.

DIABETES

In the very important disease of diabetes there are profound changes in the metabolism of all the foods. The study of these changes has thrown an enormous amount of light on the transformations of the food-stuffs which take place in normal individuals, and physiology owes a great debt to the study of this pathological condition. In severe cases the body being unable to oxidize any carbohydrate food, eliminates it in the urine as glucose. Proteins are incompletely oxidized, and about half of the protein molecule is changed into glucose and eliminated as such. Fats are incompletely metabolized, reaching the stage of beta-oxybutyric acid, which circulates in the blood as a poison in diabetics because the tissues are unable to oxidize it beyond this stage as they do in health. The level of the total heat production is not much changed in diabetes in spite of this disturbance of the intermediary metabolism. Direct evidence of the severity of the disease can be obtained by the use of the calorimeter or any other form of apparatus which determines the respiratory quotient. It is the respiratory quotient which tells the exact amount of carbohydrate that the patient is oxidizing. Severe cases can oxidize none; mild cases can derive 20 to 40 per cent of their calories from carbohydrates.

Quite recently Dr. F. M. Allen, of the Rockefeller Institute, has found that patients with severe diabetes are much benefited by periods of fasting and low diet. In almost all cases the sugar can be made to disappear from the urine and stay away as long as the diet is restricted. Several patients so treated have been studied in the calorimeter in association with Dr. Allen, and it has been found that during the period of low diet there is a great reduction in the level of the basal metabolism. The organism adapts itself to the new conditions and seems to straighten out its internal difficulties when living economically.

In this short lecture we have been able to discuss briefly a few of the factors which influence the basal metabolism in health and disease. It is only through a study of such factors that we can place dietetics and particularly hospital dietetics on a scientific basis. In most institutions the patients are fed according to customs and habits inherited by trained nurses from previous generations. Perhaps in the course of years the food of sick men may be as scientifically administered as the food of the chickens and cows on a modern farm.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, 1913 and 1914.* Daniel L. Hazard. U. S. Coast and Geodetic Survey Serial Publication No. 21. 1916.

This publication is in continuation of the series giving the results obtained at the Honolulu magnetic observatory since its establishment in 1902. It contains a summary of the monthly determinations of the scale-values of the horizontal intensity and vertical intensity variometers; the base-line values derived from the weekly absolute observations; diurnal variation tables for the magnetic elements D, H, and I, the total force F, and the rectangular components X, Y, Z; hourly values of D, H, and Z, together with daily and hourly means for each month; a tabulation of the earthquakes recorded on the seismograph; a list of the magnetic disturbances of considerable magnitude, and reproductions of the magnetograms showing the more marked disturbances. Attention is called to the fact that beginning with 1913 intensity results obtained by this Bureau have been reduced to the international standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Published results for earlier years must be diminished by one part in a thousand to reduce them to that standard.

D. L. H.

PHYSICS.—*Photometry of gas-filled lamps.* G. W. Middlekauff and J. F. Skogland. Bureau of Standards Scientific Paper No. 264. 17 pp. 1916.

The introduction of an inert gas into the bulb of an incandescent electric lamp introduces new uncertainties in photometry by the ordinary rotating lamp method. As this method of photometry is still in common use it was deemed advisable for the Bureau of Standards to investigate the effect of rotation of the gas-filled lamp on current and candlepower, hoping to derive a practical method of photometry free from the errors due to rotation.

During the investigation extreme care was exercised in the control and measurement of speed of rotation, and the precision photometer was used in making the photometric measurements. It was found that there was for every lamp investigated a speed at which both current and mean horizontal candlepower had the same values, respectively, as when the lamp was stationary, and that this speed had a value which might be conveniently employed in practice, thus suggesting a practical photometric method. It is pointed out, however, that owing to the unequal distribution of bulb discoloration during the life of the gas-filled lamp an integrating sphere should be used in measurements made during life test. G. W. M.

RADIOTELEGRAPHY.—*The effect of imperfect dielectrics in the field of a radiotelegraphic antenna.* J. M. Miller, Bureau of Standards Scientific Paper No. 269, pp. 129–136. 1916.

It has been shown by the measurements of C. Fischer and L. W. Austin that the curve which represents the variation of the resistance of an antenna with the wave length of the oscilliation has two characteristic features. Starting from the wave length corresponding to the fundamental of the antenna, the resistance of the antenna rapidly decreases with increasing wave length and reaches a minimum. As the wave length is still further increased the resistance rises again, but in a linear manner. The initial decrease in resistance is explained by a decrease in the so-called "radiation resistance." It has been difficult, however, to account for the linear increase which takes place at the longer wave lengths and it is the explanation of this feature that is here considered.

Austin has explained this phenomenon as caused by dielectric absorption and has concluded that it takes place in the ground. Austin's hypothesis with respect to dielectric absorption is confirmed but it is found that the energy loss is not caused by the ground but by the presence of poor dielectrics in the field of the antenna. This conclusion is based upon measurements of the resistance of an experimental antenna constructed so as to eliminate poor dielectrics from its field and at the same time to increase any effects which may be due to the ground. The linear rise in its resistance at very long wave lengths (even at telephone frequencies) was extremely small. It was then found that the linear increase became considerable when poor dielectrics such as wooden masts, trees, and buildings were in the field and that the resistance of the antenna was also increased at all wave lengths. It was also found that considerable energy loss may be occasioned by running the lead of an antenna into a building. It is most important to design an antenna so as to minimize these sources of energy loss. J. M. M.

GEOLOGY.—*Evaporation of brine from Searles Lake, California.* W. B. Hicks. U. S. Geological Survey Professional Paper No. 98-A. Pp. 8. 1916.

One thousand grams of brine from Searles Lake, California, were evaporated in stages on the steam bath at 78°C. and the deposited crystals were separated from the solution by filtration. The filtrate was cooled to 30°C. and a second fraction of crystals was obtained. Seven such successive stages reduced the brine to about 55 grams and yielded 14 fractions of crystals—7 deposited from the hot solution during evaporation and 7 deposited as the solution was cooled from 78°C. to 30°C. Each fraction of crystals as well as the original brine and the final filtrate was analysed. Most of the sulphate was deposited from hot solution in the first few fractions, and more than 60 per cent of the potassium was deposited as the solution was cooled to 30°C. in the last three fractions. The tabulated results give the percentage composition of the crystals deposited, the percentage of each constituent deposited, and the changes in the composition of the solution during evaporation. W. B. H.

BOTANY.—*New or noteworthy plants from Colombia and Central America—5.* Henry Pittier. Contributions from the United States National Herbarium, **18**: 143–171, *pls. 57–80, figs. 88–97.* March 3, 1916.

The present paper is the fifth of a series dealing with new or little known species from South and Central America. Besides descriptions of a few species, either old or here proposed as new and belonging to the Myristicaceae, Anacardiaceae, Hippocrateaceae, Flacourtiaceae, Sapotaceae, Symplocaceae, and Verbenaceae, it contains a full discussion of the genera *Brownea* and *Browneopsis*, based mainly on the author's collections. It includes also a comparison of *Bombax* and *Pachira*, which has resulted in the establishment of a new and intermediate genus, *Bombacopsis*, the two known species of which are natives of Panama and the eastern part of Central America. H. P.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 773d meeting was held on April 29, 1916, at the Cosmos Club. President Briggs in the chair, 43 persons present. The minutes of the 771st and 772d meetings were read in abstract and approved.

Mr. C. W. Kanolt presented a paper entitled *X-ray spectra.* The speaker presented a résumé of the subject, including a review of the state of the theories of the X-rays previous to the use by Laue of a crystal as a diffraction grating, an explanation of the theory of the three-dimensional grating presented by a crystal, and an account of the experimental methods employed and the results obtained. These results give information relative to the nature of the X-rays, permit the determination of the arrangement of the atoms in the simpler crystals, and give some information relative to the structure of the atoms. It was pointed out that it is also possible to determine atomic masses by the measurement of the angles of reflection of X-ray beams from suitable crystals, and the determination of the densities of the crystals. A knowledge of the wave-length of the rays is not required. To obtain by this method an accuracy greater than that of the results that have been obtained by chemical methods it would be necessary to make more accurate measurements of spectra than most of those made hitherto. However, in most of the work that has been done great accuracy has not been required or attempted, and it appears that the methods could be improved sufficiently to give atomic-mass determinations of greater accuracy than most of those that have been made by chemical methods.

The paper was discussed by Messrs. Crittenden, Bauer, and L. J. Briggs with reference to the highest atomic numbers and the exceptions found by Moseley in the order of the elements.

Mr. F. E. Wright then presented a communication on *The analysis of crystal structure by X-rays.* In recent years Laue and, especially, W. H. and W. L. Bragg have developed effective methods for using X-rays in the analysis of crystal structure. Laue's method is to send general X-ray radiation through a thin crystal plate and thus to obtain on a photographic plate a diffraction pattern which is an expression of the symmetry relations of the crystal plate. In the Bragg reflection method characteristic X-rays of definite wave-lengths are used and the intensity of the reflected rays is measured by means of an ionization chamber and an electroscope. The crystal plate is mounted in a spectrometer and for a given wave-length, λ, and a fixed distance,

d, between successive layers of atoms parallel with the crystal face, the rays are reflected at maximal intensity at the angle, δ, as defined by the equation $n\lambda = 2d \sin\delta$, in which n is a whole number indicating the order of the spectrum obtained. By thus measuring the distribution and relative intensities of the different order spectra, it is possible to determine the relative atomic spacing and the atomic density of the different planes of the crystal space lattice. Models showing the distribution of the atoms in isometric crystals, such as halite, sylvite, fluorite, diamond, zinc-blende, and pyrite were presented; also drawings illustrating the relations in calcite and dolomite.

Mr. Swann remarked on the regularity of crystals used as gratings and asked whether measurements made before and after magnetization in substances capable of magnetization to saturation would show different alignment through magnetization of the atoms. Mr. Wright stated that experiments along that line of investigation were proposed.

Informal communications. Mr. E. F. Mueller exhibited a fused-silicate tube with a transparent quartz window made by the Thermal Syndicate to replace glass and the more expensive quartz tubes used in the sulphur-boiling apparatus. The new type of tube is very satisfactory.

Mr. E. G. Fischer then exhibited a new signal light designed for use in the triangulation operations of the United States Coast and Geodetic Survey. The oxyacetylene lamp heretofore used is costly and expensive to use because of the bulkiness of the apparatus. The new lamp consists of a tungsten lamp so made and mounted that the filament is practically at the focal point of the parabolic reflecting mirror; it is operated by dry cells. The Bureau of Standards after test reported that the new lamp gives for 2 volts at 2 amperes 250,000 candle power in the beam at 100 feet while the old style of lamp gave only 1500 candle power in the beam at the same distance. It will be possible to make observations by the use of the new light on 20 to 30 per cent of the nights now lost in triangulation work. The relative powers of the two lights were effectively demonstrated by throwing the beam from each on the lantern screen. Mr. Bowie congratulated the designer upon the development of the new signal.

J. A. Fleming, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 555th regular meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club Saturday, April 22, 1916; called to order by President Hay at 8.00 p.m. with 24 persons present.

On recommendation of the Council George H. Clements, Washington, D. C. was elected to membership.

On recommendation of the Council the following resolutions were read:

WHEREAS, Prof. WELLS W. COOKE, distinguished ornithologist, authority on bird migration, Treasurer of the Biological Society of Washington, and an active member of the Council of the Society, has passed from this life, therefore be it

Resolved: That the Biological Society of Washington deeply regrets the death of one for many years so keenly interested in the affairs of the Society, one who was a peculiarly efficient officer, a wise counselor, and a charming companion, and extends its warmest sympathy to the family of Professor Cooke.

(Signed) N. HOLLISTER
J. W. GIDLEY
ALEX. WETMORE

Under the heading Brief Notes, Dr. HOWARD E. AMES commented upon a question raised at the 553d meeting as to the existence of a South American mammal having the mammae on the dorsal surface of the body. He had ascertained that this condition existed in the coypu (*Myocastor coypu*). Dr. Ames also offered information in regard to another question propounded at the same meeting as to the ability of camels to swim: According to Dr. E. A. Mearns dromedaries used in Abyssinia were able to swim; and in a book by an English Army officer of experience Dr. Ames had found a statement to the effect that camels were powerful swimmers. Comments followed by the chair and by Dr. L. O. HOWARD.

Under the same heading Dr. F. H. BLODGETT discussed the embryology of the duck weed, *Lemna*, and exhibited seeds, remarking that though the plant was common the seeds were seldom found. Dr. Caldwell of Chicago had worked out the development of *Lemna* to the point of fertilization. Studies made by Dr. Blodgett carried the embryology from this point. The talk was illustrated by diagrams. Discussion followed by Mr. W. L. MCATEE.

The first paper of the regular program was by T. H. KEARNEY: *Native plants as indicators of the agricultural value of land.* Mr. Kearney outlined the results of field work carried on with Dr. H. L. SHANTZ in the semiarid regions of the United States west of the 98th meridian. Typical areas were surveyed in Colorado, the Great Basin, and in the Southwest desert region. Detailed surveys defined the dominant types of vegetation and their distribution, and these were correlated with the varying degrees of salinity, moisture content, and other physical properties of the soil. Areas actually under cultivation gave a check as regards productivity. From these studies it is now possible to predict agricultural possibilities by examination of the original types of vegetation in these regions. Typical plant growths and diagrams showing distribution were illustrated by lantern slides.

Mr. Kearney's paper was discussed by Messrs. W. L. MCATEE, WILLIAM PALMER, ALEX. WETMORE, and L. O. HOWARD.

The last paper of the regular program was by Dr. R. W. SHUFELDT: *Comparative study of certain cranial sutures in the primates.* Dr. Shufeldt stated that no other single vertebrate structure had so much written about it or was receiving more attention at the present time than the skull in man and the primates in general. This study was begun over two thousand years ago and certain names of bones bestowed by Galen in the second century are still retained. In a series of 6000 human and about 1000 ape skulls in the collections of the U. S. National Museum Dr. Shufeldt found that while the bones of the face exhibited but little variation, in the bones on the lateral aspect of the cranium there were remarkable variations, many of which are not referred to in modern works on anatomy. Frontal, parietal, temporal, alisphenoid, and malar articulations show many variations in sutural lines. These again are varied by the presence or absence of epactal or epipteric bones. By means of lantern slides and diagrams these were illustrated and compared, and the speaker touched upon their value in taxonomy and racial distinction and their pathological significance. Discussion followed by Messrs. L. O. Howard, H. E. Ames, and William Palmer.

Alex. Wetmore, *Recording Secretary pro tem.*

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PHYSICAL CHEMISTRY.—*Further experiments on the volatilization of platinum.*[1] G. K. BURGESS and R. G. WALTENBERG, Bureau of Standards.

This is a continuation of an investigation[2] undertaken at the suggestion of the Committee on "Quality of Platinum Utensils" of the American Chemical Society. Seven platinum crucibles of various makes and purity have been subjected to successive heatings at 700, 1000, and 1200°C. followed by determination of iron and other materials soluble in 1:4 boiling hydrochloric acid. Among the results obtained are the following:

1. Platinum ware in the form of crucibles of whatever degree of purity behaves, with respect to gain or loss of weight on heating in air at ordinary atmospheric pressure, in a manner characteristic only of the temperature of heating.

2. Each impurity, as iridium, rhodium, or iron, appears to exert its effect on the volatilization of platinum independently.

3. For platinum crucibles of all degrees of purity containing Ir, Rh, Fe, Si (up to a content of at least 3.0 per cent Ir) the loss on heating is negligible below about 900°C.

4. Below this temperature there may even be a slight gain in weight on heating platinum, owing to the iron content diffusing to the surface and oxidizing. At higher temperatures the

[1] To appear in detail as Bureau of Standards Scientific Paper No. 280 (Bull. Bur. Stds., **13**: 365 et seq.). 1916.

[2] Bureau of Standards Scientific Paper No. 254 (Bull. Bur. Stds., **26**: 289–316. 1915). This JOURNAL, **5**: 378–380. 1915.

presence of iron will lower the volatilization loss by amounts depending on the quantity of iron present. There appears to be no platinum made which does not contain some iron.

5. The volatilization of platinum containing rhodium is less than that of pure platinum at all temperatures above 900°C.

6. The volatilization of platinum containing iridium is, above 900°C., very much greater than that of pure platinum, and increases with the Ir content and with temperature.

7. It appears to make no material difference in the volatilization results, in the range 700° to 1200°, what is the order of heating, ascending or descending temperatures.

8. In an oxidizing atmosphere at temperatures of the order of 1000°C., platinum, in the presence of but not in contact with silica, will apparently take up small quantities of this substance.

9. The loss in crucible weight due to the solution of soluble matter in HCl, after heating, is variable depending on the crucible and may be large. This loss in relatively greater at low than at high temperatures.

10. All of the above losses, caused by heating, acid treatment, and iron diffusion, apparently continue with undiminished magnitude after the first treatment, which is usually erratic.

11. The following table gives the approximate changes in weight to be expected for heating platinum containing iridium or rhodium but nearly free from iron. The presence of iron in appreciable quantities renders the prediction uncertain but it always acts in the direction of lowering the volatilization loss. Silica, if taken up from the furnace, will also tend to lower the results slightly.

Approximate loss in milligrams per hour per 100 square centimeters at temperatures indicated. Platinum nearly free from iron

TEMPERATURE	PLATINUM CONTAINING			
Degrees C.	Pure Pt	1 per cent Ir	2.5 per cent Ir	8 per cent Rh
900 or less	0	0	0	0
1000	0.08	0.30	0.57	0.07
1200	0.81	1.2	2.5	0.54

PETROLOGY.—*Note on the lithophysae in a specimen of obsidian from California.* F. E. WRIGHT, Geophysical Laboratory.

In a specimen of obsidian[1] from Little Lake, about 40 miles south of Owen's Lake, Inyo County, California lithophysae occur which resemble the lithophysae of the obsidian from Hrafntinnuhryggur, Iceland[2] and are of interest because of their bearing on the general theory of the formation of hollow spherulites. Two hypotheses have been proposed to explain the development of lithophysae: (a) the total effect is ascribed to hydrostatic tension or uniform pull resulting from the contraction of the magma during cooling; (b) emphasis is placed on the outward pressure of the gases set free during the crystallization of the spherulites. These two hypotheses are not mutually exclusive and probably both factors, shrinkage of the cooling magma and pressure of gas liberated on crystallization, play an important rôle in the development of most lithophysae. In the case of the Icelandic lithophysae it has been shown that gas pressure was probably the more important of the two factors; similarly in the present specimen from California the evidence presented below indicates that gas pressure rather than hydrostatic tension was the effective agent.

The obsidian. The specimen as a whole is jet black in color and of the characteristic vitreous aspect and conchoidal fracture of obsidian; thin splinters are relatively clear and transparent. The refractive index of the glass is low ($n = 1.484$) and indicates high silica content. Small microlites of a lath shaped mineral showing approximately parallel extinction and negative, rarely positive, elongation are scattered through the glass. The mineral is probably soda-potash feldspar. Minute particles of magnetite are abundant. The total amount of crystallized material is less than 2 per cent. The specific gravity is 2.353.

[1] Collected by Mr. Chas. R. Fletcher of Los Angeles, Cal., and sent by him for examination to Mr. F. L. Ransome, U. S. Geological Survey, who, in turn, presented it to the writer for study. The specimen is now deposited in the U. S. National Museum. Spec. No. 88922.

[2] F. E. Wright. Obsidian from Hrafntinnuhyrggur, Iceland: Its lithophysae and surface markings. Bull. Geol. Soc. America, **26**: 255–286. 1915.

The spherulites and lithophysae. All the larger spherulites are hollow and are lined with minerals similar to those contained in the lithophysae of obsidian from other localities. The predominating mineral crystallizes in fibers arranged radially, is weakly birefracting, extinguishes parallel with positive or negative elongation, and has refractive indices: $\alpha > 1.520$, $\gamma < 1.530$. Some of the sections extinguish in a manner indicative of submicroscopic twinning. These properties agree with those of a potash-soda feldspar. The size of the fibers is not uniform; near the outer wall of the spherulite the individual fibers are exceedingly fine but toward the center they increase in size, become clearer and are there associated with a second, more transparent mineral, tridymite, which appears in characteristic, small nodules and clusters, studding the cavity walls. Under the microscope the tridymite aggregates are weakly birefracting, and have an average refractive index slightly less than 1.480. Minute octahedra and irregular grains of magnetite are disseminated throughout the crystalline mass of each spherulite. These grains increase also noticeably in size from the wall toward the center of the cavity.

In addition to the above predominating minerals well developed, tabular crystals of brown transparent fayalite were observed in some of the cavities. They are identical in optical properties, so far as determined, with the Icelandic and Yellowstone Park lithophysal fayalite. In several of the cavities single, small crystals of a jet black mica of uncommonly high refractive index, apparently slightly above 1.70, were noted. The optic axial angle is small (2E less than 50°); the dispersion of the optic axes is noticeable. This mica is interesting because its presence, as a water-bearing mineral, proves that water vapor was among the gases in the lithophysal cavity.

This mineral association and the pronounced increase in granularity from the margin to the center of a cavity prove that during the crystallization of the spherulite chemically active volatile components were present and attacked part of the material of the spherulites; new crystal compounds, such as tridymite and fayalite, were formed which are absent in the solid spherulites and in ordinary rhyolites, and indicate physico-chemical conditions of formation different from those which ordinarily obtain during the crystallization of a silicate magma. The pressure of the liberated volatile components aided effectively in the original formation and subsequent enlargement of the lithophysal cavities; this is evident both from the shape of the outer walls of the cavity whose radius of curvature is not constant and whose thickness varies inversely with the radius of curvature, and also from the fact that segments of the radial spherulite were forced apart as crystallization proceeded. All these phenomena were observed in the Icelandic lithophysae; and the conclusions there drawn are corroborated in detail by the present specimen, although here the lithophysae are less symmetrical and the mechanism of the enlargement of the cavities is less difficult to understand.

Additional evidence in support of the gas pressure hypothesis is presented by three parallel bands or planes which traverse the specimen and probably represent contact planes between portions of the thick viscous lava which flowed together; flow lines occur in the obsidian parallel to these planes, which are now marked by the crystallization of minute, chiefly solid, radial spherulites. The fact that relatively few of the lithophysae are elongated parallel to these flow planes proves that the cavities are not original vesicles, from which crystallization subsequently spread in the later stages of the flow; the directions of expansion of the cavities bear, moveover, no relation to the structural planes in the obsidian as they should do, were the lithophysal cavities the result solely of contraction of the magma on cooling. In this occurrence, therefore, the evidence is in favor of the hypothesis that in the formation of the lithophysal cavities volatile gases set free during the crystallization of the spherulites were the active factor, and not a secondary phenomenon accompanying the opening of the cavities by hydrostatic tension.

BOTANY.—*Proposed classification of the genus Rollinia, with descriptions of several new species.* W. E. SAFFORD, Bureau of Plant Industry.

Among the finest fruits of tropical America are certain custard apples of the genus Rollinia. This genus, belonging to the Annonaceae, is characterized by fruits closely resembling the chirimoya (*Annona cherimola* Miller), the sugar-apple or *pomme-cannelle* (*A. squamosa* L.), and the bullock's heart (*A. reticulata* L.), but its flowers are very distinct in form from those of the genus Annona.

Much confusion exists in the botanical classification of the principal commercial species of this genus. This is owing chiefly to the fact that, in original descriptions, either the fruit and not the flower was described, or vice versa, and that botanical names have been applied to fruits in the markets unaccompanied by leaves or flowers, which are necessary to determine the species. As a result, Martius, in his great work, *Flora Brasiliensis,* applies the name *Annona obtusiflora* to a Rollinia sold in the markets of Brazil under the name *fructa do Conde,* which he imagined to have been introduced into Brazil from the Antilles; and a second species of Rollinia, mentioned by Marcgrave under the name *biribá,* he places in the genus Duguetia under the name *D. Marcgraviana.* The only large-fruited Brazilian Rollinia which he mentions under its true generic name he refers to Alphonse De Candolle's *R. orthopetala,* a species of British Guiana, the fruit of which was not seen by De Candolle.

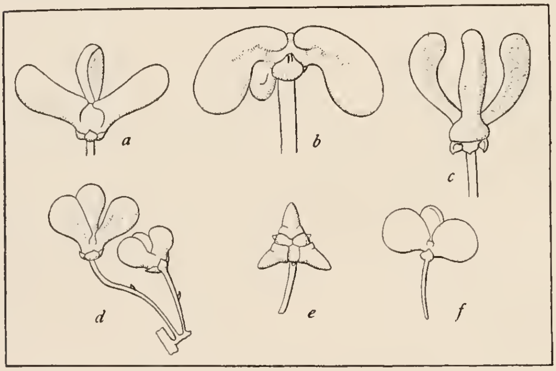

Fig. 1. Types of Rollinia flowers: *a, R. Sieberi; b, R. deliciosa; c, R. laurifolia; d. R. rugulosa; e, R. lanceolata; f, R. emarginata.*

An examination of herbarium material and of fruits of several species introduced into Florida by the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, shows that certain longstanding errors should be corrected and that the genus needs revision.

It may be well to point out, in connection with the plants above mentioned, that *Annona obtusiflora* was described by De Tussac in 1808 from a cultivated plant growing in an orchard near the western extremity of Haiti, and was regarded by Baillon as a synonym of *Rollinia mucosa*, a species based on Jacquin's *Annona mucosa* growing wild and in cultivation on the island of Martinique. The *biribá*, which Corrêa, in his recent *Flora do Brazil*, identifies with Martius's *Duguetia Marcgraviana*, must be a Rollinia; it cannot possibly belong to the genus Duguetia, since its fruit does not, as in Duguetia, consist of separate carpels borne on the indurated receptacle, but is an edible syncarpium with fleshy pulp from which a fermented drink is sometimes made.[1] The only Brazilian species of Rollinia introduced into Florida under the name *Rollinia orthopetala* which has yielded a large edible fruit cannot possibly be the true *R. orthopetala* A. DC., since its flowers are not like the flowers of that species, but have their outer corolla lobes broadly spreading and curving downward, instead of "erect and incurved," as described by De Candolle. Corrêa, in the work cited, refers the *biribá* of Pernambuco and Matto Grosso to *Duguetia Marcgraviana* Mart. and the *biribá* of Pará to *Rollinia orthopetala* A. DC.

FLOWERS OF ROLLINIA

The flowers of Rollinia differ from those of Annona in having a gamopetalous corolla composed of three large outer lobes and three minute inner lobes alternating with them. The large lobes, corresponding to the outer petals of Annona, are produced into wings or spurs, the form of which differs so widely that they offer a convenient basis for classification. In the accompanying illustration (fig. 1) the principal types of Rollinia flowers are

[1] "Os fructos são comestiveis e submettidos á fermentação ,dão bebida vinosa." —M. Pio Corrêa. Flora do Brazil, p. 22. 1909.

shown. The outer corolla lobes may be: (a) compressed, widely spreading, and more or less ascending or upcurved, as in *Rollinia mucosa* (Jacq.) Baill.; (b) decurved and obtuse or rounded at the extremity, as in *Rollinia deliciosa* and *R. Pittieri,* to be described below; (c) erect or ascending and incurved, as in *Rollinia orthopetala* A. DC. and *R. laurifolia* Schlecht.; (d) obovate and ascending, as in *Rollinia rugulosa* Schlecht.; (e) short, thick, and spur-like, as in *Rollinia lanceolata* R. E. Fries; or (f) suborbicular or broadly obovate and widely spreading, as in *Rollinia emarginata* Schlecht.

FRUITS OF ROLLINIA

In the genus Rollinia the fruit is a fleshy syncarpium, composed of a number of one-seeded carpels which become fused into a solid spheroid or ovoid head. In some cases the surface of the fruit is distinctly areolate, as in *R. mucosa,* the areoles being marked by pentagonal or hexagonal outlines and bearing mamillate projections. These may point outward, or be recurved toward the stem, or curved toward the apex of the fruit; or the areoles may be gibbous or rounded and very distinct, like those of the sugar-apple, *Annona squamosa;* or they may terminate in a blunt point. In a few species, as in *Rollinia glaucescens,* the surface of the fruit is nearly smooth, like that of the common *A. reticulata.*

The species in which the mature carpels are quite distinct and fall off separately from the indurated receptacle, or torus, have been set apart by the writer under the generic name Rolliniopsis.[2]

BOTANICAL CLASSIFICATION

The groups suggested above, based upon the form of the flowers, cannot be regarded as subgenera or even as sections, for the line of demarcation is not always sharply drawn. In some species, for example, the corolla lobes may be ascending or nearly erect at first, and at length more widely divergent; while in

[2] Rolliniopsis, a new genus of Annonaceae from Brazil. Journ. Wash. Acad. Sci., **6**: 197. 1916.

others they may be nearly horizontal when immature and at length more or less decurved. Moreover, the members of a group are not always botanically close to one another. Nevertheless the arrangement of the various species into groups according to the shape of the corolla is a great aid to classification and will prevent many errors. A striking example of erroneous identification is that of the flower figured by Baillon and reproduced in Engler and Prantl's *Natürlichen Pflanzenfamilien* under the name *Rollinia mucosa.* This is certainly not the flower of Jacquin's *Annona mucosa,* the *cachiman morveux* of Martinique, which is the type of the species. The slender, ascending, incurved lobes place it at once in the same group with *Rollinia orthopetala* A. DC. and *R. laurifolia* Schlecht. On the other hand, the widely spreading lobes of *Annona obtusiflora,* as figured by De Tussac, place that species in the same group with *Rollinia Pittieri* and *R. deliciosa,* described below. In some cases two or more species with similar leaves and fruits but with very distinct flowers have been wrongly associated under a single name, as in the case of *R. sylvatica,* as usually treated by botanists.

In a systematic study of any group of plants the desirability of going back to the original description of each species will at once be recognized. In certain monographs more easily accessible to the student than the various publications in which the species were first described, amended descriptions are often given, based not on the species itself but upon some allied species mistaken for it. In many cases the monographer has never had the opportunity of examining the type material. Martius, for instance, in describing *Annona obtusiflora* and *Duguetia Marcgraviana* could not possibly have seen the plants on which these species were based; and nothing in De Candolle's description of *Rollinia orthopetala* indicates that the fruit of the plant he described was "of the size of a child's head." The plants growing in the inundated forests along the banks of the Amazon, in the province of Pará, which yielded the fruits described by Martius, may have been specifically distinct from the type of De Candolle's species, which grew near Demerara, in British Guiana, of whose fruit we know nothing but of whose flower we know certainly that the corolla lobes were erect and incurved. To prevent possible mistakes of this kind the exact locality in which a new species was collected should always be indicated. If this is done incomplete type material may possibly be supplemented by future collections from the same plant or at least from a similar plant growing very near it.

The present writer has not sufficient material to attempt to monograph the genus Rollinia. In the following notes he has been much aided by herbarium specimens from the Botanical Museum of Copenhagen sent him for study through the kindness of Dr. C. H. Ostenfeld.

GROUP A

COROLLA LOBES OBLONG, WIDELY SPREADING AND SLIGHTLY ASCENDING OR UPCURVED

Rollinia dolabripetala (Raddi) St. Hilaire, Fl. Bras. Merid., **1**: 29. 1825.
Annona dolabripetala Raddi, Mem. Soc. Ital. delle Sci. Modena, **18**: 394. 1820.
Rollinia longifolia St. Hil., loc. cit.

In this species, the type of the genus Rollinia, the corolla lobes are laterally compressed and shaped like a hatchet or broad-bladed knife (dolabriform), at first ascending, at length broadly spreading.

Type Locality: Mount Corcovado, near Rio de Janeiro, Brazil.

Flowering specimens in the United States National Herbarium were collected in the type locality by Messrs. Rose and Russell (No. 20311).

Rollinia mucosa (Jacq.) Baillon, Adansonia, **8**: 268. 1868.
Annona mucosa Jacq. Obs. 16. 1764 (excl. syn. Rumph.).

The flowers of this species are described as having oblong corolla lobes spreading outward in such a way as "not inaptly to represent a tricorn hat." The areoles of the fruit are gibbous or convex, not papillose or aculeate. The viscous pulp is edible but of poor flavor.

Type Locality: Martinique. Growing spontaneously in the forrests and very rarely cultivated; known locally as *cachiman morveux*.

This species is described as resembling in habit *Annona reticulata* L. Specimens in the U. S. National Herbarium, collected by Père Duss in Martinique, have coarser leaves and larger flowers than *Rollinia Sieberi*, and the gibbous areoles of the fruit are bounded by raised polygonal outlines.

Rollinia Sieberi A. DC. Mém. Soc. Phys. Genève, **5**: 200, pl. 2, fig. B. 1832.

This species resembles *R. mucosa*, from which it differs in its smaller flowers, more slender pedicels, and thinner and more delicately veined leaves. De Candolle, who regarded it as specifically distinct from *R. mucosa* (which he mentions), figures the flower as solitary, with laterally compressed corolla lobes, rounded at the extremities and curving slightly upward.

Type Locality: Island of Trinidad, British West Indies, where it was collected by Sieber (No. 96) and distributed under the name *Annona reticulata*.

The fruit, according to Père Duss, is usually larger than that of *Annona squamosa*, which it resembles in its raised, squamose areoles and its pleasantly flavored, sweet, fleshy pulp. A specimen in the U. S. National Herbarium collected in Porto Rico by Sintenis (No. 4170) is referred to this species. Urban[3] refers this plant to *R. mucosa* but adds that the Porto Rico specimens have smaller flowers than specimens of *R. mucosa* from other localities. To the writer *R. Sieberi* appears to be a valid species. It is certainly quite distinct from *Annona obtusiflora* De Tussac, of which Baillon believed it a synonym, and also from the Mexican plants referred by Baillon to *R. mucosa*, collected by Liebmann at Mecapulco (No. 27) and Mirador (No. 28), the original specimens of which, with leaves velvety pubescent beneath, are before me. Specimens with flowers and fruit from Trinidad, the type locality of the species, are desired.

GROUP B

COROLLA LOBES OBLONG OR SPATULATE, HORIZONTAL OR CURVED DOWNWARD

Rollinia deliciosa Safford, sp. nov. Figure 2.

Rollinia orthopetala Corrêa, Flora do Brazil, p. 22. 1909, not De Candolle.

A medium-sized tree. Blades of the vegetative leaves obovate-oblong or elliptical, rounded or acute at the base, normally acuminate at the apex, 20 to 28 cm. long, 7.5 to 11 cm. broad, membranaceous, when young sparsely canescent-hirtellous above, densely so beneath, especially along the midrib and nerves, at length glabrous above and beneath except along the midrib and primary nerves (18 to 22 on each side), these reddish brown, slender but prominent beneath; petiole about 10 mm. long; blades of the leaves of the flowering branches smaller, the lowermost ones relatively shorter and broader, sometimes broadly

[3] Symb. Antill., **4**: 242.

ovate or orbicular, 3.5 to 6 cm. long, 3.5 to 5 cm. broad. Peduncles leaf-opposed, often in pairs, sometimes solitary, rarely in 3's, 25 to 40 mm. long, bearing a small ovate sessile bracteole near the middle, strigillose with reddish hairs, like the petioles and nerves of the lowermost leaves (prophylla) beneath. Flowers canescent-puberulous; corolla lobes compressed laterally, widely diverging and decurved, rounded at the extremity. Stamens numerous, closely crowded, the expanded connectives forming a pavement above the pollen sacs. Carpels numerous; ovaries hairy; styles expanded, glandular-puberulous. Fruit a solid subglobose syncarpium, 8 to 12 cm. in diameter, the areoles distinctly outlined and terminating in an obtuse beak; peduncle straight and woody, about 5 cm. long; flesh white or cream-colored, juicy, fine-flavored; seeds compressed, 15 to 20 mm. long, 8 to 10 mm. broad, rounded at the apex, gradually narrowing to the base; hilum not prominent; testa thin, brown, wrinkled by the inclosed ruminate endosperm.

Type material in the U. S. National Herbarium, accompanied by photographs of the flowers and fruit, from a tree growing in the Experimental Garden, Miami, Florida, propagated from seed from Pará, Brazil, sent by Mr. C. F. Baker in April, 1908 (No. 22512). Flowering specimen, sheet No. 865973, collected at Miami, Florida, March 11, 1913; fruiting specimen, sheet No. 865976, from the same tree, August 30, 1912; both collected by Edward Simmonds, in charge of the Miami garden.

This plant was introduced into the United States under the name *Rollinia orthopetala*, but it is readily distinguished from that species by the decurved wings of the corolla. Both flowers and fruit were received by the writer from Mr. Simmonds, through the kindness of Mr. P. H. Dorsett, Plant Introducer, Bureau of Plant Industry, in charge of Introduction Field Stations. Mr. C. F. Baker describes its fruit, known in Brazil as the "*biribá* of Pará," as the finest annonaceous fruit of Tropical America. The accompanying illustration (fig. 2) is from a drawing of type material by Mrs. R. E. Gamble.

Rollinia Pittieri Safford, sp. nov.

A forest tree with leaves glaucous beneath and abruptly acuminate. Blades of the vegetative leaves elliptical or obovate, 16 to 20 cm. long, 7 to 8.5 cm. broad, the midrib and primary nerves (16 to 20 on each side) reddish brown beneath; leaves of flowering branches smaller, with 10 to 12 pairs of lateral nerves. Pedicels in clusters of 3 or 4, straight or curved, graduated in length, the longer ones 35 to 50 mm. long, minutely rufous-puberulent, bracteolate near the middle. Flowers minutely puberulent, as though composed of felt; calyx and spheroid base of the corolla rufous; calyx lobes triangular, acute or acuminate, appressed to the corolla, the tips reflexed; corolla wings 15 to 20 mm. long, 6 to 10 mm. broad near the extremity, laterally compressed,

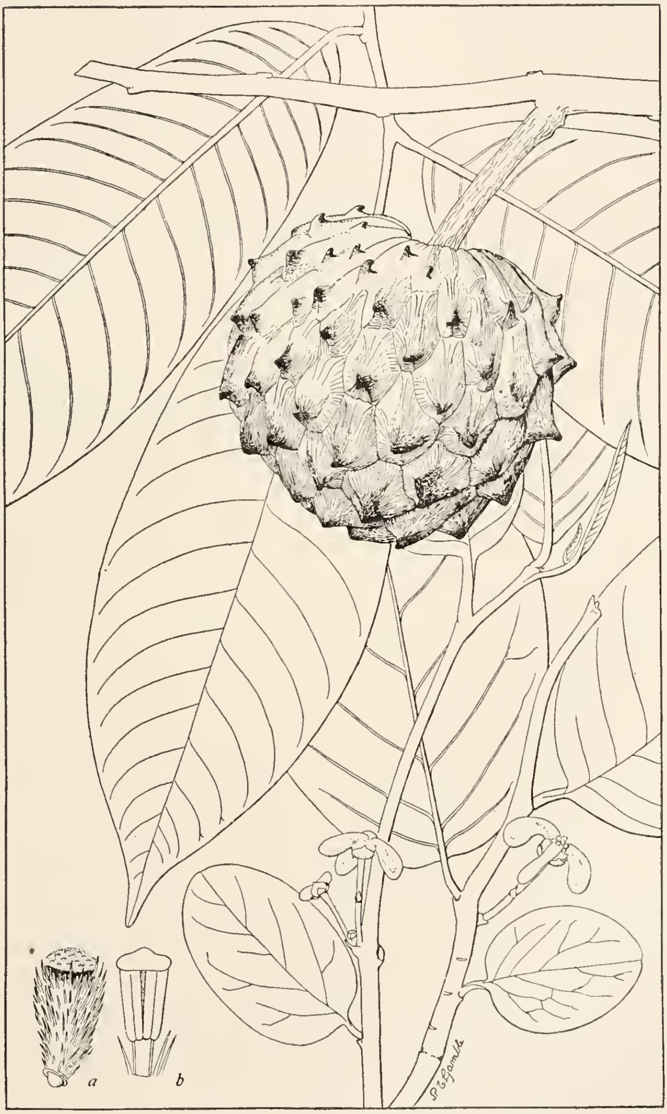

Fig. 2. *Rollinia deliciosa* Safford. From the type material. Branches with leaves, flowers, and fruit, one-half natural size; *a*, carpel, and *b*, stamen, much enlarged.

falcate, horizontally spreading and curved downward, rounded at the apex, narrowed at the base; inner corolla lobes very small, triangular, connivent, almost closing the orifice above the essential parts. Fruit not observed.

Type in the U. S. National Herbarium, No. 679511, collected near sea level, on the plain of Sperdi, near Puerto Obaldía, San Blas Coast, Panama, September, 1911, by Henry Pittier (No. 4358, in flower.)

This beautiful species is remarkable for the pale under surface of its leaves, beautifully veined with reddish brown, and its clustered inflorescence. It differs from *R. rufinervis* Triana & Planch. in having the corolla lobes curving downward instead of divergent-ascending. Specimens of the fruit are desired.

Rollinia Jimenezii Safford, sp. nov. FIGURE 3.

A small tree of Costa Rica, resembling *R. mucosa*, but the flowers in clusters of 2 or 3, the corolla wings horizontally spreading and slightly decurved, the fruit when fresh resembling that of the common sugar-apple (*Annona squamosa*), its component carpels rounded at the tips but when dry more or less beaked. Leaves ovate to oblong-elliptical, acuminate at the apex, those of the vegetative branches 18 to 30 cm. long, 6.5 to 14 cm. broad, obtuse at the base, with 18 to 22 primary nerves on each side, the leaves of the flowering branches smaller, with 12 to 16 pairs of primary nerves, usually rounded at the base; point of acumen usually obtuse or retuse; young branches, petioles, and lower surface of young leaves pubescent with ferruginous hairs, the leaves at length glabrous or nearly so except along the midrib and nerves beneath. Peduncles extra-axillary, often leaf-opposed, in clusters of 2 or 3, graduated in length, the longest about 2 cm. long, ferruginous-tomentose like the ovate-acuminate calyx lobes. Corolla lobes oblong, rounded at the tip, slightly narrowed at the base, widely spreading and usually decurved, never curving upward and inward, rufous-puberulent. Fruit subglobose, about 6 cm. in diameter, 6 to 10 cm. long, closely resembling that of *Annona squamosa*, the component carpels loosely adhering, very gibbous, rounded or often retuse at the tip when fresh; pulp white, acidulous, edible, but not so agreeably flavored as that of *Annona squamosa*.

Type material in the U. S. National Herbarium, collected by Otón Jiménez at Nuestro Amo, Province of Alajuela, Costa Rica; flowers collected March, 1912, (No. 427), and fruit from the same tree, October, 1912 (No. 543). The accompanying figure is drawn from type material and from a field photograph of the fresh fruit.

The author takes great pleasure in naming this species in honor of Mr. Otón Jiménez, of San José, Costa Rica, an accomplished young botanist to whom he is indebted for herbarium specimens of the plant,

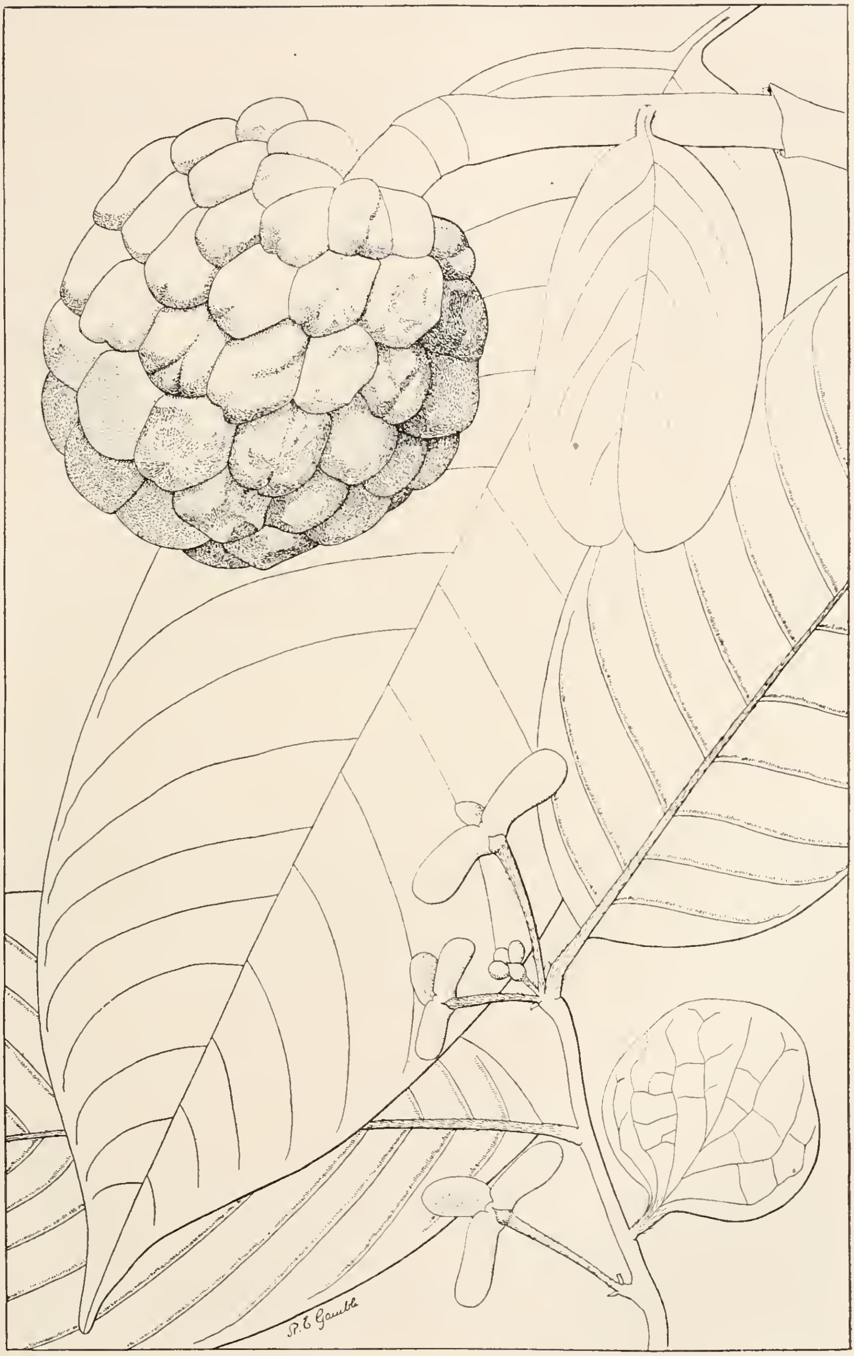

Fig. 3. *Rollinia Jimenezii* Safford. From the type material. Natural size.

field photographs of the fruit, and descriptive notes. In a letter dated September 12, 1912, Mr. Jiménez describes the plant as follows:

"At Nuestro Amo it is known as *anonillo*. The fruits are squamose and are sometimes 10 cm. by 6 cm. when mature. The skin is then yellow; but while still immature it is of a greenish and somewhat glaucous color. It is edible, with an acidulous pulp and a great quantity of seeds which have a tendency to adhere to the skin when the latter is removed. This fruit is little appreciated by the natives, but when it is kept for some time among the leaves and allowed to become fully ripe, it is rather appetizing. The trees reach a height of 8 meters. On young [vegetative] branches the leaves are often quite large, and of a beautiful green color. I hope to obtain for you fruits fully ripe, but I shall have to send them to you in fragments as I have no facility for sending them entire."

In another communication Mr. Jiménez states that all the Rollinia material from Nuestro Amo was obtained from the same tree, and that the specimens of fruits photographed in the field, so remarkably like those of *Annona squamosa*, were the same as the dried fruit forwarded to the writer, with the individual carpels much more distinctly separated and terminating in many cases in a sharp point.

GROUP C

COROLLA LOBES LINEAR-OBLONG OR SPATULATE, ASCENDING OR ERECT AND INCURVED

Rollinia orthopetala A. DC. Mém. Soc. Phys. Genève, **5**: 200. 1832.

A shrub or small tree resembling *R. Sieberi*. Branches and leaves very much as in that species; petioles slightly longer; leaf blades oval-oblong, acute at each end, pilose. Peduncles in pairs; calyx lobes smaller than in *R. Sieberi;* corolla wings erect and incurved.

Type in Herb. De Candolle, collected near Demerara, British Guiana, in 1824, by Charles S. Parker.

Martius, in his *Flora Brasiliensis*, gives an amended description of this species, the fruit of which he describes as "the size of an infant's head," with sweet, white, fleshy pulp. It is not certain, however, that the trees producing the fruits described by him really belong to this species. It is probably owing to Martius's description that the name *R. orthopetala* has been incorrectly applied to several species of Rollinia with large edible fruit. Of these the principal species, from an economic point of view, is *R. deliciosa*, described above, which is readily distinguished from *R. orthopetala* by its widely spreading, decurved corolla wings.

Specimens of *R. orthopetala*, with photographs of its fruits, from Demerara, its type locality, are much desired.

Rollinia laurifolia Schlecht. Linnaea, **9**: 319. 1835.

A shrub or small tree. Leaf blade oblong-elliptical or oblong-lanceolate, acuminate at the apex, obtuse at the base, the upper surface glabrous to the naked eye, the lower surface clay-colored. Corolla lobes ascending-erect, broadened and rounded or obtuse at the apex and incurved; peduncles solitary or in 2's or 3's, graduated in length, the longest about 3 times the length of the petioles. Fruit subglobose, about the size of a horse-chestnut, composed of many distinctly outlined carpels, and containing an edible white mucilaginous pulp, with a pleasant sweet taste.

Type material collected by Sellow in Brazil (Nos. 809, 1190). Known locally as *araticú mirim*.

This species bears a certain resemblance to *R. dolabripetala*, but differs from it in having the flowers in clusters of 2 to several, while the corolla wings are narrow, ascending, and incurved (instead of broad and widely diverging), and the lateral nerves and midrib are usually (but not always) hairy on the upper surface. A closely allied plant collected by Riedel (October, 1823) in the forest near Mandiocca has been described by R. E. Fries under the name *R. laurifolia* var. *longipes*. A specimen with geminate fruits recently collected and photographed at Sitio, Minas Geraes, Brazil, by Messrs. Dorsett, Shamel, and Popenoe (No. 37882) apparently belongs to this variety.

Rollinia incurva Moore, Trans. Linn. Soc. II. Bot., **4**: 303. 1894.

A diffuse shrub with short-petioled leaves resembling those of *R. laurifolia*, but obtuse at the apex and rounded at the base, glabrous and glossy above and paler beneath. Corolla wings spatulate-oblong, ascending and incurved, clothed with ferruginous tomentum.

Type in the British Museum, collected by the Matto Grosso Expedition in Santa Cruz, Brazil; duplicates of the type in the Herbarium of Columbia University, New York Botanical Garden.

GROUP D

WINGS COMPRESSED, OBOVATE AND ASCENDING

Rollinia rugulosa Schlecht. Linnaea, **9**: 316. 1834.

A shrub or small tree. Leaf blades lanceolate or broadly lanceolate, obtusely short-acuminate at the apex, acute at the base, on both sides subglabrous, beneath glossy; young branchlets, petioles, and midrib appressed-puberulous. Peduncles usually recurved or pendulous and thickened at the apex, warty and puberulous like the calyx, 8 to 10 mm. long. Corolla lobes obovate, ascending, rounded or obtuse at the apex, narrowed at the base, tomentose-canescent, 8 mm. long, 4 mm. broad. Fruit globose, 2.5 to 3 cm. in diameter, the component carpels forming 20 to 30 slightly raised, rounded areoles. Seeds small, pale brown, conoid, somewhat flattened.

Type in the Berlin Herbarium, collected in southern Brazil by Sellow.

Closely related to *R. rugulosa* and with very similar fruit but longer and narrower leaves (suggesting those of *R. salicifolia* Schlecht.) is *R. Warmingii* R. E. Fries, the type of which was collected on Mount Tijuca, near Rio de Janeiro, by Glaziou (No. 6079).

GROUP E

COROLLA LOBES SHORT, STRAIGHT AND SPURLIKE, HORIZONTALLY DIRECTED

Rollinia lanceolata Fries, Svensk. Vet. Akad. Handl., **34**[5]: 49, pl. 6, fig. 6. 1900.

A small tree with small leaves, the blades lanceolate, acute at the apex and base, above glabrous except along the midrib, beneath densely ferruginous-villous along the midrib. Young branches, petioles, and solitary or rarely geminate peduncles ferruginous-tomentose. Flowers ferruginous-hirsute; outer corolla lobes spur-like, short, rounded, and widely spreading. Fruit not observed.

Type in Botanical Museum of Copenhagen, collected in Brazil by Glaziou (No. 13509).

GROUP F

COROLLA LOBES BROADLY OVATE OR SUBORBICULAR AND LATERALLY COMPRESSED

Rollinia emarginata Schlecht. Linnaea, **9**: 318. 1835.

A glabrescent shrub 2 to 3 meters high, growing in marshy places, with slender branches. Leaf blades, thin, membranaceous, oval or elliptical, obtuse at both ends or acutish at the base, emarginate or retuse at the apex, on both sides subglabrous and opaque. Peduncles usually solitary, slender, about 25 mm. long, minutely bracteolate at the base. Corolla and calyx silky-hirtellous; corolla wings obovate-orbicular, widely spreading, laterally compressed. Fruit solid, about 25 to 30 mm. in diameter, ovoid globose, the component carpels scarcely at all raised or distinctly outlined.

Type in the Berlin Herbarium, collected in the province of Rio Grande do Sul, Brazil, by Sellow.

This species is very common in southern Brazil and Paraguay. It is distinguished from most of its congeners by its small smooth fruit and emarginate leaves.

Rollinia glaucescens Sond. Linnaea, **22**: 557. 1849.

A glabrescent shrub. Leaf blades thinly membranaceous, ovate or lanceolate, obtuse or rarely acute at the apex, acute at the base, 5 to 7 cm. long, 2.5 cm. broad, glaucescent beneath; petioles 6 to 10 mm. long. Peduncles in pairs, one shorter than the other, the longer one bearing a small bracteole below the middle. Flowers canescent-puberulous; corolla wings broadly obovate or suborbicular, widely spreading. Fruit broadly ovoid or subglobose, small (about 2.5 cm. in diameter), solid, and smooth, the component carpels scarcely outlined and not at all gibbous.

Type collected in the Province of Minas Geraes, Brazil, by Regnell on his second expedition.

This species is closely allied to *R. emarginata* Schlecht., a species well known to Sonder. From this it differs in its leaves, which are never emarginate, and in its smaller flowers. Specimens in the U. S. National Herbarium were collected and photographed at São João de Rey, Minas Geraes, in January, 1914, by Messrs. Dorsett, Shamel, and Popenoe (No. 286). Plants have been propagated from the seed of these specimens by the Office of Foreign Seed and Plant Introduction (No. 37880).

Rollinia sylvatica (St. Hil.) Mart. Fl. Bras. **13**[1]: 18. 1841.

Annona sylvatica St. Hil. Pl. Usuelles, pl. 29; Fl. Bras. Merid., **1**: 32. 1825.

A medium-sized tree. Leaves large, elliptical, somewhat resembling those of *Annona cherimola,* but usually acutish at the base and obtuse or very shortly cuspidate, rarely oblong-elliptical and acute or acuminate, above usually puberulous, beneath softly pubescent. Peduncles extra-axillary. Fruit usually solitary, edible.

Type collected by St. Hilaire in the forests of Minas Geraes, Brazil. Fruit, locally known as *araticú do mato* (custard apple of the forest), ripening in March.

At least two species are usually found in herbaria labelled *R. sylvatica:* one with elliptical leaves, very much like those of the chirimoya, and suborbicular corolla wings; the other with lanceolate leaves shaped very much like those of *R. laurifolia,* and with spatulate corolla wings. In both, the leaves are pubescent beneath. The first corresponds more nearly to the type described by St. Hilaire, in which flowers were lacking. Specimens in the National Herbarium recently collected and photographed in the field by Messrs. Dorsett, Shamel, and Popenoe at Bom Fim (No. 436) and Lavras (No. 250) are referred to this species. Probably distinct from this is a tree growing to a height of 20 to 25 feet, rarely cultivated in gardens at São João del Rey, in which the leaves are lanceolate, acute at the apex, and rounded at the base, very much as in *R. incurva* Moore. A photograph of a fruit-bearing branch (No. 1571) was secured. The fruit, about 4.5 cm. in diameter, is composed of comparatively few large, pointed carpels. It is yellow when mature and edible, but rather insipid. As no flowers were secured, it is not possible to place this plant in one of the groups here proposed.

ZOOLOGY.—*Ophiomaria, a new genus of ophiurans from southern South America and the adjacent portion of the Antarctic continent.*[1] AUSTIN H. CLARK, National Museum.

Two new species of ophiurans from the coast of Chile which were dredged by the *Albatross* on her journey from the Atlantic to the North Pacific represent a type which appears to be intermediate between Ophioperla and such species of Ophiosteira as *O. senoqui* Koehler and *O. koehleri* A. H. Clark, possessing the general structure of the latter combined with the granular disk covering of the former. Together with two other species, described in 1901 by Professor Rene Koehler these forms appear to represent a logical generic unit which may be known as

Ophiomaria, gen. nov.

Genotype.—Ophiomaria tenella, sp. nov.

Diagnosis.—The disk is pentagonal or more or less stellate. The dorsal surface is beset with fine granules which to a greater or lesser degree conceal the plates. In the central portion of the interbrachial spaces below there are usually numerous granules which surround, or even entirely conceal, the plates.

The arms are slender and evenly tapering, in length equal to about four times the diameter of the disk, circular in section proximally, becoming slightly flattened distally, rarely carinate.

The arm comb is represented by a narrow band of irregular plates or beadlike granules beyond the radial shields which recall the supplementary arm plates in Ophiopholis.

At the base of the arm the upper arm plates are usually very wide, narrowly oblong; they rapidly become narrowly fan-shaped, and in the distal half of the arm very small and widely separated from each other.

There are from three to five minute spaced arm spines.

[1] Published with the permission of the Secretary of the Smithsonian Institution.

The other characters are essentially as in Ophiura (Ophioglypha).

Range.—From the Antarctic regions in the vicinity of Cape Horn northward along the coast of Chile to 38° 8′ N. lat., in from 260 to 677 fathoms.

Remarks.—In addition to the two species described below, this genus includes *Ophiomaria carinifera* (Kœhler) and *Ophiomaria doederleini* (Kœhler).

Ophiomaria tenella, sp. nov.

The disk is thin and stellate, the angles continuing uninterruptedly into the arms, which taper very gradually and become very slender distally. The disk is 11 mm. in diameter, and the arms are 40 mm. long.

The central portion of the dorsal surface of the disk is covered with a close and regular fine granulation through which, in some specimens, the six small rounded primary plates are visible. Toward the periphery of the disk this granulation becomes coarser and more irregular, the granules transforming into small flat polygonal plates. In the center of the strongly excavated interbrachial margin of the disk, as viewed dorsally, there is a transversely oval or semicircular plate, usually about twice as broad as long; between this and the radial shields on either side there is usually a plate about half as large, more or less circular or irregularly polygonal in outline, and a few, very irregular, much smaller plates. Within this interbrachial border, as within the most proximal plates in the columns separating the radial shields, there may be a few irregular polygonal plates bordering the granular covering of the central portion of the disk.

The radial shields are irregular rounded triangles, nearly or quite twice as long as wide, about as long as the width of the arm immediately beyond the disk. The radial shields of each pair are separated interiorly by a series of two or three plates of which the innermost is considerably longer than the others; between this last and the granulation of the center of the disk there are usually a few irregularly polygonal plates of various sizes. From the distal end of the outermost plate in the series between the radial shields there runs around the distal borders of the latter a series of two or three or more irregular plates (more rarely a double series) which takes the place of an arm comb. The upper surface of these plates is even both with that of the radial shields and with that of the arm plates beyond them.

The interbrachial spaces below are filled with irregular polygonal scales which are largest along the lateral borders, becoming smaller and more or less surrounded by or covered with granules centrally; toward the oral shields they tend to imbricate more or less.

The genital slits are long, reaching from a notch in the middle of the sides of the oral shields to the border of the disk as viewed ventrally; they are bordered with small truncate closely crowded papillae.

The proximal edges of the oral shields are straight and make nearly a right angle with each other; the sides are roundedly incised by the proximal ends of the genital slits; the outer corners are broadly rounded; and the distal border is concave or sometimes convex. The length of the oral shields is equal to, or slightly exceeds, the breadth.

The mouth papillae are five in number; the innermost is triangular and sharp pointed, the others lower, truncated distally. Continuing these is a series of five, more rarely six, papillae bordering the first arm tentacle abradially, of which the outermost is broad and triangular, with the apex over the proximal end, the others small, subequal, rounded distally; opposite these on the first under arm plate are two, rarely three, large tentacle scales, of which the outermost is about as large as the outermost in the other series, and twice as large as the inner.

The side mouth shields are narrow, about four times as long as broad, with parallel sides, and incised near their outer ends by the furrows lodging the first arm tentacles.

The first upper arm plate distal to the row of plates bordering the radial shields is very narrow, almost bandlike, nearly spanning the arm in dorsal view; the next is longer and wider, with converging sides and a convex distal border; the following ones decrease regularly in width, increasing in relative length, at the fifteenth or sixteenth becoming triangular, twice as long as broad, with the distal border strongly convex; beyond the sixteenth each upper arm plate is separated from the preceding by an increasingly greater relative distance, as a result of the increasingly broader union of the side arm plates.

The arm spines are very short and slender, on the first ten side arm plates three or four, commonly in two well spaced pairs, beyond these five, toward the end of the arm four, usually in two spaced pairs, and at the tip of the arm three. At first the arm spines are equal in length and size; beyond the basal third of the arm the lowest increases in relative length, soon becoming twice as long as the others.

The first under arm plate is fan-shaped, the outer border strongly convex, the very short inner border strongly concave. The second is usually slightly longer, twice as broad proximally, the lateral borders slightly concave, the distal border with a median convexity and two slight lateral concavities; the tentacles on either side are protected by four scales inwardly and three outwardly. The third is similar, but with a much narrower base and more converging sides. The fourth is rhombic. The fifth is rhombic, shorter, in contact with the fourth. The next two are shorter, rhombic, but with the outer angles cut away by the tentacle grooves, widely separated from each other. The following ones have a low convex distal border and the outer part of the proximal border cut away by the tentacle grooves. Beyond the middle of the arms the under arm plates lie entirely between the tentacle grooves; they become very minute in the distal portion of the arm.

Type.—Cat. No. 38580, U. S. N. M., from *Albatross* Station 2785, off the coast of Chile, in 449 fathoms.

Ophiomaria rugosa, sp. nov.

In the largest specimen the disk is 16 mm. in diameter, and the arms are about 50 mm. long.

The disk is pentagonal with slightly concave sides, less stellate than that of *O. tenella*, thick, at the angles of the pentagon curving abruptly downward to the arm bases. It is covered dorsally with fine granules which become coarser toward the margin, where they tend to transform into an irregular mosaic of small, very irregular, polygonal plates, especially at the arm bases; the radial shields are covered.

The granulation of the disk may cover uniformly all of the plates, but usually one or more of the following series are visible; six widely separated circular or oval primary plates, much swollen and elevated above the general surface; a similar plate at each arm base, with sometimes a small one beyond it; between the plates at the arm bases a similar but smaller plate, about the size of the central plate, in the mid-interradial line; a small plate on either side of a line between each peripheral primary plate and the plate at the base of the corresponding arm; a plate in the middle of each interbrachial border, as viewed dorsally, which sometimes forms the center of a series of very irregular plates between the arm bases.

The arms are essentially as in *O. tenella*, but the side arm plates and upper arm plates are rather strongly convex in profile, so that the arms appear rugged.

The plates in the interbrachial areas below are much smaller than the corresponding plates in *O. tenella*, and the granules are more abundant, smaller, and more generally distributed.

On the ventral surface there appear to be no essential differences between this species and *O. tenella*.

Very young individuals with the radial shields exposed differ from young specimens of *O. tenella* in having smaller and more numerous central plates on the dorsal surface of the disk, and swollen arm plates.

Type.—Cat. No. 38579, U. S. N. M., from *Albatross* Station 2791, off the coast of Chile, in 677 fathoms.

PHYSIOLOGY.—*Food economics.*[1] GRAHAM LUSK, Professor of Physiology, Cornell University Medical College, New York.

The consideration of the food supply from a national standpoint was forced upon Germany at the outbreak of the great war which is now in progress. Eminent scientists combined in a report upon the prospects of the sustenance of the nation.

[1] A lecture delivered before the Washington Academy of Sciences, April 14, 1916.

Imports from oversea had been restricted. Meat, butter, cheese, and fish formerly obtained from Holland and Denmark were no longer available. The North Sea fisheries which had yielded 179,000 metric tons (1 metric ton = 2200 lbs.) of fish were closed, trained farm hands were fewer, crops in East Prussia and Alsace had been destroyed; the situation appeared serious. It was estimated that the annual amount of food fuel necessary to support sixty-eight million Germans—men, women, and children—was 56,750,000,000,000 calories. This is the equivalent of 3000 calories per adult per day. The quantity of protein required in this fuel, if the human machines were to maintain themselves in self-repair, was estimated to be 1,605,000 metric tons per annum. It was calculated that a mixed population of sixty-eight millions (men, women, and children) required the same amount of food as would 51,823,000 adults.

In order to increase the production of food and to diminish the waste, the committee recommended increasing the crop of beans, with its large protein content, reducing the unnecessarily large meat supply, and increasing the intake of cheese and skim milk (which latter should no longer be fed to pigs), improving the yield of vegetables and fruits, and reducing the quantity of butter and cream produced. A reduction in the consumption of meat, butter, and cream was necessary, because edible grains would be required for human food, and the maintenance of the usual number of cattle was no longer deemed possible.

The estimated savings as above enumerated would result in a total production of 81.25 billion food calories containing 2,022,800 tons of protein.

The conditions were summarized as shown in table I.

From these data it was concluded that the German people, through cooperation of millions of inhabitants, would be able to prevent suffering for lack of food. There can be no question that respect for the scientific knowledge of specialists, of men like Rubner, Zuntz, Oppenheimer, and Lehmann, was of highest value in the hour of national exigency. Countries in which highly educated men are very slightly esteemed would have passed over this advice, would have consigned it to the newspaper dung-hill of "highbrow" information, and starved to death in consequence.

TABLE I

Showing the Annual Food Requirements of 68,000,000 People in Germany

	PROTEIN IN 1000 METRIC TONS	CALORIES IN BILLIONS
Actual requirement	1605	56.75
Used before the war	2307	90.42
Available (unchanged habits)	1543	67.86
Available (under present recommendations)	2023	81.25

It is not unimportant to know something of the cost of these great quantities of food fuel.

If one takes the wholesale cost in the United States of food purchased on account of the Commission for Relief in Belgium as a basis, one can estimate, in terms of the cost of various simple food-stuffs, the lowest wholesale cost of the yearly food fuel requirement of the German nation, as follows:

TABLE II

Wholesale Cost in America of Food Fuel for 68,000,000 People

	COST PER POUND	COST PER 1000 CALORIES	COST FOR 56,750,000,000,000 CALORIES
Corn meal	$0.016	$0.011	$634,000.000
Wheat	0.023	0.014	794,500,000
Rice	0.03	0.018	1,022,500,000
Flour	0.033	0.02	1,135,000,000
Beans	0.045	0.029	1,634,000,000

The wholesale cost of sufficient food fuel exclusively in the form of beans to provide the United States for a period of one year would call for a sum of two and a half billion dollars. Beans are more costly than rice and wheat, but have a larger protein content.

Contrast the stupendous cost of food fuel for a nation with the living expenses of a poor family in New York City (table III).

To the man of large affairs the expenditure of twenty-five dollars a month for food appears of little moment, and yet if the 100,000,000 inhabitants of the United States lived as this

TABLE III

Family, Two Adults, Three Children

Wages	$60 per month
Rent	$15.00
Food	25.00
Coal	4.50
Insurance	2.25
Soap, matches, etc	1.00
Clothing and extras	12.25
	$60.00

typical poor man's family lived the cost of food would aggregate $6,000,000,000 per annum. To any man of large affairs the maintenance at Boston of the Nutrition Laboratory of the Carnegie Institution, with its budget of $60,000 per annum, appeals impressively to the imagination; yet this work is accomplished at an annual expense of one-thousandth of one per cent of what the American people would pay for food if each family of five had an income of $720 per annum. Is it not a little sad to think that the expenditure of thousands of millions of dollars annually for food, an expenditure frequently amounting to more than half of the income of the poor man, should take place without any real idea as to the nature of what food is?

TABLE IV

Supplies for a Boarding School Containing 355 Boys

	PROTEIN METRIC TONS	FAT METRIC TONS	CARBO-HYDRATE METRIC TONS
Food supply	20.5	25.6	60.5
Waste	3.8	5.4	4.2
Food-fuel	16.7	20.2	56.3

Mr. F. C. Gephart, of the Russell Sage Institute of Pathology, has made a study into the food consumption of the boys at St. Paul's school at Concord, New Hampshiré, one of the largest private boarding schools in the country. The total annual food supply has been computed as shown in table IV.

This amount of nourishment was taken by 355 boys and by about 100 adults (masters and servants). This quantity of food when computed on the basis of the individual meal served appears as follows:

TABLE V

Food Supply per Meal

	POUNDS	GRAMS	CALORIES	CALORIES
				per cent
Protein	0.1107	50.2	206	14*
Fat	0.1332	60.4	562	39
Carbohydrates	0.3717	168.8	692	47
			1,460	100

* 70 per cent of this is in animal protein.

The cost of this food per meal was 20 cents, or 13.8 cents per 1000 calories. The food, which was bought by a purchasing agent in the Boston market and was of the best quality, included 193 separate varieties. Such a dietary taken by the 100,000,000 inhabitants of the United States would cost per annum $11\frac{1}{2}$ billion dollars, if the German minimum of 3000 calories daily per adult were allowed. This cost is twice what the poor man in New York City pays for his food.

These growing athletic boys, however, were not satisfied with 3000 calories daily. They not only took 4350 calories daily at the table, but they bought 650 additional calories in food at a neighboring store, the principal item being chocolate.

Data concerning the subjects of the investigation are epitomized in table VI.

The basal requirement of boys is, as Du Bois has shown, 25 per cent above that of the adult. The total fuel intake was three times that of the basal level, which is the heat production when a boy is resting or asleep. The 5000 calories contained in the ingesta is half as much again as a farmer at work would require. The quantity of the calculated intake would certainly not be lowered by excluding the adults who unavoidably entered into this computation. These results explain the ravenous appetite of boys. Lack of appreciation of this factor and lack of provision for it are the probable causes of much of the undernutrition seen in children of the school age.

TABLE VI

Table Showing the Nutrition Conditions at a School Containing 355 Boys

	Average age	Height	Weight	Body surface	Basal metabolism (calc.)	Food	Food in per cent of basal
	years	*cm.*	*kg.*	*sq. m.*	*cals.*	*cals.*	*per cent*
The Upper School	16	172.7	60.6	1.73	1826	4997	274
The School	14½	165.1	50.8	1.54	1737	5126	295
The Lower School	13½	157.5	43.8	1.40	1647	4949	300

The distribution of the fuel values among the various more common articles taken as food at the school is shown in the following table:

TABLE VII

Percentage Distribution of the Calories Ingested at a Boys' Boarding School

	Per cent		*Per cent*
Bacon	1.8	Lamb	5.3
Beef	6.7	Milk	12.6
Bread and flour	13.3	Pork loins	1.1
Butter	11.2	Potatoes	5.9
Cream	1.3	Sugar	11.6
Eggs	2.3	Other items	24.5
Fowl	1.9		

It is interesting that twelve dietary items yield 75 per cent of the fuel value, and that 181 other varieties yield the remaining 25 per cent. Bread, butter, milk, and sugar together yield 50 per cent of the food fuel.

According to the German minimum allowance an average family of five (father, mother, and three children) would require 11,400 calories in food daily. If the family's dietary were based proportionately upon that of the boy's school, it would cost as follows (table VIII), provided its food supplies were purchased on Second Avenue, New York City:

TABLE VIII

	CALORIES	COST IN CENTS
Total food	11,400	
Bread	1,500	5
Butter	1,500	5
Milk	1,500	16
Sugar	1,500	4
	6,000	30

Thirty cents will buy more than half the family's food requirement at an average cost of 5 cents per thousand calories, instead of 14 cents, the average cost at the school. If $25 is spent each month for food, 80 cents a day is available, or 7 cents for a thousand calories. The margin is narrow.

It would be well if the family knew that more than half its food supply could be had for 30 cents a day, and that this bread, butter, milk, and sugar are of equal nutritive value to the best the country affords. The remaining 5400 calories could then be bought at a cost of 9 cents per thousand. This sum will purchase most of the usual foodstuffs, with the exception of meat.

As a matter of statistics, the annual consumption of cane sugar in the United States in 1912–13 reached 85.4 lbs. per capita, which is the equivalent of 2000 calories daily for a family of five, or twenty per cent of the energy requirement. This quantity of sugar costs the nation a million and a half dollars daily, and the rich harvest to be reaped by substitution of only a part of this by saccharin, which has no fuel value whatever, is obvious.

It has appeared to those at work in the laboratory that it would be of great importance to associate the caloric value of food with cost in dollars and cents. For the understanding of this, table IX has been prepared, showing the cost of 2500 calories, which is the energy requirement of an average adult of sedentary occupation.

True food reform demands the sale of food by calories and not by pounds. Professor Murlin has advocated that the

TABLE IX

Weights of Various Foods Necessary to Furnish 2,500 Calories, and Cost at Second Avenue and 90th Street, New York City

A man at moderate work requires 2,500 calories daily

Articles	Weight		Cost
	Pounds	Ounces	
Corn meal	1	8	$0.04½
Hominy	1	8	0.04½
Oatmeal	1	5½	0.05¼
Flour	1	8	0.06
Sugar	1	5½	0.06$\frac{23}{32}$
Rice (broken)	1	8½	0.07¼
Bread	2	1	0.08¼
Lard		9½	0.08$\frac{5}{16}$
Corn syrup	1	13	0.09⅔
Molasses	1	15	0.12$\frac{15}{16}$
Peanut butter		14	0.14
Pork (fat)	1		0.14
Beans (dried), pea	1	9	0.14
Oleomargarine		11	0.15$\frac{13}{16}$
Potatoes	8	1	0.16⅛
Dates	1	12	0.17½
Olive oil		9½	0.19
Hickory nuts (unhulled)	2	0	0.20
Raisins (dried)	1	12	0.21
Applies (dried)	1	13	0.21¾
Cheese, American, pale	1	3	0.23¾
Butter		11	0.24$\frac{1}{16}$
Brazil nuts (unhulled)	1	8	0.27
Cocoa	1	1	0.29$\frac{9}{16}$
Lentils (dried)	1	8	0.30
Almonds (unhulled)	1	8	0.36
Apples (fresh)	11	5	0.38
English walnuts (unhulled)	1	13	0.41$\frac{11}{16}$
Salt cod	6		0.90

government compel manufacturers to place upon each can or package of food sold the caloric content of the package.

Besides fuel value it must be remembered that the body must have protein. The machinery of the living parts of the body such as muscle is in a constant state of wearing away. The wear and tear is slight, but protein must be taken in the food to replace that destroyed in the body or the machinery of the cells will wear out and death from lack of protein will ensue.

Different proteins have different values for this purpose. Those of meat, fish, eggs, and milk will replace body protein part for part. Such proteins may be classified as proteins of Grade A. Gelatine has practically no power to replace body protein and should be classified as protein of Grade D. Wheat contains a mixture of proteins of Grades A and D in which those of Grade A predominate, so that wheat may be classified as containing protein of Grade B, whereas from analogous reasoning corn may be said to contain protein of Grade C.

An ordinary dietary with a liberal allowance of protein contains 15 per cent of its calories in that form. A can containing 15 per cent of its calories in protein should have a star placed with the letter determinative of the grade of protein. For example the label on a can of corn should read, "This can contains x calories of which y per cent are in protein of Grade C." A further desirable statement would be as to whether the foodstuff sold contained the natural mineral constituents from the organic source from which it was derived.

I have elsewhere emphasized the desirability that the government should give this information with regard to all foodstuffs sold in packages. The determination of the heat of combustion of a dried sample of food takes fifteen minutes. Probably three hours would suffice to make a complete analysis by a government expert. The manufacturer should send his sample can to the Bureau of Chemistry at Washington, declaring that to be his standard and requesting information regarding his label. He should pay for this analysis as a patentee pays for his patent. If at any time the government should find the manufacturer selling on the market a material of different character than the standard deposited with the government, the manufacturer should be heavily fined.

It is not possible to consider the details of the great amount of extremely valuable work accomplished by the scientific departments of the Washington Government and in the individual

Agricultural Experiment stations in this country and abroad. It may, however, be of interest to call attention to the results of a study of the sale of food at Childs' restaurant[2] which shows how this principle of caloric feeding, now adopted in hospitals and upon farms, may be worked out in the daily life of the people.

The main objection that has been encountered to the sale of food on the caloric basis has been the sensitiveness of the business world to the introduction of a new and unknown quantity. Why not leave well enough alone? A more highly educated generation will, however, demand that its expenditures of thousands of millions of dollars for food shall not continue to take place in unfathomable depths of darkness.

[2] Gephart and Lusk. Analysis and cost of ready-to-serve foods. Published by Am. Med. Assoc., 1915.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*Results of observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Tucson, Arizona, 1913 and 1914.* Daniel L. Hazard. U. S. Coast and Geodetic Survey Serial Publication No. 23. 1916.

This publication is in continuation of the series giving the results obtained at the Tucson magnetic observatory since its establishment in 1909. It contains a summary of the monthly determinations of the scale-values of the horizontal intensity and vertical intensity variometers; the base-line values derived from the weekly absolute observations; diurnal variation tables for the magnetic elements D, H, and I, the total force F, and the rectangular components X, Y, Z; hourly values of D, H, and Z, together with daily and hourly means for each month; a tabulation of the earthquakes recorded on the seismograph; a list of the magnetic disturbances of considerable magnitude, and reproductions of the magnetograms showing the more marked disturbances. Attention is called to the fact that beginning with 1913 intensity results obtained by this Bureau have been reduced to the international standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Published results for earlier years must be diminished by one part in a thousand to reduce them to that standard.

D. L. H.

TERRESTRIAL MAGNETISM.—*Solar radiation and terrestrial magnetism.* L. A. Bauer. Terr. Mag., **20**: 143–158. 1915.

Comparisons have been made between the records of magnetic variations and those of the solar constant as determined by Abbot. If the local magnetic constant G be defined as $(H^2 + \frac{1}{4} Z^2)^{\frac{1}{2}}$, where H and Z are horizontal and vertical magnetic intensities respectively, it is found that the 1913 results from 8 magnetic observatories indicate on the average an increase of about 0.002 of a per cent in G, and a decrease of about 1 per cent in the magnetic diurnal range for a decrease of 1 per cent in the solar constant.

It is shown further that the eclipse magnetic effects are of the same sign, and of the same order of magnitude as the magnetic effects which are, apparently, to be associated with about a 10 per cent decrease in the value of the solar constant.

It is found that on consecutive quiet days the magnetic constant is, on the average, larger on the second day than on the first by an amount equal to that which would be caused by the average daily change in the solar constant. If the quiet day magnetic effect were to persist throughout the year, it would cause a secular variation fully 10 times that generally observed. However, the quiet days are in the minority, and on the unquiet days the effect is in a direction opposite to that for the quiet days. Since there is not a complete compensation between the two opposing effects when integrated throughout a period of a year, part of the *observed* secular magnetic change should be of a type related to the annual change in solar constant. W. F. G. S.

PHYSICS.—*On the ionization of the upper atmosphere.* W. F. G. Swann. Terr. Mag., **21**: 1–8. 1916.

If the sun is taken as a black body, and if in accordance with the experiments of Hughes, ionization does not set in below wave length 135 $\mu\mu$, it appears that only about 1.6×10^{-5} of the total solar radiant energy is available for atmospheric ionization.

The results are applied to an example cited by Schuster in connection with his theory of the diurnal variations of terrestrial magnetism. Schuster concludes that if the upper atmosphere is treated as a shell 300 kilometers thick, at a pressure 1 dyne per square centimeter, a conductivity of 10^{-13} e. m. u. would have to exist in it in order to account for the necessary magnetic effects. The author finds that only about 10^{-3} of this amount can be accounted for in such a shell, by the ultra-violet radiation, and even if the whole of the sun's energy could be absorbed in producing ionization, the conductivity accounted for would yet be far too small.

The above conclusion is not intended as a criticism of Schuster's theory, however, since the ultra-violet light is not the only source of ionization in the upper atmosphere. Further, it is shown that if the calculation is not limited to a shell, but if account is taken of the infinite extent of the atmosphere, the magnetic effects which result as the ultimate consequence of a feeble source of ionization may be very much greater than those calculated on the basis of a shell of finite thickness.

W. F. G. S.

PHYSICS.—*Protected thermoelements.* ARTHUR W. GRAY. Bureau of Standards Scientific Paper No. 276. Pp. 3. 1916.

The mounting described in this paper has been found to be very convenient for protecting laboratory thermoelements from damage by contamination or by mechanical strains.

The closed tube which covers the temperature determining end of the thermoelement has its open end cemented into one end of a flexible copper tube, through which the wires, properly insulated, pass to a head at the other end. Projecting downwards, from this head is a glass tube which contains the ice junction. The head is provided with neutral binding posts for receiving the leads to the apparatus employed for measuring the electromotive-force by which the temperature is determined, and contains phosphorus pentoxide to prevent moisture films from being deposited within the protective covering.

The ice-bath is contained in a vacuum jar which is protected by a metal case. By means of a bayonet joint this is suspended from the cover, which is fastened to a rod fitting the standard laboratory clamps. The head of the thermoelement telescopes with moderate friction into a split tube which projects upward from the top of the ice-bottle cover. When it becomes necessary to renew the ice, a slight turn of the case containing the vacuum jar frees the bayonet joint and permits lowering of the ice-bath without disturbing anything else.

A. W. G.

SPECTROSCOPY.—*Interference measurements of wave lengths in the iron spectrum (3233A–6750A).* KEIVIN BURNS, W. F. MEGGERS, and PAUL W. MERRILL. Bureau of Standards Scientific Paper No. 274, pp. 245–272. 1916.

The wave lengths of 403 iron lines have been measured by means of interferometers in an effort to determine standards at intervals of about 10 angstroms. This has been accomplished in the greater part of the spectrum between 3233A and 6750A, the region in which the International secondary standards exist. As far as possible, lines of all intensities were measured.

The arc spectrum of iron was used in accordance with the recommendations of the International Wave-Length Committee. The method of procedure was that of Buisson and Fabry (*Journal de Physique*, **7**: 169. 1908). Most of the wave lengths were determined by means of three or more interferometers in which the orders of interference ranged from 15 to 60 thousand waves. The International secondary standards were used in this comparison instead of the fundamental cadmium standard. The mean difference between the present observations and the International standards is about one part in four million.

Comparisons with all the grating observations of iron lines which have been made on the I. A. system prove that more secondary standards were needed to obtain the highest accuracy in grating interpolations. Some of the grating observations show a difference in wave length which is a function of the intensity of the line. The measurements with the interferometer appear to be quite free from this effect.

In the course of the investigation over 600 lines were examined by means of several interferometers in order to discover the limiting orders of interference. This gave an idea of the width or sharpness of each line. The data on sharpness were then correlated with intensity, pole effect, and pressure shift. K. B.

GEOLOGY.—*Geology and oil prospects of the Cuyama Valley, California.* Walter A. English. U. S. Geological Survey Bulletin 631 M, pp. 191–215. 1916.

The Cuyama Valley area lies within the California Coast Ranges, south of the important oilfields which border the San Joaquin Valley along its southwest side. Although written primarily as a discussion of the oil possibilities the report also brings out certain features of the complicated Coast Range structure and stratigraphy.

The rocks outcropping are a thick Cretaceous formation of dark shale, and Tertiary clayey and diatomaceous shales and sandstones. The Cretaceous beds are quite uniform in lithologic character and vary little from beds of the same age in other parts of the Coast Ranges. The Tertiary formations, however, are of extremely variable lithology. During parts of Tertiary time the shore line probably crossed the Cuyama area, for in going from west to east within this area the lower and upper Miocene rocks are traceable from marine beds typical of Coast Range deposition into non-marine beds of the type of the Tertiary formations present in the Mojave and Tehachapi regions to the east. Lithologic variations within the marine beds are due to local differential uplifts which occurred during Tertiary time, and which formed long island ridges in the sea which then covered the present Coast Ranges. These Tertiary differential uplifts also served to complicate the structural features of the region. The present Coast Ranges are made up of a series of long northwestward trending ridges, the individual ranges of the system, separated by wide valleys. These ranges and valleys are of structural origin, having been formed by the pronounced folding and faulting of early Pleistocene time. The structure resulting from the comparatively recent folding is superimposed upon structures formed by similar earlier movements. An interesting result of this combination of structures is that, although the general trend of the major lines of structure produced by the earlier movements was northwest, and thus parallel to the later structure, the blocks subjected to differential uplift during the earlier part of the Tertiary were not always the same as those most recently uplifted. An area which formed a range during the Tertiary and from which many thousand feet of beds were eroded may now form the bottom of a structural valley, and another area which was a structural trough during parts of the Tertiary may now form a recently uplifted range. W. A. E.

BOTANY.—*Studies of Tropical American phanerogams—No. 2.* Paul C. Standley. Contributions from the U. S. National Herbarium, **18**: 87–142. 1916.

The paper consists of descriptions of new species and of taxonomic notes upon various groups of plants, chiefly the Amaranthaceae, Allioniaceae, Malvaceae, and Rubiaceae, and the association of families formerly known as the Leguminosae. Most of the new species are based upon material obtained in Panama by Mr. Henry Pittier. A large number of species published in the genus *Pisonia* are transferred to *Torrubia.* A new genus of the Malvaceae, *Wercklea,* based upon a showy-flowered tree of Costa Rica, is published jointly with Mr. Pittier. *Peltaea,* a new genus of Malvaceae, embracing 4 species, is proposed and *Lopimia,* of the same family, is restored. There are included descriptions of three new species of persimmons (*Diospyros*) from Mexico, and 11 species of *Psychotria* from Panama. Two genera of Rubiaceae, *Cassupa* and *Stachyarrhena,* are reported from North America for the first time. P. C. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 774th meeting was held on May 13, 1916, at the Cosmos Club, President BRIGGS in the chair; 53 persons present. The minutes of the 773d meeting were read in abstract and approved. After discussion the following resolution recommended by the Executive Committee was unanimously carried:

Resolved: That the Philosophical Society of Washington most heartily approves of House of Representatives bill No. 528 (known as the Johnson bill) for the adoption of the Centigrade temperature scale in Government publications with the amendments as approved by the National Academy of Sciences.

Mr. C. W. HEWLETT of the Johns Hopkins University presented a communication on *The analysis of complex sound waves* and exhibited and demonstrated the apparatus used in the investigation. The speaker first gave an example to show what is meant by the analysis of a complex sound wave. Suppose we have three tuning forks whose frequencies are related to one another as are the numbers 1, 2, and 3, and let us consider the sound waves passing through a point at some distance from the forks. If each of the forks were excited separately we should observe at the point in question three simple harmonic trains of waves of definite intensities with frequencies corresponding to the frequencies of the forks. If all the forks were excited together we should observe a complex train of waves passing through the point, and by a proper arrangement of apparatus this complex wave could be analysed. If our analysis led to the conclusion that the complex wave was composed of the three simple harmonic trains which we observed when the forks were excited separately, then we should say that the analysis was correct. But, as is well known, a Fourier analysis could be carried out which would lead to an entirely different result, and it would also be a correct analysis in the sense that the portion of the complex wave analysed could be reproduced by the combination of the components found by the analysis. Again suppose that the three forks had frequencies whose relations to one another were the same as the numbers 1, 2.1, and 3.5. The complex wave from these three forks could again be analysed, and the analysis would be again regarded as correct if it gave us three simple harmonic trains of waves with frequencies corresponding to those of the forks and intensities which we would observe with the forks vibrating separately. But a Fourier analysis in general would give us an entirely different result, and this analysis would also be correct in the sense that the portion of the wave analysed could be reproduced by combining the components found by the analysis. We thus see that a Fourier analysis does not necessarily tell anything in regard to the physical apparatus giving rise to the complex sound wave. If, however, the complex wave be explored by a system of tunable resonators the analysis so found does give information in regard to the source. The apparatus exhibited consisted of such a series of resonators. The detecting device is a Rayleigh disc suspended in the opening of the resonator and deflections are measured by a beam of light reflected from the disc.

Discussion. Mr. Swann raised questions regarding what was really of importance to the ear and whether a physical analysis can be of the same nature as that of the ear's system. In experimental work the mounting and operation of a musical instrument is entirely mechanical and without any of the effects due to a player's skill when using the same instrument. The ear apparently appreciates the energy. Mr. C. A. Briggs said that the mechanical receipt of sound by the ear might be explained by the reed frequency indicator. Mr. Curtis suggested that an improvement might be obtained by using a model of the ear's system for experimental work. Mr. Wead called attention to the fact that a large part of detail of the ear's system as generally described is due to handling in cleaning and cutting, and does not correspond to anything in the living ear. In music fixed pitch is not wanted. Mr. Hewlett stated that he hoped to take up later experimental work in connection with mechanical playing.

By invitation, Mr. J. A. Anderson of Johns Hopkins University then presented a paper on *Diffraction gratings; their preparation and use.* A reflecting diffraction grating consists of a polished plane or spherical metallic surface on which are ruled a great number of lines or grooves, all of which must be straight, parallel, and equidistant from each other. In practice these conditions are never satisfied absolutely, and the question arises as to what deviations from ideal conditions may exist without impairing the quality of the grating. A discussion shows that the lines should not have a radius of curvature of less than 3 kilometers, and the distance between them should be so nearly constant that the deviation of the last line from its ideal position should not exceed one-quarter of a wave-length. The design and construction of a machine for ruling perfect gratings is a very difficult problem, but it was solved so completely by Professor Rowland that by following him intelligently it does not now present any insurmountable difficulties. The parts of the machine must be carefully tested; methods for doing this were explained. The machine is finally tested by the method of "cross rulings," a method devised by Professor Rowland, and which is so sensitive that errors in spacing as small as $\frac{1}{3,000,000}$ inch can be detected with ease.

Discussion. Following the exhibit of a number of gratings and cutting tools Mr. Abbot asked regarding the life of a ruling tool and largest gratings made. Mr. Anderson stated that all of the gratings were made on speculum metal. This is crystalline and therefore, owing to occasional pitting, subjects the tool to slight falls with the result that the diamond may chip; the natural edges of the diamond are used for cutting; with care one tool will rule from 6 to 10 miles. The diamond would stand indefinite use on soft metals such as silver; if soft metals could be given as high a polish as speculum metal it would be possible to rule large gratings. Messrs. HUMPHREYS and WRIGHT cited a number of examples of diamonds that cannot be cut by the lapidary; they are designated as "knots." Mr. BAUER asked what is the largest number of lines ruled to the inch. Mr. Anderson stated that he had himself ruled 15,000 lines to the inch and was building a machine to rule 30,000; Professor Rowland had ruled one grating with 86,000 lines per inch but that grating had been lost; among the gratings exhibited was one with 43,000 lines per inch by Professor Rowland.

The chair extended to Messrs. Anderson and Hewlett the thanks of the Society for their very interesting papers.

J. A. FLEMING, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 308th meeting was held in the lecture room of the Cosmos Club on April 12, 1916.

REGULAR PROGRAM

J. S. DILLER: *Geologic history of Lassen Peak.* Lassen Peak is an ancient volcano at the southern end of the Cascade Range and fills the gap between the northern end of the Sierra Nevada and the Klamath Mountains composed largely of old sedimentary rocks.

Its volcanic activity began near the close of the Eocene, was greatest during the Miocene and Pliocene and decreased in the Quaternary to near extinction.

Lassen Peak is a volcano of large type surrounded by many smaller ones of later date, the whole being built up by many explosive and effusive eruptions of a notable variety of lavas. The earliest lavas are andesite, but the differentiated magma appeared later on the one hand as dacite and rhyolite, and on the other hand as basalt and quartz basalt.

In developing the peak the great volcanic vent migrated nearly 4 miles to the northwest, erupting first andesite, then dacite, which built up Lassen Peak to its present height, 10,460 feet. Later, only a few centuries ago, dacite was erupted at the northwest base of the peak forming Chaos Crags, but finally activity began again May 30, 1914, erupting dacite in the old crater of the highest summit. The basalts are mainly in the peripheral region.

In the discussion Diller asserted that the flashes of light, cloud glows and rocket-like incandescent bombs shot from the crater prove that at least some of the new lava erupted was hot enough to be luminous, and the flow structure in some of the breadcrusted bombs shows them to have been viscous.

Arthur L. Day: *Volcanic phenomena at Lassen Peak.* Since the outbreak in 1914, Lassen Peak has shown four phases of activity which may be called volcanic. The first phase began on May 30, 1914, with a series of sharp explosions in the old summit crater, which developed an opening in the scoriaceous débris at the bottom of the crater some 25 by 40 feet in size and perhaps 30 feet deep. These explosions were followed by others with increasing violence for several weeks, until the new opening reached a length of 900 feet or more. No fresh lava or other evidences of heat or chemical action appeared during this phase of the activity.

On May 21, 1915, the most violent explosion thus far noted took place, and was accompanied by a horizontal blast down the northeast flank of the mountain (phase 2), a mud flow (phase 3) following the blast, and a summit upheaval (phase 4) of much greater magnitude than any which had preceded it. The lateral blast was similar in its character and effects to the "Nuées Ardentes" of Mont Pelée, so accurately described by Lacroix. The temperature, however, though sufficient to melt the vast accumulations of snow on this flank of the mountain, and thus to cause the mud flow, was nevertheless insufficient to start a general conflagration of the kind which was visited upon Saint Pierre. The only evidences of combustion were confined to a single small area where local conditions interrupted the path of the blast and increased the time of exposure to its heat. A similar blast occurred on May 23.

That the mud flows were caused by the melting snow on the outer flanks of the mountain, rather than by an outflow of mud from the crater, as at first reported, is plainly established by the observation that no mud is found within some 1500 feet of the summit. The devastation caused by the mud flow was, nevertheless, of considerable magnitude, and involved some 5 million feet of standing timber, much of which was swept away, root and branch.

The upheaval at the summit, lifting a considerable portion of the bottom of the old crater, including sections of the east and west rims, but not being sufficiently powerful to hurl it completely off from the mountain top, produced the appearance of an area which has been effectively dynamited. At the east end, where the lateral blast found vent, some large boulders were split off and were carried by the mud flow into the valleys below. The remaining upheaved matter fell back in a wild chaos of boulders, the summit of which is now 200 feet or more above the lowest point of the old crater bowl.

A visit to this upheaved area about 4 weeks after the occurrence revealed a few cracks, adjacent to the center of explosive activity, from which hot gases were still escaping. Except for the rocks and ash adjacent to these cracks, all the upheaved matter was cold. From this and other surface indications, it seems impossible to conclude that any fresh lava reached the surface, nor could any considerable evidence of chemically active gases be found.

On the northeast flank of the mountain, a mile or more from the crater, a few breadcrust bombs were found, but these are angular in contour and are deemed to have acquired their breadcrust surface from superficial rather than from initial plasticity. Proof of this is found in the fact that some of the breadcrusted material is nothing more than scoriaceous tuff. No evidence was discovered that the breadcrusting was associated with the May outbreak.

The absence of convincing evidence of very high temperatures, or of chemically active gases, suggests the conclusion that the activity may have been caused by explosions of superheated steam resulting from the approach of meteoric water to the volcano hearth.

Carroll H. Wegemann, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 556th regular meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, May 6, 1916; called to order by President Hay at 8 p.m., with 45 persons present.

On recommendation of the Council Victor J. Evans, Washington, D. C., was elected to active membership.

The President announced the recent deaths of Charles A. Davis and S. M. Gronberger, members of the Society.

The first communication of the regular program was by M. W. Lyon, Jr., *Longevity of bacteria.* Dr. Lyon described a culture of *Bacillus paratyphosus B.* which had been hermetically sealed in a glass tube in ordinary culture medium for the past ten years, and exhibited a living subculture which had been made from it. He called attention to the short life of certain organisms and the long life of others, especially those producing spores.

This communication was discussed by Dr. L. O. Howard and Mrs. E. M. Enlows.

The second paper was by Dr. L. Stejneger: *The amphisbaenoid lizards and their geographic distribution.* Dr. Stejneger called attention to various theories that have been advanced to account for the distribution of animals, and explained how the amphisbaenoid lizards, with their peculiar morphology and habits, were particularly adapted to show former connections with now separated land masses and islands. The distribution and relationships of these lizards clearly showed a former land connection between South America and Africa.

Dr. Stejneger's paper was illustrated by charts, diagrams, and maps showing the classification, the structural taxonomic characters, the probable evolution, and the geographic distribution of the amphisbaenoid lizards. The Chair, Dr. L. O. Howard, Dr. C. H. T. Townsend, Gen. T. E. Wilcox, and others took part in the discussion.

The last paper of the evening was by W. L. McAtee: *Sketch of the natural history of the District of Columbia.* Mr. McAtee gave a very interest historical account of the study of the natural history of the District of Columbia from the earliest accounts of Capt. John Smith who ascended the Potomac River as far as Little Falls and made notes on the fauna of the region, and the accounts of other early explorers and travellers, down to recent times. The speaker gave many entertaining quotations from the writings of these early naturalists, told about the early societies interested in the natural history of the District, and described the faunal and floral lists that have appeared, mentioning the number of species in each and calling attention to the fact that the District of Columbia is the type locality for many species.

Mr. McAtee's communication was discussed by the Chair, and by Messrs. L. O. Howard, D. E. Lantz, and William Palmer.

M. W. Lyon, Jr., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 496th meeting, held March 7, 1916, Dr. C. L. G. Anderson read a paper on *Old Panama.* After reviewing the voyage of Columbus along the Panamanian coast and incidents of the early history of the Isthmus, especially the settlement of Balboa, Pizarro, and others on the Gulf of Darien in 1510, he spoke particularly of early accounts of the aborigines. West of the colony of Darien came the Indian Province of Cueva, and west of that the province of Coiba, which ended at Limon Bay and the Chagres River. Darien or Cueva is a better name than Cuna for the Indians commonly known as San Blas, Mandingas, etc. These, of course, do not include the Chocos of Columbia. The natives of Urabá, east of the Gulf of Darien, were always called Caribes; they fought with bows and poisoned arrows. The Dariens, at the time of the Conquest, did not poison their weapons or make war with bows and arrows, but with wooden swords, long lances, and javelins hurled by the use of throwing sticks. Unlike the Mexicans and Peruvians, they had no belief as to the coming of the white Messiah, and fought the Spaniards from the start.

Oviedo mentions the following among the tongues between Urabá and Cape Gracias a Dios: Cueva, Coyba, Burica, Lengua de Paris, Lengua de Veragua, Chondales, Nicaragua, Chorotegas, Oroci, Orotiña, Güetares, and Maribios.

There were four kinds of houses: (1) quadrangular, (2) circular, (3) communal dwellings similar to those among the San Blas today, and (4) dwellings in the tops of trees. The first whites exaggerated the nudity of the natives, for pages are devoted to descriptions of their clothing. They possessed both ordinary and ceremonial garments. Females wore a short skirt and often added a shirt. Chiefs wore long white robes on ceremonial occasions. According to the same early chroniclers the tribes believed in a supreme being, and worshipped the sun, moon, and many spirits. They had medicine men and priests who told the people what they should do. Puberty was attended with ceremonies. There was much drinking of chicha at weddings and a house was built for the young man by his friends. After confinement a woman bathed herself and babe in the river and the newborn was fumigated with tobacco. When not warring, the bands bartered dry fish, sea-salt, shells, pottery, etc., among themselves. Slaves were branded or had a particular tooth pulled out. Graves were covered level with the ground, although the Chibchas constructed burial mounds. The bodies of chiefs were desiccated over a slow fire. All undertakings began with drink, singing and dancing.

The best recent description of the Chocos is by Mr. H. Pittier. There is much discussion over the classification of the Indians of western Panama. A memorial of 1606 A. D. mentions among the tongues in Chiriqui Province those of the Cothos, Borisques, Dorasques, Utelaes, Bugabaes, Zunes, and others. The Bureau of American Ethnology was urged to study the Isthmian tribes before their primitive customs are lost.

Mr. Pittier said, in discussing the paper, that it had been determined that Columbus was at Limon, and that the blowpipe, as well as the bow and arrow, was used by certain tribes of the region. Dr. Anderson agreed that Panama Indians used the bow and arrow to some extent, but stated that they were not employed in warfare. Following Mr. Pittier's statement concerning slaves farther north, Dr. Swanton pointed out that there was no true slavery in North America north of Mexico, excepting on the North Pacific Coast. The so-called slaves of the Pawnee or the Green Bay tribes mentioned by others were nothing more than war captives.

At its 497th meeting, held March 21, 1916, Miss Frances Densmore, of the Bureau of American Ethnology, addressed the society on *Mandan Music*. The songs and legends presented by the speaker were collected among the Mandan Indians on the Fort Berthold Reservation, in North Dakota, during two visits to that reservation, the first in 1912, the second in 1915.

A few facts concerning the history of the tribe were given by way of introduction. The Mandan are of Siouan stock and first appear on the page of history in 1738. About ten years later they are said to have been living near the mouth of the Heart River, in North Dakota, and remains of their villages at that point were found by Lewis and Clark in 1804. An epidemic of smallpox almost obliterated the tribe in 1837, the number of survivors being estimated at about 125. Lewis and Clark give the number of Mandan previous to this epidemic as 1600. Since that time the tribe has increased and the report of the Indian Office for 1914 gives the number of full-blood Mandan as 220. Some of these are sturdy old people who have kept their tribal traditions, and from such men and women the material comprised in this paper was collected.

To the minds of the Mandan their country was peopled with spirit beings who lived in the trees and the buttes. From the spirit women who lived in Eagle Nose Butte, about 30 miles south of the present site of Bismarck, they say they received a society called the Creek Women Society, with its ceremonial songs. Some details concerning this society were given by the speaker, who also outlined the legend of the Terrible Snake who lived in Thunder Butte.

After describing briefly the life in the old Mandan village the speaker passed to the principal subject of the paper, which was the custom of eagle catching. The tradition of the origin of this custom, as well as of the wolverine fetish owned by every leader of the eagle catchers, had been secured from the last Mandan who owns such a fetish and has the inherited right to sing the songs connected with it. These songs comprised those taught to the first eagle catcher by a wolverine, and include songs given to the wolverine by the buffalo, black eagle, coyote, and snake, as well as songs to be sung when the eagle trap was constructed and the bait prepared, the cord for securing the eagle made ready, and the sweat lodge built in the eagle camp. Other songs were connected with eagle catching, which was an undertaking having a deep significance and a somewhat ceremonial character. Several of these songs were sung by the speaker, who also gave a song said to have been learned from the Moon. A song connected with the legend of the origin of the flute was given in connection with the narrative.

Charts were presented giving a comparison of Chippewa, Sioux, and Mandan-Hidatsa songs, as studied by the speaker. In these diagrams were included certain songs of the Hidatsa, who for many years have lived in the same villages with the Mandan, and other songs which cannot be accredited with exactness to either tribe. The musical material obtained on this reservation is therefore considered as Mandan-Hidatsa when placed in comparison with that of other tribes. Comparison of tonality with Chippewa and Sioux shows the Mandan to contain a larger percentage of major songs than either of these tribes, the percentages of major songs being 57 among the Chippewa, 40 among the Sioux, and 65 among the Mandan-Hidatsa. Comparison of structure showed the percentage of harmonic songs (those whose contiguous accented tones bear a simple chord-relation to each other) to be 24 per cent among the Chippewa, 12 per cent among the Sioux, and 35 per cent among the Mandan-Hidatsa. These comparisons are based upon the analysis of 70 Mandan-Hidatsa songs, while the number of Chippewa and Sioux songs examined is much larger. Further investigation may somewhat change the results of the comparative analysis.

The paper was illustrated throughout by lantern slides, and was followed by two musical numbers under the direction of Mr. HEINRICH HAMMER, showing the adaptation of Indian themes in musical composition. One of these was a fantasie for violin and piano, composed by Mr. Hammer on a theme collected by Miss Densmore and presented for the first time on this occasion.

At the 498th meeting, held April 4, 1916, Miss ADELA C. BRETON, Fellow of the Royal Anthropological Institute, read a paper on *Australasian museums and their work.* The natives are becoming absorbed into the white community and in many places are semicivilized and losing their former crafts. Nowhere except in the museums can the ethnologist get a thorough understanding of what they accomplished. The Australian Museum at Sydney has immense series of all Australian weapons, arborglyphs, etc., and a magnificent New Guinea collection, including pottery, and bone daggers. Among American things are Arkansas pottery; Peruvian figure pots, throwing sticks, and celts with lance heads; and shell beads from Yucatan (received from A. Bastian). The bone daggers are like those in the ear piercing ceremony in the Mexican picture codices. They are said to be for dispatching an enemy and are usually made from the tibia of a cassowary. The Perth Museum collection includes native string knotted bags, stone implements of an early type, glass spear heads, spear throwers, bull roarers, and the only known spear head of pottery; also pottery from Zuni, Chiriqui, and Nicaragua, sent in exchange by the Smithsonian Institution; and ancient Patagonian arrow points, stone borers, incised pottery, etc. The serrated glass spear heads of Australia exhibit the highest skill and are still made for sale by natives imprisoned at Broome on the northern coast.

The Adelaide Museum has rare, rudely made native canoes, axes, quartzite daggers in sheaths, stone picks used for fighting at close quarters, and big stone axes a foot long; also native skulls, a Pacific Islands collection with models of houses, and metal bomerangs from India and West Africa. The unwieldy stone axes are very heavy and were set in short handles of pliant wood split for the stone to pass through and fastened with resin, as in the case of tomahawks. The Melbourne Library and Museum contains Australian ceremonial objects of painted wood and feather decorations somewhat similar to those of the Hopi, on which Baldwin Spencer is an authority; also petroglyphs, boomerangs, lillil (or waggera), shields, axes, and wedges. The Kenyon and Mahony collection has 10,000 stone implements, showing a great variety of types from different places. At Portland, paleolithic types were found; on the Gouldbourne, chipped river pebbles; in the interior, where brittle stone implements were scarce, they were used and re-used to make pigmy types. The Hobart Museum has the skeleton of the last Tasmanian. This state, like the others, prepared interesting handbooks that contained much information about the natives for the British Association for the Advancement of Science, which met in Australia in 1914. The Auckland Museum of New Zealand has much Maori ornamentation. An entire house has been re-erected in the great hall, the interior walls finely carved in panels. Still finer are some panels and long pieces of carved wood from an old house that was taken down and the carved parts buried for safety during a war. Small wooden coffins shaped like fetishes and painted are shown and there is a skeleton and the unfinished stone axes buried with it. There are many carved ceremonial clubs, and all show evidence of a high state of art formerly prevailing among the Maori.

Dr. R. W. Shufeldt (a member of the Royal Society of Melbourne), Drs. Swanton, Michelson, and Folkmar, and others took part in the discussion. Special mention was made of a skull, probably pleistocene, recently discovered in the Darling Downs, this being the oldest of human remains so far found in Australia. Many photographs brought from Australia were shown by Miss Breton, including views of a settlement of aborigines 40 miles from Melbourne; also arrow heads and other artifacts. Miss Breton also read printed and manuscript accounts of the natives as seen about 1830 by her father, a naval officer, who considered the Australians the lowest race he had met in any part of the world.

Daniel Folkmar, *Secretary.*

At the 499th regular and 37th annual meeting held April 18, 1916,, Dr. John R. Swanton, President of the Society, read a paper on *The influence of inheritance on human culture.* The speaker stated that he would apply the term heredity to the inalienable things which the individual receives in body and mind through ancestors, and the term inheritance to alienable ideas and things which have been transmitted to him by the entire social body into which he was born.

The environment which one inherits is of two kinds, the environment of unaffected nature and the environment which previous generations have brought into being by their action upon nature. The direct action of nature has been much dwelt upon and would appear at first sight fundamental, but, on inquiring what environment is, we find that all depends upon the amount of environment which a people is able to grasp. Thus the same area may include tribes of very different planes of development, and the culture of succeeding generations in the same area may be wide apart. The history of man exhibits a constantly greater grasp of environment by most peoples of the earth, a grasp which extends farther and farther into the past, owing to improved methods of recording, and brings humanity more and more in touch with the future. Speaking in economic terms this heaped-up wealth is the capital of humanity, with which more capital is created in the present, to be again transmitted. All of it is not, however, of social value. The ideas which come to us down the stream of time may be false and the institutions and other creations may be injurious. There is a conservative instinct which tends to preserve what is of no real utility, an instinct comparable in many ways with that biological conservatism which tends to preserve vestigial organs in animals. Many such elements seem to have resulted from the perversion of what was once of value, but others appear never to have had any excuse for being.

One of the most pernicious of all appears to be that which permits the ownership of a disproportionate share of world capital to limited or privileged classes. Monopoly in learning, however, has been gradually destroyed by the multiplication of books, journals, and other means of education, while monopoly in things still continues. We are "the heirs of all the ages," but too many of us are younger sons, and the owners of privilege always endeavor to transmit to their blood or business descendants as much advantage as possible. One set of privileges consists in patents of nobility and governmental privileges attached thereto. Another is the ownership of some economic necessity, such as land, mineral or oil deposits, power sites, franchises involving control of means of communication or the furnishing of articles of general necessity or utility, the control of industrial establishments, and so on.

In connection with these various types of control it must not be forgotten that the value of each, as a money making proposition, depends without exception on society, because if society did not endorse privileges and purchase commodities there would be no value in ownership. To this must be added the service which society performs in defending and preserving the source of income. Such considerations limit very much our estimate of the service which even the most capable beneficiary of privilege performs; and when, under the action of our laws of inheritance, the source of income passes to another, the moral right of the heir, measured in terms of service, becomes much less. Nevertheless, it is possible that sources of income of the several kinds enumerated may descend indefinitely in particular strains of blood, and under such circumstances there appears to be little difference in position between those who enjoy titles of nobility and those who enjoy titles to industrial sources of income. The fact that control of income-yielding property may be ended by sale or bankruptcy does not alter the fact, so long as the *general* condition exists, any more than the banishment of a single nobleman and the confiscation of his possessions alters the fact of the existence of a titled nobility.

The ultimate solution of this question appears to involve one of two courses of action: either some method of binding together use and ownership so tightly that he who uses a thing will not be excluded from at least partial ownership in it, or ownership vested in the state or some other collective and immortal body, use being granted individuals during the limited period of their lives. The accumulations of human society, its capital, are primarily collective accomplishments and, therefore, society has a prior right to them. Whatever service the individual may perform, he cannot properly maintain a vicarious right to compensation after his death in the persons of his descendants or successors.

The following officers were elected for the ensuing year: *President*, Dr. John R. Swanton; *Vice-President*, Mr. William H. Babcock; *Secretary*, Miss Frances Densmore; *Treasurer*, Mr. J. N. B. Hewitt; *Councillors*, Dr. Truman Michelson, Mr. Neil M. Judd, Mr. Francis LaFlesche, Dr. C. L. G. Anderson, and Dr. Edwin L. Morgan.

Frances Densmore, *Secretary*.

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OCEANOGRAPHY.—*On the temperature of the water below the 500-fathom line on the west coast of South and North America.*[1] Austin H. Clark, National Museum.

A critical examination of the temperature observations taken by the *Albatross* in water of over 1000 fathoms in depth between California and the Hawaiian Islands[2] appears to indicate that in the oceanic abysses of the north Pacific there is a distinct, though slight, rise in temperature along this line from east to west.

A similar study has been made of all the *Albatross* records for temperatures below 500 fathoms, 417 in number, from Chile to and including the Bering Sea. The most striking feature of the abyssal temperatures of the eastern Pacific is the very small range of maximum variation (see last column of table), which is much less than in the east Atlantic.

For water of over 2000 fathoms in depth we have no records south of Mexico; on the southern coast of Mexico the water below the 2000-fathom line is $+0.65°$ (that is, $0.65°$ above the average temperature for the whole ocean at that depth as given by Murray and Hjort); off central Mexico it is slightly cooler, $+0.17°$; off northern Mexico there is almost the same drop, to $-0.30°$; the next reading, roughly between the Columbia River and southern Alaska, is warmer again, $-0.09°$, while in the Gulf of Alaska the temperature is nearly intermediate between that off northern Mexico and that off the northwestern

[1] Published with the permission of the Commissioner of Fisheries.

[2] Journ. Wash. Acad. Sci., **6**: 175–177. 1916.

United States and British Columbia, −0.21°; in Bering Sea, where depths greater than 2000 fathoms occur only in the western part, the temperatures below 2000 fathoms are intermediate between those off the northwestern United States and British Columbia and those in the Gulf of Alaska, −0.15°.

The temperatures between 1500 and 2000 fathoms show a maximum of +0.80° off northern South America and southern

TABLE I

DEPTH (FATHOMS)	500–750	750–1000	1000–1500	1500–2000	OVER 2000
Off Chile (45° 35′ to 38° 08′ S.)	**−0.20** (1)	—	+0.40 (3)	—	—
Galápagos Islands	+1.30 (4)	+0.93 (3)	+0.62 (4)	—	—
South and Central America to Mexico	+0.98 (9)	+1.22 (8)	+0.66 (17)	+0.80 (19)	—
West coast of Mexico to 16° 46′ N.	+0.92 (4)	+0.75 (2)	—	+0.66 (3)	+0.65 (2)
Mexico; 18° 23′ N. to the Gulf of California	+0.75 (6)	+0.80 (2)	+0.25 (2)	+0.13 (14)	+0.17 (9)
Gulf of California	+1.10 (1)	+0.50 (3)	+1.40 (3)	+1.10 (1)	—
Gulf of California to 32° N.	+0.50 (3)	+0.42 (4)	**−0.04** (5)	**−0.10** (4)	**−0.30** (5)
California; 32° to 33° 42′ N.	+0.22 (16)	+1.51 (12)	+0.70 (1)	—	—
33° 42′ to 45° N.	**−0.40** (13)	+0.38 (5)	—	—	—
45° to 55° N.	**−0.97** (17)	**−0.46** (16)	**−0.36** (8)	**−0.03** (12)	**−0.09** (10)
55° to 59° 19′ N.	**−1.72** (8)	**−0.85** (8)	**−0.37** (7)	**−0.09** (20)	**−0.21** (20)
Bering Sea	**−1.71** (20)	**−0.91** (12)	**−0.69** (25)	**−0.23** (20)	**−0.15** (26)
Maximum range in Temperature	3°.27	2°.36	2°.09	1°.33	0°.95

Central America, and a second more strongly marked maximum of +1.10° in the pocket-like Gulf of California. North of the Gulf of California the readings are all below normal, varying from −0.03° between 45° and 55° N. lat. to −0.23° in the Bering Sea. It is interesting that the temperature off northern Mexico and the southwestern United States (−0.10°) is approximately identical with that from 55° to 59° N. lat. (−0.09°), though the two localities are separated by a region showing a deficiency only one third as great (−0.03°).

The temperatures between 1500 and 2000 fathoms correspond closely with those below 2000 fathoms; but while south of the Gulf of California the excess is the same for both levels, north of that point the deficiency in the shallower water is approximately only one third of what it is in the deeper, excepting in the Bering Sea, where it is half again as great.

The series of temperatures between 1000 and 1500 fathoms is interesting in showing an excess of warmth off the Chilean coast (+0.40°) increasing to off northern South and Central America (+0.66°), where we noted the maximum in the preceding series, and decreasing again off central Mexico (+0.25°), as in the 1500–2000 fathom level. In the Gulf of California there is, as before, a second, higher, maximum (+1.40°). Off southern California there is apparently a considerable excess, but this is based on a single record which is very likely erroneous. Except for this the deficiency increases from the region north of the Gulf of California (−0.04°) to the Gulf of Alaska (−0.37°), becoming nearly twice as great again (−0.69°) in the Bering Sea.

The points of especial interest are the maximum off northern South and Central America, and the uniformity between 45° and 59° 19′ N. lat., the latter contrasting with what we found to be the case at the two preceding levels.

Between 750 and 1000 fathoms the points of interest are: (1) A well marked maximum (+1.22°) off northern South and Central America; (2) a relatively low excess (+0.50°) in the Gulf of California, which is continued to 32° N.; and (3) an excess, instead of a deficiency as everywhere below 1000 fathoms, as far as 33° 42′ N.

Between 500 and 750 fathoms the chief excess is in the Galápagos Islands (+1.30°) and in the Gulf of California (+1.10°). There is a deficiency off Chile, and a progressively increasing deficiency from 33° 42′ N. to the Gulf of Alaska and the Bering Sea.

If we except for the moment the pocket-like Gulf of California, which is comparable to the Red Sea or the Adriatic, the abyssal temperatures along the west American coast are found to fall into two classes, one capable of further subdivision, as follows:

(1) Temperatures all above the average (*South and Central America to the Gulf of California*)

(2) Temperatures all below the average (*southern California and northward to and including the Bering Sea*)

(*a*) Temperatures considerably below normal (*southern California and the Gulf of Alaska*)

(*b*) Temperatures slightly below normal (*central California to Alaska*)

(*c*) Temperatures intermediate (*Bering Sea*)

The regularity in the rise in the temperature of the abyssal water from Chile to the Panamic region and the subsequent drop in temperature along the Mexican coast suggests that the temperature of the deep water in the vicinity of the coast is influenced by the volume of warm water delivered in the region of Panama and southern Central America by the Equatorial Counter Current which, unable to extend to the northward because of the strong California Current which acts as a barrier, is exerted to the southward along the South American coast, within the region dominated by the Humbolt Current.

There is no need in this connection for assuming any extensive flow of water southward along the South American coast, for a relatively slight amount of water delivered in the upper layers on the northwestern South American coast would suffice to depress the isotherms sufficiently to give the figures observed.

The Gulf of Alaska is essentially a backwater or cul-de-sac, and the marked coldness of its abysses appears to indicate that this condition extends to its greatest depths; that is to say, that the coldness of its abysses is due to local causes, chiefly the chilling of its upper layers in winter. It is probably this chilled water from the Gulf of Alaska moving southward which causes the deficiency in the temperature of the deeper levels (as well as of the upper layers), all the way to the region just north of the Gulf of California.

It would appear that the water off southern California in the well known region of up-welling is colder than in the region between southern California and the Gulf of Alaska. There is no reason why this should be so unless the cold water along this coast is supplied, as I have already suggested (basing my conclusions on biological data) may be the case, from the Antarctic regions through the medium of an offshore abyssal current which is drawn shoreward by the upwelling off southern California and in the Gulf of Alaska. But the observations on the bottom temperatures between California and the Hawaiian Islands seem to cast serious doubt on the existence of such a current. The biological data are adequate, and point to a definite conclusion; but since animals readily pass from water of a certain origin to water of quite a different origin, if the two have the same biological coefficient (temperature, food value, salinity, and silt in approximately the same relative proportions), biological data are always unreliable. The physical data are far from exact, and we have no chemical data. Thus the true explanation of this phenomenon, if it be real and not merely the result of inaccurate thermometer readings, must be left to the future.

In the Bering Sea there are 103 temperature observations in water of over 500 fathoms in depth which may be regarded as approximately accurate.

Between 500 and 750 fathoms the average temperature for the Bering Sea as a whole is −1.71° below that of the entire ocean. There is an appreciable, though small, difference between the regions east and west of the 180th meridian, the former being 0.63° warmer than the latter. But below 750 fathoms there is no appreciable difference east and west of 180°—only 0.02° between 750 and 1000 fathoms, with the lower reading in the east, and 0.01° from 1500 to the deepest readings, with the lower reading in the west.

Between 750 and 1000 fathoms we find an average temperature −0.91° below that of the ocean as a whole at that depth; between 1000 and 1500 an average of −0.69°; between 1500 and 2000 an average of −0.23°; and below 2000 an average of −0.15°. This is in interesting contrast to the conditions in the Gulf of Alaska where the temperature of the water is approximately the same as in the Bering Sea as a whole between 500 and 1000 fathoms, less cold between 1000 and 2000 fathoms, more cold again below 2000 fathoms.

PHYSICS.—*Constants of spectral radiation of a uniformly heated inclosure or so-called black body, II.*[1] W. W. COBLENTZ, Bureau of Standards.

A knowledge of the exact value of the constants which enter into the mathematical equation which represents the distribution of energy in the spectrum of a black body is necessary in many physical problems, especially in extending the temperature scale higher than is possible by means of thermocouples.

Spectral energy curves have been obtained by means of a vacuum bolometer, a mirror spectrometer, and a fluorite prism; and the constants of spectral radiation of a black body have been published in a previous paper.[2]

The present paper gives the result of a recomputation of these constants. This recomputation was necessitated by the adoption of a new and apparently more reliable calibration curve of the fluorite prism used in the work, and by the discovery of a small error which was found in the previous computations. Although these errors are small (and would have been considered negligible four years ago) they happen to be of the same sign and, hence, have an appreciable effect upon the final result.

The results of the present computations give a mean value of $C = 14369$, which is close to the mean value of all the published data.

When the data of other investigators are summarized, it is found that they lie close to $C = 14350$.

From a consideration of the data now available it appears that the values of the constants of spectral radiation are close to

$$C = 14350 \text{ micron deg.}$$
$$A = 2890 \text{ micron deg.}$$

and that the coefficient of total radiation is of the order of $\sigma = 5.7 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$. This indicates that the constant h of the quantum theory is of the order $h = 6.56$ to 6.57×10^{-27} erg sec.

[1] Detailed paper to appear as Bur. Stds. Sci. Paper No. 284 (Bull. Bur. Stds., **13**: 459–477). 1916.

[2] Bur. Stds. Sci. Paper No. 204 (Bull. Bur. Stds., **10**: 1–77). 1913.

PHYSICS.—*A study of the inductance of four-terminal resistance standards.*[1] FRANCIS B. SILSBEE, Bureau of Standards.

The precise measurement of alternating currents frequently involves the use of standard resistances, the inductance of which should be known. When the currents are large the standards used are usually of low resistance, and a very small inductance in such a standard may produce a very considerable phase angle between the voltage drop across the resistance, and the current. In the range below one ohm the resistances are almost invariably of the four-terminal type and, therefore, require methods of measurement which are quite distinct from those applicable to higher resistances. The object of this investigation was to develop methods for comparing the phase angles of such four-terminal resistances and also to construct standards, having a very small known inductance, with which other apparatus could be compared.

If we consider a four-terminal resistance (or more briefly a "shunt") which carries a sinusoidal alternating current, we will find that the voltage between the potential terminals is not, in general, in phase with the current, but may be resolved into two components, one in phase and one in quadrature. The resistance of the shunt is defined as the ratio of the in-phase component of the voltage to the current, while the reactance is the ratio of the quadrature component of the voltage to the current. The angle whose tangent is the ratio of the reactance to the resistance is the phase angle of the shunt. The inductance is, of course, equal to the reactance divided by 2π times the frequency; the time-constant is the ratio of the inductance to the resistance. This latter quantity is very nearly constant over the range of commercial frequencies and is a measure of the amount by which a shunt departs from the ideal condition of giving a voltage exactly in phase with the current.

In some of the measurements described below it was necessary to use mutual inductances, and it was found that these

[1] Detailed paper to appear as Bur. Stds. Sci. Paper No. 281 (Bull. Bur. Stds., **13**:375–422). 1916.

did not in general satisfy the ideal condition of giving a secondary voltage in exact quadrature with the primary current but that the voltage had a small in-phase component. By analogy with the case of the shunt we may define the "resistance" of the mutual inductance as the ratio of this in-phase component of the voltage to the primary current. We will further define the "phase defect" as the angle whose tangent is the ratio of the in-phase component of the voltage to the quadrature component.

The method which was found most suitable for the comparison of the time-constants of two shunts may be called the *current transformer method.* It consists essentially in measuring the apparent phase angle of a current transformer by one of the usual null methods, using in succession, as the standard resistance in the primary circuit of the transformer, the two shunts to be compared. The apparent change in the phase angle of the transformer is the difference in the phase angle of the two shunts. A group of about twenty shunts were intercompared by this method and form a basis for future comparisons. A second method involving the use of mutual inductances was tried out, and gave results in agreement with the first method, but was found to be much less convenient.

Since the comparison methods just mentioned give only the difference in time constants of two four-terminal standards, some other measurement is needed to give the actual value of the time-constant of one four-terminal shunt in terms of known quantities. The simplest way to obtain this value is to construct a shunt of such shape that its inductance can be computed from its measured dimensions. This procedure requires that certain assumptions be made as to current distribution, etc.; a careful investigation using three different shapes of shunt showed that the assumptions made are completely justified. As a check, two other methods of measurement were tried; one involved the use of mutual inductances of known phase defect, and the other made use of two shunts constructed of identical dimensions but of materials of different resistivities. These methods gave results in agreement with the computed values, but were less accurate and more laborious. It is believed that the time constants of this group of 20 shunts (ranging from 0.1 ohm to 0.00025 ohm) at the Bureau of Standards are known to an accuracy of 1 or 2×10^{-7} second. With a frequency of 60 cycles and an uncertainty of 2×10^{-7} second in the time-constant the phase angle between the voltage and current is uncertain by about 15 seconds of arc.

Further measurements were made on other types of shunt and also on the effect of stray magnetic fields on the apparent time-constants of the shunts.

In the design of shunts for use with alternating currents it appears that the liability to error can be minimized by so locating the potential leads that the inductive effects in them completely neutralize the inductance of the resistance material itself so that the shunt as a whole is strictly non-inductive. The type in which the resistance material forms one or both of two concentric tubes lends itself very readily to this form of compensation.

A study of the phase defects of mutual inductances of large current capacity showed that this source of error was by no means negligible and that it was particularly large in cases where the secondary was wound in several layers. Errors from this source can be minimized by making one of the windings, preferably the secondary, in the form of a uniformly wound closed toroid of fine wire, in which case the other winding may be of large cross-section.

CHEMISTRY.—*The determination of aluminium as oxide.*[1] WILLIAM BLUM, Bureau of Standards.

From observations made with a hydrogen electrode and with suitable indicators, it has been found that the precipitation of aluminium hydroxide by ammonium hydroxide is complete when $[H^+] = 10^{-6.5}$ to $10^{-7.5}$—points which are approximately defined by the color changes of methyl red and of rosolic acid. From a study of the various factors, the following conditions are recommended for the determination of aluminium. To

[1] To appear in detail as Bur. Stds. Sci. Paper No. 286 (Bull. Bur. Stds., vol. 13). 1916.

the solution containing 5 grams of ammonium chloride per 200 cc. of solution (or an equivalent amount of hydrochloric acid) add a few drops of methyl red (0.2 per cent alcoholic solution) and heat the solution just to boiling. Carefully add dilute ammonium hydroxide, dropwise, till the color of the solution changes to a distinct yellow. Boil the solution for one or two minutes; filter. Wash the precipitate thoroughly with hot 2 per cent ammonium chloride, or nitrate, solution. Ignite in a platinum crucible and, after the carbon is all burned off, blast for five minutes; cover the crucible and place it in a desiccator till cool. Weigh (covered) as rapidly as possible. A second blasting of five minutes is desirable to facilitate rapid weighing, and thus to secure what are probably more accurate results.

PALEONTOLOGY.—*Oligocene fossil eggs.* EDWARD L. TROXELL, Ann Arbor, Michigan. (Communicated by H. H. Bartlett.)

Fossil remains of birds are rare. It is of unusual interest therefore to note the finding of two fossil eggs from the Oligocene bad-lands near Harrison, Nebraska. The specimens, which are elongated and slightly smaller at one end, resemble both in size and shape those of the domesticated chicken or of the Mallard duck. The very rugose outer surface, not found on the eggs of most modern birds, is, however, characteristic of those of the gull, and it is entirely in harmony with the theory of their deposition that they should have been laid by a water fowl. The shell, which measures about 0.6 mm. in thickness, still retains its calcium phosphate, the only part of the specimen which we can say definitely is a remnant of the original. (This chemical test is due to the courtesy of Mr. R. W. Clark of the Mineralogy Department of the University of Michigan.)

The first of the two specimens above mentioned was found by Mr. Vernon Marsteller, of Wayne College, who was a member of my party in 1915. Fossil eggs are mentioned in the South Dakota Geological Survey Report, Bulletin 9, by C. C. O'Harra, and one is fully described by O. C. Farrington in Publication 35 of the Field Columbian Museum, 1899.

FIRST SPECIMEN

The first specimen (length 59 mm., diameter 43 mm.) has the shell intact except at a few spots where it has been eroded away. Immediately beneath the shell is a layer of chalcedony about 2 mm. thick, continuous, though slightly irregular on its inner surface. The first half shows no banding but is a homogenous layer of transparent material deposited from the colloidal silica within, while the inner half, resulting from an intermittent or periodic deposition which soon ceased, shows the banding peculiar to agate.

Fig. 1. Fossil egg, first specimen. Exterior view, about natural size.

Within, the egg is filled with calcite, except for a small siliceous geode at one end; thus the calcite was formed after the outer layer of agate was in place. The diverse lines of cleavage show that the calcite is not a single crystal, although it now fills the cavity completely.

Fig. 2. Same, sawed in two and polished. About natural size. Note the band of agate next to the shell, the chalcedony geode at the smaller end, and the cleavage planes of the calcite crystals.

There must have been a hollow in the calcite at the smaller end of the egg which is now occupied by the irregular mass of chalcedony, for the outer surface of the latter, with its flat faces, sharp angles, and irregular striations, indicates that it came after and fashioned itself to the surfaces of the calcite crystals. On the other hand the space within the calcite may have been left when the growth of the crystals had reached its limit, or it may have been occupied by the desiccated residue of the egg material. The inner surface of the geode is lined with minute crystals of quartz.

Fig. 3. Fossil egg, second specimen. Top view, about natural size. The very rough surface is unlike that of most modern eggs. The cracks in the edge as well as the change in form indicate the extensive crushing.

SECOND SPECIMEN

The second specimen of fossil egg was flattened to about three fourths its former diameter; because of this distortion and because of the total absence of silica it presents some added points of interest. The dimensions are: Length 61 mm., width 48 mm., thickness 34 mm.

The hump, as shown in figure 4, appears to be a result of rigid opposition in the center while the edges were forced down. In reality it is simply the normal arch displaced. There was pliable resistance within the egg; the strain, therefore, which shortened the vertical diameter resulted in an increase in the horizontal dimensions; quite probably the volume did not change appreciably. Except for this there would have been real crushing or caving in without a corresponding increase in size laterally.

Fig. 4. Side view of specimen shown in figure 3. About natural size.

The flattening and consequent increase in circumference caused a series of perpendicular cracks around the edge, just such as might be formed by flattening a mud ball. Although fracturing occurred, the pressure within was sufficient to prevent the entrance of clay or other solid material. It is quite probable, therefore, that the egg was fresh when buried and that the surrounding mud, after settling, solidified before the removal of the animal matter and before the deposition of calcite began.

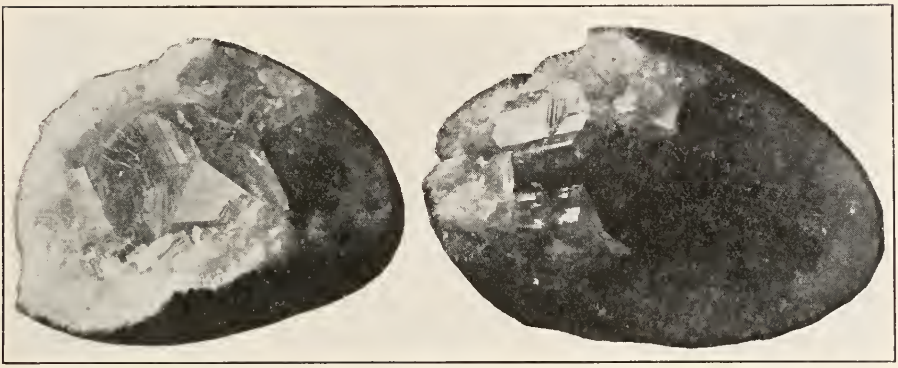

Fig. 5. Same as figures 3 and 4, showing the crystalline interior. About natural size. The large amber crystal of calcite in the center seems to have taken the place of the yolk, while the white crystals surround it. This similarity is only an interesting coincidence, for the parts, except the shell, bear no relation to the original egg.

Calcite is the only mineral occupying the cavity of this specimen; beneath the shell there is a 5 mm. layer made up of small crystals and within this, occupying the center but not entirely filling it, is a large double crystal of amber hue. One is struck at once with the great similarity in appearance to a modern egg in which are found the shell, white, and yolk in the same position and relative proportions. It is an unusual case of mimicry on the part of inanimate nature, for it is incredible that the soft part of an egg should exert such an influence on crystallizing calcite as to impose its form and color.

BOTANY.—*Pleiospermium, a new genus related to Citrus, from India, Ceylon and Java.* WALTER T. SWINGLE, Bureau of Plant Industry.

In 1834 Wight and Arnott described[1] as a new species *Limonia alata,* putting it with *Limonia missionis* in a section *Limoniae spuriae,* in contrast to *Limonia acidissima,* which constituted a section *Limoniae verae.* All subsequent authors have retained it in the genus Limonia.

It has been shown[2] that the name Limonia is untenable, so it becomes necessary to find another name for *L. alata.* The *Limonia acidissima* of writers on Indian botany is the type of the genus Hesperethusa, the oldest valid name being *H. crenulata* (Roxb.) Roem.; but a comparison of these two plants, both formerly put in the genus Limonia, has convinced the writer that they are not congeneric. The genus Hesperethusa has minute black fruits, usually 4-celled, with only a single seed in each cell; the leaves are pinnate, with a broadly alate rachis; the margins of the leaflets and of the wings of the rachis are crenate. The plant in question, *Limonia alata,* has fruits about an inch in diameter, usually with two seeds in each cell, the seeds surrounded by a glutinous fluid. The leaves are usually trifoliolate and the leaflets are entire.

These differences are of much taxonomic significance in this group of plants and in consequence it seems necessary to create a new genus to include *Limonia alata* and its little-known congener, *L. dubia* Blume.

In 1896 Engler created under the genus Limonia a new section, Pleiospermium,[3] with a single species, *Limonia alata.* This being the oldest name for the group, it may be retained as the generic designation.[4]

[1] WIGHT & ARNOTT. Prodr., **1**: 92. 1834.

[2] SWINGLE, WALTER T. *The name of the wood-apple, Feronia Limonia.* Journ. Wash. Acad. Sci., **4**: 325–328. 1914.

[3] ENGLER & PRANTL. Nat. Pflanzenfam., **3**[4]: 189. 1896.

[4] **Pleiospermium** Swingle, gen. nov. (Limonia §Pleiospermium Engl.). Genus *Pamburo* affine, foliis 3-foliolatis (vel 1–2-foliolatis), tenuibus, venis conspicuis, disco parvo, parietibus ovarii vesiculis brevibus instructis.

Folia 3-foliolata vel 2-foliolata vel 1-foliolata, petiolis plus minusve alatis,

Pleiospermium (Engler) Swingle, gen. nov.

Small trees with glabrous branchlets, sometimes with a single stout spine (or two spines) at the side of the bud in the axil of the leaf, sometimes spineless, especially the fruiting branches. Leaves typically trifoliolate with the lateral leaflets much smaller than the terminal one, sometimes bifoliolate or unifoliolate (very often so in *P. dubium*), of medium thickness, glossy above, finely netted-veined beneath; lateral veins slender, not very conspicuous, making a very obtuse angle with the midrib; margin entire, the apex obtuse or subacute, rarely acuminate, bluntly rounded at the very tip, the leaflet blade abruptly narrowed to a cuneate base; petiole variable in length, narrowly winged (in *P. dubium* sometimes nearly apterous), articulated with the blade. Flowers small, about 12 to 15 mm. in diameter, 4–5-merous, borne on rather short, finely pubescent pedicels, in clusters in the axils of the leaves or in a terminal much-branched hoary panicle. Flower buds cylindric, rounded at the tip, more or less pubescent; calyx small, 4–5-lobed; sepals deltoid, finely pubescent. Petals oblong or ovate, obtuse, entire, sparingly covered with fine pubescence on the outer surface. Stamens free, 8 or 10 (twice as many as the petals); filaments free; anthers large, erect, linear-oblong or oblong. Pistil subsessile, seated on a low annular disk; style slender, gradually merging with the tip of the ovary, ending in the somewhat thicker capitate stigma; ovary ovate, 4- or 5-celled, with 2 ovules in each cell. Fruits globose, like a small orange in appearance, the cells containing one or two seeds surrounded with an aromatic, mucilaginous fluid, and, at least in *P. dubia*, having short, slender pulp vesicles scattered on the inner ovary wall. Peel rough, dotted with numerous oil glands. Seeds oval, flattened; germination unknown.

Type species, **P. alatum** (*Limonia alata* Wight & Arn.), native to southern India and Ceylon.

Geographic range: India, Ceylon, Java, and adjacent islands (?).

The genus Pleiospermium is most closely related to Pamburus and Merope, having soft-rinded fruits resembling very small oranges or lemons in appearance but having only 4 or 5 cells, filled with a glutinous fluid, each cell containing 1 or 2 seeds. All three of these genera are

laminis articulatis; laminae tenues superne nitidae subtus reticulatae. Spinae rectae axillares solitariae vel binae vel carentes. Inflorescentiae pubescentes, 5–15-florae; flores mediocres, 4- vel 5-merae; petala alba oblonga; stamina libera, 8 vel 10, filamentis tenuibus; stylus tenuis, ovario paulo longior; stigma capitatum diametro stylo paulo majus; ovarium 4–5-loculare, ovulis in loculo binis. Fructus parvus, subglobosus, cortice ut in *Citro* carnosa, parietibus ovarii vesiculis brevibus instructis, loculis 1–2-spermis, liquore glutinoso aromatico repletis. Semina complanata, ovalia.

Arbusculae ramosae spinosae vel inermes, ramulis junioribus tenuibus plus minusve angulosis. Species typica, **Pleiospermium alatum** (*Limonia alata* Wight & Arn.). Habitat in India, Zeylona, et Java.

small spiny trees. Paramignya and Lavanga have similar fruits, but are woody lianes with recurved spines and aberrant leaf characters. The genus Pleiospermium differs from Pamburus in having thinner, netted-veined, usually trifoliolate leaves, with the lamina articulated with the petiole, instead of thick, nearly veinless, unifoliolate leaves and the lamina not articulated with the petiole; furthermore, Pleiospermium has the ovary seated on a small annular disk, while in Pamburus the disk is prominent and cylindric. The flower, fruit, and seed characters of Pleiospermium are very different from those of Merope. Pleiospermium is only rather remotely related to Hesperethusa, Triphasia, and Severinia, which all have very small red or black berry-like fruits and the leaves also very different.

Pleiospermium (or at least *P. dubium*) differs, so far as known, from all its relatives among the small, soft-rinded, gummy-celled group of citrous fruits in having short and slender pulp vesicles arising from the inner wall of the ovary. In this respect it resembles the subgenus Rissoa[5] of the genus Atalantia, belonging to a different subtribe, but it differs from that and from the other true citrous fruits in having the cells of the fruits filled with an aromatic, sticky fluid. A thorough study of the anatomy and morphology of the fruits of all of these genera is urgently needed in order to classify them in natural groups.

Pleiospermium seems to be a primitive genus, showing analogies with many rather diverse groups. It even shows a certain analogy in its leaf characters with the Philippine Chaetospermum,[6] one of the hard-shelled citrous fruits belonging to another distinct subtribe.

Two closely related species of Pleiospermium are known, one from southern India and Ceylon, the other from Java.

KEY TO THE SPECIES

Leaflets usually 3, obtuse; ovary glabrous .... 1. *P. alatum.*
Leaflets 1, 2, or 3, acute or acuminate; ovary pubescent . . 2. *P. dubium*

1. **Pleiospermium alatum** (Wight & Arn.) Swingle
    Limonia alata Herb. Madr. Wall. Cat. no. 6363. 1832 (nom. nud.).
    Limonia alata Herb. Madr. Wight Cat. no. 324. 1834 (nom. nud.).
    Limonia alata Wight & Arn. Prodr., **1**: 92. 1834.

ILLUSTRATIONS: Wight, Ill. Ind. Bot., **1**: pl. 41 (1840); Beddome, Fl. Sylvat., Outlines Bot., pl. 8, fig. 3.

TYPE LOCALITY: "Foot of the Neelgherries," Madras Presidency, southern India.

[5] SWINGLE, WALTER T. *Atalantia*, in Bailey, Standard Cycl. Hort., **1**:426. 1914.

[6] SWINGLE, WALTER T. *Chaetospermum, a new genus of hard-shelled citrous fruits.* Journ. Wash. Acad. Sci., **3**: 99–102. 1913.

Distribution: Southern India and Ceylon; common in the hot, drier parts.

The writer has seen an authentic flowering twig of this species collected by Wight under his number 324 and now in the Kew Herbarium; on the same sheet are two twigs from Wallich's set under his number 6363. There is also in Kew Herbarium a sheet of three twigs with full grown fruits, collected by Wight (No. 370) at Palagantcherry in 1850. In the Berlin Herbarium there is a sheet of material from Wight's Herbarium distributed by Kew in 1866–7 under No. 370, Peninsula Indiae orientalis, which has 7 twigs, 3 of them in flower.

This species is called *Tumpat-kurundu* in the Singhalese language of Ceylon.

2. **Pleiospermium dubium** (Blume) Swingle.

? Limonia diphylla Houttuyn, Natuurl. Hist., II. **2:** 440, pl. 9, fig. 2. 1774; [Christman] Linné Pflanzensystem nach. . . . Houttuynisch. Werks Übers., **1:** 615, pl. 9, fig. 2. 1777.

Limonia? dubia Blume, Bijdr. Fl. Ned. Ind., **1:** 133. 1825.

Paramignia Blumei Hasskarl, Tijdr. Nat. Gesch., **10:** 137–138. 1843.

Paramignya Blumei Hasskarl, Cat. Pl. Hort. Bogor., 216. 1844.

Type locality: "In collibus calcareis prope Kuripan, Provinciae Buitenzorg," Java.

Distribution: Western Java.

Hasskarl in 1843 transferred this plant to the genus Paramignya, at the same time changing the specific name to *Blumei*. Hochreutiner in *Plantae Bogorienses Exsiccatae*, under No. 111, *Limonia dubia* Blume, says that the plant growing in the Buitenzorg Garden is undoubtedly the original of Hasskarl and probably the same as that seen by Blume, though the absence of Blume's type makes it difficult to be certain.[7]

Fortunately there is in the herbarium of the Muséum d'Histoire Naturelle at Paris an authentic specimen of this species from Blume. The original label reads "*Limonia dubia* M. Blume 1836." This specimen consists of a spineless twig of three seasons' growth with 19 nodes bearing 1-, 2-, or 3-foliolate leaves, very like the specimens distributed by Hochreutiner from the type plant of *Paramignya Blumei* Hasskarl.[8]

[7] "Cette plante est sans aucun doute l'original de Hasskarl qui a complété très exactement la diagnose de Blume. Quant à affirmer que c'est bien là l'espèce que Blume avait en vue, cela est plus difficile en l'absence d'un type de cet auteur; cependant c'est probable."—Hochreutiner, B. P. G., loc. cit.

[8] Probably Blume planted in the Buitenzorg Botanic Garden the tree from which the branch now in the Paris Herbarium was cut and upon which later on, Hasskarl based his description of *Paramignya Blumei*. In this event all the specimens cut from this tree (III. G. 64, in the Buitenzorg records) are merotypes of Hasskarl's species.

It is possible that this plant is identical with the enigmatic *Limonia diphylla* published in 1774 by Houttuyn, who received a twig collected by Richter at Batavia, where it is said to produce fruits resembling limes ("regte Limmetjes of Lemisjes"), the size of a pigeon's egg, on spiny twigs. The leaves are said to be paired on the same petiole. Houttuyn's plate shows a twig with 3 binate leaves with obtuse leaflets, one small unifoliolate leaf, and a small terminal flower with 4 petals and 8 stamens. The figure seems to be diagrammatic and was probably drawn from poor material. The plant is said to be called *Crandang* by the Javanese.

It may be that Houttuyn's species was founded in part on Richter's account of a true lime, *Citrus aurantifolia* (Christm.) Swing., and in part on a twig which he brought to Holland from Batavia, possibly from some very different plant, such as a Bauhinia. It seems impossible to decide the matter unless Houttuyn's type can be found.

Pleiospermium dubium seems to be rather close to *P. alata*, but has the leaflets acute, instead of obtuse, and many leaves with only 1 or 2 leaflets instead of 3; as is common in *P. alata;* also it has the ovaries pubescent instead of smooth, as figured in the Indian species. It is said to be a small tree 3.5–4 meters high, with a twisted trunk branching at 1.5 meters and suckers from the base. It is called *Kidjeroekan* in Java.

In its foliar characters this is one of the most polymorphic species among all the relatives of Citrus. The leaves are simple or 2- or 3-foliolate, sometimes all three forms occurring on the same branch. The petioles are sometimes very short and sometimes rather long, sometimes plainly winged, often nearly wingless. The spines are sometimes single, sometimes paired, and often entirely wanting. It is undoubtedly one of the most primitive of all the citrous plants, showing as it does striking analogies with plants belonging to at least three distinct subtribes.

The fruits of this species show small and slender pulp vesicles arising from the inner ovary wall 2 to 3 or even 4 mm. long. It is not known whether *P. alatum* also has such rudimentary pulp vesicles. Both species have fruits filled with dark-colored, strong-smelling, mucilaginous gum.

POSSIBLE UTILIZATION OF PLEIOSPERMIUM

From the fact that *Pleiospermium alatum* grows abundantly in the dryer parts of Ceylon it would be desirable to test it as a stock on which to graft Citrus for culture on the dryer types of soil. The other species, *Pleiospermium dubium,* was discovered growing on limestone hills in western Java and may perhaps be able to endure more lime than the stocks now commonly used in citrous culture. Certainly both species of Pleiospermium should be introduced into this country and tested as stocks. In view of its primitive and polymorphic nature it is possible that *P. dubium* may hybridize with Atalantia or with some other true citrous fruit.

PHYSIOLOGY.—*Studies on the mineral elements in animal nutrition.*[1] E. B. Forbes, Ohio Agricultural Experiment Station.

As agricultural scientists, our interest in the mineral elements lies in that larger intermediary metabolism between the soil and the sea which begins with the weathering of the rocks, includes the whole of plant and animal metabolism, and ends with the formation of new rocks. Throughout this vast sweep of chemical change the mineral elements occupy a unique and dominating position, entering in essential ways into every process and exerting an influence in metabolism entirely out of proportion to the amounts in which they are involved.

In a large and general way life may be regarded as a coordinated system of responses to electrical stimulation. The ions, and especially the inorganic ions, are the bearers of this electricity, and it is because of this fact that they are able to play a leading rôle in the direction of the whole process of metabolism. Gustav Mann says, "So-called pure ash-free proteids are chemically inert and in the true sense of the word, dead bodies. What puts life into them is the presence of electrolytes."

This, then, is the basis of our interest. More specifically, this subject concerns us because the mineral elements of soil fertility—of plant nutrition—supply the mineral nutrients of animals. All of those conditions of growth of plants, as to

[1] A lecture delivered before the Washington Academy of Sciences, April 21, 1916.

soil fertility, heat, light, and moisture, which affect their mineral content affect the food value of these products for animals. Similarly all of those processes of treatment of foods, as to conditions of harvesting, storage, manufacture, preservation, and preparation which affect their mineral content have a bearing on the nutrition of animals. Further, the almost unlimited freedom of choice of foods afforded by our markets and our prosperity, a freedom which may profoundly affect the mineral content of the diet, furnishes a basis of interest and an obligation to understand. Finally, the mineral requirements of men and animals in their various conditions and stages of life, growth, health, and activity differ greatly in such ways as to demand our attention, since the whole range of success and profit in practical animal nutrition lies close, and ever closer, to maximum possibilities.

As this subject relates to stock feeding, we find that modern tendencies give it a special importance that it had not in times past. The forced feeding of our early-maturing meat animals and the selective improvement of our poultry and our dairy cows for greater productive capacity call for a higher percentage of mineral nutrients in foodstuffs than was necessary in the old days of less intense production. The requirement of mineral nutrients for mere maintenance is slight in amount, compared with the requirement for the production of flesh, eggs, and milk; hence, the more efficient the producer, the higher must be the ash content of the food.

My own investigations in this field consist of studies of the chemistry of foods, and metabolism experiments with swine and milch cows. I shall review briefly some of the conclusions from this program of work.

Our studies on foods comprise a series of complete ash analyses, with computations of the elements to normal solutions, these data being considered in relation to the balance of base and acid in the organism; also a study of the mineral nutrients of bluegrass, and factors which affect the quantities present; and a study of the iodine content of foods in relation to the prevalence of goiter.

It is an established fact of animal physiology that the vital processes require the maintenance of a state of approximate neutrality in the blood and lymph. Henderson has done much to show how this balance of acid and base is maintained by self-adjusting chemical and excretory equilibria. The mineral elements of the food contribute to one side or the other of this base and acid balance; and the extent and nature of this contribution are matters of importance in relation to acid intoxication, even though this condition is not commonly caused by the food. Our extensive series of ash analyses show that cereals, meats, and eggs have acid ash, while fruits, roughages, vegetables, milk, and most legumes have alkaline ash. While healthy animals have means of neutralizing all ordinary excesses of acid in the food it is safest that the bases should predominate, since we do not know that the neutralization of acids is always accomplished without expense, and since in any such physiological state as causes acid intoxication (and there are many such) an excess of mineral acid to mineral base in the food is undoubtedly a matter of positive disadvantage.

Acid intoxication is met with most commonly in the feeding of infants and older children suffering from fever, undernourishment, or indigestion especially involving the fats of the food. In these cases the use of whey in the diet furnishes mineral nutrients of value; and the administration of sodium citrate (1 to 2 grains per ounce of milk) is also a beneficial practise in that it furnishes a readily oxidizable alkali salt. The presence of this citrate is also favorable to the digestion of casein. Many a so-called idiosyncrasy against milk protein has disappeared under the influence of sodium citrate and a low-fat diet.

Our study of the mineral nutrients of bluegrass touches a subject of deep significance. Through its habit of growth grass is the great conserving factor in agriculture. As the basic requirement of livestock breeding it makes for all the benefits of this system of farming, especially the maintenance of the fertility of the land and the maintenance upon the land of the presence of the family of the owner. The permanent prosperity of an agricultural community is assured by the excellence of its grass lands.

Now we have shown that the mineral nutrients of bluegrass vary more than 100 per cent in accord with the fertility of the soil. The skeletons of growing animals respond readily to the mineral nutrients of the food. There is no definite upper limit of phosphate deposit in the bones. The quality of the grass must affect the quality of the bones; and strength and soundness of bone favor long-sustained efficiency. Probably the greatest strain to which the bones of animals are subjected is in the service of our large, early-maturing horses on hard-surfaced roads and pavements. The most famous horse-breeding center of the United States is a region of limestone soils and luxuriant bluegrass which our analyses show to be unusually rich in bone food. We have always bowed while the Kentuckian asserts that his state produces the most beautiful women and the finest horses in the world, and now we know that in so far as these claims depend upon a superior quality of bluegrass they rest on a substantial basis of fact.

It is also true that in many localities in this country, on impoverished soils, we find horses and cattle suffering from malnutrition of the bones. This ailment is most common during periods of rapid growth or milk production, especially during and immediately after seasons of drouth and restricted food supply. This condition responds readily to treatment with calcium phosphate.

Among the several mineral elements present in foods in minute quantities especial interest attaches to iodine, because of its importance in metabolism. The only tissue in the bodies of vertebrate animals which contains iodine in apparently essential relations is the thyroid gland. The iodine content of the thyroid may be increased by the administration of iodine; one of the active principles of the thyroid is its iodine-containing constituent; and goiter in certain stages responds favorably to iodine treatment. Further, there is a marked and continuous local prevalence of goiter in many regions. These facts furnish sufficient basis for our interest in the iodine content of foods.

In our study iodine was estimated in 927 samples of animal and vegetable products. These products were in part common foods from the market; a large number were from the fertilizer plots of the experiment stations of the country; others were from regions of interest because of the extreme prevalence or rarity of goiter; still others were products from an extensive metabolism experiment with milch cows. The method of estimation used was accurate to three-millionths of a gram of iodine.

About one food sample in five contained iodine. The amounts present were usually too small for expression otherwise than as traces. In 18 samples each of cow's milk, urine, and feces no iodine was found. Iodine was found in considerable quantity only in agar and in Irish moss (from which *blanc mange* is made). No other seaweeds were examined. No iodine was found in 16 samples of table salt or in any one of seven kinds of nuts. It is very rarely present in spices and condiments.

Among the animal products the only one containing iodine in more than traces was hair and hoof, from swine, a sample prepared in the course of a complete chemical accounting for the bodies of some experimental subjects. Traces were found in butter, in eggs, and in several kinds (but by no means in all samples examined) of meat, fish, and crustacea (shrimp and lobster).

Among the cereals iodine was found as an uncommon constituent, usually in traces only. None of the fruits contained more than the smallest recognizable traces of iodine, and very few contained even so much.

Among the garden vegetables and root crops beets rather commonly contained traces of iodine (9 samples out of 25), and in one case a larger amount. Two out of three samples of cucumber contained iodine; also one out of three samples of celery. Iodine was found in single samples of endive, kohl rabi, and lettuce. Among onions five samples out of 15 contained iodine, and in parsnips two out of six. Six samples of potatoes out of 21 contained iodine; it was also found in spinach and in rhubarb. We found iodine in one sample of turnips out of 11, but none in tomatoes, pumpkin, and squash.

Of the hays, silage, and forage crops about one sample in four contained iodine. Among leguminous seeds iodine was found in 11 samples out of 32, more commonly among beans, peas, and cowpeas than among soy beans.

The manufactured foods, and milling and manufactory by-products contained iodine in 13 samples out of 25; of those containing iodine 10 were made from cereals. The offal portions of the grains are apparently richer in iodine than the more starchy parts.

The more important sources of iodine in the human dietary, then, are the garden vegetables, though some is also found in the cereal foods and in several foods of animal origin, mostly of the sorts less commonly used.

Among the foods used by livestock the more important sources of iodine are the hay, silage, and forage crops, and also the milling and manufactory by-products, comparatively little being found in the natural grain foods.

No consistent or orderly geographic distribution of iodine in foods was revealed; nor were there noticeable effects of the type of soil or method of fertilization on the iodine content of foods. We found nothing characteristic in the iodine content of foods from regions where goiter was especially prevalent. The iodine content of samples of the same crop from different plots of the same field sometimes varied greatly.

The general conclusion from this study was that iodine is a comparatively unusual food constituent and that its presence is commonly accidental in the sense of standing in no essential relation to the growth of the food products. Variations in the iodine content of foods were not successfully correlated with any associated conditions.

It is possible that the total iodine requirement of the organism is gleaned from foods containing so little of this element that its presence would escape detection by our best methods of estimation. It is also possible that the iodine content of the drinking water is of greater importance in relation to the cause of goiter than is the iodine content of the foods.

The general effect of this study is to direct us elsewhere, especially toward the metabolism of the organism, in our search for the cause of goiter.

We shall now consider the results of mineral metabolism studies with swine. This subject is of especial importance in this connection because no other animals are so grievously sinned against in the provision of their mineral requirements. Several factors unite in bringing about this state of affairs. Among these are the extreme rapidity of growth of improved hogs, the great weight of fat carried, the early age at which reproduction and lactation occur, the custom of rearing hogs in comparatively close confinement, and the feeding of too little else than corn. This combination of conditions often results in the crippling of hogs during shipment to market, the breaking down of sows while suckling pigs, and a general abbreviation of the period of usefulness of breeding stock.

Our studies with swine have been on the specific effects of corn and of supplements to corn, and a comparison of the nutritive values of several pure compounds of phosphorus, these studies having been conducted by feeding, slaughter, and carcass analysis experiments, and by metabolism investigations.

In these feeding and carcass analysis experiments the specific effects of corn as an only food for growing swine were shown to be, in general, a retarded development of proteid and bony tissues and an over-development of fatty tissue. This results in the production of fine-boned, poorly muscled, undersized, and over-fat animals, which reach their limit of growth prematurely and which are characterized by less than normal breeding capacity. Impaired fecundity seems to result from discouragement of proteid increase generally and from the lessened circulation of blood in the female reproductive organs, this last being caused by pressure of the excessive amounts of internal fat which accumulate about these parts. With hogs fed on corn alone, the bones, muscles, liver, kidneys, lungs, heart, and spleen all compose an abnormally small proportion of the increase in weight, and fat composes an abnormally large part of the increase. The bones are lacking both in density, as indicated by ash content, and in breaking strength.

Many of the specific effects of corn as an only food for growing animals are due to its insufficient content of protein and to the incomplete character of its largest protein constituent, zein. The only effects which can safely be attributed to the mineral constituents of corn are those affecting the skeleton.

In one experiment corn alone was compared with corn supplemented by soy beans, linseed oilmeal, wheat middlings, tankage, and skim milk. The rations of corn alone and of corn and soy beans produced the least bone. The rations of corn supplemented by tankage and skim milk produced the most bone. Rations of cereals or other seeds will not produce normal growth of bone in swine. These facts depend directly on the content of these foods in the chemical elements which compose bone.

The proportion of calcium, magnesium, and phosphorus in the bones tends strongly to remain constant, but may be modified to a certain extent by the limitations of the food. The amounts of these elements in the bone, however, are susceptible of much greater modification through the composition of the food. Bone meal, when added to a ration which is low in calcium and phosphorus, will greatly increase the ash and strength of the bones. The change in external dimensions is slight, but increase in the density and thickness of the walls of the bones may proceed indefinitely. The readiness with which minerals may be deposited in the bones, the lack of a definite upper limit of such deposit, and the readiness with which these minerals may be withdrawn constitute the skeleton a true store of mineral nutriment.

We have not been able by any method of feeding, in confinement, to produce bones as strong as are the bones of pigs raised on pasture. It seems quite possible that exercise, as well as food, has its effect to strengthen the bones through inducing an added avidity of the osteogenic cells for bone salts.

In a metabolism investigation with swine five pigs, all from the same litter, were taken through eight 10-day collection periods separated by 7-day intervals. The feeds, as in the experiment last mentioned, were corn alone, compared with corn supplemented by soy beans, linseed oilmeal, wheat middlings, tankage, and skim milk; also one ration was composed of rice polish and wheat bran. The pigs grew normally, and stored nitrogen and sulphur liberally in each period, though, naturally, less of these elements was stored from the ration of corn alone than from rations containing more protein.

Potassium was stored in all periods except one; strange to say, the ration composed of rice polish and wheat bran was the one in which this element was supplied in the greatest amount. Animals have no means of storage of large amounts of potassium salts. The large excretion of potassium on this maximum intake may be considered as a protective measure. In this case the negative balance did not signify insufficiency.

Sodium and chlorine balances were much affected by the water drunk. The intake of these elements would have been insufficient had not the amounts present in the foods been supplemented by the use of salt. Those individuals which drank the least water retained the most sodium and chlorine.

The more significant results of this experiment have to do with calcium, magnesium, and phosphorus. These elements are closely associated in metabolism. In the two rations where the corn was supplemented by skim milk and by tankage (containing a considerable amount of bone scrap) the calcium retention was 9 to 10 times as great as in any of the rations composed of grains and other seeds and seed products. On rations of corn alone, of corn and soy beans, and of rice polish and wheat bran the calcium balances were negative; that is, more calcium was given off in excreta than was received in the food. This result emphasizes the fact that the cereals are very poor bone-foods. The negative calcium balances from the ration of corn and soy beans call attention to the fact that the phenomenally high calcium content of legumes is true of the plants as a whole and not of the seeds. This emphasizes the value of leguminous roughage as bone-food.

In these rations the retention of calcium was closely related to the intake of the same, and not appreciably affected by the excess of mineral acid. Physiologically, calcium and magnesium are balanced opposites. An excess of magnesium in the blood causes a counter-active liberation of calcium; but the proportion of these elements in the blood does not follow closely their proportions in the food, and we did not find the calcium retention to be limited by an excess of magnesium in the food except perhaps in one ration, composed of rice polish and wheat bran and containing 12 times as much magnesium as calcium. In this case the great excess of magnesium seems to have been unfavorable to calcium retention. This proportion seems not to be a matter of practical importance in ordinary rations.

The phosphorus balances in these rations were always positive, but the retention was much below normal on the ration of corn alone. The more important reason for this deficient storage of phosphorus from corn was the lack of calcium, since calcium was more deficient than phosphorus, and since neither can be stored in large quantity except as they are combined in the calcium phosphate of the bones.

There were large excesses of inorganic acid elements in these rations. They were neutralized by ammonia. We observed no evidence of acid intoxication. We do not have knowledge of any such prevalence of acid intoxication in domestic animals as that with which we are familiar in human beings.

The urinary ammonia excretion was found to vary in the same order with the excess acid of the ration, providing that the protein remained about the same in amount; but any considerable increase in the food protein also increased the urinary ammonia.

Another series of experiments with swine dealt with phosphorus metabolism. Considering the phosphorus compounds of plants and animals the most obvious distinction among the various groups is that in certain of these the phosphorus is organically combined, as part of the living tissue, while in others it is present as simple salts of the mineral bases, either in solution, or deposited in supporting structures (in animals), or as crystals or incrustations (in plants). Our object was to learn whether organic and inorganic phosphorus in the food could serve equally well all of the purposes for which the animal needs phosphorus.

Our practical interest in the problem is due largely to the relative availability of organic and inorganic phosphorus. Inorganic phosphorus may be had in unlimited quantities as prepared from old bones and rock phosphate, and the inorganic phosphorus content of foods may be greatly increased by the fertilization of the soils upon which they are grown. Organic phosphorus we get from such expensive foods as milk, eggs, and beef, and from cereals. The organic phosphorus content of foods is not susceptible of important modification by treatment of the soil.

In this study we included orthophosphates because of their cheapness and availability, hypophosphites because they are so much used in human medicine, phytin as an especially abundant phosphorus storage compound of vegetable foods, glycerophosphates because of their relation to lecithin, a universal cell constituent, and nucleic acid because it is found in the nuclei of all cells.

These compounds in the pure form were added to a low-phosphorus basal ration in amounts contributing equal quantities of phosphorus. The subjects were growing pigs. Results were obtained by the method of the metabolism experiment and by the analysis of the carcasses of the animals.

It would seem, at first glance, that this problem should readily yield to careful experimental investigation, but intimate acquaintance has shown it to be extremely complicated and difficult. Many investigators have studied it, and the problem has been finally answered many times but in many different ways. If this problem is settled, in the end, as many such subjects of controversy have been, most of those who have studied it will be at first surprised, then chagrined, and then gratified that so much of truth was found on both sides of the discussion. Recent evidence has been mostly with those who believe that inorganic phosphorus can serve all of the purposes for which animals need phosphorus, but there is still much uncontroverted evidence that there are differences in the metabolism of some organic and inorganic phosphoric compounds which imply at least a greater usefulness of some organic compounds for some purposes with some animals.

In our work orthophosphates, gylcerophosphates, hypophosphites and yeast nucleic acid, when added in the pure form to rations which are low in phosphorus but capable of maintaining phosphorus equilibrium, were all to some extent absorbed and retained.

Prominent differences were observed in the tolerance of the pigs for these pure phosphorus compounds. The limit of tolerance for glycerophosphates was not reached in any of our tests, but the other compounds were not so well taken. These drugs, when taken into the alimentary tract in quantity, in readily soluble condition, produced marked specific therapeutic effects which were, at least to a large extent, unrelated to fundamental nutritive values, and were likewise different from the effects of the same compounds as occurring in their natural physical and chemical relationships in foods. It is, therefore, impossible to state, from investigations of this sort, on pure compounds, what may be their nutritive values in common foods.

That the particular organic compounds used in this investigation (nucleic acid, phytin, and glycerophosphates) have nutritive values, to growing swine, superior to simple inorganic phosphates was not shown. No fundamental differences in the methods of usefulness of the phosphorus compounds studied were established, though, under our experimental conditions, they differed greatly in the extent of their usefulness; for instance, glycerophosphates were acceptable and useful in large quantities, the limit of which was not reached in our work; orthophosphates were distinctly less acceptable; phytin and nucleic acid were tolerated in still smaller amounts; while hypophosphites were the least acceptable of all. Still, so far as our results indicate, these compounds were all useful in the same way.

No basis was discovered for a differentiation between the nutritive values of organic and inorganic phosphorus compounds generally. It should be borne in mind, however, that no representatives of the two classes, phosphoproteins and lecithins, were included in this investigation, and results obtained under conditions of such rigid experimental control may not accurately represent the facts under optimum, normal conditions of life.

These results are not considered to controvert evidence as to specific therapeutic effects of these phosphorus compounds in relations other than those considered in this study.

Even granting the debated superior nutritive value of organic or inorganic compounds of phosphorus, however, it is undoubtedly a fact that the organic phosphorus content of the animal body is a very small part of the total phosphorus, and as certainly true that a very much larger proportion of organic to inorganic phosphorus prevails in the diet of all omnivora and herbivora than in the bodies of these animals; and as for carnivora, the consumption of flesh and bones together would give them approximately the same proportion of organic to inorganic phosphorus in the diet as in their own bodies. It would seem, therefore, that for purposes of growth, the usual diet of animals must contain a sufficiently large proportion of organic to inorganic phosphorus. In this relation, then, the important consideration is simply one of the total phosphorus of the ration, and any such supplemental phosphorus as is to be added to the diet of the healthy, growing animal may be added as inorganic phosphate.

The amount of phosphorus which an animal will tolerate, when added to the ration in readily soluble form, is definitely limited at an amount much less than will be acceptable in its natural relationships in foods.

It seems unlikely that, with grown or growing animals, any ration composed from natural foods, and supplying the nitrogen requirement, will fail to furnish enough total phosphorus to maintain phosphorus equilibrium. That many such rations are lacking in the amount of phosphorus essential to maximum retention and growth, however, is as certainly true.

The results of our experiments indicate that the possibility of influencing, to a practical extent, the relative development of tissues and organs of livestock by the addition of isolated compounds of phosphorus to the ration is probably limited to the density and strength of the bones; but this is not saying that we may not be able by the use of these same compounds profoundly to influence physiological functions.

Throughout these studies of the influence of foods upon the nutrition of swine numerous effects of the mineral constituents of the rations on minor details of qualitative composition of the tissues have been noted, but the importance of such effects, as related to the functions of the parts, has not been demonstrated.

Our latest study in mineral metabolism was with cows. The milch cow greatly excels any of the other farm quadrupeds in the rapidity and efficiency with which she produces proteid and mineral nutriment. This unrivaled productive capacity calls for as unusual supplies of the kinds of nutriment involved. So far as protein is concerned this requirement is amply recognized; but, with almost no evidence on the subject, we have assumed that the cow's mineral requirements are fully met without any attention being given to the matter. Our results show this assumption to be unwarranted and untrue.

Six cows were used in this study, in two groups of three each. Each cow was taken through three experimental periods, usually of 19 or 20 days' duration, separated by 10-day intervals. The excreta were caught by attendants sitting behind the cows. Complete ash analyses, as well as ordinary proximate analyses, were made on foods, milk, urine, and feces.

We found that liberal milk production, on common practical winter rations fed in quantities sufficient to maintain the live-weight and to cause regular and extensive nitrogen and sulphur storage, caused large and consistent losses of calcium, magnesium, and phosphorus from the skeleton. These losses occurred in spite of liberal supplies of these nutrients in the food. The very limited response of the cows to large increase in the intake of these elements suggests that the selective improvement of the milch cow, for milk production, has outrun her capacity to digest mineral nutrients. A further study is in progress in which we hope to learn whether under any circumstances it is possible to protect the cow from loss of minerals during heavy milk production.

An extensive metabolism of silicon was demonstrated; and an excess of inorganic acids over inorganic bases in the ration, due largely to the silicon of timothy hay, caused an acid reaction and an increase in the ammonia of the urine.

From this study it appears that a failure to maintain mineral equilibrium must be so common among cows of the more profitable sort that it may be considered a normal condition during the time of larger production, at least if this occurs during the winter, that is, while the cows are off from pasture.

A common failure of cows to maintain exceptionally high production during consecutive periods of lactation may be due to mineral depletion, as may also be a frequent failure of cows to breed after having been subjected to a period of forced production, as in the establishment of records.

Since extensive milk production is sustained, in part, by drafts upon the mineral reserves of the body; since this process can not continue indefinitely; and since there is in cows a gradual shrinkage and final cessation of milk production coincident with this depletion of nutrient reserves, it is believable that this mineral exhaustion may be among those factors which cause the gradual shrinkage of milk, and that by preventing, as largely as possible, these losses from the body we may be able to lessen the shrinkage and to extend the duration of the production of milk.

The results of this study indicate that especial attention should be given to the calcium, magnesium and phosphorus contents of the rations of heavily-producing cows, in order that the loss of these elements from the skeleton may be kept as low as possible; and a liberal supply of foods rich in these elements should be allowed after a cow has ceased to produce heavily, during the latter part of the period of lactation, in order to refund previous overdrafts before the birth of the next calf.

It is impossible, of course, to draw any one conclusion which will express the full significance of so varied a program as that which I have reviewed with you, but to me the results of these studies have appealed, more than in any other way, as related to the service of lime and legumes in agriculture.

Calcium is very much the most abundant mineral in the animal body. Physiologically it is the great mineral stabilizer.

Practically, it is much more frequently lacking in the food of men and animals than is any other mineral nutrient. Lime as applied to the soil liberates organic nutriment and enriches the grass in calcium. It stimulates the growth of grass and makes it a better food for animals. In a sense, "All flesh is grass." Lime also maintains in the soil conditions favorable for the growth of legumes. The legumes draw heavily upon this lime and furnish it to animals in quantities not approached by any other food plants. Through the activity of the bacteria which cause their root-nodules they are enabled not only to store nitrogen in abundance but also to feed the grasses with which they are associated. Thus the lime in the soil favors the growth of legumes. Lime and legumes favor the growth of grass. Grass and legumes control the breeding of livestock. Grass, legumes, and livestock control the destinies of nations.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Distribution of energy in the visible spectrum of an acetylene flame.* W. W. Coblentz and W. B. Emerson. Bureau of Standards Scientific Paper No. 279 (Bull. Bur. Stds., **13**: 355–364). 1916.

Data on the distribution of energy in the visible spectrum of a standard source of light are frequently needed in connection with investigations in physiology, in psychology, and in physics; especially in photoelectric work, in photography, and in the photometry of faint light sources. Frequent requests for such data have come to this Bureau. The acetylene flame appears to be a promising source of light having a high intensity and a white color. The present paper gives data on the distribution of energy in the visible spectrum of a cylindrical acetylene flame, operated under specified conditions.

In the region of the spectrum extending from the yellow to the violet the spectral energy distribution of all the flames examined appears to be the same, within the limits of observation. On the other hand, in the region of the spectrum extending from the red toward the long wave lengths the emissivity is greatly affected by a variation in thickness of the radiating layer of incandescent particles in the flame. Hence, in and beyond the red part of the spectrum the data apply only to cylindrical flames which are operated under specified conditions.

W. W. C.

PHOTOMETRY.—*An interlaboratory photometric comparison of glass screens and of tungsten lamps, involving color differences.* G. W. Middlekauff and J. F. Skogland. Bureau of Standards Scientific Paper No. 277 (Bull. Bur. Stds. **13**: 287–307). 1916.

In 1911 the Bureau of Standards and the National Physical Laboratory of England, in coöperation, established groups of 1.5 wpc tungsten standards, using Lummer-Brodhun contrast photometers in stepping from corresponding groups of 4 wpc carbon standards. Although the agreement between the two laboratories was very satisfactory and subsequent measurements of the new standards at the Bureau checked the original values, it was realized, in view of the small number of observers in each laboratory, that if other groups of observers had made the measurements or if some other photometric method had been used the results might have been different.

Therefore, in order to obtain information as to the agreement which might be reasonably expected among different groups of experienced observers working by the same and by different methods, the Bureau invited the Nela Research Laboratory, the Electrical Testing Laboratories, and the Physical Laboratory of the United Gas Improvement Company to cooperate in an intercomparison of photometric measurements of blue glass screens and tungsten lamps involving color differences such as were encountered in the establishment of the new standards. The first two laboratories, like the Bureau, used Lummer-Brodhun contrast photometers, while the third used a special flicker photometer, and in no laboratory were the screens and lamps measured at the same time.

The results of the intercomparison show that each observer, regardless of the kind of photometer used, maintained a fairly definite criterion with respect to the mean of his laboratory, and that each laboratory likewise consistently maintained its relation to the mean of all, as judged from the measurements on the screens and those made on the lamps some months afterward.

Considering the difficulties involved in the measurements, the different characteristics of observers, and the wide difference in illumination employed, the agreement among the laboratories was remarkably good. It is true, however, that although the differences are small they are not negligible in precision photometry. It is evident, therefore, that measurements to establish standards involving color difference should be left as much as possible to the standardizing laboratory, where the observers must be carefully selected and a considerable number employed, and the kinds of instruments and other conditions definitely fixed.

An examination of the Bureau's observers who took part in this intercomparison and who were included in a group of 114 observers tested at the Bureau by Crittenden and Richtmyer, using a special flicker photometer, shows that their mean characteristic is very approximately the same as that of the average of the 114.

Furthermore, the flicker values found in this intercomparison and also by Crittenden and Richtmyer for the tungsten lamps at 1.5 wpc are in agreement with the Bureau's values. Hence it is concluded that the values which were originally assigned to the new 1.5 wpc tungsten standards as a result of the intercomparison with the National Physical Laboratory can be considered as average eye values.

G. W. M.

GEOLOGY.—*Economic geology of the North Laramie Mountains, Converse and Albany Counties, Wyoming.* ARTHUR C. SPENCER. U. S. Geological Survey Bulletin No. 626, pp. 46–81, with 2 plates and 4 figures.

This report includes a description of the broader geological features of the North Laramie Mountains and detailed notes on localities where prospecting work has been done in the search for copper ores. A colored geologic map of the general region, contributed by N. H. Darton, shows a central belt of pre-Cambrian rocks, flanked by areas of stratified rocks ranging in age from Carboniferous to late Cretaceous. With one exception the metalliferous deposits examined occur in the old crystalline rocks, which comprise granite, serpentine, and schists of various kinds.

In general the copper deposits of the region are not promising, though it is possible that in a few places small deposits will be profitably worked. Deposits of chromite and of asbestos occurring in the western part of the region appear not to be of economic importance.

A. C. S.

GEOLOGY.—*Geology and underground water of Luna County, New Mexico.* N. H. DARTON. U. S. Geological Survey Bulletin No. 618. Pp. 188, colored map, 12 other plates, 15 text figures. 1916.

A large part of Luna County consists of a desert plain underlain by sand, gravel, and clay of Quaternary age. Rising from this plain are narrow rocky ridges which contain a thick succession of sedimentary and igneous formations resting on pre-Cambrian granite, the whole considerably flexed and faulted. The sedimentary rocks include formations of Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Triassic (?), Cretaceous, and Tertiary age but only a portion of each period is represented. Most of the formations present features similar to those in other parts of southern New Mexico and western Texas but some of them are local or present peculiarities. The Tertiary rocks consist of thick accumulations of agglomerate, tuff, and ash and thin sheets of various kinds of lava.

The principal mineral resource is underground water, which occurs in large quantities in the deposits underlying the plain, and is pumped for irrigation. It is supplied by percolation from Mimbres River and by local rains. Tests of five wells by A. T. Schwennesen gave yields ranging from 122 to 603 gallons per minute, or from 14.5 to 88 gallons per minute for each foot of drawdown. O. E. M.

GEOLOGY AND ENGINEERING.—*Contributions to the hydrology of the United States, 1915.* Nathan C. Grover. U. S. Geological Survey Water-Supply Paper No. 375. Pp. 131, 9 plates, 31 text figures. 1916.

This volume includes the following papers:

Ground water for irrigation in the Sacramento Valley, California. Kirk Bryan. Sacramento Valley, 150 miles long, 40 miles wide, and containing more than 3,000,000 acres of agricultural land, is remarkable for its great supply of ground water, the rapid recharge of this supply in the rainy season, and the large area in which the water table stands close to the surface. More than 80 per cent of the valley has a depth to water of less than 25 feet. In 1913, water was drawn from wells at 1664 pumping plants for the irrigation of 40,859 acres.

Ground water in Paradise Valley, Arizona. O. E. Meinzer and A. J. Ellis. Paradise Valley affords an example of "stream escape," in contrast to "stream capture." Cave Creek, entering this valley from the side, formerly discharged through it, but built up its alluvial fan until it found an exit through a pass in the opposite mountain wall. It now crosses the valley and still furnishes most of its ground-water supply.

The relation of stream gaging to the science of hydraulics. C. H. Pierce and R. W. Davenport. This paper emphasizes the modernness of stream gaging as a science and coordinates it with the science of hydraulics and the still more comprehensive science of hydrology. The evolution of stream gaging to its present status has involved in a high degree that balancing of practice against abstract theory which has made hydraulics to so large an extent an empirical science. The importance of analytical studies and of utilizing the established facts of the science of hydraulics in the practice of stream gaging is illustrated by examples. Stream gaging, or, in a broad sense, hydrometry, has a steadily expanding field in the collection of stream-flow data, both for statistical purposes and as a basis for the design of various kinds of hydraulic works, in drainage investigations, in the operation of irrigation systems in the arid regions, in the determination of hydraulic constants and coefficients, in the testing and operation of water-power plants, and in other directions.

Ground water in Big Smoky Valley, Nevada. O. E. MEINZER. Big Smoky Valley is a typical desert valley occupying a closed basin of 3250 square miles. Numerous beach ridges and embankments, 50 feet in maximum height, show that in the Pleistocene epoch this valley contained two lakes—Lake Toyabe, which covered 225 square miles, and Lake Tonopah, which covered 85 square miles. The alluvial slopes are broken by fault scarps, indicating maximum displacements of more than 100 feet. Nearly 50 small mountain streams discharge into the valley, 10 of which, according to measurements made in October, 1914, contribute 7000 acre-feet a year to the ground-water supply. Ground water is discharged into the atmosphere from two areas which together cover about 205 square miles. These areas were mapped on the basis of (1) soil moisture and position of the water table, (2) soluble salts at the surface and in the soil, and (3) native plants that feed on ground water.

A method of correcting river discharge for a changing stage. B. E. JONES. When a river is rising fast it has a greater velocity and a greater discharge than it has at the same height when its stage is constant. This is caused by the increase in slope due to the rising stage. Likewise, when it is falling fast it has a lower velocity and a lower discharge. A formula is obtained for comparing the discharge under changing stage conditions with that under constant stage conditions, as follows:

The change in slope is assumed equal to the change in stage per second divided by the distance the water travels per second. Then as the discharge varies as the square root of the slope, the relation of the discharge under constant stage conditions (Q_1) to the discharge under changing stage conditions (Q_2) would be

$$\frac{Q_1}{Q_2} = \frac{\sqrt{S_1}}{\sqrt{S_1 + \dfrac{\textit{rate of change of stage}}{\textit{velocity}}}}.$$

S_1 in the equation is the surface slope under constant stage conditions.

As it is shown that a flood travels nearly at the rate of the surface velocity, the velocity used in the formula is the surface velocity which is obtained by dividing the mean velocity of the stream by 0.90.

If K stands for the change of stage per second, V for the mean velocity determined during the changing stage, and N for the coefficient for obtaining mean velocity from surface velocity, the formula may be written:

$$\frac{Q_1}{Q_2} = \frac{\sqrt{S_1}}{\sqrt{S_1 + \frac{NK}{V}}}$$

Tables and curves are given showing the results obtained by this method on streams varying in size from a canal carrying 50 second-feet up to the Ohio River carrying 365,000 second-feet.

Conditions requiring the use of automatic gages in obtaining records of stream flow. C. H. PIERCE. In 1913–14 the U. S. Geological Survey maintained 1741 gaging stations of which 325 were equipped with automatic gages. The conditions which require the use of automatic gages are (1) regulation of the stream by power developments; (2) operation of canals and ditches delivering water for irrigation; (3) fluctuations due to variation in run-off under natural conditions (a) caused by rain and (b) caused by melting ice and snow; (4) inaccessibility of gaging station or lack of reliable observer; (5) continuous record needed for legal purposes; and (6) human fallibility of most gage observers.

Ground water in Lasalle and McMullen counties, Texas. ALEXANDER DEUSSEN and R. B. DOLE. (Abstract in Journ. Wash. Acad. Sci., **6**: 224–225. 1916.)

O. E. M., R. W. D., B. E. J.

GEOLOGY.—*Geology and water resources of Tularosa Basin, New Mexico.* O. E. MEINZER and R. F. HARE. U. S. Geological Survey Water-Supply Paper No. 343. Pp. 317, with maps, sections, and views. 1915.

Tularosa Basin is a closed drainage basin in south-central New Mexico covering about 6,000 square miles. Its central plain is in part underlain by sediments to depths of more than 1,000 feet and is bordered on both sides by fault scarps several thousand feet high. Features of special interest are: (1) basaltic lava sheets of two ages, both Quaternary, with three volcanic cones; (2) recent fault scarps and shore features;

(3) steep-walled alkali flats, covering 165 square miles, formed chiefly by wind erosion; (4) dunes of gypsum sand, covering 270 square miles, on the leeward side of the alkali flats; (5) sink holes developed in the gypseous valley fill; and (6) numerous large mounds produced by springs.

The basal granite is unconformably overlain by Carboniferous rocks which comprise Mississippian limestone at the bottom and limestone, red beds, gypsum, etc., of the Magdalena and Manzano groups at the top. Cretaceous deposits, chiefly of the Dakota to Montana groups, are well represented; also younger intrusive rocks. Coal was observed in Carboniferous as well as in the Cretaceous strata.

Water occurs in valley fill and in Cretaceous and Carboniferous rock. About 150 analyses were made. The waters differ widely in chemical character and concentration, several distinct types being recognized and correlated with different rock formations. Various relations of alkali in soil and of zones of vegetation to water supplies are described.

O. E. M.

MINERALOGY.—*Mineralogic Notes, Series 3.* WALDEMAR T. SCHALLER. U. S. Geological Survey Bulletin No. 610. Pp. 164, with 5 plates and 99 figures. 1916.

New minerals described are as follows:

Koechlinite, bismuth molybdate, $Bi_2O_3 \cdot MoO_3$, from Schneeberg, Germany, as small greenish-yellow rectangular plates, orthorhombic, simple and twinned.

Inyoite, from Inyo County, California, as white rhombic-shaped monoclinic crystals, $2CaO \cdot 3B_2O_3 \cdot 13H_2O$, largely altered to meyerhofferite.

Meyerhofferite, alteration of inyoite, colorless to white, prismatic, triclinic crystals, $2CaO \cdot 3B_2O_3 \cdot 7H_2O$.

Lucinite, dimorphous form of variscite, $Al_2O_3 \cdot P_2O_5 \cdot 4H_2O$, from Lucin, Utah. Very small green, octahedral-shaped orthorhombic crystals, directly associated with variscite.

Velardeñite, from Velardeña, Mexico, $2CaO \cdot Al_2O_3 \cdot SiO_2$, tetragonal, is an essential component of the "gehlenites" and enters into the composition of the "melilites."

Fremontite is the name proposed to replace the objectionable term natramblygonite for the hydrous sodium aluminum phosphate member of the amblygonite group, found in Colorado. Triclinic crystals of fremontite are described.

The other mineralogic papers treat of: (1) The crystallography of variscite, extending the crystal forms to 14 and noting several different habits. (2) The composition of schneebergite is definitely fixed as $2CaO \cdot Sb_2O_4$. The paragenesis of the schneebergite specimens from Schneeberg, Austrian Tyrol, is fully described and illustrated. (3) Romeite from Italy and from Brazil is analyzed and its composition determined as $5CaO \cdot 3Sb_2O_5$. The romeite from Brazil has been erroneously called atopite. (4) The natural antimonites and antimonates are listed. (5) The melilite group is studied and it is concluded that all melilites and gehlenites may be considered as isomorphous mixtures of the tetragonal minerals, velardeñite, $2CaO \cdot Al_2O_3 \cdot SiO_2$, sarcolite, $3CaO \cdot Al_2O_3 \cdot 3SiO_2$, and åkermanite, $4MgO \cdot 8CaO \cdot 9SiO_2$. (6) Thaumasite crystals, from West Paterson, N. J., are hexagonal, $c\{0001\}$, $m\{10\bar{1}0\}$, $p\{10\bar{1}1\}$, the c-axis being 1.09. (7) The water in tremolite is held to be essential and not "as dissolved water . . . . not chemically combined . . . ." Analyses suggest the formula, $8SiO_2 \cdot 5MgO \cdot 2CaO \cdot H_2O$; (8) Massive guanajuatite was identified from Salmon, Idaho, brilliant yellow to orange greenockite from Topaz, California, and well-crystallized jarosite from Bisbee, Arizona. (9) Gigantic crystals of spodumene (one 47 feet long) from the Etta mine, South Dakota, are described and illustrated. (10) Mariposite from California, and alurgite from Italy probably represent the same mineral species.

The bulletin also includes reprints of papers on cebollite, nephelite, bloedite, alunite, custerite, hodgkinsonite, pisanite, strengite, and a note on the calculation of a mineral formula. W. T. S.

BOTANY.—*The genus Espeletia.* Paul C. Standley. American Journal of Botany, **2**: 468–485, pl. 17, f. 1–6. 1915.

The genus Espeletia is a member of the family Asteraceae. Its representatives, natives of the high mountains of northeastern South America, are conspicuous among the composites because of the dense woolly covering of their leaves and inflorescence, and the peculiar habit of many of the species. The present study is based chiefly upon material from Venezuela received recently by the U. S. National Herbarium. Seventeen species are recognized, six of which are described as new. Six of the species previously described are represented in the National Herbarium by recent collections. P. C. S.

REFERENCES

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Taboga, Cenopaschia, Pocopaschia, Stenopaschia, Glossopaschia, Difundella, Anypsipyla, Drescoma, Zamagiria, Cabima, Chorrera, Homalopalpia, Illatila, Anthopteryx, Bema, Relmis, Moerbes, Harnocha, Eurythmasis, Harnochina, Hypermescinia, Calamophleps, Comotia, Strymax, Microphycita, Microphestia, Micromescinia, Tinitinoa, Schenectadia, in the Pyralidae; together with 474 new species, 6 new subspecies and 5 new varieties, a few being extra-limital, coming from Brazil, British Guiana, Argentina and Ecuador. J. C. C.)

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PHYSICS.—*Recent improvements in the petrographic microscope.* F. E. WRIGHT, Geophysical Laboratory.

1. *Sliding objective changer.* In modern microscopes two forms of objective changer are in common use. On ordinary, non-polarizing microscopes (biological, etc.) the revolving nose piece is universally favored and serves the purpose well. In case exact centering is required, however, the revolving nose piece is mechanically inadequate and for this reason has never proved satisfactory in petrographic microscope work. In its place some form of objective clamp is usually adopted in polarizing microscopes; but with such a clamp each change from one objective to another involves a number of different operations which together require from 10 to 30 seconds to accomplish; in the course of a day's work, especially with fine grained and artificial preparations, this may consume 5 and even 10 per cent of the observer's available time. From an efficiency standpoint such a procedure cannot be considered satisfactory; but it can fortunately be remedied by a simple arrangement such that the time involved in changing objectives is of the order of half a second with the result that the total time is reduced to a fraction of 1 per cent of the day's working hours. The new device has been in constant use for nearly a year and has proved its usefulness.

The device is shown in figure 1 and consists simply of a sliding brass carriage in which are mounted two objectives in excentric conical steel rings, so cut that there is no change in focus in passing from one objective to the second. Each objective is centered, once for all, in a vertical direction by rotation in an excentric steel supporting ring and in a horizontal direction by one of the hardened steel screws *A* or *B;* against the flanges of these screws the hardened steel face-plates of the carriage strike. Mechanically the bearing surfaces are wide and the objectives return to exact center and focus on changing. For most petrographic work two objectives only are required (high power, *E. F.* = 4 mm., and low power *E. F.* = 16 mm.) and one carriage suffices for the purpose. But occasionally objectives of other focal length are desired; these are then mounted on a second slider which is slipped into the mount in place of the first carriage. In this operation the semi-circular flange of the stop screw *B* (fig. 1) is first turned through 90° to allow the slider to pass.

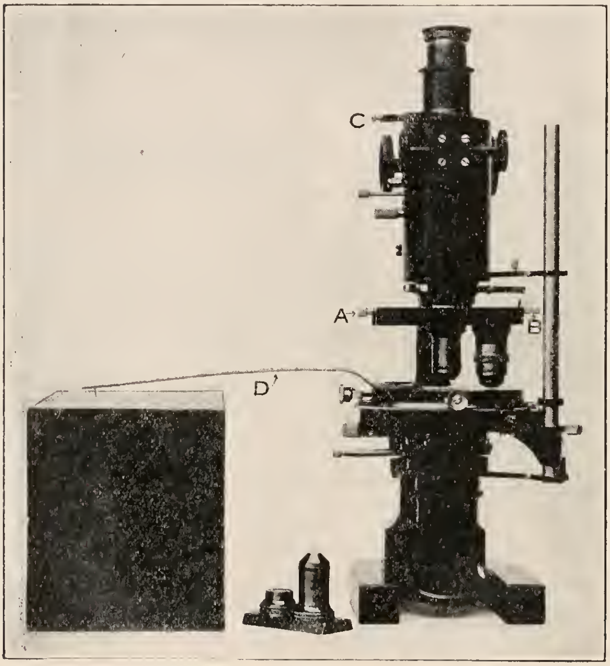

Fig. 1, Petrographic microscope with new accessories: *A*, sliding objective changer; *B*, lens system for removal of astigmatism caused by analyzer; *C*, prism for observation of interference figures; *D*, device for use in the accurate measurement of extinction angles.

2. *The removal of the astigmatism introduced by the analyzer.* It has long been known that the introduction of the analyzer into the optical system seriously disturbs the optical quality of the image by introducing into it astigmatism and other defects.

Tissot and Pellin[1] sought to remove the astigmatism by means of a cylindrical lens placed above the eye lens of the ocular, but this arrangement proved to be only partially successful. Recently S. Becher[2] has studied the question in detail and suggests that the astigmatism can best be obviated by converting the microscope lens system into a telecentric system such that the rays pass through the analyzer as parallel beams. He proposes to accomplish this by using objectives specially corrected for image plane at infinity and to employ a weak positive lens above the analyzer to focus the parallel beams emerging from the nicol on the image plane of the eyepiece.

Experience has shown that Becher's plan to remove astigmatism by means of the telecentric lens system is feasible; but that other arrangements in the optical system are better adapted from a practical standpoint to accomplish the same purpose.

In the first place it is not convenient to require a specially computed objective for the observations in polarized light. Such objectives would have to be computed and made specially, and would serve only a special purpose. On taking up this matter with the Bausch & Lomb Optical Company it was suggested to the writer by Dr. H. Kellner[3] that a weak negative lens may be used below the nicol in conjunction with an ordinary objective, the negative lens to be of such focal length that the rays converging toward points in the image plane are converted into parallel beams and pass as such through the nicol. After emergence from the nicol they are rendered again convergent by means of a weak positive lens. The new plan was tried out nearly a year ago and has been regularly introduced since then on all research model microscopes constructed by the Bausch & Lomb Optical Company. For observations in parallel polarized light the new scheme works well and is satisfactory, but for observations in convergent polarized light it is useless, as is also the plan suggested by Becher.

[1] Comptes Rendus, **145**: 866–877. 1907.

[2] Siegfried Becher. *Über den Astigmatismus des Nicols und seine Beseitigung im Polarisations Mikroskop.* Ann. d. Physik: 4 Folge, **47**: 285–364. 1915.

[3] Letter of September 18, 1915.

Some of the most important measurements in petrologic microscopic work are made in the interference figure (optic axial angles and angular distances of isochromatic curves), and it is highly desirable that a method be available for eliminating the astigmatism and distortion from the interference figure,[4] as this seriously affects the degree of attainable precision. The interference figure is formed in the upper focal plane of the objective and the rays from its points are imaged, after passage through the analyzer and Bertrand lens, in the image plane of the eyepiece. In order to fulfil the condition that these rays enter the nicol as parallel beams, a weak positive lens must be introduced below the analyzer in such a position that the lower focal plane of the lens coincides with the plane of the interference figure. The rays after emergence from the analyzer are focussed by means of a weak positive lens in the image plane of the eyepiece. In effect this arrangement is that of two astronomical telescopes in series, the objective and lens below the nicol forming the first system, the lens above the polarizer and the eyepiece the second.

The practical problem, to combine the arrangement for eliminating astigmatism in parallel polarized light with that for convergent polarized light, is being met on the writer's microscope as follows: The negative lens and the positive lens required for the correction in parallel polarized light are fitted below and above the nicol respectively. To pass to convergent polarized light a positive lens is introduced in a slider in a slot between the analyzer and the objective; the focal length of this lens is such that its combination with the negative lens functions as a positive lens whose lower focal plane coincides with the plane of the interference figure. By this arrangement the interference figure is imaged slightly magnified (magnification approximately equal to the ratio of the focal length of upper positive lens to that of combination positive and negative lens below the analyzer) in the image plane of the eyepiece. In the case of small sections it is essential that all extraneous light from adjacent sections be excluded from the field; this can only be done by means of a stop

[4] See, F. E. WRIGHT. *Methods of petrographic microscope research.* Carnegie Institution of Washington, Publication No. 157, pp. 53–56. 1911.

in the image of the object plane. To accomplish this a sliding stop or iris diaphragm is introduced just beneath the sliding positive lens; by raising the objective the object is imaged in the plane of the stop, which allows only light from the particular section to pass. In the writer's microscope the correct position of focus is determined by means of the Bertrand lens which together with the ocular constitutes a weakly magnifying microscope focussed on the plane of the stop.

For most petrographic microscope work relatively low magnifications are used and the astigmatism introduced by the nicol is not a serious factor either in parallel or convergent polarized light. It would seem, therefore, that except in work of precision the above changes are in a sense refinements which add to the complexity of the instrument.

The assertion of Becher that the telecentric system permits the use of the oblique end type of nicol prism as analyzer is not borne out either by theory or by practice, because the oblique ends of such a prism rotate the plane of vibration of the emergent rays and are under all conditions inferior to the square end type such as the Glan-Thompson prism.

3. *The prism method for the observation of interference figures.* In 1906 the writer described[5] a simple method for the observation of interference figures by the Lasaulx method; the method consisted essentially in reflecting, by means of a prism mounted in a slider, the rays of light from the axis of the microscope out to a path outside the tube of the microscope, thus obviating the necessity of removing the eyepiece each time an interference figure is observed by the Lasaulx method. Improvements in this device have been made by replacing the two reflecting prisms by a single doubly reflecting prism; in reducing the size of the prism so that it cuts out a small part of the center of the field and thus serves as an effective stop sufficiently small to include only one section or grain of ordinary size; and in placing the prism slider directly beneath the field lens of the ocular so that the part of the field covered by the prism can be viewed directly

[5] Am. J. Sci. (Series 4), **22**: 19. 1906.

(fig. 1, *C*). These improvements have greatly extended the usefulness of this device, which experience has shown to save an appreciable amount of the observer's time in routine work.

4. *A device for use in the accurate measurement of extinction angles.* The measurement of an extinction angle involves two operations: (*a*) the setting on the position of darkness, and (*b*) the placing of some definite crystallographic direction, as a cleavage line or a line of crystal growth, parallel with one of the cross hairs in the eyepiece. The precision of the second operation depends largely on the quality of the crystallographic direction which is used as line of reference; in case this is sharply developed there is no difficulty in setting with a precision of 1′ of arc. The first operation, on the other hand, depends on a number of factors, one of the most important of which is the sensitiveness of the eye of the observer and his personal equation. The eye is sensitive down to a certain value (threshold value) below which the field appears dark. Under ordinary conditions of illumination in microscope work there is a region of 1° to 2° within which the average birefracting plate between crossed nicols can be rotated and yet appear to be dark. The common practice in measuring extinction angles is to ascertain the position of maximum darkness on rotation of the crystal plate a number of times to the right and stopping at the position judged to be the darkest; this operation is repeated a certain number of times; and similarly for an equal number of rotations to the left. The average of these readings is then considered to be the most probable position of darkness. In principle this method is excellent, especially if the half shade principle be introduced to increase the precision of each setting; but in practice there is a tendency, which is exceedingly difficult to correct, for the observer unconsciously to attach special importance to the first reading and thus to give it undue weight.

In all measurements of this type, where settings of relative intensity are made, it is essential for accurate work to eliminate this element of the undue weighting of first readings and to make each setting without knowledge of its agreement or lack of agreement with foregoing readings. Only in this way can a proper random distribution of errors be obtained which will furnish a good probable value.

To apply this principle to the measurement of extinction angles a simple flexible arm of brass was cut out and attached by means of tightly fitting plugs into the clip holes on the microscope stage (fig. 1, *D*). At the other end of the arm a needle point is soldered. To record a setting, a mark by the needle point is made in a sheet of millimeter cross section paper mounted in proper position on a block of wood (shown greatly foreshortened in fig. 1). A convenient length of radius to use is 28.66 cm; each degree on the arc of the circle is then 5 mm. and readings can readily be made to tenths of a degree and even to fiftieths.

Experience with this simple device which can easily be made in an hour has shown that much time can be saved by its use. Settings are made by simply pressing down the needle and no readings are required. A number of settings are made with clockwise rotation of the stage, and an equal number with counter-clockwise rotation. By reference to the graduated circle on the microscope stage the angular position of the average position of the points punched in the paper can be read off directly and with it the most probable extinction position. Experience has shown that the eye can estimate the average center of a series of points grouped about the center with sufficient accuracy for practical purposes. The actual angular position of each point can, of course, be ascertained and an arithmetical average then taken, but for most purposes this is unnecessary.

It is of interest to note that the mean position of clockwise rotation may be situated a whole degree away from the mean position of counter-clockwise rotation, thus showing the importance of making measurements by approaching the position of extinction from the right and from the left as well. The above device is useful also in enabling the observer, especially if he be a student, to ascertain the probable error of the single settings and at the same time to increase the precision of his measurements without extra labor.

PHYSICS.—*The calculation of Planck's constant C_2.*[1] J. H. Dellinger, Bureau of Standards.

This constant, which is of great importance in high temperature measurements and in atomic theory, has heretofore been obtained from radiation data by processes involving the use of a graph. It may be calculated directly and very simply from any two observations. A solution of Planck's equation for C_2 in terms of the ratio of energies at any two wave lengths and temperatures is readily obtained, C_2 appearing in a correction term in the solution. The various relations which have been used for obtaining C_2 from radiation data are deducible as special cases.

The equation for two observations of wave length at constant temperature is of special interest; the following approximate expression is sufficiently exact for most cases.

$$C_2 = \frac{\lambda_1 \lambda_2 \theta}{\lambda_2 - \lambda_1}\left[\log \frac{J_2}{J_1} + 5 \log \frac{\lambda_2}{\lambda_1} - e^{-\frac{C_2}{\lambda_2 \theta}}\right]$$

An approximate value of C_2 always suffices for the last term. This general method of solution is superior to the method of equal ordinates. No curve has to be drawn, and the calculations are not limited to particular pairs of points. The method is more powerful in determining whether an observed curve fits the Planck equation. In fact, curves which give normal values for C_2 by the method of equal ordinates were found to give very high values when calculations were made by this method for two points both on the same side of the maximum.

Points on the Planck curve for which Wien's displacement law holds, in particular the maximum of the curve, have been considered as furnishing additional ways of determining C_2. Such methods are debarred by lack of accuracy, and in fact these special points may themselves be obtained most accurately and conveniently by the same process of using two observations which is used for obtaining C_2. Substantially the same simple equation suffices to determine C_2 and all the special points.

[1] Detailed paper to appear as Bureau of Standards Scientific Paper No. 287 (Bull. Bur. Stds., **13**: 535–545). 1916.

PHYSICS.—*Some new designs of radiometers.* W. W. COBLENTZ, Bureau of Standards.

In continuing the improvement of stellar radiometers several new designs of instruments were considered and some of the preliminary tests of their efficiency appear to be of sufficient importance to warrant publication.

When a very thin strip of blackened metal, e. g. a bolometer strip, is exposed to radiation it becomes warmed and it in turn emits radiation. In previous investigations of the diffuse reflecting power of various substances[1] and of the behavior of an absolute thermopile[2] it was found that this warming of the receiver is quite appreciable, and that this receiver can be a very efficient secondary source of radiation which, in turn, can be used to operate a radiometer. The utilization of this secondary source of radiation can be accomplished by placing the receiver at the center of an accurately ground hollow sphere having an opening to admit radiation. In this case one would utilize the "reradiation" which has to be very carefully excluded in diffuse reflection measurements.[3]

Another logical method for utilizing this radiation is the employment of multiple receivers, one being placed back of another; for example, a thermopile receiver back of a bolometer strip, or one bolometer strip (or thermopile receiver) back of another. It is with this method that the present paper is chiefly concerned.

[1] Bull. Bur. Stds., **9**: 283. 1913.

[2] Bull. Bur. Stds., **11**: 157. 1914.

[3] PASCHEN (Ber. Berliner Akad., p. 409. 1899) appears to have been the first one to use a hemispherical mirror in front of a bolometer in order to "blacken" it. The device has been used extensively by the writer (Bull. Bur. Stds., **4**: 392. 1908). In spectral radiation work care must be exercised to avoid reflection of radiation from the adjacent parts of the spectrum upon the bolometer strip. In investigations where it is unimportant whether some of the incident beam of radiation falls upon a reflecting surface at the rear of the receiver before it falls upon the receiver (i.e. in cases where it is unimportant whether the complete beam of incident radiation is completely intercepted by the receiver) it is possible to place the receiver at the center of an accurately made hollow sphere as just mentioned. PFUND (Phys. Rev. **34**: 288. 1912) claims a very large increase in sensitivity as the result of using a thermojunction at the focus of a spherical mirror.

The efficiency of such a device was tested in the following manner. Two strips of very thin platinum, such as is used in bolometers (thickness about 0.001 mm.), about 6 by 20 mm. in area were mounted over slits cut in cardboard which was 0.45 mm. thick. Both sides of these strips were painted with a thin coat of lamp black and covered with soot from a sperm candle. The thermopile receiver was 1.8 by 16 mm. Slits of bright aluminum, 0.85 mm. thick, were placed in front of the thermopile or in front of the blackened platinum strips when they were in front of the thermopile. The distance between the thermopile receiver and the platinum strip (and between the two platinum strips) was 0.45 mm. When the thermopile was exposed directly to a standard of radiation the deflection was 12.15 cm.; when one platinum strip intervened the deflection was 5.88 cm.; and when the two platinum strips were in front of the thermopile the deflection was 3.57 cm.

The multiple bolometer receiver. Since there is but little difference between the radiation sensitivity of a bismuth-silver thermopile and a bolometer, the above tests show that the radiation sensitivity of a bolometer can be increased by 50 per cent by having the receiver (the arm of the bridge) consist of two strips, one back of the other, the front strip being exposed to radiation. By using three strips placed one back of another the galvanometer deflection would be increased by about 80 per cent, and by using four strips (joined in series, or a single strip folded three times) the deflection will be double that produced by the front strip. The sensitivity of the whole combination would be further increased by placing this multiple receiver at the focus of a hemispherical mirror.

The bolo-pile. This is a combination of a single bolometer strip, close back of which is placed the receiver of a thermopile. The latter is so constructed that the pairs of receivers are in two rows corresponding to the two bolometer strips. In this manner the heating produced by the current passing through the bolometer strips will produce no deflection in the thermopile circuit. The manner of connecting the bolometer and the thermopile circuit to the galvanometer will depend upon the relative change in voltage of the two circuits when the receiver is exposed to radiation. If the error due to shunting is too great when the two circuits are joined to the same binding posts, the bolometer current can be passed through one galvanometer coil and the thermopile current through another coil.

The simplest and probably the most useful arrangement is a bolometer consisting of two branches of thin narrow strips of platinum close back of which is placed a thermocouple. In measuring the heat from stars a gain of only 50 per cent in sensitivity is worth considering.

The multiple thermocouple receiver. The use of two thermocouples, joined in series, with the receivers one back of the other, has not yet proved to be so efficient, because of the greater heat capacity of the thermocouple receiver used as compared with a bolometer. The comparison of this combination with the two preceding instruments, and with a single thermocouple (or bolometer) in the focus of a spherical inclosure, in which all the parts are reduced to the dimensions which would be used in measuring stellar radiations, is in progress.

In conclusion it may be added that as a result of the writer's previous measurements of stellar radiation[4] the conclusion was arrived at that, in order to do much successful work in stellar radiometry, it will be necessary to have a 100-fold greater sensitivity than that previously employed. This gain in sensitivity was to be attained by increasing the light-gathering power of the telescope 5 times, the sensitivity of the galvanometer 10 times, and the radiometer sensitivity 2 times. In a paper[5] just published data are given showing an increase of more than 10 times in the galvanometer sensitivity, while the present paper indicates the way to double the radiometer sensitivity. Apparently then it remains to find a suitable mirror and funds to operate it.

[4] Bull. Bur. Stds., **11**: 613. 1914.
[5] Bull. Bur. Stds., **13**: 423. 1916.

PHYSICS.—*Criteria for gray radiation.* P. G. NUTTING, Rochester, New York. (Communicated by N. E. Dorsey.)

If the logarithm of the energy radiated from a body within a short range of wave lengths be plotted against the reciprocal of the absolute temperature, the result is known to be a sensibly straight line over a wide range of temperatures. These logarithmic isochromatic lines pass through a common point in some cases, not in others. Benedict[1] concludes that this stigmatic condition is characteristic of gray radiation, while the lack of it means that the radiation is selective. Hyde[2] from his own data on lamp filaments concludes that the stigmatic condition is insufficient as a criterion for grayness. Foote and Fairchild[3] have shown further that the stigmatic condition may hold even for a body known to be strongly selective.

The mathematical side of the problem appears to have been neglected, although capable of rather simple treatment. Let the equilibrium radiation from a "black body" be represented by

$$J = B_1 \lambda^{-5} e^{-\frac{B_2}{\lambda T}} \tag{1}$$

in which B_1 and B_2 are independent of wave length and temperature. Also let

$$E = C_1 \lambda^{-n} e^{-\frac{C_2}{\lambda T}} \tag{2}$$

represent radiation from some body, but not in equilibrium with it.

From (1)

$$\log J = \log (B_1 \lambda^{-5}) - \frac{B_2}{\lambda T} \tag{3}$$

hence for any fixed wave length, $\log J$ is a linear function of $1/T$. Writing (3)

$$y = a - bx \tag{4}$$

it is seen to represent a family of straight lines whose Y intercept is a and whose direction tangent is b.

But the general representation of a stigmatic pencil of lines passing through the point $(x_0, y_0,)$ is

$$y - y_0 = -b\,(x - x_0), \tag{5}$$

[1] E. BENEDICT. Ann. d. Physik, (4) **47**: 641. 1915.
[2] E. P. HYDE. Ann. d. Physik, (4) **49**: 144. 1916.
[3] FOOTE and FAIRCHILD. This JOURNAL, **6**: 193. 1916.

hence the necessary and sufficient condition that the pencil of lines represented by (4) be stigmatic is that a be a linear function of b,

$$a = y_0 + bx_0 \tag{6}$$

x_0 and y_0 being constants independent of both wave length and temperature.

This condition however is *not satisfied* even for equilibrium radiation, for $a = \log (B_1 \lambda^{-5})$ and $b = B_2/\lambda$, and neither of these expressions can be a linear function of the other. Over but a moderate range of wave lengths the expression holds to a fair approximation (probably to within the limits of experimental error). For, let $\lambda = \lambda_0 (1 \pm \delta)$ where δ is so small that its square may be neglected in comparison with its first power. In this case a and b are both linear functions of δ and hence of one another.

Consider now the free radiation represented by (2) whether gray or selective. The parameters C_1, n and C_2 vary not only from surface to surface but (in general) with both wave length and temperature; in other words, the equation is too simple to represent free radiation. However, the stigmatic condition may be applied even though no parameters are constant. If the data indicate that a number of logarithmic isochromatic lines pass through a common point, then an equation similar to (6) must hold over the range of wave lengths covered by the data. Hence, for any variation $da = x_0\, db$; for example, $da/d\lambda = x_0\, db/d\lambda$. The linear relation (6) requires

$$\log C_1 \lambda^{-n} = y_0 + \frac{C_2 x_0}{\lambda} \tag{7}$$

Hence, by substitution in (2), in any region within which the stigmatic condition holds, even though C_1, n and C_2 vary,

$$\log \frac{E}{E_0} = \frac{C_2}{\lambda}\left(\frac{1}{T_0} - \frac{1}{T}\right) \tag{8}$$

where E_0 and T_0 are *fixed constants* such that $\log E_0$ and $1/T_0$ are the coordinates of the point of stigmatism.

This is of the same form as the Paschen-Wanner equation, used so much in monochromatic pyrometry, but with a somewhat different interpretation. Imposing the stigmatic condition has eliminated both n and C_1 with their possible variations. It is well known from experimental data that this form of equation holds well and that the stigmatic condition is frequently fulfilled.

For gray radiation $\log(E/J)$ is by definition independent of wave length. In case C_1, n and C_2 are all constant, as with equilibrium radiation, the stigmatic condition can hold for but a limited range of wave lengths. The gray condition in the general case with varying parameters gives

$$\log \frac{C_1 \lambda^{-n+5}}{B_1} = \text{constant} + \frac{C_2 - B_2}{\lambda T}$$

This is consistent with the stigmatic condition (7) for free radiation, but either may be true without the other.

We have shown that the logarithmic isochromatic lines representing equilibrium radiation do not form a stigmatic pencil except for a limited range of wave lengths. For free radiation, the stigmatic condition gives an equation known to be of wide validity. The stigmatic condition and the condition for grayness may both be satisfied, but either may hold without the other.

PHYSICS.—*Summary of experiments on the silver voltameter at the Bureau of Standards.*[1] E. B. ROSA AND G. W. VINAL, Bureau of Standards.

The investigation of the silver voltameter at this Bureau was first begun by the late Dr. K. E. Guthe in 1904. His results were published in two papers about a year later. In 1907 the work was again taken up by Dr. N. E. Dorsey in cooperation with the present authors, but the results obtained at this time did not confirm the newly published experiments of the National Physical Laboratory, and new difficulties arose which were not understood. These experiments were not published. In the following year the work was resumed and preparations were made for a very thorough study of the silver voltameter. The voltameter received added importance when the ampere was adopted by the London Electrical Congress as the second funda-

[1] A more detailed summary will appear as Bureau of Standards Scientific Paper No. 285 (Bull. Bur. Stds., **13**: 479–514. 1916).

mental electrical unit, so that the investigations which the present authors began in the summer of 1908 have passed beyond the original plans in scope and duration. This has also been due, in large measure, to the numerous and intricate sources of error which were discovered in the course of the work, all of which required painstaking investigation.

Other experimenters who have cooperated with us at various times during the course of the work are Dr. A. S. McDaniel, Prof. S. J. Bates, Prof. G. A. Hulett, and Mr. Wm. M. Bovard. The results of these investigations have been published in a series of eight papers.[2]

A few of the principal results may be summarized as follows:

1. The effect of filter paper on silver nitrate solutions (whether the paper is used in the voltameter itself, as has been commonly done, or whether it is used in the preparation of the silver nitrate solution) was shown to be serious and to result in the formation of colloidal silver. This effect of the filter paper is due to the formation of reducing agents from the oxycellulose of the paper itself and is not due to impurities.

[2] E. B. Rosa and G. W. Vinal. Bur. Stds. Sci. Paper No. 194 (Bull. Bur. Stds., **9**: 151. 1913); summaries in this Journal, **2**: 451. 1912; Elec. World, **60**: 1261. 1912; Elektrotech. Zs., **34**: 232. 1913.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 195 (Bull. Bur. Stds., **9**: 209. 1913); summaries in this Journal, **2**: 509. 1912; Elec. World, **60**: 1262. 1912; Elektrotech. Zs., **34**: 233. 1913.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 201 (Bull. Bur. Stds., **9**: 493. 1913); summaries in this Journal, **3**: 40. 1913; Elec. World, **61**: 84. 1913; Elektrotech. Zs., **34**: 1168. 1913.

G. W. Vinal and S. J. Bates. Bur. Stds. Sci. Paper No. 218 (Bull. Bur. Stds., **10**: 425. 1914); Journ. Am. Chem. Soc., **36**: 916. 1914; summary in this Journal, **4**: 69. 1914.

E. B. Rosa, G. W. Vinal, and A. S. McDaniel. Bur. Stds. Sci. Paper No. 220 (Bull. Bur. Stds., **10**: 475. 1914); summaries in this Journal, **4**: 52. 1914; Elec. World, **63**: 373. 1914; Elektrotech. Zs., **35**: 789. 1914.

G. A. Hulett and G. W. Vinal. Bur. Stds. Sci. Paper No. 240 (Bull. Bur. Stds., **11**: 553. 1915); Journ. Phys. Chem., **19**: 173. 1915; summary in this Journal, **4**: 593. 1914.

G. W. Vinal and W. M. Bovard. Bur. Stds. Sci. Paper No. 271 (Bull. Bur. Stds., **13**: 147. 1916); Journ. Am. Chem. Soc., **38**: 496. 1916; see also this Journal **6**: 222. 1916.

E. B. Rosa and G. W. Vinal. Bur. Stds. Sci. Paper No. 283 (Bull. Bur. Stds., **13**: 447. 1916); see also this Journal, **6**: 500. 1916.

2. The appearance of the deposit is altered by the presence of impurities in the solutions (such as those resulting from filter paper). Pure solutions give crystalline deposits of very pure silver, but colloids, if present, break up the crystals and produce striated deposits which are too heavy to represent accurately the amount of electricity which passed through the voltameter.

3. Many forms of voltameter have been compared. The Bureau has found that the most satisfactory are the porous cup voltameter and the new form devised by Mr. F. E. Smith of the National Physical Laboratory.

4. The Bureau has devised means of preparing pure silver nitrate and suitable tests for it, so that an electrolyte of a uniformly high state of purity can be prepared. These tests are for acidity and for reducing agents. The Bureau has also found that the agreement between the results obtained from large and from small sizes of voltameters, used simultaneously, is a valuable test of purity; impure solutions (except for acid) invariably give heavier deposits in the large size voltameters. This phenomenon we have called the *volume effect.*

5. The temperature coefficient of the voltameter is found to be zero.

6. Tests of the purity of the silver deposits show that when made from pure electrolyte, the impurities included with the silver crystals represent on the average only 0.004 per cent of the weight of the deposit.

7. The absolute electrochemical equivalent of silver was found to be 1.11800 mg. per coulomb and the voltage of the Weston normal cell was found to be 1.01827 volts at 20°C.

8. Comparisons with the iodine voltameter were made and the ratio, the amount of silver deposited to the amount of iodine deposited by the same current, was found to be 0.85017, which, corrected for the inclusions in the silver deposits, gives 0.85013. The electrochemical equivalent of iodine in absolute measure was computed to be 1.31507 mg. per coulomb.

The value for the faraday on the basis of the absolute electrochemical equivalent of silver and of iodine and their atomic weights is as follows:

On the silver basis (Ag = 107.88)	96,494
On the iodine basis (I = 126.92)	96,512
Mean	96,503

The best round value which can be assigned to this constant appears to be 96,500 coulombs.

A brief history of the specifications for the voltameter, as well as revised specifications proposed by the Bureau of Standards, will be given in the detailed paper.[3] As no adequate specifications have been adopted since the London Conference of 1908 it is hoped that the carefully drawn specifications which the Bureau will present may be adopted as a whole or in part, whenever it is possible to reach an international agreement. In any case, for the present, these specifications will be available for the guidance of such investigators as may wish to use the silver voltameter.

An appendix to the paper will contain an extensive bibliography of the subject.

CHEMISTRY.—*A note on the sulphone-phthaleins as indicators for the colorimetric determination of hydrogen-ion concentration.*[1] Herbert A. Lubs and William Mansfield Clark, Bureau of Animal Industry.

In a previous paper[2] from this laboratory there were described several new indicators of the sulphone-phthalein series and an improved method for the preparation of those previously made by others. In our subsequent work on indicators suitable for the colorimetric determination of hydrogen-ion concentration, we have investigated other compounds of this series and have found another that promises to be particularly useful for this purpose; namely, dibrom-o-cresol-sulphone-phthalein. We have also found that slight modifications in the methods of preparation of some of the indicators described in our earlier paper will insure

[3] Shortly to appear as Bur. Stds. Sci. Paper No. 285 (Bull. Bur. Stds., **13**: 479–514. 1916).

[1] From the research laboratories of the Dairy Division, Bureau of Animal Industry. Published by permission of the Secretary of Agriculture.

[2] Journ. Wash. Acad. Sci., **5**: 609. 1915.

better products. These modifications will be discussed under the indicators in question. At the end of the article will be found a list of the sulphone-phthaleins which have been investigated in this laboratory, with their color changes and the ranges over which the changes occur. An account of our investigations of the more useful indicators will shortly appear in the Journal of Bacteriology.

O-CRESOLSULPHONE-PHTHALEIN

Ten grams of the chloride of o-sulphobenzoic acid, 10 grams of freshly fused zinc chloride, and 15 grams of o-cresol were heated for 6 hours at 110°–120°, instead of at 165°–170° as previously recommended. At the lower temperature a purer product was obtained.

DIBROM-O-CRESOL-SULPHONE-PHTHALEIN

This indicator was prepared practically as described by Sohon.[3] Two grams of o-cresolsulphone-phthalein was suspended in 10 cc. of glacial acetic acid and 2 cc. of bromine was added. The flask was allowed to stand over night and the reddish-white crystals were filtered off the next morning. These crystals can be recrystallized by dissolving in boiling toluol and allowing the solution to cool.

The color changes are from yellow to a brilliant purple and occur over the range P_H^+ 5.2 to P_H^+ 6.8. A 0.04 per cent aqueous solution of the mono-sodium salt is satisfactory for the indicator solution.

THYMOLSULPHONE-PHTHALEIN

This compound can be prepared more satisfactorily by heating the mixture of the chloride of o-sulphobenzoic acid, zinc chloride, and thymol at 100°–110° for 6 hours, instead of at 140° as recommended in our previous paper.

DIBROMTHYMOL-SULPHONE-PHTHALEIN

In our earlier paper this compound was described simply as bromthymol-sulphone-phthalein. Subsequent analyses have shown that it is the dibrom compound.

[3] Amer. Chem. Journ., **20**: 257. 1898.

ANALYSES

I. 0.1456 gram gave 0.0881 gram AgBr.
II. 0.1865 gram gave 0.1158 gram AgBr.
Calculated for $C_{27}H_{28}Br_2O_5S$, 25.6 per cent Br.
Found, I, 25.8 per cent; II, 26.4 per cent.

TABLE 1

COLOR CHANGES AND APPROXIMATE RANGES OF THE VARIOUS SULPHONE-PHTHALEINS

INDICATOR	COLOR CHANGE	RANGE P_H
Thymolsulphone-phthalein†	Red—yellow	1.2–2.8
Tetrabrom-phenolsulphone-phthalein	Yellow—blue	2.8–4.6
Tetrachlor-phenolsulphone-phthalein*	Yellow—blue	2.8–4.6
Dibrom-o-cresol-sulphone-phthalein	Yellow—purple	5.2–6.8
Dibromthymol-sulphone-phthalein	Yellow—blue	6.0–7.6
Phenolsulphone-phthalein	Yellow—red	6.8–8.4
o-Cresolsulphone-phthalein	Yellow—red	7.2–8.8
Phenol-nitro-sulphone-phthalein*	Yellow—red	6.8–8.4
α-Naphtholsulphone-phthalein	Yellow—blue	7.4–9.0
Thymolsulphone-phthalein	Yellow—blue	8.0–9.6
Thymol-nitro-sulphone-phthalein*	Yellow—blue	8.0–9.6
Carvacrolsulphone-phthalein*	Yellow—blue	8.0–9.6

* These compounds were prepared only in small amounts. Upon investigation we found that they showed no advantage over compounds more easily prepared. On this account we did not attempt to find the best conditions for their preparation, and for this reason the details of methods for their preparation are not given.

† This indicator shows color changes in both alkaline and acid solutions. Between P_H^+ 3 and P_H^+ 8.0 its solution is yellow in color.

CHEMISTRY.—*The colorimetric determination of the hydrogen-ion concentration of bacteriological culture media.*[1] WILLIAM MANSFIELD CLARK and HERBERT A. LUBS, Bureau of Animal Industry.

In a previous note[2] we described some new indicators which are especially useful in colorimetric determinations of hydrogen-ion concentrations. In the present number of this JOURNAL we present some further notes.

[1] From the research laboratories of the Dairy Division, Bureau of Animal Industry. Published by permission of the Secretary of Agriculture.

[2] LUBS, H. A., and CLARK, W. M. Journ. Wash. Acad. Sci., **5**: 609. 1915.

The chief object of these studies has been to assemble a set of indicators which may be used from about $P_H = 1.0$ to $P_H = 10.0$ and which will have such brilliancy and such reliability that they may be used in the colored and turbid solutions handled by the bacteriologist. Preliminary tests had shown the value of some of the indicators of the methyl red and sulphone-phthalein types. We have now concluded a more extensive investigation in which over four hundred electrometric measurements were made of the hydrogen-ion concentrations of a variety of culture media and cultures with simultaneous measurements by the colorimetric method.

In these studies we have had to test the applicability of the indicators upon a heterogeneous collection of solutions such as are used in bacteriological work and, in order to subject the method to the severe conditions which it will have to meet if applied to many bacteriological problems, we have devoted most of our attention to measurements of colored and turbid solutions. The material was therefore not favorable for any systematic study of the so-called "protein and salt errors." Furthermore, since we consider the colorimetric method to be only supplementary to the more precise electrometric method, we confined our attention to very simple and rapid colorimetric procedures, such as are available to all and such as are convenient for handling the enormous number of tests which certain classes of research and routine bacteriological work require. The electrometric measurements, on the other hand, were made with care and with the improved equipment described by Clark[3] and by Clark and Lubs.[4]

The details of these extensive comparisons between the electrometric and the colorimetric determinations are beyond the scope of this brief article. They will be published elsewhere, together with a discussion of the applications of the colorimetric method in bacteriology. The main results may be briefly summarized as follows.

Since the colorimetric method, if applied extensively in routine, should be made as convenient as possible, we devised and carefully

[3] Clark, W. M. Journ. Biol. Chem., **23**: 475. 1915.

[4] Clark, W. M., and Lubs, H. A. Journ. Biol. Chem., **25**: 479. 1916.

studied a new set of standard buffer solutions which has several advantages over those formerly used. The details of this part of our investigation have recently been published.[5]

A new set of indicators has been assembled. Each of them has been studied sufficiently to enable us to make a selection of the most promising. The selection is listed in table 1, together with the short names we suggest for laboratory parlance. In this table are included the apparent dissociation constants. These constants, which are, of course, not the true dissociation constants, were determined by the method of Salm.[6] While they are only approximate, they are probably accurate enough to be used by those who may wish to apply them to titrimetric problems (see Bjerrum).[7] We have used them in our more detailed paper merely to illustrate some points in the discussion and to determine the approximate theoretical limits of P_H within which the several indicators may be used. The limits so found are in substantial agreement with those found empirically. They are given in table 1.

TABLE 1

Selection of Indicators

CHEMICAL NAME	SHORT NAME	K AS P_H	USEFUL RANGE P_H
Thymolsulphone-phthalein (acid range)	Thymol blue	1.7	1.2–2.8
Tetrabrom-phenolsulphone-phthalein	Brom-phenol blue	4.1	2.8–4.6
Ortho-carboxy-benzene-azo-dimethyl-aniline	Methyl red	5.4	4.4–6.0
Ortho-carboxy-benzene-azo-dipropyl-aniline	Propyl red	5.1	4.8–6.4
Dibrom-o-cresol-sulphone-phthalein	Brom-cresol purple	6.3	5.2–6.8
Dibromthymol-sulphone-phthalein	Brom-thymol blue	7.0	6.0–7.6
Phenolsulphone-phthalein	Phenol red	7.9	6.8–8.4
o-Cresolsulphone-phthalein	Cresol red	8.3	7.2–8.8
Thymolsulphone-phthalein (alk. range)	Thymol blue	8.9	8.0–9.6
o-Cresolphthalein	Cresol-phthalein	9.4	8.2–9.8

The confusing effect of the natural color of most culture media, vegetable extracts, etc., can be overcome to a large extent by using brilliant indicators such as the sulphone-phthalein indicators are, and by using the compensation method of Walpole.[8] The simple comparator

[5] Clark, W. M., and Lubs, H. A. Journ. Biol. Chem., **25**: 479. 1916.
[6] Salm, E. Zeitschr. physik. Chem., **57**: 471. 1906.
[7] Bjerrum, N. Sammlung chem. u. chem.-tech. Vorträge, **21**: 1. 1915.
[8] Walpole, G. S. Biochem. Journ., **5**: 207. 1910.

of Hurwitz, Meyer, and Ostenberg[9] has been found useful for this purpose. We have also developed the dilution method, which consists in diluting about 2 cc. of the tested solution to 10 cc. with distilled water and measuring the P_H of this comparatively clear dilution. As is well known, this degree of dilution of solutions such as those tested has so small an effect on the P_H value that it can seldom be detected by the crude colorimetric method.

TABLE 2

DEVIATIONS OF COLORIMETRIC FROM ELECTROMETRIC P_H DETERMINATIONS OF BEEF INFUSION MEDIA

NO. OF DETERMINATIONS	INDICATOR	METHOD	AVERAGE	MEAN	MAXIMUM	MINIMUM
7	Brom-phenol blue...	comparator	−0.05	0.16	−0.38	−0.01
6	Methyl red..........	comparator	+0.10	0.11	+0.28	±0.00
4	Methyl red..........	dilution	+0.08	0.08	+0.18	±0.00
4	Propyl red..........	comparator	+0.08	0.08	+0.18	±0.00
2	Propyl red..........	dilution	±0.00	0.00	±0.00	±0.00
10	Brom-cresol purple..	comparator	−0.01	0.04	±0.07	±0.00
5	Brom-cresol purple..	dilution	−0.03	0.05	−0.14	−0.01
14	Brom-thymol blue..	comparator	−0.10	0.15	−0.25	+0.03
5	Brom-thymol blue..	dilution	−0.10	0.12	−0.26	+0.01
12	Phenol red..........	comparator	−0.04	0.04	±0.07	−0.01
8	Phenol red..........	dilution	−0.06	0.06	−0.12	−0.02
6	Cresol red...........	comparator	−0.03	0.03	−0.07	−0.01
3	Cresol red...........	dilution	−0.06	0.06	−0.11	−0.02
3	α-Naphtol-phthalein	comparator	−0.06	0.06	−0.12	−0.02
5	Thymol blue........	comparator	−0.04	0.09	+0.14	−0.02
3	Thymol blue........	dilution	−0.01	0.03	−0.06	−0.01
3	Phenol-phthalein....	comparator	+0.03	0.07	+0.14	−0.01
3	o-Cresol-phthalein ..	comparator	+0.03	0.07	+0.14	−0.01

The confusing effect of turbidity has been found to be more serious in many instances than the coloration usually encountered. This has been especially noticeable when either brom-phenol blue or brom-cresol purple was used. These indicators are red in thick layers of their solutions but blue in thin layers (at the proper P_H). The impossibility of establishing with such indicators a good comparison between a turbid solution, which can not be effectively viewed in any great depth, and a clear comparison standard of the same P_H is quite evident. With

[9] HURWITZ, S. H., MEYER, K. F., and OSTENBERG, Z. Bull. Johns Hopkins Hospital, **27**: 16. 1916.

such meagre aid as a small hand spectroscope afforded we were able to trace the nature of this "dichromatism" and to devise a light source with which the effect may be avoided. This source is simply a bank of ordinary electric lights from which the shorter wave lengths are screened by a translucent paper coated with an acid solution of phenol-sulphone-phthalein. With this screen fairly good measurements could be made with brom-phenol blue and excellent measurements with brom-cresol purple.

To illustrate the accuracy attained we may quote two tables. Table 2 summarizes some measurements made upon ordinary beef infusion media, some samples of which were quite dark or else turbid from addition of the acid or alkali used to bring the P_H value within the range of the indicator used.

In table 2 "comparator" indicates that the determination was made by the compensation method of Walpole. "Dilution" indicates that the tested solution was diluted five times with distilled water before measurement. "Average" deviation is the average of the positive and negative deviations when the electrometric value was subtracted from the colorimetric value in each case. "Mean" deviation is the average of the deviations, neglecting sign.

Table 3, which gives a few determinations made on urines is self-explanatory.

In regard to each indicator the following points may be noted:

Thymol blue, which was previously described for use in alkaline solutions, exhibits very brilliant color changes at high acidities. Although we have made only a comparatively few determinations in the acid range, the indicator seems to be reliable and promises to be useful in a zone of P_H for which there has been no very satisfactory indicator. It is hoped that others will try it in studies of the gastric contents. It should be useful for vinegars and for cultures of yeast and moulds.

Brom-phenol blue has not proved reliable when used in turbid solutions without a properly screened light, but for many approximate measurements it is useful. One may show, for instance, that material such as silage which is fermented by organisms of the *bulgaricus* type has about the same P_H as pure cultures of *B. bulgaricus.*

Methyl red has given some irregular results, for instance in Dunham's solutions, where frequently errors of 0.2 P_H were found. In media such as those used in the differentiation test of Clark and Lubs[10] methyl red has been found to give excellent results.

[10] Clark, W. M. and Lubs, H. A. Journ. Infect. Diseases, **17**: 160. 1915.

Propyl red we have used chiefly to cover a zone between the ranges of methyl red and brom-thymol blue. This zone may now be studied with the aid of brom-cresol purple. The latter indicator is "dichromatic" like brom-phenol blue, but lends itself well to use in the screened light. It may be noted especially that this indicator is useful in that P_H zone within which the reactions of most urines fall.

TABLE 3

COLORIMETRIC AND ELECTROMETRIC DETERMINATIONS OF THE P_H OF URINES

INDICATOR	P_H COLORIMETRIC	P_H ELECTROMETRIC
Methyl red	5.5	5.54
	5.3	5.38
	5.5	5.55
	5.3	5.33
Propyl red	5.7	5.77
	5.6	5.62
	6.0	6.01
Brom-cresol purple	6.4	6.39
	5.9	5.88
	6.5	6.67
	6.1	6.01
	6.0	6.04
	6.4	6.36
	5.7	5.62
	5.7	5.77
	5.5	5.54
Brom-thymol blue	6.8	6.80
	6.5	6.67
	6.5	6.43
	6.4	6.38
Phenol red	6.8	6.80

With both thymol blue (alkaline range) and its dibrom derivative discrepancies between the colorimetric and electrometric determinations appear more like uncertainties in judgment than like consistent errors. In general, good agreement was found, but it is the unfavorable nature of the colors which we believe may lead to error.

Phenol red and cresol red are undoubtedly the most reliable indicators of the series.

In regard to phenol-phthalein we may say in the first place that neither it nor its homologue, ortho-cresol-phthalein, is as useful in the solutions we have studied as the two-colored indicator thymol blue. In our experience a two-colored indicator is generally to be preferred for hydrogen-ion determinations, especially when the solution itself is colored. On the other hand these phthaleins can be used at slightly higher P_H than thymol blue and consequently must be used in certain instances. Of the two we prefer the cresol compound, because of its greater brilliancy. Indeed we now use the cresol compound in place of phenol-phthalein in ordinary titrations.

Determinations with whey, banana juice, unfiltered extract of cow feces, thick green silage juice, overheated bouillons containing sugar decomposed to a dark brown solution, and vegetable extracts such as that of the potato which had oxidized till it appeared perfectly black in bulk are samples of the material we have handled with errors in P_H which seldom were as great as 0.3 P_H and generally much less.

A consideration of certain broad principles involved in bacteriological studies has led us to believe that in general the order of accuracy which may be attained with these indicators when using simple and rapid procedures is quite adequate for the testing of acid and alkali fermentations, for the study of the effect of P_H upon the stability or decomposition of culture media, for studying the effect of P_H upon the filterability of toxins, enzymes, etc., for determining the effect of P_H upon bacterial metabolism in general and enzyme activity in particular, and for controlling the reaction of solutions during the study of various processes. One of us[11] has already called attention to the inadequacy of the titrimetric method of adjusting the so-called degree of reaction of bacteriological culture media. For adjusting to various P_H values the indicators are quite adequate.

It may be mentioned that many of the criticisms which we have urged against the use of titration methods by the bacteriologist apply with equal force to many tests of the so-called titratable acidity of natural products or extracts thereof. To maintain that the analytical content of acid in some of these solutions can be determined by titration to a given tint of phenolphthalein is untrue. The differences which are determined and which often are of great practical value may frequently be observed with greater clarity by colorimetric P_H determinations. The indicators we have described should therefore be useful in a wide variety of instances.

[11] Clark, W. M. Journ. Infect. Diseases, 17: 109. 1915.

BOTANY.—*The early European history and the botanical name of the Tree of Heaven,* Ailanthus altissima. WALTER T. SWINGLE, Bureau of Plant Industry.

The story of the first introduction of the Tree of Heaven from China into Europe presents some features of interest which seem to have been overlooked by botanists and arboriculturists of recent times.

INTRODUCTION INTO EUROPE FROM CHINA

The seeds of the Tree of Heaven were first sent from China to the Royal Society of London in 1751 by Pierre d'Incarville, a French Jesuit missionary then residing at Peking. He sent the seeds under the impression that they were secured from the lacquer or varnish tree at Nanking. These seeds were turned over to Philip Miller at Chelsea Gardens and to Philip Carteret Webb at Busbridge near London.

About four years later, on March 18, 1755,[1] Philip Miller, writing to the Royal Society from Chelsea, notes that "the seeds, which were sent to the Royal Society some years ago, for those of the true varnish-tree, by the Jesuits at China, prove to be of this wild sort;" . . . . [Kaempfer's "Fási no ki. *Arbor vernicifera spuria, sylvestris, angustifolia*" =*Rhus succedanea* L.].

John Ellis, afterwards famous for his discovery of the Venus fly trap, *Dionaea muscipula*, sent to the Royal Society on November 8, 1756, an illustrated paper[2] on the lacquer or varnish tree in which he contends that the trees raised at Busbridge and Chelsea from seed sent by Pierre d'Incarville are not the spurious varnish tree of Kaempfer, but a new species of sumac of which he says: "As it has not been yet described, I shall call it . . . . 'Rhus sinense foliis alatis, foliolis oblongis acuminatis, ad basin subrotundis & dentatis.'"[3] He mentions that in Mr. Webb's greenhouse the foliage developed an odor so intensely disagree-

[1] Phil. Trans. Roy. Soc., **49**[1]: 163. 1756.

[2] Phil. Trans. Roy. Soc. **49**[2]: 870–871, pl. 25, fig. 5. 1757.

[3] The Latin term *alatis,* in English *winged,* was used by both Ellis and Miller to denote what we now call pinnate.

able that he frequently got headache and a sickness at the stomach by remaining too long near it. In the summer of 1755 he measured a leaf 3 feet in length and also notes that the tree "throws out a great number of suckers." The base and tip of a leaf are figured and the leaflets show near the base the prominent dentation characteristic of the Tree of Heaven and quite unlike the lacquer tree (*Rhus vernicifera* DC.) or the false lacquer tree (*Rhus succedanea* L.).

Philip Miller replied to Ellis, in a paper published in the Philosophical Transactions two years later,[4] attributing the discrepancies between the leaf characters of Kaempfer's spurious varnish tree, the "*Fási no ki*" of Japan, and the tree grown from the seeds sent from China by Pierre d'Incarville to the difference in situation of the leaves, those of Kaempfer's figure being supposed to be on fruiting branches, while those figured from the tree in Mr. Webb's garden were taken from lower branches. He goes on to cast doubt on the idea of the tree belonging to Rhus, as the seeds he planted "were shaped like a wedge, being thicker on one edge than the other, and not unlike those of the beech-tree."[5]

Ellis, in turn, replied to Miller's criticism in the same number of the *Philosophical Transactions* (pp. 441–456, pls. 17–18), defending his view that the American poison sumac, the Japanese true varnish tree, the Japanese false varnish tree, and the so-called Chinese varnish tree are all different species, and in par-

[4] Phil. Trans. Roy. Soc. 50[1]: 430–440. 1758.

[5] This would indicate that the seeds had been removed from the indehiscent winged fruit. Perhaps this unusual method of treating the seeds may have been to deceive d'Incarville, who supposed he was sending seeds of the lacquer or varnish tree from Nanking when in reality he was sending seeds of the Tree of Heaven, disguised by having been removed from the fruits. The herbarium of d'Incarville, now in the Muséum d'Histoire Naturelle at Paris, contains specimens of *Ailanthus glandulosa* Desf. collected at Peking, with a note: "Cet arbre resemble au Frêne, mais le fleur ny le fruit conviennent point au Frêne, son fruit resemble plus tost à l'Érable." (FRANCHET. *Les plantes du père d'Incarville dans l' herbier du Muséum d'histoire naturelle de Paris.* Bull. Soc. Bot. France, **29**: 7. 1882.)

As d'Incarville noted the similarity of these fruits to those of the maple he would doubtless not have been deceived by the *Ailanthus* seeds had they not been taken out of the fruit.

ticular insisting that d'Incarville's supposed China varnish tree was distinct from the Japanese false varnish tree. To substantiate his claim he figured side by side a leaf from d'Incarville's tree grown in Mr. Webb's garden and one of Kaempfer's false varnish tree from the Sherardian herbarium at Oxford. He also examined Kaempfer's specimens in the British Museum. It is but just to say that in this contention Ellis has been fully justified by later botanists.

In neither of his articles did Ellis adopt the Linnaean trivial names introduced in the *Species Plantarum*, published in 1753 (only two to four years before), and so did not publish a name for the Tree of Heaven valid under our present rules of nomenclature.

This appears to have been done for the first time in 1774 when Houttuyn in his *Natuurlyke Historie* reprinted Ellis's Latin diagnosis with the second word set off in parentheses and printed in italics, thus: "Rhus (*Sinense*) Foliis alatis, Foliolis oblongis acuminatis, ad basin subrotundis et dentatis." This is a method of publishing trivial names adopted by Linnaeus in editing the works of travel written by his pupils and also used a few years previously by Philip Miller in the 8th edition of his *Gardeners' Dictionary*, published in 1768. As Ellis had in the meantime adopted the Linnaean nomenclature,[6] it was perfectly proper for Houttuyn to make effective Ellis's vigorously expressed view that the Tree of Heaven constituted a new species of *Rhus* distinct from the Chinese lacquer or varnish tree and from the Japanese false varnish tree.[7]

Owing to the delay in the publication of Ellis's name it was, unfortunately, antedated by *Toxicodendron altissimum*, published by Philip Miller in the eighth edition of his *Gardeners' Dictionary*

[6] In 1768 he wrote an account of the famous Venus fly trap, naming it *Dionaea muscipula*.

[7] The fact that this tree was not listed as a separate species by Houttuyn, but was merely referred to incidentally in his account of *Rhus Vernix* L., does not invalidate this publication, since he refers in the same way on a preceding page to *Rhus succedanea* published by Linnaeus, whom he professes to follow. Furthermore, though he refers to Ellis's species under *Rhus Vernix* L., he could not have meant it as a synonym, since he says it seems to be more nearly related to *Rhus javanica* L., which he describes in another place.

(1768). Without a knowledge of Miller's previous papers it might easily be assumed that this name was applied to the false varnish tree of Kaempfer, which is cited as a synonym after a very short description. However, a closer study shows unmistakably that the name is based on the plant grown in England from the seeds sent by d'Incarville. The specific name *altissimum,* explained in the English paraphrase as the "tallest Poison-tree," is significant, since the wax tree of Japan (the spurious varnish tree of Kaempfer, *Rhus succedanea*) is not taller than the oriental lacquer tree, *Rhus vernicifera* DC., or the American poison sumac, *Rhus Vernix* L., which two latter species were held by Miller to be a single species, *Toxicodendron pinnatis.* The note in the body of the text referring to the new species is still more explicit. It reads as follows: "The tenth sort came from China. This grows to a large size, sending out many branches on every side, which are garnished with very long winged leaves, each leaf having fourteen or sixteen pairs of lobes, which stick close to the midrib; as this has not produced flowers in England, so we are at a loss where to place it, but it is hardy enough to live in the open air in winter. This propagates fast enough by the many suckers sent out from the roots."

There can be no longer any doubt that Miller is basing his new species on the plants grown by him in England. The tall growth, the very long leaves, the abundant suckering, all apply to the Tree of Heaven and not to the Japanese wax tree. Furthermore, his doubts as to the botanical position of the new species, which he puts as the last of the species of *Toxicodendron,* are doubtless based on his memory of the unusual shape of the seeds he planted in 1751 and would not be justified by anything to be found in Kaempfer's description or figures. We must, then, conclude that Miller's *Toxicodendron altissimum* was based on the Tree of Heaven grown in England from seeds sent from China by Pierre d'Incarville in 1751 and that the validity of his species is in no way impaired by his citing of Kaempfer's *Fási no Kj,* *Arbor vernicifera spuria,* etc., Amoen. Exot. 5: 794, as a synonym, but merely proof that he persisted in his mistaken notion that these two were the same species.

In September, 1782, Friedrich Ehrhart, in the course of a journey in Holland, visited the commercial nurseries of a Mr. Brakel in the outskirts of Utrecht just in front of the Kermis-Waterpoortje. Here he found many rare plants, among them, growing in the open, a tall tree looking something like *Juglans nigra* and having a trunk a foot thick. He named it *Rhus Cacodendron*,[8] basing his diagnosis on leaf characters alone, as he had no flowers or fruits. His article was dated Herrenhausen, 23 Nov., 1782.

In an article dated Herrenhausen, 4 Aug., 1783, published in 1788, Ehrhart reprinted his diagnosis of *Rhus Cacodendron*, which he calls the large-leaved sumac ("*Der grossblättrige Sumac*"),[9] adding that it is a native of North America and occurs in the Dutch gardens and also at Harbke.

In the *Mémoires de l'Académie Royale des Sciences* for 1786, published at Paris in 1788, René Louiche Desfontaines described the Tree of Heaven as *Ailanthus glandulosa*, new genus and new species. This excellent description, accompanied by a good copper plate drawn by L. Freret, is based on a fertile tree growing, presumably at Paris, in the garden of M. le Monnier, first physician-in-ordinary to the king.

In the following year, 1789, William Aiton in his *Hortus Kewensis* recognized *Rhus Cacodendron* as a synonym of *Ailanthus glandulosa* Desf., in spite of Ehrhart's error in assigning a North American origin to his species. Up to within a very few years Desfontaines' name has been almost universally applied to the Tree of Heaven, but recently (in 1912) Ehrhart's older name, *Rhus Cacodendron*, was taken up by Schinz and Thellung and transferred to the genus *Ailanthus*, as *A. Cacodendron*, on the supposition that this was the oldest valid name for this species. As has been shown above, this is not the case, there being at least two older trivial names applied to this species.

[8] EHRHART, FRIEDRICH. *Meine Reise nach der Graffshaft Bentheim, und von da nach Holland, nebst der Retour nach Herrenhausen.* Hannoverisches Magazin, **21**: 225–226 (No. 15, Feb. 21), 1783; reprinted in EHRHART, Beiträge zur Naturkunde, etc. **2**: 111. 1788.

[9] EHRHART, FRIEDRICH. *Bestimmung einiger Bäume und Sträuche aus unsern Lustgebüschen.* Beiträge zur Naturkunde, **3**: 20. 1788.

The oldest valid name applied to the Tree of Heaven was *Toxicodendron altissimum;* consequently its synonomy becomes as follows:[10]

Ailanthus altissima (Miller) Swingle, comb. nov.
Toxicodendron Altissimum Miller, Gard. Dict., ed. 8. 1768.
Rhus Sinense Ellis: Houttuyn, Natuur. Hist., II. **2**: 212. 1774.
Rhus Cacodendron Ehrhart, Hannov. Mag., **21**: 225–226, Feb., 1783; Beiträge, **2**: 111. 1788.
Ailanthus glandulosa Desf. Mém. Acad. Sci. Paris, **1786**: 265, pl. 8. 1788; L'Heritier, Stirp. Nov., 179–181, pl. 84. 1791.
Ailanthus procera Salisbury, Prodr. 171. 1796.
Pongelion glandulosum Pierre, Fl. Cochinchin., **4**: text pl. 294. 1893.
Ailanthus Cacodendron Schinz & Thellung, Mém. Soc. Sci. Nat. Cherbourg, **38**: 679. 1912.

In spite of the derivation of the generic name from the native name of a tree growing in Amboyna, *Ailanthus* is not based upon the Amboyna species described by Rumphius but on *A. glandulosa*, as Desfontaines says that the *Arbor coeli*[11] of Rumphius *seems* to belong to his genus, which of course makes it clear that he does not definitely include it.

ORIGIN OF THE NAME "TREE OF HEAVEN"

The common name of this tree also has a curious history. At first it was supposed to be the Chinese varnish tree, because seeds had been sent from China under that name by d'Incarville. When Desfontaines constituted a new genus for this Chinese species he named it *Ailanthus* from the native name *Aylanto* of a tree growing in Amboyna, as he thought the Amboyna tree

[10] There is no warrant for using the generic name *Pongelion* Adans., 1763, or *Pongelium* Scopoli, 1777, for this tree and its congeners, since no species were published under either name until 1893, when Pierre resuscitated *Pongelium* under the mistaken idea that it was established before *Ailanthus* of Desfontaines.

[11] "*Il* [*Ailanthus glandulosa*] est originaire de la Chine. & *l'arbor coeli* de Rumphius, *hort. amboin.* que les Indiens appelent *ailanthe,* dans leur langue, est une espèce qui nous paroît appartenir au genre que nous venons de décrire; c'est pourquoi nous avous conservé cette dénomination pour nom génerique." (DESFONTAINES. *Mémoire sur un nouveau genre d'arbre Ailanthus glandulosa. L'Ailanthe glanduleux.* Mém. Acad. Sci. Paris, **1786**: 271. 1788.

probably belonged to the same genus. Rumphius, in his *Herbarium Amboinense*, says:[12] "*Arbor coeli* is called in Malay *Caju langit*, in Amboyna, *Aylanto*, that is, heaven-tree,[13] as if they would accuse it of lacerating the heaven because of its height." Rumphius had previously said it was the tallest tree known to him in Amboyna.

Rumphius' species (*Ailanthus Pongelion* Gmel., figured in Herb. Amboin 3, pl. 132) was at first confounded with the Chinese tree and probably this led to the transfer of the Malayan name, "tree of heaven," to the Chinese species. Even without this confusion of the species, the name "tree of heaven" could easily be formed by a mere translation of the generic name.

Curiously enough, although the modern Chinese name around Peking is *Ch'ou Ch'un* 臭 椿 or stinking ch'un (in contrast to *Hsiang Ch'un* 香 椿 or fragrant ch'un, *Cedrela sinensis* Juss.), it is known to the Chinese poets of older times as *Shên shu* 神 樹 or God's tree. It is interesting to note that this old Chinese epithet is exactly translated in the German *Götterbaum*. Su Shih (or Su Tung-po), 1036–1101 A. D., a famous scholar of the Sung dynasty, wrote a stanza beginning, "Since ancient times it was called God's tree," and goes on to lament the departure of the spirit formerly supposed to dwell within this tree. (Imperial Encyclopedia, T'u shu chi ch'êng, Science, Vegetable Kingdom, Bk. 253). In the Book of History and in other ancient Chinese works this plant is called *Ch'u* 樗 , which name is still used in some parts of China at the present time.

THE TREE OF HEAVEN IN THE UNITED STATES

According to A. J. Downing, the Tree of Heaven was introduced directly from China into Rhode Island under the name

[12] **3**: 206. According to the Century Dictionary (1913 Edition, **1**: 121) the native name *aylanto* is apparently derived from *ai lanit*, a Moluccan form of the Malayan *kāyu langit*, tree of the sky.

[13] Possibly this ties up with the "heaven-tree," said by James H. Murray (New English Dict., **5**: 177) to be a "mythical tree, which figures in some Malay and Polynesian beliefs, as reaching from the under-world to the earth, or from earth to heaven."

tillou.[14] Sprouts from the roots of these original trees were used to propagate the species which was common in the nurseries of this country as early as 1841, when Downing published the first edition of his famous work on landscape gardening.[15]

Ailanthus altissima grows like a weed and is in fact a common weed in the towns and villages of the northern United States. Even in the outskirts of New York, Washington, and other large cities it is spreading rapidly over waste land by means of its abundant root sprouts. It is undeniably a handsome tree and grows most luxuriantly even in cities where smoke and dust harm most other trees; furthermore, its foliage is almost immune to attack by insects. The leaves fall suddenly in autumn after the first frosts, exposing the smooth-barked branches which are destitute of small lateral twigs.

Experts have prized the wood of the Tree of Heaven very highly both for fuel and for cabinet-making. They have ranked its wood with that of the white oak, black walnut, and birch for fuel, and considered it as having few superiors among woods in temperate regions as material for the cabinet-maker's use. Its heavy, strong, clear, light-yellow wood does not shrink or warp in drying and although coarse grained it takes a fine polish. It is said to produce wood, even on poor soil, more than twice as fast as any native tree having wood of anything like the same fuel value.[16]

The greatest drawback to this tree is the disagreeable odor of the male flowers, probably carried by the pollen, which is said also to cause irritation of the throat and eyes, to some persons at least. If only fertile trees are propagated, which is easily done by taking suckers from seed-bearing trees, this drawback is in large part overcome, for the fertile trees, although usually

[14] This name cannot at present be traced; it is perhaps a South Chinese name, as the China merchants of the eighteenth and early nineteenth centuries traded chiefly with Canton.

[15] Downing, A. J. *A treatise on the theory and practice of landscape gardening,* Ed. 1, p. 174. 1841.

[16] [Stiles, William Augustus]. *The Ailanthus,* [Editorial] in Garden and Forest, **11**: 385–386. 1888.

having fertile stamens, do not produce nearly so much pollen as the male trees.

Other drawbacks to this species as an ornamental tree are its habit of sprouting profusely from the roots and the fact that its leaves and twigs are malodorous if rubbed or bruised even slightly. Ailanthus trees, if cut off after they are once well established, send up astonishingly vigorous shoots that sometimes grow 12 to 15 feet high in a single season and bear leaves 4 or 5 feet long. Because of this they are sometimes used as a screen, being cut to the ground every year.

AILANTHUS A FOOD FOR WILD SILK WORMS

In China a silk worm, *Attacus cynthia* or *Philosamia cynthia*, eeds on the leaves of *Ailanthus* and produces a very durable kind of silk, similar to shantung or pongee. An account of the wild silk worms of China was published in 1777 by the French Jesuit missionary Martial Cibot.[17] He noted this tree under its Chinese name, *Ch'ou ch'un* (tcheou-tchun), as one of the three species on which the Chinese wild silk worm feeds. This Ailanthus silk worm has been introduced into Europe and America and has become naturalized in the eastern United States. It would be hard to find a plant capable of producing a larger bulk of leaves than the Tree of Heaven, and as these so-called wild silk worms feed out of doors and can endure cold and even wet weather, it would seem worth while to experiment in raising them in this country for silk production.

[17] CIBOT, PIERRE MARTIAL. *Sur les vers à soie sauvages.* Mém. concernant l'hist. les sciences etc. des Chinois, **2**: 575–598. Paris, 1777

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Sensitivity and magnetic shielding tests of a Thomson galvanometer for use in radiometry.* W. W. Coblentz. Bureau of Standards Scientific Paper No. 282 (Bull. Bur. Stds., **13**: 423–446). 1916.

The present paper gives the results of an investigation of the force exerted by various galvanometer coils when operated under standard conditions. Some of the coils were wound according to theoretical requirements, while others were wound empirically. Numerical data are given relating to coils having various resistances.

A simple coil is described, wound with a single size of wire (No. 28 B & S) which is as efficient as a compound coil wound upon the same mandrel but in three sections of graded wire.

A 9-ohm coil of graded wire is described which is very efficient and is well adapted for use with the bismuth-silver thermopiles previously described.

A comparison is made of various astatic magnet systems, and data are given showing the importance of using small mirrors, in order to increase the sensitivity.

Experiments in shielding the galvanometer from external magnetic disturbances are described. Various shields are described consisting of laminated cylinders made from transformer iron and solid cylindrical shells cut from wrought iron gas pipe. By embedding the galvanometer coils in blocks of Swedish iron which are surrounded by cylindrical shells of transformer iron and of wrought iron, the effect of external magnetic perturbations upon the astatic needle system is easily reduced to 1/2000 of its original value. This embedding of the coils also reduces the air space; the resultant elimination of convection currents greatly improves the steadiness of the needle system.

Experiments on a vacuum galvanometer, in which a sensitivity was attained which is more than 10-fold that used in the writer's previous work on stellar radiation, are described. W. W. C.

METROLOGY.—*Report of the tenth annual Conference on Weights and Measures, May 25–28, 1915.* BUREAU OF STANDARDS. Bur. Stds. Special Publication. Pp. 254. 1916.

The report is a record of the proceedings of the Conference, which is composed of State and local weights and measures officials and weights and measures manufacturers from various parts of the United States.

The report consists of the papers presented and of the general record of the conference proceedings. It includes short reports of about twenty-five State delegates on the progress made in the enforcement of local laws during the year and a report of the Bureau of Standards showing the progress made in the track scale tests for States, railroads, and industrial corporations; papers on the methods of testing track scales, on the construction of automatic scales, and on the meaning and effect of the standard barrel law recently enacted by Congress; a general discussion of legislation pending in Congress and of the proper limits for suggested legislation. The tolerances and specifications for commercial weighing and measuring apparatus and a model State law on weights and measures adopted by the conference are given in full in the appendix. L. A. F.

ELECTRO-CHEMISTRY.—*The volume effect in the silver voltameter.* E. B. ROSA and G. W. VINAL. Bureau of Standards Scientific Paper No. 283 (Bull. Bur. Stds. **13**: 447–457). 1916.

Some years ago the Bureau discovered that the silver deposits in large size voltameters were consistently heavier than the deposits in small voltameters which were used in series with them. The cause of this effect was attributed to impurities in the solution, but this explanation was not accepted by all the observers who have worked with the voltameter. Because the evidence rested principally on the results with the porous cup form of voltameter, Jaeger and von Steinwehr thought that the effect was due to the porous cup. Richards, on the contrary, thought that the greater surface of the large cathodes permitted greater inclusions and therefore the deposit appeared heavier. The recent experiments of Vinal and Bovard have shown that Richards' theory is not correct, but some further experiments were necessary to answer Jaeger and von Steinwehr's contention.

The authors have analyzed all of their former observations with reference to the volume of the electrolyte, the weight of the deposit, and the purity of the solution. They have also made some further experiments with especially impure solutions and with other forms of the voltameter than the porous cup form. All of these observations have been treated by statistical methods, and the authors show, first, that the volume effect is not confined to the porous cup form of voltameter, but that it is common to all forms of voltameter, and, sec nd, that it is caused by impurities in the electrolyte. The authors give a theory of the mechanism of the effect, and they believe that the evidence proves conclusively that the effect is a valuable criterion for the purity of the silver nitrate. G. W. V.

PALEONTOLOGY.—*Cambrian trilobites.* CHARLES D. WALCOTT. Smithsonian Misc. Coll., **64**: No. 3, 1916.

The purpose of this paper is to afford data to aid in clearing up some of the problems of formations of the Appalachian region by a careful comparison of portions of their contained faunas with those of the Mississippi Valley, the Cordilleras, and other localities. No thorough study and comparison of many genera of the Cambrian faunas has been made, though collections from many outcrops have been in the writer's possession for years, awaiting the opportunity to make these studies so necessary in his work on the Cambrian trilobites.

The paper is illustrated with fifteen plates, containing 280 figures of trilobites. Two new families are proposed, Menomonidae and Norwoodidae, and seven new genera: *Menomonia, Millardia, Dresbachia, Norwoodia, Saratogia, Vanuxemella,* and *Hanburia;* 46 new species and three new varieties are described and figured, with 19 earlier described species and several genera. One of the marked features of the paper is the description of a number of genera of the order Proparia: *Menomonia, Millardia, Dresbachia,* and *Norwoodia.* These, the writer says, taken in connection with the genus *Burlingia,* described in a previous paper [*Cambrian trilobites.* Smithsonian Misc. Coll., **53**: No. 2, p. 14. 1908.] establish the existence of a strong group of the order in Cambrian time.

The stratigraphic position of the Weeks formation is changed from Middle to Upper Cambrian, and the problem of whether the Conasauga formation of the Coosa Valley and adjoining areas shall be restricted to the Upper Cambrian, and the Middle Cambrian beds there given a formation name, is left for further detailed study.

The discussion and comparison of the *Crepicephalus* group of trilobites is particularly interesting, including a comparison of 17 different species, 10 of them new species, 3 new varieties, and two undetermined species. The five plates of illustrations of this large trilobite also present many new and interesting features of the animal, now so long extinct.

G. R. B.

GEOLOGY.—*The Caddo oil and gas field, Louisiana and Texas.* GEORGE C. MATSON. U. S. Geologicl Survey Bulletin 619. Pp. 62, with map, sections, and illustrations. 1916.

This bulletin contains a description of the physiography, geology of the Cretaceous, Tertiary, and Quaternary systems, and the structure of the rocks in the Caddo oil and gas field. It also discusses relations of oil and gas and the possible extensions of the Caddo oil field.

R. W. S.

GEOLOGY.—*Ground water in San Joaquin Valley, California.* W. C. MENDENHALL, R. B. DOLE, and HERMAN STABLER. U. S. Geological Survey Water-Supply Paper No. 398. Pp. 310, 5 plates and 4 figures. 1916.

This report outlines the geography and geology of the valley, the character of the soils, and the availability of the surface waters, and describes in detail the occurrence, utilization, and quality of the ground waters, especially in reference to their availability for irrigation, boiler supply, and domestic use. The great value of the agricultural products and the lack of sufficient surface water in this valley have brought about unusual development of ground water resources. Nearly every phase of practical irrigation is illustrated, including flood, deep-ditch, and subterranean irrigation, the utilization of deep waters, the use of steam and gas engines and electric motors for power, the disastrous rise of alkali, the effect of alkali on growing plants, and the application of strongly mineralized waters. Ground water of good quality can be pumped at moderate expense throughout the east side of the valley, but the level of the ground water on the west side is much deeper and the mineral content of the water is much greater; yet neither its cost nor its quality will prevent its ultimate use in many parts of the west side. The axis of the valley includes a long narrow area yielding flowing water that ranges widely in chemical character at different depths and in different places. The report as a whole exemplifies geologic, engineering, and chemical methods for reconnaissance of ground water resources in large areas. It includes records of more than 8,500 wells, 500 assays and analyses, and 55 tests of pumping plants. R. B. D.

GEOLOGY.—*Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914.* B. L. JOHNSON. U. S. Geological Survey Professional Paper 98–C. Pp. 5, with illustrations. 1916.

This short paper gives the linear retreat of the Barry glacier for a number of years and 6 photographs taken in different years and from different points of view illustrating the face of the glacier during different stages of retreat. R. W. S.

GEOLOGY.—*Ground water in the Hartford, Stamford, Salisbury, Willimantic, and Saybrook areas, Connecticut.* HERBERT E. GREGORY and ARTHUR J. ELLIS. U. S. Geological Survey Water-Supply Paper No. 374. Pp. 146, with maps, sections, and views. 1916.

The areas covered by this report represent the typical geologic conditions of Connecticut. The Hartford area, in the Connecticut River Valley, is underlain by Triassic sediments and lavas; the Stamford area, in the southwest corner of the State, is underlain by crystalline rocks; the Salisbury area, in the northwest corner of the State, has its lowlands underlain by Cambrian or Ordovician limestone; the Willimantic area, in the eastern highlands, is underlain by metamorphic rocks of various types on which a highly varied topography has been developed; the Saybrook area, at the mouth of Connecticut River, is low and comparatively flat and the presence of salt water is a feature of ground water problems.

The chief water-bearing formation in all of these areas is the glacial drift overlying the bedrocks. It includes unstratified drift, or till, and stratified drift, or glacial outwash. The latter occurs principally as valley fill and in the Connecticut Valley attains a thickness of more than a hundred feet. Unstratified drift is the principal source of private domestic water supplies, which are generally obtained from wells less than 30 feet deep. Municipal supplies could be developed from the stratified drift in the Connecticut Valley by sinking gangs of driven wells similar to those successfully used at Brookline, Mass., Brooklyn, N. Y., and Plainfield, N. J., which are described in the report.

The bedrocks are practically impervious, but they are intensely fractured, and contain numerous water-bearing joints. Wells drilled to depths of 200 or 300 feet rarely fail to intercept a sufficient number of these joints to furnish supplies of water adequate for domestic use.

A. J. E.

GEOLOGY.—*Experiments on the extraction of potash from Wyomingite.* R. C. Wells. U. S. Geological Survey Professional Paper 98-D. Pp. 4. 1916.

This paper describes investigations made in the chemical laboratory of the U. S. Geological Survey to determine the possibility of extracting potash from Wyomingite and lava occurring extensively in the Leucite Hills, Sweetwater County, Wyoming. While all the experiments described can not be considered as suggestions of commercial possibilities, a record of them may save much repetition of preliminary investigation on the part of private investigators. R. W. S.

GEOLOGY.—*Geology and coal resources of Castle Valley, in Carbon, Emery, and Sevier Counties, Utah.* Charles T. Lupton. U. S. Geological Survey Bulletin No. 628. Pp. 86, with 12 plates and 1 figure. 1916.

This report describes the geology and coal resources of Castle Valley, a belt of country 10 to 20 miles wide and 80 miles long lying between San Rafael Swell and Wasatch Plateau in central Utah. It includes also general descriptions and sections of those formations outcropping from the interior of the Swell to the top of the Plateau, a stratigraphic distance of more than 11,000 feet. The rocks exposed range from Carboniferous to Quaternary in age.

The Ferron sandstone member of the Mancos shale, which varies greatly in thickness and character, is described and indicated on the maps. At the northeast end of the field it is about 75 feet thick and consists mainly of shaly sandstone containing concretions. It thickens gradually, reaching a maximum of about 800 feet of sandstone, shale, and coal beds near the southwest end of the area described. This sandstone, in the northern part of Castle Valley, is believed to represent the feather edge of a series of coal-bearing rocks in the lower part of the Colorado group recognized in northern Arizona, southwestern, west-central, and northern Utah, and southwestern Wyoming.

A large part of the report consists of a description of the coal, which is bituminous and occurs principally in the above mentioned sandstone. A little coal is present in the Dakota sandstone but is not economically important. A large amount of coal is contained in the Mesaverde formation in Wasatch Plateau, but it was not extensively studied. C. T. L.

GEOLOGY.—*The physical conditions and age indicated by the flora of the Alum Bluff formation.* E. W. Berry. U. S. Geological Survey Professional Paper 98-E. Pp. 18, with illustrations. 1916.

This paper describes a small flora from the Alum Bluff formation in Liberty County, Florida. This flora represents a horizon hitherto unrepresented paleobotanically in southeastern North America. It is concluded that the Alum Bluff formation as a whole is a predominantly shallow water deposit of clays and sands, and that the flora preserved at Alum Bluff records the last phase of sedimentation before the area emerged from the sea. The most profound break in Tertiary sedimentation in the southeastern United States is represented by the unconformity at the top of the Alum Bluff formation. R. W. S.

GEOLOGY.—*The Chisana-White River district, Alaska.* Stephen R. Capps. U. S. Geological Survey Bull. 630. Pp. 126, with maps, sections, and views. 1916.

The Chisana-White River district comprises that portion of the White River basin which lies west of the international boundary and the headward portion of the Chisana River basin east of that river and south of the north front of the Nutzotin Mountains. The oldest rocks of the district are basic lavas and pyroclastics with a considerable amount of black shale of Devonian age. The next succeeding system, the Carboniferous, comprises a great thickness of interbedded lavas, tuffs, agglomerates, and breccias, containing very little sedimentary material. Upon these lies a bed of massive limestone, associated with thin-bedded limestones and shales. Above the limestones and shales is a great thickness of lavas and pyroclastic rocks similar to those mentioned, again interrupted by other massive limestones. These in turn are succeeded by other bedded basic lava flows, which form the highest part of the Carboniferous system recognized in this district.

The rocks next younger are massive limestones carrying Triassic fossils. In the Nutzotin Mountains there are banded slates and graywackes, scantily fossiliferous, which may be in part Triassic.

Shales and graywackes of Jurassic age have been recognized in the region, but their upper and lower limits were not determined. Shales and graywackes, carrying Lower Cretaceous fossils, lie immediately above the Jurassic beds, without any observed stratigraphic break.

Tertiary sediments are represented by small, detached areas of shale, sandstone, conglomerate, and tuff, with minor amounts of lignite. Certain old but unconsolidated gravels are also probably of Tertiary age. The extrusion of widespread lava flows was also begun in Tertiary time and has continued intermittently ever since, so that it is difficult to separate the Tertiary from the Quaternary lavas.

Quaternary deposits are present in considerable variety and abundance. The oldest consist of glacial till and outwash gravels interbedded with lava flows, representing a stage of glaciation much earlier than the last notable ice advance. These older glacial deposits are overlain by extensive lava flows. During their last great advance the glaciers left deposits of morainal material scattered throughout the district. Large deposits of outwash gravels were laid down during the retreat of the ice and are still accumulating in the valleys of the glacier-fed streams. Accumulations of talus, peat, and muck, with some volcanic ash, and the products of normal stream deposition make up the postglacial materials in the areas not now receiving glacial and glacio-fluvial deposits. A. H. B.

TECHNOLOGY.—*The properties of some European plastic fire clays.* A. V. Bleininger and H. G. Schurecht. Bureau of Standards Technologic Paper No. 79. Pp. 34. 1916.

The properties of five well known European plastic fire clays, largely used for glass pots, graphite crucibles, etc., have been studied for the purpose of securing data, making possible a comparison with similar American clays. Such properties as the content of shrinkage and pore water, drying shrinkage, fineness of grain, rate of drying, mechanical strength in the dry state, rate of vitrification, final softening temperature, and the chemical composition were determined.

From the results obtained it was shown that these famous European clays do not differ radically from similar materials found in this country but that the same, or possibly superior, results can be obtained with mixtures of known American clays. A. V. B.

TECHNOLOGY.—*Further data on the oxidation of automobile cylinder oils.* C. E. Waters. Bureau of Standards Technologic Paper No. 73. Pp. 20. 1916.

In continuation of work already published by the Bureau of Standards, as well as in the Journal of Industrial and Engineering Chemistry, a study was made of the rate of oxidation of three automobile cylinder oils when exposed to sunlight and air. This was done by determining the increase in weight and in acidity at intervals during a period of 438 hours exposure. The accompanying changes in the carbonization values were also determined. The general result was that there is a gradual lessening of the rate at which the weight increases, and at the same time the formation of acid and the carbonization value increase more and more rapidly.

The Maumené numbers of the oils increased greatly as a result of oxidation, while there was a marked drop in the iodine numbers. After oxidation the oils showed a much greater tendency than before to emulsify when agitated with water. Filtration through animal charcoal removed, to a certain extent, the substances that caused this tendency and that raised the carbonization values.

When the three oils used in the work above, and eight others, were heated to 250°C. for periods ranging from one to seven hours, the formation of carbonized matter proceeded at a rapidly increasing rate. The same was true of the eleven oils when heated for three hours at various temperatures from 230° to 280°C. It was found that in both cases, the greater the carbonization value at first, the more rapidly did it increase as the temperature was raised or the time of heating extended. In other words, an oil which had a low carbonization value if heated to 250° for two or three hours, and an oil showing a somewhat higher value under the same conditions, will be farther and farther apart as the conditions become more strenuous. This being so, it is unnecessary to prolong greatly the time of heating in routine testing.

The need of extreme care in taking and preserving samples, as well as in testing them, was emphasized, because the presence of rust particles or other extraneous matter increases the amount of carbonization.

In conclusion it is shown that the carbonization value is independent of the flash and fire points and of the evaporation loss on heating.

C. E. W.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 112th meeting of the Washington Academy of Sciences was held in the Auditorium of the New National Museum, Thursday evening, May 11, 1916, with President L. O. Howard in the chair and a large audience present.

Dr. Erwin F. Smith, Chief of the Laboratory of Plant Pathology, Bureau of Plant Industry, delivered an illustrated lecture on *Resemblances between crown gall in plants and human cancer.* The speaker reviewed the objections that have been raised to the theory that cancer is of bacterial origin, and showed that such objections do not rest upon a sound experimental basis. He then developed the striking parallelism which exists between human cancer and crown-gall in plants, the latter being of unquestioned bacterial origin and readily developed by inoculation with pure cultures.

The address has been published in *Science* (New Series, **43**: 871–889. June 23, 1916) under the title, *Further evidence that crown gall of plants is cancer.*

W. J. Humphreys, *Recording Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 309th meeting of the Society was held in the lecture room of the Cosmos Club on April 26, 1916.

REGULAR PROGRAM

K. F. Kellerman: *Bacteria as agents in the precipitation of calcium carbonate.* Precipitation of calcium carbonate from solutions of calcium sulphate, calcium acetate, and artificial sea water by bacteria. Formation of spherulites. (Illustrated.) No abstract.

John Johnston: *Some factors which influence the deposition of calcium carbonate.* By means of the solubility-product constant of calcite we are enabled to calculate its solubility under various conditions; whence it appears that this solubility is affected materially by variations of the temperature and of concentration of free CO_2 in the water which may well occur in nature. For example, a change in the proportion of CO_2 in the air from 3.2 to 3.0 parts per 10000, or a rise of temperature of 2°C., would result ultimately in the precipitation of about 2 grams $CaCO_3$ from each cubic metre of a solution saturated with it. Consequently, since the warmer portions of the ocean are substantially saturated with calcite, precipitation must take place, independent of any other agencies, wherever the water is being warmed, or is losing free CO_2, or both. This view that this mode of precipitation, brought about by the operation of purely inorganic factors, actually takes place on a large scale, does not exclude the other views which have been proposed to account for the deposition of limestones, and is not in conflict with any facts which are definitely ascertained. It could be established or disproved by systematic bathymetrical and chemical investigation of the ocean, an investigation which would have an important bearing on many biological as well as geological processes.

H. E. Merwin: *The forms of calcium carbonate and their occurrence.* A new form of calcium carbonate which is hexagonal, optically positive, and less stable than aragonite, was described. It forms readily in solution at about 60°. Criteria for distinguishing the three established forms of calcium carbonate were discussed, and the necessity for distinguishing the properties of aggregates from those of definitely bounded crystal fragments was emphasized in connection with evidence which was given to show that "vaterite" is really porous calcite and that "ktypeite" is porous aragonite. The precipitation of aragonite is favored by the presence of sulphate, but magnesium has little influence. Sulphate is taken into solid solution in aragonite in sufficient quantity to make it more stable probably than calcite. Aragonite containing sulphate was separated from muds of the shoal waters of the Bahamas. Four types of original structure of oölites were described and illustrated.

Discussion led by T. Wayland Vaughan, Chas. D. Walcott, G. R. Mansfield.

The 310th meeting was held in the lecture room of the Cosmos Club on May 10, 1916.

INFORMAL COMMUNICATIONS

Fred. E. Wright described a more delicate method than those usually employed for determining isotropic and anisotropic character in opaque minerals.

REGULAR PROGRAM

Henry S. Washington: *The persistence of the volcanic vents at Stromboli.* When Stromboli was visited in August, 1914, it was in a state of moderate activity, there being five vents on the crater terrace. The most active of these, that at the east end of the upper edge of the Sciarra, is called "l'antico," and Bergeat pointed out in 1899 that this vent had probably occupied the same location for over a hundred years. Search through the literature yielded evidence, especially in the form of sketches and plans of the crater terrace, favoring Bergeat's view, and going to show that not only this vent, but also another on the west, scarcely less active in 1914, have not materially altered their positions for a period of at least about a century and a half. It may be mentioned that the crater of Stromboli is an exceptionally favorable one for the study of such a feature, as it is bounded on two sides by prominent ridges, one or both of which appear in all views and plans, that form permanent landmarks by which the relative positions of the several vents at different dates can be readily established. A series of about 15 of these views and plans, dating back to 1768, was shown.

This feature of Stromboli, and possibly of other volcanoes, as it seems to be presented at Kilauea and elsewhere, does not appear to have been generally recognized. It would, however, seem to have an important bearing on certain volcanological problems, such as, among others, the size of the lava reservoir immediately beneath the crater floor. Such a persistence of location of volcanic vents apparently favors Daly's view that the size of volcanic conduits is small, rather than Dana's, that they are nearly commensurate in size with the whole crater floor. The formation of these relatively small vents may possibly be explained by Daly's "gas-fluxing" hypothesis.

F. C. Schrader: *Ore deposits of the Rochester district, Nevada.* The deposits consist of silver and gold-bearing veins, lodes, and associated replacement bodies. They occur in volcanic rocks which are chiefly rhyolites of Triassic age. The rocks, nearly 2,000 feet in thickness, dip gently to the east. The veins dip steeply to the west. In some of them good ore bodies are opened to the depth of a thousand feet.

The deposits lie in two north-south belts, Henzel Hill belt on the east and Lincoln Hill belt on the west, which are about two miles apart, each a mile wide and five miles long. In the Henzel Hill belt they are chiefly silver-bearing, in the Lincoln Hill belt gold-bearing.

Henzel Hill belt near its middle point contains Henzel Hill, an oval silicified knob 3000 feet long, the seat of the most important deposits. Here the deposits occur in and associated with fissures, joint planes, and shear zones. Some of them are 40 feet in width. The ores which average about $20 to the ton contain chiefly silver but carry also several dollars to the ton in gold, which increases in amount with depth.

The ore minerals are chiefly argentite and sulphantimonites with a little associated proustite, cerargyrite, bromyrite, pyrargyrite, scales of native silver, and specks of free gold. From the 200-foot level down the ore minerals are mostly sulphides.

At Packard, 2 miles south of Henzel Hill, the deposits occur as massive replacement ore beds, nearly 100 feet in maximum width, in soft schistose rhyolite. They contain but little quartz. The ore minerals are chiefly cerargyrite and argentite. Most of the ore produced up to 1916 averaged in silver about $50 to the ton.

In the Lincoln Hill belt the deposits are more distinctly narrow veins of the filled fissure type. The gangue is quartz which contains almost exclusively free gold ores, averaging about $140 to the ton, with some that are very rich. The associated minerals are pyrite, arsenopyrite, tourmaline, specularite, argentite, bromyrite, and a gold telluride. Some of the gold is coarse, which fact suggests that these veins probably represent an important source of the rich placers mined in neighboring Spring Valley and American Canyon.

From the presence of minerals of deep-seated origin, the replacement character of the deposits, and hydrothermal alteration of the rocks, the Rochester deposits seem to have been formed at relatively high temperatures and at considerable depth. Their origin is referred to magmatic solutions and gases emanating from post-Jurassic granite, which as a batholithic mass intrudes the rocks on the north and is believed to extend beneath the district. The deposits therefore are probably of early Cretaceous age.

From the deep-seated character of the deposits and their close association with the major geologic structures which are very persistent, it is believed that some of the deposits may extend to considerable depth.

W. C. Alden: *The Iowan stage of glaciation—a review of the evidence based upon field studies in 1914 and 1915, by the United States and Iowa Geological Surveys.* For résumé of the facts presented in this paper see Bull. Geol. Soc. Amer., **27**: 117–119. 1916.

Carroll H. Wegemann, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 557th regular meeting was held at the Cosmos Club on May 20, 1916; called to order by President Hay at 8 p.m.; 30 persons present.

On recommendation of the Council, James L. Peters was elected to active membership.

The President announced that the Council of the Society had voted to adopt the custom of the medical and of many other scientific societies of allowing members to speak but once during the discussion of a paper and of asking the original speaker to answer all questions at the end of the discussion and to close the same.

Under the heading of *Brief notes and exhibition of specimens*, Dr. Howard E. Ames referred again to the dorsally placed mammae of the coypu (*Myocastor coypu*) and exhibited photographs of a female coypu in the collection of the Philadelphia Zoological Society showing the mammae so placed.

The first paper of the *Regular program* was by A. T. Speare: *Some fungi that kill insects.* Mr. Speare spoke briefly of certain experiments that were conducted in Europe about 1885, in which the "green muscardine" fungus was used in a practical way to combat the cockchafer of wheat. Reference was also made to similar work that has recently been conducted in Florida, and Trinidad, B. W. I. The writer spoke also of the present status of the chinch bug disease and of the brown tailed moth disease. In regard to the latter he spoke in detail of the methods employed in spreading this disease in the field. At the end of the paper he exhibited slides illustrating various types of entomogenous fungi, some of which were collected by him in the Hawaiian Islands. Mr. Speare's communication was discussed by General T. E. WILCOX and by Dr. L. O. HOWARD.

The second paper was by L. O. HOWARD: *The possible use of Lachnosterna larvae as a food supply.* Dr. Howard briefly referred to the prejudice against insects as food and gave an account of his experiments recently undertaken with white grubs sent in from Wisconsin. They were sterilized, thoroughly washed, the contents of the alimentary canal removed, and were then served as a salad and in a broth. They were eaten by several members of the Bureau of Entomology and by Mr. VERNON BAILEY of the Biological Survey and were pronounced distinctly edible. The speaker urged further experimentation with numerous species of insects as to their food value. Dr. Howard's communication was discussed by the Chair, Mr. W. E. SAFFORD, General WILCOX and Medical Inspector AMES.

The last paper was by W. E. SAFFORD: *Agriculture in pre-Columbian America.* Mr. SAFFORD described various plants used by the early inhabitants of America, particularly those of Mexico and of Central and South America, and the manner of their use and preparation, and called attention to those employed at the present day and adopted by civilized man. The prominent part which these plants played in the life of the pre-Columbian inhabitants is shown in ceremonial objects, earthenware products, etc., ornamented by designs based on these plants and in some cases by molds of parts of plants. Mr. Safford's communication was illustrated by numerous lantern slide views of the plants under consideration and of many objects bearing plant designs. It was discussed by the Chair, General WILCOX and by Prof. E. O. WOOTON.

M. W. LYON, JR., *Recording Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

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MATHEMATICS.—*A precision projection plot.* F. E. Wright, Geophysical Laboratory.

For the solution of spherical triangles and of certain crystallographic-optical problems graphical methods are often used. These problems involve the angular relations between directions in space and are best presented and solved by means either of a sphere or of some projection of the sphere such as the stereographic projection. The first stereographic projection plot or net of which the writer has found record was published in 1854 as "The Great Circle Protractor" by Prof. W. Chauvenet[1] of the U. S. Naval Academy in Annapolis, Md., and was intended for use by navigators in great circle sailing and in the solution of spherical triangles. This chart consists of an equatorial stereographic projection net, 15 inches in diameter and with parallels and meridians 1° apart. A second and similar plot printed on transparent material was placed above the first net on a pivot and could be rotated about the common center. The maze of lines hereby introduced rendered, however, the application of the projection difficult and the method was not used to any great extent; it was found that tracing paper served

[1] First described in May, 1854, at the Washington meeting of the American Association for the Advancement of Science. It was adopted the same year by the U. S. Navy Department and the U. S. Naval Academy; was reissued in 1867 by the U. S. Hydrographic Office. Described also in *Great Circle Sailing*, by G. W. Littlehales. U. S. Hydrographic Office, No. 90, 1889; see also S. L. Penfield, Am. J. Sci. (4), **13**: 250. 1902.

the purpose better, as the observer could draw on it only those lines which he needed in his triangles.

In 1885 Commander C. D. Sigsbee[2] published a paper on Graphical Methods for Navigators in which was included an exceedingly exact stereographic projection net 18 inches in diameter. The great and small circles are drawn at 1° intervals on this net, which is the most accurate in existence. This net was issued as a separate sheet in 1888 by the U. S. Hydrographic Office.[3] Solutions with it were made commonly on a sheet of tracing paper placed above the net and rotated about the center point. Experience has shown that projection nets printed on paper suffer distortion as a result of the unequal contraction of the paper on drying. To obviate this difficulty, which may become

Fig. 1. Precision projection plot and stand.

[2] Proc. U. S. Naval Institute, **11**: 241–263. 1885.

[3] *Graphical Solution of Spherical Triangles.* By Commander C. D. Sigsbee, U.S.N. Published December, 1888. U. S. Hydrographic Office. Plate 513. Price 40 cents. Republished in 1896 in Sigsbee's *Graphical Methods for Navigators.* U. S. Hydrographic Office.

serious when accurate measurements are to be made, R. A. Harris[4] suggested that a polar stereographic net be drawn over the Sigsbee equatorial net, so that all rotations can be accomplished directly in the projection itself and the errors due to distortion after printing be thus eliminated.

Stereographic projection nets were made use of by Fedorow[5] and Michel Lévy[6] for the representation of the optical data of the plagioclase feldspars. In 1901 Penfield[7] published an extended account of the stereographic projection and described several protractors to facilitate its practical application. In 1902 G. Wulff[8] published a stereographic net and claimed to introduce new and improved methods of using the stereographic projection; his method is commonly referred to in the literature as Wulff's method. It is of interest to note, however, that both Chauvenet and Sigsbee had published stereographic projection nets many years before Wulff and that their nets were of greatly superior precision. In view of the fact that the new method described by Wulff is identical with that which Sigsbee described many years before, it is incorrect to name the method after Wulff; if the method is to be called after its first originators it should be named the Chauvenet-Sigsbee method.

In 1906 G. W. Littlehales[9] published an atlas of many plates of a carefully drawn stereographic projection net 12 feet in diameter. By use of this net spherical triangles can be solved with an error of only 2′ in favorable cases.

Improvements in the method of mounting and rotating the projection paper were suggested by Wülfing,[10] Johannsen,[11] Wright,[12] and Noll.[13]

[4] G. W. Littlehales. *Great circle sailing.* 2d edition. U. S. Hydrographic Office, No. 90: 41–45. 1899.

[5] Zeitschr. Krist., **21**: 574–714. 1893: **22**: 229–268. 1894; **26**: 225. 1896; **27**: 337. 1897; **29**: 604. 1898.

[6] *La Determination des Feldspaths. I,* Paris, 1894; *II,* Paris, 1896.

[7] Am. J. Sci. (4), **11**: 1–24, 115–144. 1901; **13**: 245–275, 347–376. 1902; **14**: 241–284. 1902.

[8] Zeitschrift f. Kristallographie, **36**: 14. 1902.

[9] *Altitude, azimuth, and geographic position.* Philadelphia, 1906.

[10] Centralblatt für Mineralogie, 1911.

[11] Journ. Geology, **19**: 752. 1911.

[12] Carnegie Institution of Washington Publication **157**: 166. 1911.

[13] Centralblatt für Mineralogie, 380, 1912.

The device described below is similar in principle to that adopted by Wülfing, Johannsen, and Noll; but its design and construction are different; it is built with special reference to precision and convenience. A metal stand (fig. 1) supports an electric lamp at *C* which illuminates a disk of frosted plate glass; this plate in turn supports an equatorial projection net, stereographic or angle (globular), printed on thick, transparent celluloid. The two nets are 40 cm. in diameter and were reduced photolithographically by the precision methods of the U. S. Geological Survey,[14] the first from a carefully taken print of the Sigsbee projection net,[15] the second from an accurate drawing 50 cm. in diameter of an angle (globular) projection net. On both these nets, either one of which may be used, the curves are at 1° intervals and are sufficiently separated (nearly 2.5 mm. on an average) that 0.1° can be read off without difficulty. The celluloid disk rests on the glass disk and by means of centering screws can be centered to the axis of rotation of the outer steel ring which runs in an accurately turned bearing and carries the tracing paper on which the measurements are plotted in the positions indicated by the underlying projection net.

Experience extending over several years with this apparatus has shown that it meets the exacting requirements of accurate work well and is, moreover, convenient to use. The tracing paper is held in place by means of the hinged iron bars which pass over the outside square ends of the rotating ring and clamp the paper securely.

Experience has also shown that the distortion of the stereographic projection has in certain instances an appreciable effect on the attainable accuracy, and that for most purposes of calculation and of projection of optical data the angle (globular) projection net is preferable.

[14] The writer is indebted to Dr. Geo. Otis Smith, Director of the U. S. Geological Survey for having had these reproductions made.

[15] Furnished to the writer through the courtesy of Geo. W. Littlehales of the U. S. Hydrographic Office.

PHYSICS.—*The theory of the torsion and the rolling ball viscosimeters, and their use in measuring the effect of pressure on viscosity.*[1] M. D. HERSEY, Bureau of Standards. (Communicated by S. W. Stratton.)

Theory of the torsion viscosimeter. By dimensional reasoning, the torque exerted on the suspended inner cylinder, by the uniformly rotating outer cylinder of liquid, is found to be

$$T = \mu n r^3 f\left(\frac{rn^2}{g}, \frac{r^2 n}{\nu}, \text{shape}\right) \tag{1}$$

in which μ denotes viscosity, n revolutions in unit time, r radius of inner cylinder, g gravity, and ν kinematic viscosity μ/ρ, where ρ is the density. The unknown function f may be determined empirically by varying the arguments shown, and this may be done without altering r. Three interesting cases are, first, that in which turbulence and the drag on the bottom are negligible, while the inner cylinder projects above the free surface. In this case we may calculate, approximately, the proportions for which the concavity in the free surface, due to centrifugal force, will serve to secure compensation against speed fluctuations, thus dispensing with the use of either a speed governor or a stop watch. It turns out that a large sample of the liquid will be required. The second special case is that in which the torque is not independent of the density of the sample, owing to spiral flow across the bottom or to turbulent end effects, but in which the free surface is level, so that the argument containing g in (1) drops out. In this case the instrument is self-calibrating; by observing with a single liquid what function of speed the deflection is, we can at once infer what function it is of the viscosity. Finally, a third case is that of a completely immersed cylinder, so slender that the end effects are small, and running so slowly that the final deflection is independent of the density. For this case we may integrate the equations, and

[1] This work was done at the Jefferson Physical Laboratory, Harvard University. It will later be published in detail, as a part of a more general paper on lubrication.

design the instrument so that it shall have any desired characteristics; referring to experiment only after the instrument has been set up ready for use, and then only to get a more accurate value of the single calibration constant which is required, namely τ_0, the deflection at unit speed in water.

The constants of performance of such an instrument, besides τ_0, are: the free period t; the stress in the suspension at unit deflection; the lag, or time required to attain a stated fraction of the final deflection; and the viscosity for critical damping. Of these τ_0 and t are the most important, and are given by

$$\tau_0 = 256\,\pi \frac{\mu_0}{\eta} \frac{lHr^2}{d^4} \frac{R^2}{R^2 - 1} \tag{2}$$

and

$$t = \frac{8\sqrt{2\pi}}{d^2} \sqrt{\frac{Il}{\eta}} \tag{3}$$

in which μ_0 is the viscosity of the standardizing liquid, η the shear modulus of the suspension (assumed circular; for a ribbon the coefficient 256π would give way to some larger number); l the length and d the diameter of the suspension, H the height of the inner cylinder, R the ratio of outer to inner radii, and I the moment of inertia of the suspended system. Note from (2) the insensitiveness of the instrument to changes in outer radius when the clearance is large. It is desirable that τ_0 be large, and imperative that t be small.

Construction and use. A simple form of this instrument, roughly constructed for immediate use, had the calculated values $\tau_0 = 0.32$ radian /r. p. s. in water at 20°C., and $t = 6$ sec.; and the observed values $\tau_0 = 0.38$ and $t = 5$. Deflections were read off by a pointer and graduated circle, and, subject to deviations of several per cent, were found proportional to the speed, and therefore to the viscosity. An ordinary test tube forms the outer cylinder. In changing samples, one test tube is bodily removed, and the next inserted. Thus 30 cc. is a sufficiently large sample, and the container need not be cleaned. This use of the test tube, together with the fact that the shape of the parts permits its performance to be predicted mathematically, are the advantages of this modification over those recently used by McMichael, and by Hayes and Lewis.

The torsion viscosimeter was used to determine the viscosities of a series of liquids, ranging from water to castor oil, subsequently needed in calibrating the rolling ball viscosimeter.

Theory of the rolling ball viscosimeter. The time required for a ball to roll down a slanted tube, filled with the liquid, has been proposed and used by Flowers, who resorts to a fine bore to make roll time proportional to viscosity. In adapting this type of viscosimeter to observations under pressure, the writer has avoided the difficulties of technique accompanying small tubes, by using a large tube, for which the roll time is not proportional to the viscosity, and then determining its characteristics by dimensional reasoning.

Assuming no surface friction, some relation must subsist between the roll time t, the kinematic viscosity ν, density ρ, ball density ρ_0, gravity g, tube diameter D, ball diameter d, tube length l, angle with horizontal α, and roughness r. If so, the relation can be completely mapped out, for any one series of geometrically similar arrangements, by varying experimentally the three arguments $\frac{\nu t}{D^2}$, $\frac{gt^2}{D}$, and $\frac{\rho_0}{\rho}$. Or, without stopping to establish the complete relation, we can at once determine relative viscosities by comparing observations taken under dynamically similar circumstances; for, as long as the above arguments are kept constant,

$$\frac{\nu}{\nu_0} = \left(\frac{t}{t_0}\right)^3 = \left(\frac{D}{D_0}\right)^{3/2} \tag{4}$$

Finally, by observing the transit time τ per unit length, between two points for which the speed is sensibly constant, the three arguments above may be coalesced into two, leaving

$$F\,(x, y) = 0 \tag{5}$$

in which x denotes $\tau\sqrt{Dg\left(\frac{\rho_0}{\rho} - 1\right)}$ and y denotes $\nu\sqrt{D^3 g\left(\frac{\rho_0}{\rho} - 1\right)}$.

An experimental determination of this function F affords the desired calibration equation for viscosity in terms of roll time.

Experimental test of the theory. Equations (4) and (5) were verified in the course of a series of experiments in which the behaviour of the tubes was minutely studied, and the linear relation

$$y = a + bx \tag{6}$$

was found to hold over the range from $y = 0.0001$ to $y = 0.1$, the constants having the values $a = -0.0009$ and $b = +0.00027$, (subject to accidental errors of several per cent due to temperature uncertainties); provided $\alpha = 15°$ and $\frac{d}{D} = 0.63$, and that the ball and tube are of ordinary smoothness. The experiments on which the above generalized equation is based were made with a glass tube about 1 cm. in diameter, containing a $\frac{1}{4}$ inch (0.635 cm.) steel ball. Since x, y, a, and b are dimensionless, the numerical values given are common to all systems of normal units.

Construction for use under pressure. The foregoing details were duplicated, except for small corrections, in the steel tube used under pressure. This tube was fitted with electric contacts, and with pressure-tight plugs of the type developed by Bridgman, in whose laboratory the work was carried on. It was connected to the pump and gage by a considerable length of copper tubing, and swivelled so that either end could nstantly be thrown up to a prescribed angle. This steel tube was calibrated for different densities by reference to equation (6).

Results on two lubricating oils. Lard oil and minera machine oil were selected for testing, because of the well known difference in their behaviour as lubricants, although, under atmospheric conditions, they have nearly the same viscosity. Expressing the resu'ts in the form

$$\mu = \mu_0 (1 + \alpha p) \tag{7}$$

and measuring pressure in atmospheres, (kg./cm.^{2}), the value of the pressure coefficient of viscosity, α, at 20°C., was found to be 0.0023 for lard, and 0.0032 for machine oil, over a range of

200 atm. The lard oil was later carried to 500 atm., and its viscosity found to increase much more rapidly than at the lower pressures. These results point to the advisability of now mapping out the μ, p, t surfaces of all lubricants in a systematic manner. In doing so, it is possible that both the above method and the free discharge method suggested below will be found simpler than the immersed capillary tube under differential pressure, used by Faust in some recent experiments not embracing lubricants.

The extension of Poiseuille's law to high pressures. Various equations relating to lubrication might well be generalized to include the effect of pressure. Thus Poiseuille's law may be rewritten

$$Q = \frac{\pi}{8} \frac{G}{\mu_0} r^4 C \tag{8}$$

in which Q is the volume discharged in unit time, by steady isothermal stream line flow, through a tube of radius r under a pressure gradient G; μ_0 being the viscosity at the outlet pressure, and C a dimensionless coefficient depending on the viscosity-pressure curve of the liquid. Thus

$$C = \frac{\mu_0}{P - P_0} \int_{P_0}^{P} \frac{dp}{f(p)} \tag{9}$$

P_0 being the outlet, and P the inlet values of the pressure p, and $\mu = f(p)$ being some empirical formula for the viscosity. By postulating a particular form for f, we could, in theory, evaluate the coefficients therein (such as α of equation (7)), by observing the discharge from a high pressure reservoir through a long water-jacketed tube into the free air.

To determine how nearly isothermal such flow could be made, note that, when K is constant, the final temperature rise of any incompressible viscous fluid, during steady (unaccelerated) adiabatic flow, is rigorously given by the formula

$$\Delta t = \frac{\Delta p}{JK} \tag{10}$$

in which Δp is the total pressure drop, $P - P_0$, J the mechanical equivalent, and K the thermal capacity of the liquid per unit volume. Thus the temperature rise depends solely on Δp and K; it is independent of the shape, diameter, or length of the tube, the viscosity of the liquid, or the rate of discharge.

CHEMISTRY.—*The saccharimetric normal weight and the specific rotation of dextrose.*[1] RICHARD F. JACKSON, Bureau of Standards. (Communicated by S. W. Stratton.)

Pure dextrose was prepared from starch conversion products and from invert sugar solutions. After a preliminary purging had removed a great portion of the adhering impurities, the substance was dissolved to form a 60 per cent solution in water and the crystals allowed to form slowly during continuous agitation. Two or three recrystallizations were sufficient to produce dextrose of high purity. A portion was subjected to a fractional crystallization and another portion precipitated by ethyl alcohol. The various purified samples showed essentially identical properties.

Dextrose crystallizes from water solution with one molecule of water of crystallization which it loses very readily at 60°C. The residual moisture was removed by heating in a vacuum at 60°–80°C. for several hours.

To prepare the solution for polarization, approximately the quantity required was weighed and dried in a weighed volumetric flask, and the solution was made up to the graduation mark of the flask at 20°C. From the data obtained the densities of dextrose solutions were calculated and found to correspond to the formula:

$$D\frac{20^\circ}{4^\circ} = 0.99840 + 0.003788\,p + 0.00001412\,p^2$$ where p is per cent anhydrous dextrose by weight in vacuo. The formula is valid for values of p between 5 and 30.

The solution was allowed to stand over night at room temperature in order to destroy the mutarotation.

Twelve independent measurements were made to determine the weight of substance which, contained in 100 cc. of solution,

[1] To appear in detail as a Scientific Paper of the Bureau of Standards.

would cause a rotation of 100°S on the scale of the quartz-wedge saccharimeter. If the latter is controlled by the conversion factors determined by Bates and Jackson,[2] namely, 34°620 for $\lambda = 5892.5\ A$ or 40°690 for $\lambda = 5461\ A$ or by the rotation of 26.000 gm. of pure sucrose in 100 cc., the normal weight of dextrose is 32.231 gm., weighed in air with brass weights. If the saccharimeter is calibrated by the Herzfeld-Schönrock factor, 34°657, which Bates and Jackson have shown to be in error, the normal weight of dextrose is 32.264 gm.

For solutions more dilute than normal the rotations deviate from proportionality. It is, therefore, necessary to apply corrections, to make the scale reading indicate the per cent of substance. These corrections are given in Table 1.

TABLE 1

Reading:	90°S	80°S	70°S	60°S	50°S	40°S	30°S	20°S	10°S
Correction:	+0.20	+0.35	+0.46	+0.53	+0.55	+0.53	+0.46	+0.35	+0.20

The rotation of the normal solution (32.231 gm.) for $\lambda = 5461$ A is 40°898. Since the normal quartz plate rotates 40°690, it is evident that there is a considerable divergence between the rotary dispersion curves of dextrose and of quartz. Thus, when the quartz-wedge saccharimeter is set for a photometric match, the field is slightly heterochromatic and the degree of reproducibility of the setting is necessarily less than that of sucrose, whose dispersion curve coincides more closely with that of quartz. This difficulty is only overcome by an increased number of settings and by some preliminary experience on the part of the observer.

The specific rotation, which is a function of the concentration of dextrose, corresponds to the formula

$$[\alpha]^{20°0}_{5461\ A} = 62.032 + 0.04257\ c$$

where c is grams of anhydrous dextrose weighed in vacuo and contained in 100 cc. of solution, or to the formula

$$[\alpha]^{20°0}_{5461\ A} = 62.032 + 0.04220\ p + 0.0001897\ p^2$$

where p is per cent dextrose by weight in vacuo.

[2] Journ. Wash. Acad., **6**: 25. 1916; Bull. Bur. Standards, **13**: 67. 1916.

CHEMISTRY.—*Preliminary report on the system, lime: ferric oxide.* R. B. Sosman and H. E. Merwin, Geophysical Laboratory.

Previous work. Apart from various isolated observations on the calcium ferrites, the only extensive investigation of the system calcium oxide: ferric oxide has been by Kohlmeyer.[1] He observed the melting and freezing temperatures of 44 mixtures, containing from 5 up to 95 molecular per cent CaO. The density and external crystal form, as well as the chemical behavior toward water, carbon dioxide, etc., of the products, were also determined. Unfortunately no optical examinations were made, and no optical properties measured.

Experience has shown that in the study of such systems as the silicates and ferrites the assistance of the petrographic microscope is almost indispensable; false conclusions may easily be reached from thermal data alone. Such was the case with Kohlmeyer's study. We have proved the existence of only one out of his five supposed compounds, while we have found one new compound, the existence of which was not shown by his thermal data.

Dissociation of the ferric oxide. A certain amount of ferrous iron is formed in all melted mixtures of CaO and Fe_2O_3. Between 50 and 100 molecular per cent CaO the percentage of ferrous oxide is small in mixtures heated to 1400°–1500°; but in melts containing from 0 to 50 per cent CaO the amount of ferrous oxide increases rapidly with the temperature and with the proportion of Fe_2O_3, so that some of the melting and solidifying points observed may actually belong in the three component system: lime-iron-oxygen. The completion of the diagram from 0 to 50 per cent CaO will therefore have to await experiments under oxygen at pressures higher than atmospheric.

Since apparatus for such experiments is not immediately available, and since the results already obtained are of some interest, particularly in connection with certain problems of Portland

[1] Diss., Berlin 1909. Ber. Deu. Chem. Ges., **42**: 4581–4594. 1909.

cement, we are publishing this preliminary report in order to make these results accessible to those interested.

It is possible that work on three component systems in which Fe_2O_3 and CaO are components, especially on the system $SiO_2 - CaO - Fe_2O_3$, in which quenchings can be made, will indicate changes that should be made on the accompanying $CaO - Fe_2O_3$ diagram, which, however, represents satisfactorily the facts so far obtained.

Method and materials. For the thermal data we depended almost entirely upon thermal curves (temperature-time curves). The method of quenching in mercury is of little avail in the system $CaO - Fe_2O_3$, for the reason that the products crystallize so easily and so rapidly that undercooled "glasses" are not obtained as in the case of the silicates, and the primary phase cannot, therefore, be always identified. Heating curves combined with optical examinations are, however, sufficient for the working out of the diagram. The optical properties are not as readily determinable as those of the silicates, on account of the deep colors and high indexes of refraction of the compounds, but the use of high refracting immersion glasses makes it possible to identify the phases with certainty.

Thermal curves and optical examinations were made on various mixtures of CaO and Fe_2O_3, made up initially from chemically pure $CaCO_3$ (J. T. Baker, and Baker and Adamson) and Fe_2O_3 (Baker and Adamson, and Kahlbaum). Charges of from 1.0 to 2.5 grams were used, in small platinum crucibles in a platinum-wound furnace. The carbonate-oxide mixtures were first melted down and then ground and re-melted for the determination of the thermal breaks. The mixtures containing less than 50 molecular per cent CaO were not heated above 1250°, to avoid, as far as possible, dissociation of the Fe_2O_3. Temperatures were measured by the platinum-platinrhodium thermoelement and potentiometer.

The composition-temperature diagram. We find only two binary compounds in the system $CaO - Fe_2O_3$. These are: (1) the 1 : 1 compound, $CaO.Fe_2O$; (2) the 2 : 1 compound, $2CaO.Fe_2O_3$. Both of these appear to be dissociated at their melting points.

The melting point of *pure CaO* is 2570°, according to Kanolt.[2] Its properties have been published elsewhere.[3]

The "transition temperature" at which the compound $2CaO.Fe_2O_3$ dissociates and is in equilibrium with CaO and liquid is 1436°. All mixtures from about 64 molecular per cent (about 38 weight per cent) of CaO up to pure CaO liquefy in part at this temperature, leaving pure CaO as the solid phase in excess. This

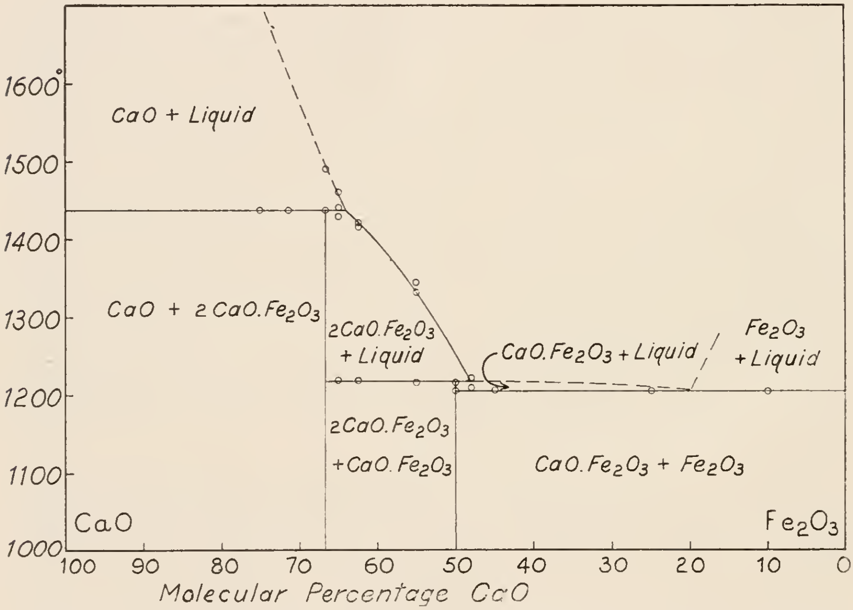

Fig. 1. Composition-temperature diagram of the system $CaO\text{-}Fe_2O_3$. Circles represent observed thermal breaks.

forms relatively large, rounded, clear grains, which dissolve as the temperature is raised, until they disappear completely at the temperature of the liquidus curve.

The compound $2CaO.Fe_2O_3$ crystallizes well, giving black crystals which are of a yellowish brown color by transmitted light under the microscope. The liquid can be undercooled to 1385°

[2] This Journal, **3**: 315–318. 1913.

[3] Rankin and Wright. Am. Journ. Sci., **39**: 3. 1915.

or lower. The crystallized product then shows traces of free CaO and $CaO.Fe_2O_3$, which are due to dissociation, and which have not combined during cooling. The compound forms from a finely powdered mixture of $CaCO_3$ and Fe_2O_3 at a temperature considerably below its liquefying point; under our conditions a considerable quantity of the compound formed during 30 minutes heating at 1000°, although none was visible in a mixture heated rapidly to 950°, at which temperature most of the carbon dioxide had been expelled.

The optical properties of the compound $2CaO.Fe_2O_3$ are: biaxial, positive, with a moderate optic axial angle. $\alpha_{Li} = 2.200 \pm 0.005$, $\beta_{Li} = 2.220 \pm 0.005$, $\gamma_{Li} = 2.290 \pm 0.005$. The optical dispersion of α is the same as of the immersion medium, therefore α_{Na} is about 2.25; β and γ have lower dispersion. α is absorbed considerably through the red as well as for shorter wave-lengths. β and γ are absorbed little at wave-lengths longer than $620\mu\mu$, and are transmitted considerably at $550\mu\mu$.

There is no optical evidence of solid solution either of CaO or of $CaO.Fe_2O_3$ in the compound.

The transition temperature at which the compound $CaO.Fe_2O_3$ dissociates, and is in equilibrium with liquid and with $2CaO.Fe_2O_3$ is 1216°. All mixtures between about 48 and 65 molecular per cent of CaO (about 24.5 to 38 weight per cent) liquefy in part at this temperature, forming liquid and leaving excess of $2CaO.Fe_2O_3$ as the crystalline phase, which dissolves with rising temperature and disappears at the liquidus curve.

The compound $CaO.Fe_2O_3$, after dissociating and nearly all liquefying at 1216°, becomes completely liquid at about 1250° by the disappearance of the solid $2CaO.Fe_2O_3$ formed by dissociation. The liquid crystallizes with less undercooling than does the compound $2CaO.Fe_2O_3$, and the temperature of the thermoelement sometimes rises to within a few degrees of 1216°. The crystallized product contains an appreciable amount of $2CaO.Fe_2O_3$, and dark dusty ferric oxide. When powdered and reheated at 1190°, these dissociation products recombine completely, forming a homogeneous product of red $CaO.Fe_2O_3$; the powder also sinters together.

The compound forms from a finely powdered mixture of $CaCO_3$ and Fe_2O_3 at a temperature well below the melting point, just as the 2 : 1 compound does. It crystallizes well, giving black crystals. The crystals are frequently in the form of long needles,[4] but no evidence of prismatic habit is visible in the powdered preparation under the microscope.

The optical properties of the compound $CaO.Fe_2O_3$ are as follows: *Color:* deep red, about like hematite; *optical character:* nearly or quite uniaxial, negative; *indexes of refraction:* $\omega_{Li} = 2.465 \pm 0.005$, $\epsilon_{Li} = 2.345 \pm 0.005$. For sodium light ω is about 2.58 and ϵ about 2.43. These values were determined by observing that throughout the red and orange the dispersion of the compound was not noticeably different from that of the immersion medium. ϵ is absorbed slightly more than ω in the orange and at shorter wave-lengths, but not noticeably more in the red. Grains 0.01 mm. in thickness show scarcely any absorption at wave lengths longer than $610\mu\mu$; at wave lengths shorter than $580\mu\mu$ they are very dark.

There is no optical evidence of solid solution either of $2CaO.Fe_2O_3$ or of Fe_2O_3 in the compound.

There is a *eutectic* at 1203° between $CaO.Fe_2O_3$ on the one hand, and ferric oxide (hematite) on the other. The mixture containing 10 molecular per cent CaO shows clearly an excess of hematite. The mixture with 25 molecular per cent CaO consists almost entirely of a deep red, apparently homogeneous, material, which is probably an intimately intergrown eutectic of $CaO.Fe_2O_3$ and Fe_2O_3; the mixture contains also a little excess of red $CaO.Fe_2O_3$. The eutectic composition is therefore between 10 and 25 per cent CaO, and probably near the latter.

The melting point of *pure* Fe_2O_3 is unknown, as it dissociates under atmospheric pressure of oxygen before the melting point is reached into oxygen and a solid solution of Fe_3O_4 in Fe_2O_3.[5] Its optical properties have been published elsewhere.[6]

[4] See photographs by Hofman and Mostowitsch, Bull. Am. Inst. Min. Eng. **39**: 628–653. 1909.

[5] Sosman and Hostetter. Jour. Am. Chem. Soc., **38**: 807–833. 1916.

[6] Merwin. Jour. Am. Chem. Soc., **38**: 830. 1916.

The Fe_2O_3 fragments in the preparation containing 10 molecular per cent CaO, which had been heated to 1250° but was not completely melted, had a variable and lower refractive index than pure hematite (ω as much as 0.05 lower). This is due to solid solution either of $CaO.Fe_2O_3$ or of Fe_3O_4. ω was measured in an amorphous mixture of selenium and arsenic selenide (As_2Se_3), by means of which, with the addition of tellurium, a refractive index of about 3.15 for red can be reached.

We have found no evidence as yet of a 3 : 1 compound analagous to tricalcium aluminate. Samples of this composition quenched[7] after 15 minutes at 1575°, 15 minutes at 1525°, 15 minutes at 1325°, and 3 hours at 1375° all consisted only of CaO and $2CaO.Fe_2O_3$. Thermal curves on this mixture showed only the melting at 1434–1436°.

Chemical analogy has naturally led several authors to expect a phase rule diagram for the system $CaO - Fe_2O_3$ similar to that for $CaO - Al_2O_3$. Campbell,[8] for instance, assumed the existence of the compound $5CaO.3Fe_2O_3$, analogous to the 5 : 3 compound of lime and alumina, and claimed to have found chemical evidence for its existence. We find no evidence of such a compound. Instead of being analogous to $CaO - Al_2O_3$, the diagram of the system $CaO - Fe_2O_3$ resembles that of $MgO - SiO_2$[9] much more clearly than it resembles that of any other of the silicate systems with which we are familiar.

PLANT MORPHOLOGY.—*Morphology and evolution of leaves.* O. F. Cook, Bureau of Plant Industry.

In seedlings of many palms, grasses, and other plants the first leaves are simple, bladeless sheaths, or the blade appears as an appendage or expanded outgrowth from the rim of the sheath. Leaves with larger blades are produced as the plant grows, until the adult degree of specialization is attained. The essential feature of the primitive leaf is the basal sheath, in the form of a

[7] Quenchings by G. A. Rankin.
[8] E. D. Campbell. Jour. Ind. Eng. Chem., **7**: 835–837. 1915.
[9] N. L. Bowen. Am. Jour. Sci., **37**: 487–500. 1914.

cylinder. Each sheath in turn encloses the terminal bud of the shoot, and later encircles the stem.

Three elements of leaf structure—blade, petiole, and stipules—are recognized generally in manuals and textbooks. These are convenient for purposes of description, but for understanding the structure and evolution of leaves it is better to begin with the sheath or with the sheath and the blade, the two elements that appear to have been differentiated in advance of the others. Sheaths have been looked upon as expanded petioles or united stipules, instead of being considered as a primitive element. It has seemed reasonable to suppose that the petiole and the stipules have been derived from the blade, which in most plants is the largest and most important part of the leaf, but a general interpretation in accord with evolutionary facts is needed in the study of structural variations of plants.

THE PRIMITIVE FUNCTION OF LEAVES

In plants like *Equisetum*, *Ephedra*, and *Casuarina* the internodes perform the vegetative functions. Leaves are represented only by sheaths or scales which are mere appendages of the internodes, apparently of little use except for protecting the buds. Palms and many other plants afford examples of internodes and sheaths that have chlorophyll and stomata in the epidermal tissues and share the vegetative functions with the blades of the leaves. Cacti and specialized desert plants of other families have very small or rudimentary leaves, thus reducing transpiration.

It is customary to think of bud scales and similar organs as leaves that have been specialized by reduction, but it may be more correct morphologically to think of foliage leaves as enlarged bud scales that have assumed the vegetative functions formerly discharged by the internodes. The function of the bud scales is older than are the present forms of leaves, and may date back to the stage when the sheaths were simple cylinders, before the development of more specialized forms of leaf structure. It is unnecessary to suppose that the early types of seed plants lacked bud scales.

THE COURSE OF SPECIALIZATION IN LEAF-FORMS

Other specialized forms of leaves, such as sepals, bracts, and scales of subterranean rootstocks, may also be considered as representing primitive sheaths or bud scales, rather than as reductions from the fully developed type of foliage leaves. From this point of view the foliage leaves appear to be the most specialized. Yet in developing the foliage leaves plants have not lost the ability to produce the simpler organs—sheaths, bud scales, or bracts. The plant body is a succession of different kinds of internodes, or metamers, bearing different kinds of leaves. At one end of the series are the cotyledons or seed-leaves, at the other the carpels or fruit-leaves, with many intermediate stages between the different kinds of foliar and floral organs.

As stamens are often transformed into petals, so we may think of cotyledons and foliage leaves as sterile carpels performing vegetative functions. Some of the species of *Sterculia* have broad leaflike carpels that persist and remain green long after the seeds have been shed. That the stamens and carpels of the different families of plants are generally more alike than the leaves or other parts of the plant body is more easily understood when we consider the evolution of plants as a process of intercalation of more numerous and more specialized forms of metamers. Plants like the junipers, pines, and eucalypts have two distinct kinds of foliage leaves, showing clearly that a double evolution of these organs has taken place.

The succession of different kinds of leaves, the classical example used by Goethe in presenting the idea of evolutionary changes in the forms of the same organ, may not be less significant for the strictly morphological purpose of understanding the origin and homologies of the structural elements of the leaves. The changes that take place in passing through the succession of leaf-forms, during the development of the plant, are also of interest for the study of heredity.[1]

[1] Cook, O. F. *Dimorphic leaves of cotton and allied plants in relation to heredity.* U. S. Dept. Agric., Bur. Pl. Ind., Bull. 221. 1911. *Heredity and cotton breeding.* U. S. Dept. Agric., Bur. Pl. Ind., Bull. 256. 1912.

DIFFERENTIATION OF THE LIGULE

In the development of foliage leaves the ligule was probably the first structure to be added after the sheath and the blade. The ligule may be described as a thickened rim of the leaf sheath, bearing the weight of the blade or holding the sheath in place around the stem. In *Serenoa* and related genera of fan-palms the ligule is supplemented by a ligule-like expansion of the rim that supports the bases of the segments on the under side of the leaf. Although these subligules, as they may be called, appear in only a few palms, they are not without general interest as organs that are closely parallel in structure and function with the true ligules.[2]

The sheaths of most palms are thickened on the side that supports the petiole, and are split on the opposite side, allowing the leaf to diverge more widely from the trunk, but the more primitive condition of closed sheaths with nearly uniform texture is also found, as in *Calamus, Desmoncus,* and *Chamaedorea.* Even in the large royal palms and many others the sheaths are not split until the leaves are ready to fall.

In palms like *Desmoncus* and *Pyrenoglyphis,* as in many members of the family Polygonaceae, the sheath, instead of being specialized at the mouth to form a ligule, is prolonged far above the insertion of the petiole, forming what is known as an ocrea. A similar prolongation of the sheath beyond the point of attachment with the petiole is found in the bud scales of *Magnolia* and *Ficus.* Some writers have taken it for granted that the ocrea, or the entire sheath, has been formed by the union of stipules, but the indications point rather to the formation of stipules by reduction and specialization of the sheaths of the more primitive forms of leaves.

Whether we consider that the blade arose simply as an expansion of the upper portion of the sheath or as an outgrowth from the rim of the sheath, the ligule may be considered as marking

[2] My attention has been called by Mr. H. Pittier to illustrations of the subligule of *Trithrinax campestris* published by C. De Candolle, Bull. Soc. Bot. Genève, II. **5**: 106, pl. 3. 1913.

a line of separation of the two portions of the primitive leaf that became specialized. Even this indication of definite specialization of parts is lacking in many plants, as among the lilies, orchids, and plantains, where the leaves still appear as simple sheaths with a gradually broadened distal portion to serve as a blade, but no distinct separation of special parts. The idea of leaf blades arising as outgrowths from leaf sheaths appears more probable, or at least less fantastic, when we consider such a case as the leaf of *Smilax*, where the end of the sheathing base produces a pair of slender tendrils several inches in length, in addition to the blade of the leaf. It may not be without significance that rudimentary blades of abnormal or reduced leaves often assume very slender, tendril-like forms.

THE EVOLUTION OF STIPULES

It has been supposed that stipules were developed from basal lobes of leaf blades. This interpretation was suggested by Ward and later adopted by Berry on the basis of evidence drawn from fossils and abnormal leaf-forms of *Liriodendron*, but these can be understood as intermediate stages between normal leaf-forms and bud scales. It seems unnecessary to suppose that stipules began with *Liriodendron*, or that the stipules of *Liriodendron* are not homologous with those of other genera and families.[3]

The very general occurrence of stipules or stipular structures is in itself a fact that must make it difficult to credit the idea of recent development or independent derivation of such organs, either in the family Magnoliaceae or in the many and widely different families of plants that have stipules. The stipules of *Liriodendron* may be more primitive than those of other Magnoliaceae in retaining more of the vegetative functions of the primitive sheath, but their nearly complete separation from the petiole and from each other may be considered as a specialization, since partially united stipules occur. Union between the stipules and the petiole is shown in many of the reduced leaves or the large floral bud scales that have small petioles and blades. Union

[3] Berry, E. W. *The origin of stipules in Liriodendron.* Bull. Torrey Bot. Club, **28**: 493. 1901.

between the stipules on the side opposite the petiole is sometimes shown in very large stipules of strong shoots.

Another line of evidence tending to throw doubt on this idea of stipules as specializations of leaf blades might be drawn from bracts and other organs that take the form of sheaths, even in families whose normal foliage leaves are without stipules. Thus, in the genus *Hicoria* the outer scales of lateral buds have the form of a closed sheath, carinate on each side, somewhat similar to the prophylla of grasses and palms. The large membranous bud scales that precede the leaves on new shoots of *Hicoria* also represent sheaths and sometimes appear in modified form as stipular wings of the petiole, on abnormal leaves of shoots developed late in the season.

Considerations drawn from the study of "nodal anatomy" have been used recently by Sinnott and Bailey as the basis of interpretation of leaf morphology. Stipules, sheaths, and ligules are classed together as "modifications of the base of the petiole," the final conclusion being that "a leaf with two distinct stipules is more ancient in type than one with a sheathing base."[4]

Stipules have also been considered as "accessory leaves," or as a specialized development of the basal portion of the "true petiole."[5] In the present view, stipules, bud scales, and various forms of bracts appear to have been derived not from the blade or the petiole of specialized leaves, but from the primitive sheath. The ligule and even the blade itself are considered as specializations from the distal end of the sheath; but scales and stipules as specializations of the basal portion. Petioles are not all homologous, but are of two kinds, some derived from the sheath, and others from the blade.

THE TWO KINDS OF PETIOLES

Taking account of the ligule or the ocrea as marking the end of the primitive sheath makes it possible to distinguish very

[4] Sinnott, E. W., and Bailey, I. W. *Investigations on the phylogeny of the angiosperms. 3. Nodal anatomy and the morphology of stipules.* Amer. Journ. Bot., **1**: 441–453, pl. 44. 1914.

[5] See, Tyler, A. A. *The nature and origin of stipules.* Ann. N. Y. Acad. Sci., **10**: 1–49, pls. 1–111. 1897.

clearly the two kinds of petioles. Both kinds are represented among the palms. In fan-palms the so-called petiole is below the ligule, whereas the part described as petiole in some of the pinnate-leaved palms certainly is above the ligule or ocrea. In the fan-palms it is plain that the petiole is a narrowed, elongated portion of the leaf sheath, ending at the ligule, whereas the petiole of the Cocaceae and Chamaedoreaceae represents a naked basal portion of the rachis or midrib.[6]

That the petioles are of two kinds is apparent also from the fact that in the fan-palms the petioles agree in structure and are entirely continuous with the leaf sheath, while in the pinnate-leaved palms there is equally complete agreement and continuity with the rachis. But the leaf structure is not the same in all of the pinnate-leaved families. There appear to have been several independent derivations of pinnate leaves from fan-leaved ancestors. The Geonomaceae are a pinnate-leaved family in which the petiole appears to be a part of the sheath, the same as in fan-palms.

The magnolia family affords another example of double differentiation of the petiole, the lower part of the organ being formed by a thickened segment of the leaf sheath, while the upper part is a narrowed base of the blade, as shown by the decurrent margins which run down to the ligule. In such species as *Magnolia virginiana* the lower portion of the petiole is marked very distinctly by the scar of the deciduous leaf sheath, with a minute hairy prominence at the end, which may be considered as a thickened base of the ligular prolongation that forms the apex of the sheathing bud scale.

It is conceivable that a petiole formed originally from the sheath element might become separated from the remainder of the sheath, which would account for the evolution of such organs as the deciduous bud scales of the Artocarpaceae. But all petioles formed from sheaths would remain essentially different morphologically and developmentally from those that were formed originally as basal elongations of the midrib of a simple

[6] Cook, O. F. *Origin and evolution of angiosperms through apospory.* Proc. Wash. Acad. Sci., **9**: 174. 1907.

leaf, or by moving the pinnae farther up the rachis of a compound leaf, as in the pinnate palms.

SHEATH PETIOLES AND BLADE PETIOLES

The recognition of the two kinds of petioles as representing distinct morphological elements makes it necessary to have more convenient ways of designating the two classes of organs to which the word petiole has been applied indiscriminately. The use of such terms as *sheath petiole* and *blade petiole* would afford a way of indicating the distinction. Sheath petioles would be understood as those that represent specializations of the primitive sheath, and blade petioles as specializations of the blade or midrib of the leaf.

Other terms that might be used are *infraligular* for the sheath petioles and *ultraligular* for the blade petioles, in allusion to the differences of position in relation of the ligule. It might be objected that ligules are confined to a few families, but the terms would still serve to indicate the homologies of the parts to those of plants whose possession of ligules gives the most definite basis for the distinction between the two kinds of petioles.

THE FOOT AS A NEW ORGAN

For general descriptive purposes and especially for dealing with plants in which the resemblance to the primitive sheath has entirely disappeared, it may be simpler to treat the petiole-like sheath element as a new organ not formally distinguished hitherto. On this basis instead of *sheath petiole* or *infraligular petiole,* a single word like *foot,* in Latin descriptions *pes,* might be used. This would have the advantage of leaving the term petiole as nearly as possible in its present signification, which would need to be modified only in those cases where the so-called petiole might be found to represent the sheath element. No doubt there are many plants where not only the stipules are lacking, but also the foot.

From this point of view it would be possible in dealing with different families of plants to define the foot in any way that might be most convenient, as a thickened segment of the primitive sheath, as the element of the primitive sheath that supports the blade, as the element that is between the petiole and the internode, or as the element to which the stipules are attached. Thus in the peaches, almonds, plums, and other members of the family Amygdalaceae, the petiole is articulated at its base to the foot, to which the stipules are attached. The petiole is deciduous with the blade, but the foot persists for another season and functions as a bud scale. The foot is present also in apples, pears, and roses, but falls with the leaf, there being no joint at the base of the petiole.[7] The joint is present in Oxalis and in many leguminous plants.

Objection might be taken on etymological grounds to using the word *foot* for an element that in many plants is smaller than the petiole, which term means a small foot. It does not seem, however, that this is likely to cause confusion, since the obvious signification of foot is in relation to the lowest, most truly basal portion of the leaf. Absence of the foot is to be considered as a specialization of leaf structure, and it will be interesting to determine the status of the organ in the different families. Even though not present in the foliage leaves, the foot may still be represented in the bud scales, bracts, or other organs which from our present point of view appear to be more primitive and less specialized than the foliage leaves. That the cotyledon is sometimes called the nursing foot, or simply the foot, hardly constitutes an objection to the use of this word, with other leaves, for the element that corresponds to the cotyledons and primitive bladeless sheaths of seedlings.

PULVINI AND ARTICULATIONS

Pulvini and articulations represent special forms of tissue connected with the ligule or base of the blade in grasses and palms, and found in corresponding positions in other families of plants. The chief function of pulvini is to control the position of the leaf blade, which is accomplished by varying the turgidity or water pressure in the rather loose cells of which the pulvini are composed. A flexible pulvinus is in the nature of a joint.

[7] Cook, O. F. *Jointed leaves of Amygdalaceae.* Journ. Wash. Acad. Sci., **2**: 218–220. 1912.

Many leaves have a basal pulvinus, with a layer of absciss tissue to form an articulation with the internode, when the leaf separates at maturity. In other leaves the joint that provides for the detachment of the leaf is between the foot and the petiole, as in the case of the peaches, plums, cherries, and related plants. In *Magnolia virginiana* there is a pronounced development of the entire upper surface of the foot as a pulvinus, which has a special function in lifting the winter bud scales in the spring.

The organ that is usually described as a true petiole may prove to be a foot in cases where there are pulvini at both ends, as in cacao. In the patashte tree, a relative of cacao, the petioles of the leaves of the fruiting branches have the structure of pulvini for their whole length.[8] In the cotton plant also there are pulvini at both ends of the petiole. Other reasons for considering the cotton petiole as a foot may be found in the fact that while the margins of the leaf blade never show any tendency to become decurrent, the petiole is often united with the margins of enlarged stipules like those that form the involucral bracts.

The suppression or extreme reduction of the blade in the formation of the involucral bracts of the cotton plant might also be considered as an indication that the blade, in spite of its much greater size, still behaves in some respects as an appendage of the sheath. That the general course of evolution has been in the direction of enlarging the blade and reducing the sheath element may be considered as at least a partial explanation of the fact that enlargement of the stipules is almost invariably accompanied by reduction of the blade of the leaf. If only one stipule is enlarged, a lobe is likely to be wanting on the same side of the blade.[9]

SUMMARY

The leaves of angiosperms show a primary division into two morphological elements, (1) a basal sheath supporting (2) an expanded blade, as represented in the leaves of palms, grasses, and many other plants. The organs that are usually described

[8] Cook, O. F. *Branching and flowering habits of cacao and patashte.* Contr. U. S. Nat. Herb., **17**: 609–625, pls. 44–54. 1916.

[9] Cook, O. F. *Brachysm, a hereditary deformity of cotton and other plants.* Journ. Agric. Research, **3**: 387–400, pls. 53–62. 1915.

as petioles are of two kinds, (1) some that appear to have arisen through a narrowing of the base of the blade, and (2) others through a narrowing of the primitive sheath. The name foot is suggested for a specialized portion of the leaf sheath that serves as a petiole. Both the petiole and the foot are represented in many plants, in such families as the Amygdalaceae, Rosaceae, and Magnoliaceae. Stipules, bud scales, bracts, ligules, and pulvini are other specializations of the primitive sheath element, and the blade also appears to have arisen as an outgrowth or expansion of the sheath.

ETHNOBOTANY.—*Identity of cohoba, the narcotic snuff of ancient Haiti.*[1] WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.

The natives of Hispaniola, or Haiti, at the time of the Discovery made use of a narcotic snuff, which they inhaled through the nostrils by means of a bifurcated tube. This snuff induced a kind of intoxication or hypnotic state, accompanied by visions, which were regarded by them as supernatural. While under its influence the necromancers, or priests, were supposed to hold communication with unseen powers, and their incoherent mutterings were regarded as prophesies or revelations of hidden things. The same practice was also followed by their physicians in treating the sick, in order to ascertain the cause of maladies and to determine remedies which should be used for their cure. This snuff was called in the language of the islanders "coxoba" (the sound of the *x* approaching that of the German *ch*, or the guttural Spanish *j*). In Spanish orthography the word was written "cojoba," and in Italian "cogioba," a form which has been incorrectly transcribed "cogiba" and "cojiba." These various forms of the word might lead to confusion, were it not for the fact that Las Casas clearly indicates its pronunciation, as follows: "These powders and these ceremonies, or acts, were called *cohoba*, the middle syllable long in their language, in which they pronounce as in the Arabic, or like the Germans confusedly."[2]

[1] Published with the permission of the Secretary of Agriculture.

[2] LAS CASAS. Apolog. Hist. de las Indias, Chapt. 166, pp. 445–446, ed. Serrano y Saenz, Madrid. 1909.

FIG. 1. Cohoba, *Piptadenia peregrina* (L.) Benth., the source of the narcotic snuff of Hispaniola. Natural size.

By nearly all authors who have written of ancient Haiti or on the history of tobacco, *cohoba* snuff has been confused with tobacco, and the bifurcated snuffing tubes have been mistaken for nose pipes used for smoking. This confusion can be traced to Oviedo, whose account of tobacco is misleading and incorrect. Oviedo, indeed, is responsible for many mistakes that have been handed down from writer to writer. His statements are often contradictory, and not infrequently he confesses that he writes from memory or from the testimony of others. In his first work, *De la natural hystoria de las Indias* (1526), he does not mention either *cohoba* or tobacco, in connection with the natives of Hispaniola. In his *Historia general de las Indias* (1535) he says nothing of snuff but speaks of the evil custom of taking certain fumigations, which the Indians call tobacco, in order to lose their senses; "and this they did with the smoke of a certain herb, which, according to what I have been able to learn, is of the quality of hen-bane [Hyoscyamus] but not resembling that plant in form and habit;"[3] and he further states that the smoke was inhaled through certain canes with two tubes, of which he presents a Y-shaped figure, which, like his description of the method of using them, was certainly drawn, not from his personal observation, but from the descriptions of others. Oviedo, unfortunately, has been quoted by many authors, and his Y-shaped figure, with its branches so diverging that they could not possibly have been simultaneously inserted in the nostrils of a human being, has been copied again and again.[4]

EARLIEST ACCOUNTS OF COHOBA

The ceremonial use of *cohoba* is described in the very first work which treats of the ethnology of the New World, written in 1496

[3] "Usavan los indios desta isla entre otros sus vicios uno muy malo, que es tomar unas ahumadas que ellos llaman tabaco para salir de sentido: y esto hazian con el humo de cierta yerva, que a lo que yo he podido entender es de calidad del veleño: pero no de aquella hechura o forma a la vista." OVIEDO, op cit., fol. xlvii. 1535.

[4] Among the earliest writers to cite Oviedo was Purchas, who states that the natives of Hispaniola "had tobacco in religious veneration, not only for sanity, but for sanctity also, as Oviedo writeth, the smoke whereof they took into the nose

by Ramon Pane, who accompanied Columbus on his second voyage. This paper, originally in Spanish, is best known through an Italian translation published as an appendix to the *Historie* of Fernando Colombo (1571), now a rare work, a copy of which is in the Library of Congress. The author, whose name appears in the introduction as "Frate Roman, povero Eremita del l'ordine di San Gieronimo," wrote, in obedience to the command of the illustrious Lord Admiral and Viceroy, what he was able to learn concerning the beliefs and idolatry of the Indians. In describing their snuff he calls it in one place *cohoba* and elsewhere *cogioba* (Italian orthography, like "*Gieronimo,*" quoted above). Writing in the present tense, he says: "This powder they draw up through the nose, and it intoxicates them to such an extent that when they are under its influence they know not what they do."[5] In striking contrast to Oviedo, Fra Ramon wrote only what he had actually seen, and he confined the field of his observations to the natives of the island of Hispaniola, stating: "Color, de' quali ciò scrivo, son dell'Isola Spagnuola; percioche delle altre Isole io non so cosa alcuna, non havendo mai veduto."[6]

Peter Martyr's account of the inhabitants of Hispaniola, in his *De Orbe Novo*, is simply a paraphrase of Fra Ramon's paper, in Latin. It adds nothing to his description of *cohoba*, but on the other hand it is misleading, since it refers to it as "an herb which they pound up and drink;" and though it states that the natives "absorb the intoxicating herb called cohobba, which is the same as that used by the bovites to excite their frenzy," it fails to

with a forked pipe fitted to both nostrils, holding the single end in the smoke of that herb burning in the fire until they became senseless. Their priests most used this, who, coming to themselves after this sleepy fume, delivered the oracles of their zemes or devils, which sometimes spake by them."—*Purchas, His Pilgrimage,* **5**: 957. 1626. Among the latest authorities to be misled by Oviedo is H. Ling Roth; see his account of tobacco in *The aborigines of Hispaniola,* in Journ. Anthrop. Inst. **16**: 258. 1887. See also, Bourne, Edward Gaylord, in Proceedings of the American Antiquarian Society of Worcester, n. s., **17**: 327. 1906; and Fewkes, J. W., in Twenty-fifth Ann. Rept. Bur. Amer. Ethn., 630. 1907.

[5] "Una certa polvere, chiamata Cohoba, tirandola a se per il naso, la quale gli imbriaga de tal maniera, che non sanno quel, che si fanno."—Ramon Pane, (1496), in appendix to Fernando Colombo's *Historie*, cap. XV, f. 134. 1571.

[6] Ramon Pane, op. cit., f. 126. 1571.

specify that they breathed it through their nostrils by means of a forked tube. Nothing is said of the apparatus by which the snuff is taken, and indeed Ramon Pane himself neglects to give a description of it. Fernando Colombo, however, in the work already cited, states that for holding the snuff the natives had a finely wrought table of a round form, resembling a trencher (*come un tagliere*), and that they took it by means of a bifurcated tube: "*con una canna di due rami, che si mettono al naso.*"

The description of Las Casas, who was an eye-witness to the ceremony of the cohoba, is even more precise. The snuff-tray he describes as "a plate, not flat but slightly concavish or deep, made of wood, so handsome, smooth, and pretty, that it could not be very much more so, were it made of gold or silver; it was almost black and polished like jet" (*cuasi negro y lucio como de azabache*). The tube, he says,

> was fashioned the size of a flute and was quite hollow like a flute. From two-thirds of its length onward it divided by means of two hollow canes, just as we open the two middle fingers, leaving out the thumb, with the hand extended. The ends of these two canes inserted into the windows of the nostrils, and the base of the flute, let us say, into the powder on the plate, they would draw in their breath and snuffing up, would receive through the nostrils as much of the powder as they wished to take, which, when taken, would go at once to the brain, almost as though they had drunk strong wine; for they would become drunk or almost drunk. . . . . It was their custom, in coming together to decide difficult matters, such as the manoevures of one of their war parties, or the performance of other things which they deemed important, to make their cohoba and with it intoxicate themselves or nearly so to do. . . . . I saw these people on several occasions celebrate their cohoba, and it was an interesting spectacle to witness how they took it and what they spake. The Chief began the ceremony, and while he was engaged all remained silent. When he had taken his cohoba (that is, when he had snuffed up the powder through his nostrils, as I have described), they being seated on certain handsomely carved low benches which they called *duohos* (the first syllable long), he remained silent for a while with his head inclined to one side and his arms placed on his knees. Then he raised his face heavenward uttering certain words which must have been his prayer to the true God, or to him whom he held as God; after which all responded, almost as we do when we say *Amen;* and this they did with a loud voice or sound. Then they gave thanks and said to him certain complimentary things, entreating his benevolence and begging him to reveal to them what he had seen. He described to them his vision, saying that the *Cemi* had spoken to

him and had predicted good times or the contrary, or that children were to be born or to die, or that there was to be some dispute with their neighbors, and other things which might come to his imagination, all disturbed with that intoxication; or if perhaps without it, what the devil, to deceive them and win them to his worship, had brought to them.[7]

The snuff itself was described by Las Casas as "finely ground and of the color of cinnamon or powdered henna" (*de color de canela ó de alheña molida*).[8]

THE COHOBA TREE STILL PERSISTS IN HAITI

That a substance with the intoxicating effects of *cohoba* should have been identified with tobacco seems strange; but if not tobacco, what could have been its origin? Is the custom of taking a narcotic snuff by means of a bifurcated tube still in existence in any part of America? If so, from what plant is the snuff prepared, and is this plant to be found growing on the island of Haiti? These questions may be answered as follows: The custom of taking a narcotic snuff still prevails in various localities of South America, showing that at one time it must have been widely spread. In inhaling it some tribes used bifurcated tubes which correspond very closely with the descriptions of those used in Hispaniola. The plant from which the snuff is derived is *Piptadenia peregrina*, a tree which grows both spontaneously and in cultivation on the banks of the Orinoco and Amazon Rivers and their tributaries. This tree does grow on the island of Hispaniola, or Haiti, as well as upon the neighboring island of Porto Rico and several other of the Antilles; and—most interesting and convincing of all facts connected with it—it still bears the name *cohoba*, which was applied in ancient times both to the snuff itself and to the ceremonial practice of using it.

[7] Las Casas. Apol. Hist. de las Indias, Chapt. 166, pp. 445–446, ed. Serrano y Saenz, Madrid. 1909.

[8] Alheña is the name of the so-called Egyptian privet, *Lawsonia inermis*, the powdered leaves of which, called henna, were used by the Egyptians for coloring their finger-nails. The fragrant flowers of this plant are the principal source of the perfume wafted by the breezes of "Araby the Blest."

NARCOTIC SNUFFS OF SOUTH AMERICA

It was in connection with his studies of the economic plants and plant products of the aborigines of America that the writer came upon a description of the custom of snuff-taking by certain tribes of Indians inhabiting the tributaries of the Orinoco, in Padre Gumilla's *El Orinoco Ilustrado*, printed in Madrid in 1741. In describing the customs of the Otomaco Indians this venerable missionary bewails their use of inebriants, as follows:

They have another most evil habit of intoxicating themselves through the nostrils, with certain malignant powders which they call *yupa*, which quite takes away their reason (*que les quita totalmente el juicio*), and furious, they grasp their weapons; and if the women were not adept at seizing and tying them, they would commit cruel havoc every day; this is a tremendous vice. They prepare this powder from certain pods of the *yupa* (*unas algarrobas de yupa*) from which the name is derived, but the powder itself has the odor of strong tobacco. That which they add to it, through the ingenuity of the devil, is what causes the intoxication and the fury. After eating certain very large snails which they find in the inundated areas along the river they put their shells into the fire and burn them to quicklime whiter than snow itself. This lime they mix with the *yupa* in equal quantities, and after reducing the whole to the finest powder there results a mixture of diabolical strength; so great, that in touching this powder with the tip of the finger, the most confirmed devotee of snuff cannot accustom himself to it, for in simply putting his finger which touched the *yupa* near to his nose, he bursts forth into a whirlwind of sneezes. The Saliva Indians and other tribes of which I shall later treat also use the *yupa*, but as they are people gentle, benign, and timid, they do not become maddened like our Otomacos, who, even on account of this, have been and still are formidable to the Caribs; for before a battle they would throw themselves into a frenzy with *yupa*, wound themselves, and full of blood and rage (*llenos de sangre y de saña*) go forth to battle like rabid tigers."[9]

Shortly afterwards (1743) M. de la Condamine, while exploring the Marañon River, found the Omagua Indians living at a village near the mouth of the Rio Napo making use of two narcotic plants:

One called by the Spaniards *floripondio* [*Datura arborea*], with flowers shaped like a drooping bell, which has been described by Père Feuillée; the other in the native vernacular called *curupa*, both of them purgatives. They cause intoxication lasting 24 hours, during which it is pretended that they have strange visions. The *curupa* is taken

[9] Gumilla, Joseph. El Orinoco Ilustrado, pp. 117–118. 1741.

in the form of powder, as we take tobacco. but with more apparatus. The Omaguas make use of a cane tube terminating in a fork, of a Y-shaped form, each branch of which they insert into one of their nostrils. This operation, followed by a violent inspiration, causes them to make diverse grimaces.[10]

This snuff, called *curupa* and also, according to Gilii, *curuba*.[11] was afterwards identified by Humboldt with the *yupa* or *ñupa* of the Otomac Indians, described by Gumilla, and the *paricá* of Brazil,[12] and traced to a tree, which he called *Acacia Niopo*. Humboldt states that the missionaries on the Orinoco commonly call it tree-tobacco (*tabac en arbre*) to distinguish it from the ordinary herbaceous tobacco (Nicotiana).

Fig. 2. Bifurcated tube for snuffing powdered seed of *Piptadenia peregrina*. Used by Otomac Indians of the Orinoco River. Berlin Museum. Scale ⅓.

HUMBOLDT'S DESCRIPTION

Humboldt, who observed a party of Otomac Indians at Urana, a mission on the Orinoco River, says of them:

> . . . . they throw themselves into a peculiar state of intoxication, one might almost say of madness, by the use of the powder of *niopo*. They gather the long pods of a Mimosacea, which we have made known under the name *Acacia Niopo*, cut them to pieces, moisten them, and cause them to ferment. When the softened seeds begin to turn black they are ground into a paste, and after having mixed with them some flour of cassava and some lime made from the shell of an Ampullaria, they expose the whole máss to a very brisk fire, on a gridiron of hard wood. The hardened paste is given the form of little cakes. When wanted for use it is reduced to a fine powder, and placed on a dish five or six inches wide. The Otomac holds this dish, which has a handle, in his right hand, while he inhales the *niopo* by the nose, through a forked tube of bird's bone. This bone,

[10] See, *Relation abrégée d'un voyage fait dans l'intérieur de l'Amérique méridionale*, etc. par. M. de la Condamine, in Mém. de l'Acad. Roy. des Sciences, Année 1745, p. 428. Paris, 1749.

[11] Gilii, F. S. Saggio de storia Americana, **1**: 201–202. 1780.

[12] Humboldt & Bonpland. Voyage aux regions équinoxiales, **2**: 620. 1819.

without which the Otomac believes he could not take this kind of snuff, is seven inches long: it appeared to me to be the leg-bone of a sort of plover.

A snuffing tube of the Otomac Indians, corresponding to this description of Humboldt and now in the Berlin Museum, is shown in the accompanying illustration, drawn by Mrs. R. E. Gamble after Max Uhle (fig. 2). Its form is closely similar to that of the polished wooden tubes of the Tainos of ancient Haiti, as described by Las Casas.

RUBBER SYRINGES OF THE OMAGUAS

De la Condamine, after describing the use of narcotic snuff by the Omagua Indians of the Marañon, tells of their peculiar use of syringes of rubber (*Cahuchu*). It was from these Indians, he says, that the Portuguese of the Pará learned to make rubber "pompes ou seringues" which do not require a piston.

> They have the form of hollow pears, pierced with a little hole at their end, in which a tube of wood is fitted . . . . This instrument is much used by the Omaguas. When they assemble together for some fête the master of the house does not fail to present one, as an act of courtesy, to each one of the guests, and its use always precedes, among them, the repasts of ceremony.[13]

Why such a peculiar custom should have become established among these Indians seems at first inexplicable; but the testimony of other travellers shows that similar practices exist, or did exist, among other tribes inhabiting the shores of tributaries of the Amazon; and that for these injections not water was used, but an extract of the same narcotic seeds as those from which snuff was made.

ACCOUNT OF SPIX AND MARTIUS

After describing the use of *paricá* snuff by the Mura Indians of the Rio Negro, Spix and Martius, in the narrative of their travels, tell of a custom of these people, during their strange annual assemblies which last eight days and are accompanied by all sorts of debauchery, of taking a decoction of *paricá* in the

[13] De la Condamine, in Mém. de l'Acad. Roy. des Sciences, Année 1745, pp. 430–431. 1749.

form of an enema: "Ein anderer Gebrauch des *Paricá* ist, einen Absud davon sich selbst als Klystier zu geben." Administered in this way, they say, the narcotic effect of the *paricá* is similar but weaker than when taken in the form of snuff. Commenting upon the custom, they continue:

> Man kann nicht umhin, durch diese viehische Lustbarkeit an die eckelhafte Sitte der Ostiaken und Kamtschadalen erinnert zu werden, welche sich bekanntlich durch den Genuss des Fliegelschwammes [*Amanita muscaria*] . . . . zu einer ähnlichen Wuth erhitzen.[14]

ROBERT SOUTHEY'S ACCOUNT OF PARICÁ SNUFF

The Mura Indians of the Rio Negro, instead of Y-shaped tubes, made use of tubes of another form, by means of which the men, in pairs, blew the snuff into each other's nostrils. The following description, published in 1819 by Robert Southey, was taken by him from the MS. of P. Joam Ribeiro:

> Some of the Rio Negro tribes have an extraordinary and tremendous ceremony, for which a large house is set apart in all their villages. It begins by a general flogging, the men in pairs scourging and lacerating one another with a thong, and a stone at the end: this continues eight days, during which the old women, who, among the American savages, officiate at most works of abomination, roast the fruit of the Parica tree, and reduce it to a fine powder. The parties who had been paired in the previous discipline are partners also in the following part, each in turn blowing this powder with great force through a hollow cane into the nostrils of his friend. They then commence drinking; and the effect of the drink and the deleterious powder is such, that most of them lose their senses for a time, and many lose their lives. The whole ceremony continues sixteen days: it is observed annually, and is called the feast of the Parica.[15]

IDENTITY OF TREES YIELDING SNUFF

In early descriptions of *cohoba* snuff of Hispaniola there is nothing to indicate the nature of the plant producing it. Oviedo, as we have seen, confused it with tobacco. On the other hand nearly all the descriptions of similar snuff used by South American Indians pointed to a mimosaceous tree bearing algaroba-like pods as its origin. Humboldt, as cited above, described the *yupa*, or *niopa*, as an Acacia; Spix and Martius, in the narrative

[14] SPIX UND MARTIUS. Reise in Brasilien, **3**: 1075. 1831.
[15] SOUTHEY, ROBERT. History of Brazil, **3**: 722–723. 1819.

of their travels, referred to the *paricá* tree as a species of Inga; specimens collected by Schomburgk were described by Bentham under the name *Mimosa (?) acacioides*; Lieutenant Herndon, U. S. Navy, in the report of his exploration of the valley of the Amazon (1853) called it *Acacia angico*. Finally Bentham made a careful study of all the botanical material he could lay his hands on, and came to the conclusion that all the South American trees above referred to as the source of narcotic snuff were probably one species, and were identical with Linnaeus' *Mimosa peregrina*, which was first described in 1737 from a seedling growing in the celebrated Clifford Garden in Holland. In studying the flowers of this tree Bentham came to the conclusion that it could be regarded neither as a true Mimosa nor as an Acacia, but that it must be placed in a closely related genus, which he called Piptadenia, and consequently, in accordance with the rules of priority, be called *Piptadenia peregrina*. In his synonymy he made no reference to the *cohoba* tree of Haiti and Porto Rico. In Martius's *Flora Brasiliensis* this and several very closely related species are set apart as a section of Piptadenia, called *Niopo*. It is quite possible that some other of these species, especially *Piptadenia macrocarpa* Benth., are also a source of narcotic snuff; and it is either this species or *P. peregrina* itself from which the Quichua Indians derived their intoxicating *huillca*, or *vilca*, with which, according to Acosta, they used to get gloriously drunk (*emborrachanse bravamente*).

SEBIL AND HUILLCA SNUFF OF ARGENTINA AND PERU

Still another very closely allied species of Piptadenia was described by Grisebach from specimens growing in the vicinity of Cordova, Argentina. A careful study of Grisebach's description inclines the writer to believe it possible that the plant in question, described by Grisebach first under the name *Acacia Cebil* and afterwards as *Piptadenia Cebil*, is a variety of *P. peregrina*, or of *P. macrocarpa*. Grisebach does not indicate the narcotic properties or indeed any uses of this plant, but in his first description he gives its vernacular name in Tucuman as *cebil*.[16] Of the

[16] See Grisebach, in Abhandl. der königl. Gesellsch. der Wissensch. zu Göttingen, **19**: 136. 1874; ibid., **24**: 121. 1879.

use of the fruit of this same tree for snuff we have an early account, written about the year 1583. In Pedro Sotelo Narvaez's *Relacion de las Provincias de Tucuman*, he says of the Indians living in the vicinity of Cordoba:

They do not make such great use of *azua* (fermented chicha) as the Indians of Peru. They take through the nostrils the *sebil*, which is a fruit like the *vilca*; this they pulverize and inhale through the nostrils (*hácenla polvos y bébenla por las narices*).[17]

Vilca, also written *huilca*, or *huillca*, described by certain writers as little beans (*frisolillos que llaman vilca*), remained unidentified until very recently, although, as cited above, it was mentioned at a very early date by Acosta as an intoxicant used by the Quichuas. Specimens were secured by Mr. O. F. Cook, of the U. S. Department of Agriculture, from an Indian drug-vender in southern Peru, in 1915. They were labeled *huillca*, and proved to be seeds of a Piptadenia, if not identical with *P. peregrina*, at least very closely allied to that species.

FIG. 3. Snuffing tube of llama bone from Tiahuanaco, Bolivia. Philadelphia Museum. After Uhle. Scale 1/3

Huillca, like *cohoba*, *ñopa*, and *cebil*, was snuffed up by means of tubes. Max Uhle obtained a remarkable snuff tube, in all probability used in the process by the ancient Quichuas, at Tiahuanaco, Bolivia, in June, 1895. This tube (fig. 3) is now in the Philadelphia Museum of Science and Art (No. 36095). It resembles closely a specimen, recently discovered in a burial cave at Machu Picchu by the Peruvian Expedition sent out under the auspices of Yale University and the National Geographical Society.[18] The fork of the snuffing tube is formed by the bifurcation of the distal end of the metatarsus or leg-bone, of a llama. The Tiahuanaco specimen, finished and ornamented by incised carving, has been slightly chipped at the lower end; the Machu Picchu specimen, in the first stages of manufacture, has a trans-

[17] Relaciones Geograficas, Peru, **2**: 152. 1885.

[18] See, EATON, GEORGE F., in Mem. Conn. Acad. Arts and Sciences, **5**: 58, *pl. 4, fig. 8.* May, 1916.

verse cut across the bifurcation; this in all probability was intended to be cut off, so that the ends might fit the nostrils.

The Tiahuanaco specimen is described at length by Max Uhle, who published a photographic illustration of it,[19] from which the figure here shown was drawn. Uhle believed that this tube was used for snuffing tobacco; but this I think doubtful. Humboldt, as already quoted, says that Piptadenia was commonly called "tree-tobacco," and the custom of snuffing its powdered seeds was common among many tribes inhabiting the banks of the tributaries of the great rivers of South America, which extended to the boundaries of Peru and Bolivia; and we have the definite statement that the snuff made from the seeds of *P. Cebil* was quite similar to the *vilca* (or *huillca*) of the Peruvians.

In the paper above cited, Uhle recognized that *cohoba* snuff and tobacco had been confused by various authors, and even suggests the possibility of the common origin of the names *cohoba* and *curupa*, but he says nothing of the actual presence of *Piptadenia peregrina*, the true "tree-tobacco," in Hispaniola. It was not until the writer consulted Urban's recent work on the flora of the Antilles that he found mention not only of the tree itself but of the ancient name by which it was known to the aborigines of Hispaniola.[20] Urban, however, gives no hint of its former use as a source of snuff, or of the narcotic properties of its seeds.

BOTANICAL DESCRIPTION OF COHOBA

Piptadenia peregrina (L.) Benth. Journ. Bot. Hook., **4:** 340. 1842.
Mimosa peregrina L. Sp. Pl., 1504. 1753. (*Mimosa inermis*, etc. Hort. Cliff. 209. 1737.)
Inga Niopo Willd. Sp. Pl., **4:** 1027. 1806.
Acacia peregrina Willd. Sp. Pl., **4:** 1073. 1806.
Acacia microphylla Willd. Sp. Pl., **4:** 1073. 1806.
Mimosa Niopo Poir. in Lam. Encycl. Suppl., **1:** 48. 1810.
Acacia Niopo Humb. & Bonpl., Relation Hist., **2:** 620–623. 1819; H. B. K., Nov. Gen. et Sp., **6:** 282. 1823; Kunth, Synop. Pl., **4:** 20. 1825.
Acacia angustiloba DC. Prodr., **2:** 470. 1825.
Mimosa (?) *acacioides* Benth. Journ. Bot. Hook., **2:** 132. 1840.
Piptadenia Niopo Spruce, Notes of a Botanist, **2:** 426. 1908.

[19] See, Bull. Mus. Science and Art, University of Pennsylvania, Vol. 1, No. 4. 1898.

[20] URBAN, I. Symbolae Antillanae, **4:** 269. 1905.

Piptadenia peregrina is a Mimosa-like shrub or a tree reaching the height of about 60 feet, with a trunk about 2 feet in diameter. The bark is often more or less muricated, but the branches and leaves are unarmed. The leaves are bipinnate, resembling those of many Acacias and Mimosas, with 15 to 30 pairs of pinnae and very numerous minute leaflets (30 to 80 pairs), these linear in shape and apiculate at the apex. On the petiole at some distance from the base there is a conspicuous oblong nectar-gland and on the rachis, between the last pair or last two or three pairs of pinnae, there is usually a minute gland, as in many of the Mimosaceae. The inflorescence is in the form of spherical heads of minute white flowers, borne on long slender peduncles in terminal or axillary racemose clusters. As seen under the lens the calyx and corolla are both 5-toothed, the former campanulate, the latter connate to the middle. The 10 stamens are free, much exserted, the anthers at anthesis bearing a minute stipitate gland. The ovary contains several to many ovules, and develops into a broadly linear, flat, leathery, or woody 2-valved legume, rough on the outer surface and thickened along the sutures, and resembling that of an Inga, but without pulp surrounding the seeds. The seeds are flattish and orbicular, greenish at first, at length black and glossy.

So far as the writer can ascertain, no figure of this species has hitherto been published. The accompanying illustration (fig. 1) is from a photograph of a specimen in the U. S. National Herbarium (No. 847320), collected on a hillside near Mayagüez, Porto Rico, in March, 1906, by John F. Cowell (No. 630).

GEOGRAPHICAL DISTRIBUTION

Piptadenia peregrina has a most appropriate specific name, for it has a wide geographical range. This has undoubtedly been increased by human agency. Various travellers have noticed it planted near villages, as well as growing spontaneously in the forests bordering the great rivers of South America. It was in all probability carried to Haiti and Porto Rico by the ancestors of the Tainos, whom Columbus found inhabiting those islands. Including with it the very closely allied *Piptadenia macrocarpa* Benth. and *P. Cebil* Griseb., its distribution may be roughly indicated as follows:

Haiti, or Hispaniola, where according to Ramon Pane and Las Casas, it was called *cohoba*, or *cogioba;* Porto Rico, where it is still called *cojoba* or *cojobo* (Urban), or *cojobana* (Cook and

Collins); Venezuela, where it is called *curuba, ñupa, ñopa, niopa, niopo* (Gumilla; Gilii; Humboldt); Northeastern Peru, on the Marañon, where it is called *curupa* (de la Condamine); Southern Peru, where it is called *vilca, villca, huillca* (Acosta; O. F. Cook); Argentina, where it is called *cebil,* or *sebil* (Grisebach; Sotelo Narvaez); Guiana, where two varieties are found, *paricá* and *black paricá* (Schomburgk); Brazil (many parts), where it is generally known as *paricá* (Spix and Martius; Lieutenant Herndon; Spruce).

CHEMICAL PROPERTIES AND PHYSIOLOGICAL ACTION

The most remarkable fact connected with this narcotic is that its chemical properties are still unknown. An exhaustive search through literature, in a vain attempt to find something bearing upon the subject, indicates that it has never been studied chemically or therapeutically. The only authority who mentions it is Dragendorff, who dismisses it with the statement: "Der Same zu Schnupftabak (Niopo, Nupa), der stark aufregen soll, verwendet." No authority is quoted, except for the botanical name and its synonyms. This may have been in consequence of the remark Humboldt made in connection with the snuff:

> La famille des Légumineuses varie singulièrement dans les propriétés chimiques et médicales de ses graines, de ses sucs et de ses racines; et quoique le suc du fruit du *Mimosa nilotica* soit très-astringent, on ne peut croire que ce soit principalement la silique de l'*Acacia Niopo* qui donne la force excitante au tabac des Otomaques. Cette force est due à la chaux fraîchement calcinée.'[21]

That Humboldt was mistaken is indicated by Spruce's observations. Moreover it is not so strange, as Humboldt would indicate, that the seeds of certain Leguminosae have narcotic properties. The red seeds of *Sophora secundiflora* of Texas and northern Mexico are very narcotic and are still used by certain Indian tribes to cause intoxication. They are used in certain secret ceremonies by the "Red Bean Society" of the Iowa Indians, which takes its name from them. Spruce witnessed the preparation of *ñopa* snuff without the addition of lime, in June, 1854, by a party of Guahibo Indians from the Rio Meta, temporarily

[21] Humboldt & Bonpland. Voyage aux regions équinoxiales, **2**: 621. 1819.

encamped near the cataracts of the Orinoco. In his account of it he says: "In the modern *niopo*, as I saw it prepared by the Guahibos themselves, there is no admixture of quicklime, and that is the sole difference [from the method of its preparation described by Humboldt]." He describes the process of roasting and powdering the seeds, and the snuff-tube made of the leg bones of birds, shaped somewhat like a tuning fork, with the forked ends tipped with small black knobs (the endosperms of a palm). This instrument, which he secured and deposited in the Museum of Vegetable Products at Kew, is almost identical in form with that of the Otomac Indians in the Berlin Museum (fig. 2), and also very much like the one used in ancient Haiti, so accurately described by Las Casas and incorrectly figured by Oviedo.

SUMMARY

Cohoba, a narcotic snuff which the aboriginal inhabitants of Haiti took by means of a bifurcated tube, has hitherto been regarded by most writers as a form of tobacco. It was, however, prepared from the seeds of a Mimosa-like tree, *Piptadenia peregrina*. This tree is widely spread in South America, and by several tribes of Indians its seeds are used, or have been used until recently, as a source of snuff, the effects of which are highly intoxicating. Among several of these tribes the snuffing tubes are bifurcated and very similar to those of the ancient Haitians. The source of the snuff on the island of Haiti has remained unknown for so long a time on account of the early annihilation of the aborigines and their replacement by Africans, who did not adopt the habit of snuffing. The most remarkable fact connected with *Piptadenia peregrina*, or "tree-tobacco," is that, though its fruit has been reported by many explorers and botanists as highly narcotic, it has never been studied chemically or therapeutically, and the source of its intoxicating properties still remains unknown. Abundant material may be obtained from the island of Porto Rico, where the tree is common, and it is hoped that a careful study may be made of the seeds, the peculiar properties of which were noticed in the very first work which treated of the ethnology of the New World.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Wheatstone bridges and accessory apparatus for resistance thermometry.* E. F. Mueller. Bureau of Standards Scientific Paper No. 288 (Bull. Bur. Stds., **13**: 547). 1916.

A type of Wheatstone bridge, suitable for use in resistance thermometry, has been developed, in which plugs or dial switches are used, and the circuits so arranged that the errors due to contact resistances are no greater than with the mercury contact bridges heretofore used. With a comparatively simple and inexpensive type of apparatus it has been possible to attain the high degree of precision and accuracy demanded in modern work with resistance thermometers.

A method of measuring potential terminal resistances by the Wheatstone bridge method is also given, and the necessary accessory apparatus for this purpose is described. E. F. M.

PHYSICS.—*The damping of waves and other disturbances in mercury.* M. H. Stillman. Bureau of Standards Scientific Paper No. 289 (Bull. Bur. Stds., Vol. 13). 1916.

In instruments involving the use of mercury, the waves and other disturbances, produced by the unsteadiness of the containing vessel, are a frequent source of trouble. If the mass of mercury be subjected to a strong magnetic field, the direction of the field being approximately at right angles to the direction of motion of the mercury, these motions will be strongly damped.

The substitution of a non-magnetic metallic container for a glass container greatly increases the magnitude of the damping.

It is suggested that this method might sometimes be used when it is desired to obtain accurate adjustments of mercury surfaces at sea and in other places where unsteadiness of the mercury container is unavoidable. M. H. S.

GEOLOGY.—*The flora of the Fox Hills sandstone.* F. H. Knowlton. U. S. Geological Survey Professional Paper 98–H. Pp. 8, with one illustration. 1916.

The known flora of the Fox Hill sandstone includes only thirteen forms. Of these it appears that only four of the species have been previously known, the remainder being new to science or so fragmentary as not to merit specific designation. This little Fox Hills flora shows distinctly Upper Cretaceous affinities, being, as might be presumed from its stratigraphic position, intermediate between the older floras of the Montana group and the younger flora of the overlying Laramie, but having a preponderance in its resemblances to the Montana. Ecologically this flora appears to indicate a much more abundant supply of moisture than now exists in the region, though this should naturally follow from the fact that it must have been growing near the sea and not far above sea level. The meager data appear to indicate a warm-temperate climate. Descriptions of the species are given together with illustrations. R. W. S.

GEOLOGY.—*The fauna of the Chapman sandstone of Maine, including descriptions of some related species from the Moose River sandstone.* H. S. Williams, assisted by C. L. Breger. U. S. Geological Survey Professional Paper 89. Pp. 347, 27 plates, 3 figs. 1916.

The Chapman sandstone is exposed over a small area in Chapman Township, Aroostook County, Maine. It includes at least 500 feet of medium, fine grained, brown to gray sandstone, much of it thick bedded, with some fine grained shaly layers separating the beds. In these shaly sandstones occur most of the fossils which are marine. Here and there fragments of plants appear in the sandstone. In the supposedly overlying Mapleton sandstones only plant fossils have been discovered. A detailed study of the fauna described in this volume demonstrates its general affinity with the later phase of the American Helderbergian fauna. Several species from the Moose River sandstones are mentioned and figured, from which it is evident that this Moose River sandstone is roughly equivalent to the Oriskany sandstone of New York and the York River of Gaspe Peninsula. The evidence is clear that the Chapman forms, closely related to the Moose River species, are earlier representatives of the evolutional lines to which they belong than the Moose River forms. This report contains, besides the detailed descriptions of many genera, 27 plates depicting hundreds of fossils. R. W. S.

GEOLOGY.—*Revision of the Beckwith and Bear River formations of southeastern Idaho.* G. R. MANSFIELD and P. V. ROUNDY. U. S. Geological Survey Professional Paper 98–G. Pp. 9, with illustrations. 1916.

It has been found necessary to apply new names to strata hitherto referred to the Beckwith and Bear River formations or to portions of the Laramie as mapped by the Hayden Survey. The formations discussed extend from the northeastern part of the Montpelier quadrangle northward through the eastern part of the Wayan quadrangle and thence northward an undetermined distance, possibly including a considerable part of the Caribou Range. They include about 17,000 feet of strata, unless there are unrecognized repetitions by folding or faulting. The strata in this area that were formerly called the Bear River are here assigned to the Wayan formation, of Cretaceous, possibly Lower Cretaceous, age, and the so-called Beckwith is divided into seven formations, of which the lower two are marine formations of Jurassic age, and the remaining five are nonmarine formations assigned to the Ganett group, of Cretaceous (?) age. This paper gives a statement of the stratigraphic problems involved and a description of the formations.

R. W. S.

GEOLOGY.—*The Yukon-Koyukuk region, Alaska.* H. M. EAKIN. U. S. Geological Survey Bulletin 631. Pp. 85, with maps, sections, and view. 1916.

The Yukon-Koyukuk region lies in central Alaska and is drained by the two rivers from which it takes its name. Most of its relief is low, but locally there are northeasterly trending mountain ranges (5000–6000 feet). The predominant type of topography consists of rolling, maturely dissected uplands of moderate relief broken by extensive lowlands. The timber is chiefly spruce and birch, and timber line is at an altitude of about 2000 feet. Meadows of luxuriant growths of grass break the timbered areas.

The bed rock consists of metamorphic sediments (Paleozoic or older), greenstones (Post Devonian?), and more extensive areas of conglomerates, sandstones and shales probably chiefly of Upper Cretaceous age. Two epochs of granitic intrusion are recognized. The older granites cut the metamorphic series and are more or less altered while the younger granite is intruded into the Cretaceous and is in most places entirely massive. There is some auriferous mineralization along the margins of the younger intrusive masses. The Quaternary is represented by the alluvium of the lowlands and valleys, by high gravel and silt terraces, and in the higher mountains by local glacial deposits. The metamorphic series is intensely deformed and the Cretaceous strata also exhibit complex structures.

There is clear evidence that very extensive changes of drainage have taken place during Quaternary times. This is believed to have been due to the advance of glaciers from the mountains which bound the central Yukon region. The terraces are believed to have been formed in lakes caused by ice damming. A. H. B.

GEOLOGY.—*Natural gas resources of parts of North Texas.* E. W. Shaw, et al. U. S. Geological Survey Bulletin 629. Pp. 129, with maps, sections and illustrations. 1916.

The examination on which this report is based was instigated by the citizens of Dallas and Fort Worth, for the purpose of getting information as to the sufficiency and the prospective duration of the gas reserves within reach of these cities. The two reports contained in this volume describe not only the geology of several gas fields but also discuss the original quantity of the gas, the present capacity and the probable life of the fields. Areas that are worthy of prospecting with the drill are pointed out and it is concluded that the Petrolia field from which the present supply is being drawn would last the cities only 3 or 4 years. The other known pools of Texas being small it becomes necessary either to discover new gas pools or to lay pipe lines to those of Oklahoma. E. W. S.

GEOLOGY.—*Petroleum withdrawals and restorations affecting the public domain.* Max W. Ball. U. S. Geological Survey Bulletin 623. Pp. 427, with 9 maps. 1916.

This bulletin contains true and accurate copies of orders of withdrawal, restoration, modification and classification and of the more important correspondence leading to changes of policy regarding these; an index to the orders, township by township; a short statement of the purpose of the withdrawal policy; and a brief review of the history of oil withdrawals. In addition, it includes a chapter on oil-land law, giving the statues and decisions, judicial and departmental, which may be of most interest to the oil operator on the public domain. It is accompanied by maps showing the areas withdrawn in each state—Arizona, California, Colorado, Louisiana, Montana, North Dakota, Utah, and Wyoming—where oil withdrawals were outstanding January 15, 1916). R. W. S.

GEOLOGY.—*The physical conditions indicated by the flora of the Calvert formation.* E. W. BERRY. U. S. Geological Survey Professional Paper 98-F. Pp. 12, with illustrations. 1916.

This paper gives a summary of the small flora preserved in the Miocene diatomaceous beds of the Calvert formation in the District of Columbia and Virginia, and discusses its bearing on the physical conditions of the Calvert epoch. It is concluded that the Calvert flora was coastal flora of strikingly warm-temperate affinities, comparable with the existing coastal floras of South Carolina and Georgia, or with those along the coast of the Gulf of Mexico from western Florida to eastern Texas. The climate of the Chesapeake Miocene epoch,cooler undoubtedly than that of the Apalachicola or preceding epochs, was neither cold nor cool-temperate. The age indicated by the Calvert flora is middle Miocene. R. W. S.

GEOLOGY.—*Antimony deposits of Alaska.* ALFRED H. BROOKS. U. S. Geological Survey Bulletin 649, Pp. 64, with maps. 1916.

Stibnite is widely distributed in Alaska having been found in 67 localities. In many of these it occurs simply as an accessory mineral, but lodes have been found in the Fairbanks, Kantishna, Innoko, Iditarod, Nizina, and Port Wells districts and on the Kenai and Seward peninsulas in which stibnite forms the principal metallic mineral.

The country rock of the stibnite lodes is sedimentary as a rule, but differs greatly both as to age and lithology in the different districts. Some deposits have been found in highly metamorphosed schists of pre-Cambrian age. Others are found in little-altered clastics, as young as Upper Cretaceous. Practically all the antimony lodes occur in association with granular acidic intrusive rocks, among which the dominating lithologic types have been described as quartz diorite and monzonites.

The Alaska antimony deposits may be classed in three principal groups—siliceous gold-bearing stibnite lodes, stibnite-cinnabar lodes, and stibnite-galena lodes. Of these the first two can be further divided according to structure as fissure veins, shear-zone deposits, and stockworks.

The evidence at hand indicates that most of the stibnite deposits were formed at a later time than the widespread epoch of Mesozoic mineralization to which so many of the gold deposits have been assigned. Formerly it was generally believed that nearly all the metalliferous deposits of Alaska were associated with Mesozoic intrusives. It is only in recent years since the metalliferous deposits of the lower Yukon and Kuskokwim regions have been studied that the importance of the Tertiary period of mineralization has been recognized. Localities in this general province as widely separated as the lower Kuskokwim and northern British Columbia are now known to have been mineralized in Tertiary time, but between these localities there are mining districts in which the metallization is of Mesozoic age. Thus there seems to be here an overlapping of the two metallogenetic provinces. Like the Mesozoic mineralization, that of Tertiary age is genetically connected with granular acidic intrusive rocks, but the later intrusives seem to have been less widely distributed than the earlier.

It should be noted that though mineralization accompanied the Tertiary intrusives, no metalliferous lodes have been found in the Tertiary sediments. It appears that the conditions for the formation of the metalliferous veins necessitated a deeper cover than that furnished by these beds. A. H. B.

ENGINEERING.—*Surface water supply of the United States, 1914. Part III. Ohio River Basin.* Nathan C. Grover, et al. U. S. Geological Survey Water-Supply Paper 383. Pp. 121, with two illustrations. 1916.

This volume is one of a series of reports presenting results of measurements of flow made on streams in the Ohio River Basin during the year ending September 30, 1914. It includes also a list of the stream gaging stations and publications relating to water resources in this Basin. O. E. M.

TECHNOLOGY.—*The correlation of the mechanical and magnetic properties of steel.* Chas. W. Burrows. Bureau of Standards Scientific Paper No. 272, pp. 173–210. 1916.

This paper is a review of the work done in correlating the magnetic and mechanical properties of steel with special reference to the commercial application of the magnetic data as criteria of the mechanical fitness of a given steel and of magnetic changes under stress as indications of the state of strain. C. W. B.

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PHYSICS.—*The theory of the stiffness of elastic systems.*[1] By M. D. Hersey, Bureau of Standards. (Communicated by Louis A. Fischer.)

Introduction. The stiffness of a body, or of a system of bodies, we define as the ratio of the force[2] applied to the deflection produced. It is not, of course, an intrinsic property of the body or system itself, but depends also on the manner of applying the force, and on the point whose displacement is to be observed. The stiffness of a body under given conditions is, however, its most important elastic property. The conception is useful in dealing with the vibrations of structures; the yielding of the supports of instruments; the design of aneroid barometers, pressure gages, torsion meters,[2] etc.; and with springs wherever they occur. But the tendency in elasticity, as in other branches of physics today, appears to be to desert the obvious and to court the remote. Instead of treating stiffness directly, writers on elasticity make a detour, first determining the strain distribution throughout the interior of the body; a procedure which, besides being laborious, limits the validity of the result to certain rather simple geometrical shapes. This detailed analysis is indispensable for some purposes but not for all, as the theorems presented in this paper will show. All of these theorems have

[1] This work was done at the Jefferson Physical Laboratory, Harvard University. It is expected that it will be published in more detail upon the completion of a series of experiments on the subject recently begun at the Bureau of Standards.

[2] The reader interested in galvanometer suspensions or other torsion problems can readily modify the formulas of the present paper so as to make them apply to couples instead of to translational forces.

applications to the aneroid barometer, which will be treated elsewhere, but their applicability is not confined to that particular elastic system.

The stiffness of coupled systems.[3] Having given the individual stiffness s_a and s_b of two systems A and B (ordinarily but not necessarily single bodies) which are coupled together, let it be required to find the stiffness, S, of the coupled system. It is understood that s_a and s_b refer to forces and displacements at the coupling, while S refers to a displacement at the coupling, but to a force applied anywhere. The desired general relation is found to be[4]

$$S = \lambda(s_a + s_b) \qquad (1)$$

where λ is a dimensionless characteristic of the component to which the external force is applied, and denotes the ratio of its stiffness with respect to that force, to its stiffness (s_a or s_b) with respect to a force at the coupling. If the external force is itself applied at the coupling, $\lambda = 1$, and the stiffness of the coupled system equals the sum of the stiffnesses of the components. This can be shown by a simple experiment. Make a rigid frame about a foot square and cut off two five-inch lengths of the same helical spring. Fasten the two springs, respectively, each by one end, to two opposite sides of the frame, in

[3] In treating coupled systems, the displacements are assumed small. This restriction does not apply to the subsequent discussion of a single body.

[4] Let x be the displacement of a reference mark at the fraction r of the distance along the coupling piece from A toward B, while x_a and x_b are the respective displacements necessary for coupling the two members, t being the tension in the coupling, and F the particular external force, applied to A, with respect to which we seek the stiffness of the coupled system, S. Then, by definition, $S = \frac{F}{x}$, while the conditions of equilibrium and constraint are expressed by the four equations

$$x = (1-r)\, x_a - r x_b \qquad\qquad x_a + x_b = \text{constant}$$

$$x_a = \frac{F}{\lambda s_a} + \frac{t}{s_a} + \text{const.} \qquad\qquad x_b = \frac{t}{s_b} + \text{const.}$$

in which the forces and displacements are interpreted vectorially. Eliminating the three quantities x_a, x_b, and t gives

$$F = \lambda(s_a + s_b)x + K$$

in which K denotes a term involving r, s_a, and s_b, but obviously vanishing if the system is so adjusted that $x = 0$ when $F = 0$. Dividing through by x now gives the result (1).

such a way that the springs fail to meet by about an inch. Holding the frame vertical, hang a weight to the free end of the upper spring, and note the deflection. Then couple the two springs together. The same weight will now cause but half that deflection. The experiment can readily be extended to show the effect of using springs of unequal stiffnesses, or of weights hung not at the coupling.

Influence of temperature and elastic after-effect on coupled systems.[5] Differentiating (1) gives for the fractional change in the stiffness of the coupled system, in terms of the fractional changes in the stiffnesses of the components, due to any cause whatever,

$$\frac{dS}{S} = \eta \frac{ds_a}{s_a} + (1 - \eta) \frac{ds_b}{s_b} \tag{2}$$

in which the dimensionless characteristic η denotes $\dfrac{s_a}{s_a + s_b}$, and depends evidently on the two components but not on λ, and, therefore, not on the manner of applying the external force. The changes ds_a and ds_b may equally well be interpreted as temperature effects, or elastic after-effects. In either case (2) shows that the relative contributions of the two components are fixed by the single factor η and are proportional to the respective stiffnesses. We therefore pass to the consideration of the stiffness of a single body.

General expression for the stiffness of a body. The treatment of non-homogeneous or anisotropic bodies will be simplified by the conception of *generalized shape.* Two bodies may be said to have the same generalized shape when not simply linear magnitudes, but all physical quantities associated with points in the bodies, are similarly distributed in the two bodies; that is, distributed so that the ratio of the two magnitudes of any one such quantity is the same at all pairs of corresponding points. Thus two pieces of rolled sheet metal of different sizes and materials have the same generalized shape if they have been cut out to the same geometrical shape, similarly oriented with respect to the direction of rolling, and if the rolling has pro-

[5] The displacement due to temperature or to elastic after-effect at constant load is assumed so small that, in differentiating (1), λ may be regarded as constant.

duced in each case the same relative variation of elastic constants over the cross section. When any elastic constant of a series of bodies is represented by a single symbol, it is to be understood that this refers to its mean value, or to its value at a particular point and in a particular direction, and that all bodies in the series are of the same generalized shape. Finally, if the bodies in such a series, although not violating Hooke's law at any point within the material, are so greatly deformed that there is no longer a direct proportionality between load and deflection, it is to be understood that the bodies remain geometrically similar to each other while being deformed.

With this understanding, it may be shown by dimensional reasoning that the stiffness of any of a series of perfectly elastic bodies of different sizes or materials but of the same generalized shape is given by

$$S = LE \cdot \phi(\sigma) = L\mu \cdot \psi(\sigma) = L \cdot f(E,\mu) \tag{3}$$

in which L denotes any chosen linear dimension, E Young's modulus, μ the rigidity (i.e., shear modulus) and σ Poisson's ratio. The functions ϕ, ψ, and f are to be found, if they need to be known at all, by detailed calculations employing the conventional theory of elasticity, or by model experiments.

Thus to find φ (σ) we need only plot observed values of $\frac{S}{LE}$ against known values of σ for a series of models of the same generalized shape, but having any convenient values of L, E, and σ covering the desired range along the σ scale. In practice, the method of model experiments will be limited by the difficulty of procuring materials, which, if intended to be isotropic, are sufficiently so; or which, if intended to be anisotropic, are sufficiently similar in internal structure sensibly to satisfy the requirement of having the same generalized shape.

The change in stiffness with temperature, and criteria for compensation. Differentiating (3) gives, for the fractional change in stiffness with temperature, θ,

$$\frac{1}{S}\frac{dS}{d\theta} = A\alpha + B\beta + \gamma \tag{4}$$

in which

The condition (10) for compensation therefore reduces to $\frac{\beta}{\alpha} = 1.7.$

When β/α exceeds that value, and if, as usual, both α and β are negative, we are led to the paradoxical conclusion that the disc will become stiffer when heated. Nor can the paradox be avoided by supposing that no such materials will be found or that α and β depend on the state of stress—both of which possibilities may in themselves be true—for the variable θ in the differentiation was in fact arbitrary, so that we may restate the conclusion thus: Of two discs having the same Young's modulus, that with the less rigidity is the stiffer.

Note on the proposed experiments. The experiments referred to in footnote (1) have as their ultimate object the development of formulas for the stiffness of corrugated diaphragms. In the course of the experiments it is proposed to determine anew α and β for a series of materials, and thus to test directly the above paradox. A preliminary group of experiments on flat circular discs, conducted at the Bureau of Standards in July with the assistance of H. B. Henrickson, and in which both the increase in hysteresis and the decrease in stiffness with rising temperature were observed, led to the following progression of materials when arranged in descending order of magnitude of the latter effect: soft sheet iron, tempered steel, phosphor-bronze, zinc, aluminum, copper, brass, and German silver. The value of $\frac{1}{S}\frac{dS}{d\theta}$ was about -6 per cent per degree C. for the iron disc, and for German silver it was 0 at small deflections and just perceptibly positive at large deflections; intermediate, but very small and nearly equal, values were found for the intervening materials.

PHYSIOLOGY.—*The importance of vitamines in relation to nutrition in health and disease.*[1] CARL VOEGTLIN, Professor of Pharmacology, United States Public Health Service.

The purpose of my lecture is to give you a brief outline of the most recent phase of the science of nutrition; namely, the impor-

[1] A lecture delivered before the Washington Academy of Sciences, April 28, 1916.

tance of the presence in the diet of man of small quantities of substances essential for the maintenance of health. Until very recently physiology taught that the human diet should meet the following requirements: (1) It should contain an adequate amount of protein, fat, carbohydrate, and inorganic salts; and (2) the daily ration should conform to certain definite requirements in regard to its caloric or fuel value. Once these requirements were met the diet was considered as being physiologically satisfactory.

However, a number of unexplained facts did speak in favor of the assumption that the human diet should also contain some other substances, so-called accessory dietary constituents. For instance, it has been known for some time that scurvy is a disease which occurs in man and certain higher animals when the diet does not contain fresh vegetables or animal foods. Epidemics of scurvy broke out on sailing vessels when the crew was forced to live for several months on such food as canned beef and dried cereals to the complete exclusion of food in the fresh state. During the siege of Paris in the year 1871 part of the population was also deprived of fresh food and an epidemic of scurvy appeared. Scurvy was apparently due to the lack of fresh food in the diet. This conception of the cause of scurvy is supported by the fact that a corresponding change of diet and especially the administration of fresh milk or lemon juice leads to a rapid recovery of most cases affected by this disease. Hence, we might conclude that there exist in fresh food some substances which are essential for the prevention of scurvy. These substances may be designated as *antiscorbutic substances*. As stated previously, they have no direct relation to the other known dietary constituents such as the proteins, carbohydrates, fats, and salts. The chemical composition of the antiscorbutic substance is still unknown, although numerous fruitless attempts aiming at its isolation have been made. All we know about this substance is that it is fairly stable in acid media. This is probably the reason why lemon juice with its high acidity is the classical preparation used in the prevention and treatment of scurvy. For the same reason fresh milk, having a neutral reaction, on being exposed for a considerable length of time to a temperature exceeding 100°C. loses its antiscorbutic properties and when forming the exclusive diet of children may give rise to infantile scurvy, or Barlow's disease.

Another interesting disease which has been shown to be caused by a diet deficient in the above sense is beri-beri. This disease, being especially prevalent in eastern countries, as Japan and the Philippines, is a disease of the nervous system, and appears in people having lived for several months on a diet which consisted mainly of highly milled (white) rice or wheat. It is interesting to note that this disease is not so apt to appear if the rice forming the diet is not deprived of its outer layers, including the so-called aleurone. Evidently the whole rice grain meets all the requirements of a diet for the prevention of beri-beri. Although beri-beri was known to occur for centuries in the East, many students of this disease were struck by the intimate relation which seemed to exist between the prevalence of the disease and the introduction of highly milled (white) rice. In prisons where the highly polished rice was substituted in the diet of the inmates for the rice of lower milling, epidemics of beri-beri seemed to follow this dietary change. Time does not permit me to go into further detail concerning the many interesting observations which were made in the study of the dietary peculiarities of this disease. It may suffice to say that Eykman, a Dutch investigator, by accident discovered in 1897 that chickens fed exclusively on white rice developed within three to four weeks a disease which he considered as practically identical with human beri-beri. This discovery marked the beginning of the epoch of the systematic study of this disease, and opened up a new field for nutritional studies. By means of chickens or pigeons which had developed symptoms of experimental beri-beri it was possible to test the therapeutic value of food extracts of assumably prophylactic and curative properties. Thus it was soon found that extracts made from rice polishings representing the outer portions of the rice kernel brought about a cure of birds affected with the disease. Efficient extracts were also prepared from beans, brewers' yeast, and many other raw products. These same extracts were also shown to have some curative value in cases of human beri-beri.

Before entering into the question of the chemical isolation of these curative substances, I should like to call attention to the work of some American investigators which furnished additional evidence as to the importance of some accessory food constituents essential for normal growth. McCollum, Osborne, and Mendel found that a diet of purified protein, fat, carbohydrates, and mineral salts was inadequate for the maintenance of the normal growth of young rats. These discoveries were in contradiction to the previously held conceptions of growth. The diet of these rats was in every respect balanced from the point of view of its content of protein, carbohydrate, fats, and salts, yet normal growth was not observed in rats fed exclusively on this artificial diet. There was obviously something lacking in this diet, which was essential for normal growth.

CHEMICAL ISOLATION OF VITAMINES

Having definitely established the presence in certain foods of unknown accessory food components, it became a matter of considerable importance to determine their chemical nature and physiological action. An enormous amount of energy and time on the part of investigators interested in this question was necessary to obtain our present knowledge of these substances. Preliminary experiments showed that the antiscorbutic and antineuritic substances[2] could be extracted from certain foods by means of water. The antineuritic substances were also found to be soluble in alcohol. By submitting these primary extracts to further chemical purification various workers succeeded in preparing fractions which seemed to be fairly pure and possessed high curative properties. We are especially indebted for this pioneer work to Funk and Suzuki and their collaborators. Funk, in 1912, succeeded in devising a method which led to a product

[2] Antineuritic substances prevent beri-beri and polyneuritis in birds.

of high physiological activity. Two to three milligrams of this substance (that is to say, an exceedingly minute amount) produced a cure of completely paralyzed pigeons sometimes within two to three hours. This substance was obtained in crystalline form, being composed of small needles. The substance seemed to have a definite melting point (233°), and on analysis contained carbon, hydrogen, nitrogen, and oxygen. The properties of the substance in regard to its behavior toward various precipitating agents seemed to warrant the conclusion that it was an organic base; this led Funk to designate this substance as *vitamine,* from *vita* (life) and *amine,* meaning that this substance was an amine essential for life. It is true enough that Funk did not have sufficient evidence to prove that the substance was an amine in the chemical sense, nor did he know whether or not other accessory food substances belonged in the same chemical group. However, he applied the term vitamines to the substances preventing beri-beri and scurvy. These diseases were called *deficiency diseases* or avitaminoses, meaning that the diet which gives rise to these diseases is deficient in certain vitamines. I fully realize the objection which might be, and has been, raised to the use of the term vitamine; at the same time we may, for the present at least, accept this designation, as it is brief and undoubtedly has some truth in it, as these substances are essential for normal life.

The work of Funk and Suzuki has been repeated and somewhat elaborated during the last three years by a number of other investigators. The main difficulty which presented itself in the study of these substances was the fact that with the available methods only small amounts of the relatively pure substances could be obtained from hundreds of pounds of the most suitable raw material, such as yeast and rice polishings. Realizing this difficulty, work was started over a year ago at the Hygienic Laboratory, and somewhat later at the Pellagra Hospital of the U. S. Public Health Service, in search of improved methods for the isolation of vitamines. I am glad to say that the work resulted fairly successfully, although it is by no means completed. For each raw product it seems necessary to make some modification in the method, in order to obtain the maximum yield. Thus, Dr. Seidell succeeded in removing practically all of the antineuritic vitamine from an active solution of autolyzed yeast filtrate by means of a special preparation of kaolin, or fullers' earth. It was found that the so-called Lloyd's reagent (hydrous aluminium silicate) removes the vitamine from autolyzed brewers' yeast. We must assume that this reaction is based on adsorption, a view which will be referred to later. Vedder and Williams had previously shown that animal charcoal will also remove the antineuritic vitamine from an extract of rice polishings. Furthermore, Funk had observed that kaolin removed the antiscorbutic vitamine from cow's milk. We were able to show quite recently that mastic, a resin, also removes the antineuritic vitamine from an autolyzed yeast solution. Dr. Seidell demonstrated that his preparation of vitamine was fairly stable and inasmuch as it is very easily prepared and at low cost this preparation may be expected to be of value in the treatment of certain deficiency diseases. The preparation is being tested clinically at present. The work along this line at the Pellagra Hospital has also yielded encouraging results. Dr. Sullivan and myself have succeeded in modifying Funk's method in such a way as to give a much better yield and a fairly stable preparation.

I now shall call your attention to some other results obtained by Williams, of the Bureau of Chemistry. Williams prepared some oxypyridines, and on testing these substances on pigeons found that they effected a temporary cure in doses of about 1 mg. This is a most interesting observation. Suzuki and also Funk had previously isolated nicotinic acid from the crude vitamine fraction of rice polishings and yeast. Funk had expressed the opinion that nicotinic acid may be part of the vitamine molecule. It is, therefore, very important that Williams should have discovered the antineuritic properties of some pyridine derivatives, especially as nicotinic acid is also a pyridine derivative. This latter substance, however, has no curative action. Whatever may be the final solution of the chemical constitution of this vitamine, whether the synthetic product has any chemical relation to the natural vitamine or not, the work just referred to is certainly exceedingly interesting.

CHEMICAL PROPERTIES OF VITAMINES

At present relatively little is known regarding the chemical and physiological properties of vitamines. Some facts, however, have been established. The antineuritic vitamine, for instance, is present in the natural foods, largely in a combined form which is soluble in 90 per cent alcohol, or water. This mother substance can be split into the physiologically highly active substance by acid hydrolysis or autolysis by means of enzymes. Very little is known as to the chemical nature of the mother substance of this beri-beri vitamine. The observations that foods rich in lipoids are also rich in vitamines and the solubility of the mother substance in alcohol might lead to the belief that vitamines enter into the molecule of certain lipoids, an assumption which recent experiments by Sullivan and myself have made highly improbable. The antineuritic substance is probably not in combination with carbohydrates, as the starchy part of cereals seems to be extremely poor in this substance. The probability that certain parts of the protein molecule (nucleic acid) may hold in combination the active substance is still open for consideration.

A fact of fundamental importance is that *vitamines are fairly susceptible to temperatures above 100°C.* A large number of observations made on man and experimental animals show that the prolonged heating of most of the natural foods to a temperature of 120° for one to three hours will destroy most of the physiological activity of the vitamines originally present in these foods. Beef which is submitted to such treatment is found to lead to symptoms of scurvy in man, if forming the exclusive diet together with other food deficient in vitamines.

The vitamines which prevent scurvy and beri-beri seem to be fairly resistant to strong acids. As a matter of fact certain acids seem to prevent the deterioration of vitamines. On the other hand, strong alkalies under certain conditions seem to destroy the physiological activity of vitamines; at least, at higher temperature. The behavior of vitamines to acids and alkalies is of great importance from a dietary point of view, as we shall see later.

In closing this chapter I should like to raise one more question, namely: Do vitamines occur in colloidal form? Although this question is of a highly technical nature, I do not feel that I can omit giving it some consideration. I have already stated that certain adsorbing agents, such as charcoal, kaolin, and mastic, remove the vitamines from autolyzed yeast solutions, as well as milk. Now we know that these reagents remove substances by means of adsorption, a physico-chemical process characterized by a particular property of the surface of some finely divided substances to condense on it other substances of a similar nature. In order that such a condensation can take place, the adsorbing as well as the adsorbed substance must be in the colloidal state. We have, therefore, good reason to assume that vitamines may occur in the colloidal state. If this should be proven beyond doubt by future investigations, it certainly would help in explaining the remarkable physiological action of vitamines.

PHYSIOLOGICAL ACTION OF VITAMINES

As to the physiological action of vitamines, but very little is known at the present time. Of course, we can easily demonstrate the relief of the paralytic symptoms of polyneuritis in birds by means of vitamines, but we know very little as to the physiological mechanism by which the symptoms are removed. Anybody who has ever observed the effect of an active preparation of vitamine on a completely paralyzed pigeon must be impressed by the marvelous action of these preparations. The animals may look as if on the verge of death, exhibiting a complete paralysis of the voluntary muscles, accompanied with a deep and abnormally slow respiration and a weakened heart action, yet the injection of a few milligrams of active substance will change the picture often completely within three hours. At the end of this time the bird may be seen walking about normally, and greedily eating the food which he had refused before the treatment was initiated. To the pharmacologist the clinical picture appears to possess all of the earmarks of an intoxication. The rapid recovery might be considered as an antagonistic action of the vitamine to some toxic product contained in the tissues of the animal. This leads me to mention a very striking relation that exists between the beri-beri vitamine (antineuritic) and carbohydrate metabolism. Funk, and Braddon and Cooper observed that for each gram of carbohydrate in the diet there must also be present a certain minimal quantity of vitamine, in order to prevent the occurrence of experimental beri-beri in pigeons. If the carbohydrate or starchy component of the diet is increased, the vitamine content must be increased accordingly. This explains some of the earlier observations that a diet rich in carbohydrates is more apt to give rise to the appearance of beri-beri in man. It is possible that in the absence of a sufficient vitamine content of the body the intermediate products of carbohydrate metabolism may exert a toxic action of some kind which is antagonized by the administration of a sufficient amount of vitamine. So far the natural vitamines were shown to be devoid of any toxic action, if given in moderate doses.

It is of prime importance to state here that *the animal body is not capable of manufacturing the known vitamines from vitamine-free food.* All of the higher animals, including men, receive their vitamine supply directly or indirectly from plants. It is the plant that synthesizes the vitamine, and we obtain our necessary vitamine supply either by eating vegetable food or animal food. Cows store up in their bodies the vitamines which they consume in their fodder; part of it is secreted with the milk, supplying the calf with the necessary vitamines, as well as furnishing a valuable source of vitamine for man. Chickens transfer part of the vitamine content of their cereal food into the eggs they lay. *It is the plant which keeps up the vitamine supply essential for animal life.* The plant is capable of building up the vitamine from simple inorganic compounds, another example of the wonderful synthetic power of plants.

What becomes of the vitamines in the body of animals? This is a very pertinent question, which is not easily answered. Some years ago Funk was able to obtain a small quantity of antineuritic vitamine from dried ox brain. A little later Dr. Towles and myself were able to demonstrate the presence of this substance in crude extracts from the spinal cord which was free from blood and other contaminations and, therefore, represented, to a large extent, nerve cells and nerve fibers. From this it would appear that the antineuritic substance under normal conditions forms an essential part of the nerve cell and fiber and that its presence in nervous tissue in sufficient amounts is essential for the proper function of this organ. When the vitamine content of the nervous tissue is no longer replaced by an adequate supply in the diet, degeneration of the nervous tissue begins. In this connection I also call attention to the fact that lipoids and antineuritic vitamine seem to be distributed in the body in similar proportions. This may be due to the lipoid solubility of the antineuritic vitamine. Another point of importance is that the animal body has the capacity of holding on to its vitamines. If we change the diet of man from one sufficient in vitamines to one deficient or free of vitamine, we find that as a rule it takes several weeks and even months before obvious and well defined symptoms of deficiency diseases appear. One might ask why the body does not react more rapidly to a deficient diet. Apparently the initial vitamine content of the body, which in absolute terms probably amounts to only a few grams in a person weighing 100 pounds, is not easily used up or eliminated together with the excretions. The katabolism of vitamines, if there is such a thing, must be extremely slow. If my statement that vitamines may occur in the colloidal state be correct, and we have seen that a number of facts seem to prove this assumption, it is very likely that certain other body colloids may fix the vitamines in the tissue fluids by means of adsorption. Traube has shown that certain alkaloids with very powerful and prolonged physiological action occur in the form of colloids. The fact that these substances are colloidal may be one of the reasons for their powerful physiological activity, especially as the recent teachings of biochemistry seem to support the view that life itself is largely dependent on the colloidal state of living matter.

Before closing the chapter of the physiological action of vitamines it may be well to point out that recent experiments have demonstrated that normal growth of certain higher animals, and probably also of man, requires a diet which must be sufficient in certain accessory foods or vitamines.

DISTRIBUTION OF VITAMINES IN FOODS

From the practical point of view of human nutrition it is highly desirable to know something of the distribution of vitamines in the various natural foods. It is important to know roughly whether a certain food like milk or barley is relatively rich or poor in vitamines. Unfortunately we do not possess at the present time a quantitative method for estimating the vitamine content of a given food. The preceding table (Table 1) illustrates the relative vitamine content of foods, beginning with those richest in vitamines. I do not pretend that this table is a very accurate compilation, but in our present state of knowledge it will probably be found of some use in deciding questions as to what constitutes a satisfactory diet from this point of view.

TABLE 1

ANTI-NEURITIC PROPERTIES		ANTI-SCORBUTIC PROPERTIES	
Relatively rich	Relatively poor	Relatively rich	Relatively poor
Brewers' yeast	Sterilized milk	Fresh vegetables	Dried vegetables
Egg yolk	Sterilized meat	Fresh fruits	Dried fruits
Ox heart	Cabbage	Raw milk	Sterilized milk
Milk (fresh)	Turnips	Raw meat	Canned meat
Beef and other fresh meats	Carrots and other vegetables of this type	Cereals, sprouting	Dried cereals
Fish	Highly milled cereals		Pork fat
Beans	Starch		Starch
Peas	Molasses		Molasses
Oats	Corn syrup		Corn syrup
Barley			
Wheat			
Corn			
Other cereals			

It is fortunate that most people, on account of their dietary habits, live on a mixed diet containing enough of these accessory foods to prevent an outbreak of scurvy or beri-beri. The average mixed diet is composed of animal food, which, with few exceptions (meat fat), is relatively rich in vitamine, and vegetable food. The latter may contain sufficient vitamines (legumes) or may be relatively deficient in this respect.

FACTORS WHICH TEND TO REDUCE THE VITAMINE CONTENT OF THE DIET

The food supply of the human race is, however, subjected to various changes which may lead to more or less radical changes in the nutritive value and availability of certain foods. The trend of modern civilization, leading to the concentration of the population in large cities away from the source of food production, has strongly influenced the methods of food production and with it also the composition of some foods. This whole question was discussed in an excellent address by Prof. L. B. Mendel before the Second Pan-American Scientific Congress, held in Washington last December. It remains for me only to point out the changes in the food supply which have affected the vitamine content of our diet. We can state without exaggeration that this country has led the world in the introduction on a large scale of modern methods of food production, preservation, and conservation. A number of industries have seen radical changes in modern times. I have only to refer to the development of the canning industry, the packing houses, and the great cereal mills, in order to illustrate this point. These changes, together with increased transportation facilities, have resulted in a wonderful change of our whole economic life. Whereas, people a hundred years ago used to live largely on food raised in this country, the market basket of today is made up of food coming from all parts of the world. The diet of the population of larger cities, and to a lesser extent that of the rural districts, has been subjected to great changes. Nowadays, we are able to purchase all the year around foods which formerly were only available at certain seasons. New foods have appeared on the market. Without these changes in food supply, food production, and preservation the development of our modern industrial life would have been utterly impossible, as it is a very essential thing that people should be properly fed. The pertinent question arises: Have these changes in our diet affected its nutritive value favorably or unfavorably? It is perfectly evident that such a question is not answered without a great deal of thorough investigation. All I can say today is that it seems that the diet of a certain proportion of the population may have been materially improved in recent years, leading to a greater variety of dietary components. On the other hand, I firmly believe, as a result of personal observations in a limited portion of the South, that the diet of some Southern people has markedly decreased in nutritive value from the point of view of its vitamine content. This is especially true of people living under rather poor economic conditions. I observed that the poorer people usually were unable to obtain the more expensive foods like beef, or other fresh meat, eggs, and milk, foods which are relatively rich in vitamines. Their diet was largely composed of cereal products, pork fat, carbohydrates in the form of molasses or corn syrup, and a few canned products. During the summer, and less so in the winter, fresh vegetables also were procured, some from their own gardens. The following table is an example of the yearly food supply of a family of cotton mill workers in Spartanburg County, South Carolina.

This dietary record is representative of a fairly large percentage of the cotton mill workers of this section of the South. It should be emphasized that the wheat flour which is used by these people is highly milled (patent) and forms perhaps the most important staple article of the diet. The diet as a whole must be considered as deficient in antineuritic vitamines, with the exception of the beans, which this family raised in their garden. During the winter time the cereal products, namely, wheat flour, corn meal, and grits, and pork fat (fatback) form the bulk of the diet. It is evident, therefore, that under these conditions it is important that the vitamine content of the cereal products should be sufficient, in order to prevent the consumption of a deficient diet. From the point of view of public health it is of considerable importance that the bread supplied for human consumption should contain the highest possible nutritive value.

TABLE 2

Example of Yearly Food Supply of a Family of Cotton Mill Workers

	COST	AMOUNT	PROTEIN	CARBOHYDRATE	FAT	CALORIES
		gram	*gram*	*gram*	*gram*	
Baking powder..........	$4.35	9,222				
Beans (dried)...........	.55	3,624	816	2,160	66	12,840
Blackberries (canned)...	.25	1,410	18	153	14	837
Bread (wheat)..........	.50	3,670	390	1,770	43	9,260
Butter..................	2.85	6,114	61		5,165	49,103
Candy..................	.50	2,265		2,172		8,922
Cheese..................	3.45	7,224	2,139		2,774	30,799
Chicken (one)...........	.25	1,132	154		139	1,937
Corn (canned)..........	.20	250	28	198	12	838
Corn meal..............	10.25	184,824	17,001	139,352	3,504	675,240
Crackers................	3.00	3,660	358	2,729	329	15,617
Cream of wheat.........	.45	2,400	264	1,830	33	8,907
Dried peaches...........	.25	1,812	119	1,607	17	7,163
Fat salt pork...........	22.41	58,663	2,944		72,962	690,498
Jelly....................	1.25	3,240	40	1,935		8,115
Lard, Compound........	10.30	43,486			43,486	405,120
Watermelon.............	.75	3,000	9	137		585
Oatmeal................	.15	588	98	389	43	1,964
Peanuts.................	.05	126	32	31	48	716
Porkside................	1.12	4,303	408		2,650	26,410
Potatoes, Irish..........	9.00	224,235	4,933	41,269	224	190,575
Salmon (canned)........	3.95	19,756	4,112		2,341	39,864
Sardines (canned).......	.25	475	95		85	1,220
Soda....................	.50	3,971				
Sour kraut (canned)....	.40	3,716	64	140	18	1,000
Sugar...................	5.95	37,824		37,824		155,304
Syrup (corn)............	.25	2,730		1,932		7,608
Syrup (cane)............	1.80	16,308		11,298		46,440
Tomatoes (canned).....	1.45	9,888	118	394	17	2,228
Wheat flour.............	31.35	429,897	48,987	325,102	4,298	1,575,340

From all of the available data one may conclude that the nutritive value of bread made from corn or wheat remained much the same from the time of the early settlers to about 1880. During this long period bread was prepared from wheat flour or corn meal and salt, with or without addition of other ingredients, such as fresh milk, buttermilk, molasses, et cetera. The wheat flour or corn meal was obtained by simply crushing the whole grain between stones, by various means, to the desired degree of fineness. The resulting flour or corn meal, from which the coarser particles of bran were partly sifted out, was then used for baking bread. Accordingly, the bread contained practically all of the nutritive elements of the whole grain. During the last fifty years, however, radical changes have taken place, with the tendency of reducing considerably the vitamine content of bread.

The introduction of the roller mill system into the United States in 1878 represents probably the most important change in this direction. By means of the roller process it was made possible to separate more or less the various parts of the kernel, namely, the germ, or embryo, the bran, and the endosperm, or starchy part. The latter represents the bulk of the fine (patent) flour, which, on account of its white appearance, appealed to the housewife as an assumably purer product. Accordingly the germ and bran were largely discarded as human foods. While it is quite true that the highly milled products (wheat flour, corn meal, corn flour, and grits) obtained by the roller process are far superior to whole wheat flour and the old-fashioned corn meal, as far as the keeping qualities are concerned, at the same time this modern process deprives the finished products of some of their vitamine content, an assumption which has been amply verified in some recent work by Myers and myself. These substances are located in the intact kernel in the outer layers (aleurone layer) and probably also in the germ.

Fowl, the classical experimental animal for the physiological estimation of the vitamine content of foods, will live in perfect health for many months on an exclusive diet of wheat, corn, whole wheat flour, or so-called water ground corn meal. If these animals are fed, however, on highly milled products, they will die within a month or two of polyneuritis, a disease very similar to beri-beri. There seems, therefore, to exist a perfect analogy between the well known relation of the polishing of rice and its nutritive value, and the milling of wheat and corn and the nutritive value of wheat flour and corn meal. As stated previously, numerous observations have demonstrated the fact that if the diet of people is largely made up of highly polished rice and is otherwise deficient in vitamines, beri-beri will make its appearance; whereas, if undermilled rice is substituted for the highly milled variety the disease is not so likely to break out. Little[3] reports an epidemic of beri-beri among the fishermen of Newfoundland who lived mainly on bread made from highly milled wheat flour.

From these considerations it would appear that a simple method for the determination of the vitamine content of cereal products would be of great value. Unfortunately it is still impossible to base such a method on the direct isolation of these substances from the natural foods. The determination of the total phosphorus content of these products, however, seems to give a fairly accurate index of the relative amounts of vitamines present. While phosphorus does not enter into the vitamine molecule, the distribution of phosphorus and vitamines within the grain run practically parallel. Fraser and Stanton, on the basis of a large number of observations and analyses, came to the conclusion that rice containing less than 0.4 per cent of P_2O_5 is deficient in vitamines. Myers and myself have used this method in order to correlate the vitamine content of wheat and corn products as found by animal experimentation with that of the quantitative estimation of the P_2O_5 content of these same products. Without going into detail it was found that in the case of these cereals the same relation exists between P_2O_5 and vitamine content as in the case of rice. (See Table 3.)

We believe that the determination of the P_2O_5 index will be found of value in all cereal products, except the so-called "self-rising flours." These latter products contain baking powders which often are composed of phosphates. As the label of these flours always indicates whether baking powder has been added, it will be an easy matter to discard such flours for this purpose.

I now should like to call attention to another factor involved

[3] Little. Journ. Am. Med. Assoc., 58: 2029. 1912.

$$\left.\begin{aligned} A &\equiv \frac{1}{\phi(\sigma)}\frac{\partial}{\partial E}f(E,\mu), & B &\equiv \frac{1}{\psi(\sigma)}\frac{\partial}{\partial \mu}f(E,\mu), \\ \alpha &\equiv \frac{1}{E}\frac{dE}{d\theta}, \qquad \beta \equiv \frac{1}{\mu}\frac{d\mu}{d\theta}, & \gamma &\equiv \frac{1}{L}\frac{dL}{d\theta} \end{aligned}\right\} \tag{5}$$

It is significant that there are no terms inseparably involving both shape factors and thermal properties; as a consequence of this, the complete expression for the effect of temperature on the stiffness of a body, made of a material whose temperature coefficients, α, β, and γ, are known, can be developed empirically without changing the temperature. The dimensionless factors A and B depend only on Poisson's ratio and the generalized shape, while α, β, and γ are familiar thermal properties of the material as such.

It would appear that a body of any fixed shape could be compensated for temperature, provided materials for its construction could be found having such values of α, β, and γ as will make the right hand side of (4) vanish; and, conversely, that a body of any fixed material could be compensated, if its shape could be so modified as to give to A and B values which would make that member vanish.

Simplified expressions for homogeneous isotropic bodies. When the relation

$$\frac{E}{\mu} = 2\ (1 + \sigma) \tag{6}$$

characterizing homogeneous isotropic bodies is satisfied, the two factors A and B coalesce into one factor, C, giving

$$\frac{1}{S}\frac{dS}{d\theta} = (1 + C)\alpha - C\beta + \gamma \tag{7}$$

in which

$$C \equiv (1 + \sigma)\frac{d}{d\sigma}\ \log\varphi(\sigma) \tag{8}$$

where, by (3)

$$\phi(\sigma) = \frac{S}{LE} \tag{9}$$

The procedure for determining C is simple. Plot the values of $\log \frac{S'}{LE}$, observed in a series of model experiments, as ordinates against σ as abscissa; S' being any magnitude (for example, the weight needed to give a certain deflection of a spot of light on some arbitrary scale) which is proportional to the true stiffness, S. The value of C, at any part of this curve, will then be $(1 + \sigma)$ times the slope of the curve.

Note from (7) that, when C is positive, the β term has an opposite effect from the α term and may outweigh it. In fact, the condition for temperature compensation is

$$\left.\begin{aligned} \frac{\beta}{\alpha} &= 1 + \frac{1}{C} + \frac{\gamma}{C} \\ &= 1 + \frac{1}{C} \text{ approx.} \end{aligned}\right\} \tag{10}$$

Numerical results in particular cases. For pure stretching or bending, $C = 0$; for pure twisting or shearing, $C = -1$.

For a thin flat circular disc deflected at the center by a so-called concentrated load, while freely supported at the rim, we may take the deflection formula readily available in treatises on elasticity,[6] and, by recasting it into the form of (3), just as if it were the result of model experiments, and then applying (8), obtain the expression

$$\left.\begin{aligned} C &= \frac{2\,(1+\sigma)^2}{(1-\sigma)\,(3+\sigma)} \\ &= 1.5 \text{ for } \sigma = 0.3 \end{aligned}\right\} \tag{11}$$

[6] Thus from Love, *Theory of Elasticity*, 2nd edition, eq. (57), p. 454, by putting $r = 0$ and $h = 0$ and taking the value of D given by eq. (16). p. 443, we find for the stiffness of an infinitely thin disc of radius a and thickness $2\,h$,

$$S = a\,E\,\frac{32\,\pi}{(3+\sigma)\,(1-\sigma)}\left(\frac{h}{a}\right)^3$$

Comparing this expression with our eq. (3), and treating a as the linear dimension L, evidently

$$\varphi(\sigma) = \frac{\text{const.}}{(3+\sigma)\,(1-\sigma)}.$$

Differentiating logarithmically, according to (8), immediately gives (11). In the case of a disc clamped at the edge, the expression for C would be $\frac{2\sigma}{1-\sigma}$.

in the reduction of the vitamine content of corn bread. This concerns the *use of baking soda in the preparation of bread.* Simultaneously with the introduction of highly milled corn meal it was found that this product, when mixed with salt and water, did not yield a bread of the same lightness as the old-fashioned meal. Housekeepers, therefore, began to resort to artificial leavening. Baking soda (sodium bicarbonate) became very popular among

TABLE 3

SUMMARY OF EXPERIMENTS

	PER CENT P_2O_5 IN DRY FOOD	NUMBER OF DAYS REQUIRED FOR APPEARANCE OF POLYNEURITIS IN FOWL FED EXCLUSIVELY ON THIS FOOD
Wheat bread, made from highly milled flour	0.114	20–32 days
"Patent" wheat flour	0.20–0.25	20–40 days
"Whole wheat" flour	0.61	Remained well
"Graham" flour	0.86	Remained well
Whole wheat	1.120	No symptoms developed
Corn grits (highly milled)	0.210	30 days
Corn meal (highly milled)	0.30	35 days
Corn meal (old fashioned rock ground)	0.659	Remained well
Corn meal (rock ground)	0.772	Remained well
Corn germ	2.816	Remained well
Corn whole	0.760	Remained well

The various methods for the estimation of P_2O_5 yield different results. The method used in this work was described in Hygienic Laboratory Bulletin No. 103, and is considered as being very satisfactory for comparative analyses. Explanation of terms used: (1) "Undermilled cereal products," cereals retaining a large share of the aleurone layers and germ; (2) "highly milled cereal products," products that have been deprived to a great extent of the above mentioned parts of the germ. These terms have been in common usage in the scientific literature and are, therefore, adopted in this paper.

the housekeepers. This preparation is used very extensively for this purpose in South Carolina, where I had an opportunity of studying its uses in cooking. Bread made by means of baking soda has often a distinctly alkaline taste. In order to prepare bread in this way corn meal is mixed with water or sweet milk, and fat, to which baking soda has been added. The resulting mush is baked in the oven. The high temperature in the oven liberates carbon dioxide from the baking soda (sodium bicarbonate) and the latter is transformed into sodium carbonate, a strong alkali. The evolution of CO_2 causes the bread to rise. Recent experiments by Sullivan and myself have clearly demonstrated the destructive action of alkalies, under certain conditions, on vitamines. These substances lose their physiological activity when exposed to alkalies, this being especially true at higher temperature. Corn bread made from old-fashioned (whole) corn meal, sweet milk, and soda, when forming the exclusive diet of chickens leads to symptoms of polyneuritis, whereas, corn bread prepared

TABLE 4

LABORATORY NUMBERS OF ANIMALS	NUMBER OF DAYS REQUIRED FOR APPEARANCE OF POLYNEURITIS AFTER FEEDING WAS BEGUN
31	13
32	14
33	27
34	13
35	22
36	14
37	19
38	21
39	18
40	16
	17 days (average)

from corn meal, sweet milk, and salt (NaCl) does not give rise to any symptoms and fowls seem to live in perfect health. Chickens which have developed polyneuritis on the corn bread made with sweet milk and soda are cured by the administration of vitamines prepared from various foods. *Hence, we may conclude that corn bread prepared by means of baking soda, without the addition of butter-milk, or substances of an acid character* (cream of tartar), *is deficient in antineuritic vitamines and that this deficiency is due to the destructive action of the alkali* (baking soda) *on the vitamines which were originally contained in these foods.*

The preceding table (Table 4) illustrates the destructive action of baking soda on the vitamine content of corn bread. Ten chickens were fed on corn bread of the following composition: 600 gm. of corn meal, 800 cc. of sweet milk, and 10 gm. of baking soda. Chickens fed on corn bread made with 600 gm. of corn meal, 800 cc. of sweet milk and 10 gm. sodium chloride did not subsequently exhibit at any time symptoms of polyneuritis.[4]

It should be strongly emphasized, however, that the old-fashioned way of combining baking soda with butter-milk in the preparation of bread is a perfectly harmless procedure, provided that sufficient butter-milk is added to neutralize fully the alkalinity of the baking soda. The label of the brand of baking soda in use in Spartanburg County, South Carolina, clearly states that butter-milk or tartaric acid should be added in order to obtain the best results. The prevalent use in that section of the country of baking soda *without butter-milk or tartaric acid* seems to be due to the lack of knowledge on the part of the housewives, as well as to the fact that it is often very difficult to obtain butter-milk.

We do not mean to imply that the use of baking soda will always lead to an injurious action on the health of persons eating bread prepared by this method, although such bread is undoubtedly deficient in vitamines. However, when the other dietary components, outside of corn bread, are also deficient in vitamines, the consumption of corn bread made with baking soda accentuates this dietary deficiency and may lead to an impairment of health. The same statement holds true in the case of highly milled cereals.

A few words about the *effect of food preservation on vitamines* may not be out of place here. Various methods have been in use for this purpose. Simple drying at ordinary temperature of such food as legumes, cereals, etc., has been in vogue for many centuries. In the absence of moisture food decay does not take place. Drying, however, seems to reduce the content of foods in antiscorbutic vitamines. The antineuritic vitamine, on the

[4] One chicken of this series, however, developed after a very long time symptoms of paralysis which were relieved by the administration of vitamine.

other hand, is only slightly affected by this treatment.[5] Salting and smoking food is also commonly resorted to. Little is known as to the effect of these last mentioned methods of preservation on the vitamine content. Another method of food preservation which has assumed immense proportions within the last 50 years is the canning of food. The process of canning was discovered in the time of Napoleon the first, who offered a prize to the scientists of his country for a method of preserving fresh foods. Appert received the prize, as he was able to show that food exposed for some time to the temperature of boiling water and kept from contact with the air could be stored for a considerable time without danger of decay. This process was used to a limited extent in the period immediately following its discovery, but the credit belongs to this country for having put it on a large scale, until nowadays nearly everybody consumes part of his diet in the form of canned foods. It seems important, therefore, to determine whether or not canning of food deprives the food of some of its vitamine content. Experiments having this idea in view have been made by myself and others on a small scale, but it is altogether too early to draw any definite conclusions. Thus, several statements can be found in the literature pointing to the destructive action of the canning on the antineuritic vitamine present in fresh meat and fresh milk. On the other hand, I have been able to show that canned peas and beans seem to retain a considerable amount of antineuritic vitamine. Such questions should be given considerable attention, keeping in mind, however, that the benefits derived from the fact that canned foods are available for human nutrition are very considerable. This statement applies equally well to the milling of cereals. While it is of prime importance to preserve the full nutritive value of foods, at the same time it is imperative that we also consider the great benefit which our modern methods of food production and food preservation have yielded. Any deficiencies in these methods from the point of view of the

[5] Holst and Froelich in 1907 succeeded in producing scurvy in guinea pigs by means of an exclusive diet of dry cereals.

preservation of vitamines which might possibly be discovered in the future should be removed if possible without disturbing the normal continuation of these valuable industries.

OUTLOOK

Looking back over the history of the discovery of the accessory foods and especially the vitamines, we at once realize that it has opened up a new field of investigation, undreamed of a relatively short time ago. Fundamental problems in physiology, pharmacology, and pathology are awaiting the worker interested in this field. The purely scientific, as well as the practical, aspects of this field should stimulate research, which will require a small army of workers in order that rapid progress be made. It is of great importance that vitamine preparations should become available for the practicing physician for the treatment of deficiency diseases. It is quite possible that a number of indefinite complaints and symptoms of adults and infants may be due to a partially deficient diet and would be benefited by the administration of vitamines. It is not always necessary that the full picture of a deficiency disease make its appearance. Such vague symptoms as loss of appetite and general weakness might very well, in some instances, be due to a deficient diet. In passing, it should also be stated that the scientific and practical problems of stock-raising will probably be very greatly benefited by researches on the effect of vitamines on the growth of animals and the composition and nutritive value of cows' milk. Efforts should be made to make use of certain industrial wastes rich in vitamines, such as brewers' yeast, rice polishings, etc. If certain reports are correct, Germany at the present time is fully aware of the great nutritive value of brewers' yeast, inasmuch as this raw product is now used in that country for human nutrition.

In conclusion I should like to emphasize an old truth quoted by Langworthy to the effect that "Each country and each epoch has its own food problems." It is up to us to solve them.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Weather forecasting in the United States.* ALFRED J. HENRY and others. Weather Bureau Publication No. 583. Pp. 370, with 199 charts and diagrams. 1916. (For sale by Superintendent of Documents, Washington, D. C.)

It is a matter of common knowledge that although weather forecasts have been made in the United States for upwards of forty years, scarcely anything has been written to explain in more or less detail the processes by which weather forecasts are made. This volume is the result of an attempt to put on record the rules and considerations which have been found useful by experienced forecasters of the Weather Bureau. The volume has been prepared primarily as an aid to beginners in the art, and presupposes some acquaintance on the part of the reader with graphic methods of presenting weather data. It is not for general distribution.

Preliminary chapters upon the theoretical aspects of the problem of atmospheric motions have been contributed by C. F. Marvin and Wm. J. Humphreys.

The relation of atmospheric pressure distribution and of certain well known barometric configurations to subsequent weather is discussed in three chapters by Alfred J. Henry. The well marked phenomena of the weather, such as cold waves, frosts, high winds, fog, snow, sleet, and thunderstorms, are discussed in four chapters; cold waves and frosts are discussed by Henry J. Cox; high winds, by Edward H. Bowie; fog, snow, and sleet, by H. C. Frankenfield.

Three chapters, devoted to the routine forecasts of wind and weather, are contributed by the district forecasters for the five forecast districts of the country, and, finally, a chapter on long range forecasts is presented by E. H. Bowie. A bibliography concludes the work.

A. J. H.

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PHYSICS.—*A note on electrical conduction in metals at low temperatures.* F. B. Silsbee, Bureau of Standards. (Communicated by P. G. Agnew.)

Some time ago I had occasion to study the accounts of the brilliant experiments of Kamerlingh Onnes on the resistivity of various metals at liquid helium temperatures. In so doing I have noticed a certain correlation between the phenomena of critical current density and critical magnetic field. Though the relationship seems quite obvious I have come across no mention of it in the literature of the subject, and think it worthy of notice as furnishing a possible clue to further theories of metallic conduction.

The present state of our experimental knowledge of the subject is somewhat as follows. Certain metals—mercury, tin, and lead—at the very low temperatures obtainable in a bath of liquid helium show a very greatly increased electrical conductivity, to which Kamerlingh Onnes has given the name "superconductivity." The actual resistivity of the metal in this state is too small to measure but has been shown[1] to be less than 2×10^{-11} times the resistivity at 0°C. As the temperature of any of these metals is lowered from room temperature, the resistance decreases uniformly with the normal coefficient of about 0.4 per cent per degree until the temperature has become very low, then the rate of decrease becomes for a time less rapid. At a certain critical temperature (4°2 K for mercury, 3°8 K for

[1] Kon. Akad. v. Weten. Amsterdam, **17**: 280.

tin, and 6° K for lead),[2] however, there is a sudden break in the curve connecting resistance and temperature, and within a temperature range of a few hundredths of a degree the resistance drops from about 10^{-3} times its value at 0°C. to less than 10^{-10} times the same value. Other metals, such as gold, silver, platinum, and iron, do not show this phenomenon but tend to approach a constant value as the temperature is lowered to the lowest value (1°.6 K) at which such measurements have been made. The critical temperature at which the change occurs is very definite when the current used to measure the resistance is small, but when the measuring current is very large the critical temperature is found to be definitely lower. Conversely, if the temperature of the bath be held constant some degrees below the critical value and the current be increased, a certain "threshold" value of current will be found at which the resistance suddenly appears.[3] The lower the temperature the greater the value of the critical current.

It is further found that when a superconductor is placed in a weak magnetic field it remains superconducting; but that, as the field is increased, the normal resistance appears suddenly at a certain critical value of the magnetic field, and for still higher values of the field it increases slowly with the field.[4] The critical value is slightly less when the field is transverse to the direction of current flow than when it is longitudinal, but the difference is not great.

The particular point which is the subject of this note is that *the "threshold" value of the current is that at which the magnetic field due to the current itself is equal to the critical magnetic field.* In other words the phenomenon of threshold current need not be regarded as a distinct phenomenon, to be explained by heating, or otherwise, but is a direct result of the existence of the phenomenon of threshold magnetic field.

If the specimen is in the form of a coil of wire it is evident that the inner turns are in a magnetic field, due to the current in the

[2] Comm. Phys. Lab. Leiden, No. 133, pp. 7, 52, 60.
[3] *L.c.*, p. 3.
[4] Comm. Phys. Lab. Leiden, No. 139, pp. 65–71.

other turns, which is very similar to that due to an entirely external electromagnet. Consequently, when this field reaches the critical value, first the inner turns will become resisting and, as the current is increased, more and more of the wire will cease to be superconducting. Because of the enormous factor by which the conductivity decreases from the superconducting to the normal state, most of this decrease will take place when only a small fraction of a turn of the coil ceases to be superconducting. Owing to the cumulative effect of the successive turns, the field produced by a given current is much greater in the coil than in the same wire when straight, and, consequently, the current required to give the critical field strength will be much less. This is verified by the results of Onnes[5] on coils of lead and tin wire for which the critical currents were, respectively, $\frac{1}{15}$ and $\frac{1}{8}$ of those for the same wire when straight. No attempt has yet been made to measure the further gradual increase of resistance, which would be expected on this theory, as the current is further increased and more and more turns become resisting.

In the case of a straight wire of circular section the effect to be expected is rather more complicated. Consider a superconducting wire of radius r_0 carrying a current I, uniformly distributed over the cross-section. The magnetic field intensity H at any point, distant r from the axis, but *inside* the wire, is given by

$$H = \frac{2Ir}{r_0^2} \tag{1}$$

and that at the surface of the wire by

$$H_0 = \frac{2I}{r_0} \tag{2}$$

If the current be increased to a value slightly greater than $\frac{H_c r_0}{2}$, where H_c is the critical field intensity for the material, the outermost layer of the wire will become resisting. Since this

[5] Comm. Phys. Lab. Leiden, No. 133, pp. 57, 60.

layer is shunted by the superconducting core, the whole current will tend to flow in this core. This, however, would make the field at the edge of the core even greater than that in the former outer layer, since by equation (2) the field varies inversely as the external radius.

The system is therefore unstable and the current will shift suddenly to a new distribution. This distribution will depend on the exact form of the relation connecting resistivity with magnetic field; and if this relation were known, the current distribution might be computed from the usual electromagnetic equations.

If it be assumed that the resistivity increases discontinuously by a large factor, k, at a definite field intensity H_c, then for a current very slightly in excess of the critical value there will be a superconducting core of radius $\frac{r_0}{k}$, in which the current density will be k times the average value; and therefore $\frac{1}{k}$ of the total current will flow in this core. Outside of the core the material will be in a field equal to or greater than H_c and will by hypothesis have an increased and uniform resistivity. Since the core is so small that in spite of the great current density existing there it carries only a small part of the total current, the resistance of the wire as a whole is nearly k times the superconducting value. For the materials studied k is of the order of 10^7, so that the effect of the core is negligible.

For any other relation between resistivity and field there would be a corresponding current distribution. In general the abruptness of the increase of resistance with current would be similar to that of the increase of resistivity with field.

Owing to the great experimental difficulties of working at these extreme temperatures the data available for an experimental verification of this theory are rather scanty. Table 1 contains in condensed form the observed values of threshold current for various wires at different temperatures, as published by the Leiden laboratory. Since the threshold values depend considerably on temperature, a comparison is possible only when observations have been made on two wires at the same temperature; the table contains the results of practically all such observations that have been published.[6]

TABLE 1

Critical Values of Current for Various Metals and Temperatures
Data by H. K. Onnes

TEMP.	AREA	THRESHOLD CURRENT	THRESHOLD CURRENT DENSITY	MAX. MAG. FIELD
		Mercury		
deg, K	*mm.*^{2}	*amperes*	*amperes /mm.*^{2}	*gauss*
4.1	0.0016	0.17	107	15
	0.0025	0.17	69	12
	0.0055	0.23	42	11
	0.0055	0.32	58	15
3.6	0.0016	1.00	625	89
	0.0025	1.07	427	76
	0.0040	>1.04	>260	>59
	0.0052	0.78	151	39
		Tin. $H_{crit.}$ = 200 at 2°K		
1.6	0.0143	1.0	70	430 coil
	0.0143	8.0	560	240 st. wire
		Lead. $H_{crit.}$ = 600 at 4°.2 K		
4.25	0.025	9.0	680	385 st. wire
	0.014	>4.0	>300	>110 in vacuo
	0.014	0.6	41	375 coil
1.7	0.014	0.84	60	550 coil
	0.014	11.10	790	330 st. wire

In the last column is given the maximum value, within the conductor, of the magnetic field due to its own threshold current, that is, the field at the surface of a straight wire or at the inner turns of a coil (the computations for the latter case being only

[6] Comm. Phys. Lab. Leiden, No. 133.

approximate). It is seen from the table that at each temperature this magnetic field is much more nearly a constant of the material than either the current or the current density. In the case of mercury the effect of a magnetic field on the resistance in the superconducting state has not been measured. For tin the threshold value at 2°K is about 200 gauss, which is in good agreement with the slightly larger values computed from the threshold current corresponding to a slightly lower temperature. In the case of lead the agreement of the observed critical field (600 gauss at 4°K) with the computed values is not so good, particularly in the case of the straight wire. Any discrepancy here, however, is easily explained by the possibility (frequently referred to by Onnes) of the existence in the wire of thin spots where the field intensity would be much greater for a short length.

Further experiments immediately suggest themselves. The critical magnetic fields for mercury should be determined. The relation here advanced would indicate a critical field of only about 15 gauss at 4°.1K and less than 100 gauss at 3°.6K. It would also be of interest to observe the threshold value of current when the material is in very thin films. In this case, for a given section of material the magnetic field resulting from a given current density is less than in the case of a straight wire, and the threshold current density would consequently appear larger.

The theories thus far proposed by Onnes,[7] Lindemann,[8] and Thomson[9] to account for superconductivity do not specifically indicate the existence of a critical magnetic field, and only the latter (by assuming a saturation effect) accounts for a threshold current density. If it is true, as indicated in this paper, that the magnetic effect is the more fundamental, it would seem that this fact might afford a valuable clue leading toward a more satisfactory theory of the superconducting state and perhaps of metallic conduction in general.

[7] ONNES. Comm. Phys. Lab. Leiden, No. 119.
[8] LINDEMANN, F. C. Phil. Mag., **29**: 127. 1915.
[9] THOMSON, J. J. Phil. Mag., **30**: 192. 1915.

BIOLOGY.—*Geochemical evidence as to early forms of life.*[1] F. W. Clarke, Geological Survey.

When life began on earth the conditions favorable to its development were, generally speaking, somewhat different from what they are today. Rocks derived from the remains of living organisms did not, of course, exist; and the only sediments were those due to erosion, increased, doubtless, by volcanic dust and other ejectamenta. The surface of the land was made up of primitive rocks, and among them the specifically lighter varieties probably predominated. By erosion these rocks were gradually decomposed, and their more soluble constituents were taken up by the primeval waters, whose character gradually changed as the process of erosion went on. At first, silica and alkalies passed into solution, with lime and magnesia in much smaller proportions. A large part of the lime and magnesia in the waters of today is derived from the solution of limestones of organic origin, which came into existence later. Possibly algal and foraminiferal limestones were among the earliest to form large masses, but of that it is not well to be too positive. We can only assume that the simplest forms of life came first, even though their remains have since been obliterated. In geologic time the complex forms are relatively modern.

So far as we are able to judge from anything like positive evidence, the earliest living organisms were aquatic, and their physical constitution was determined by the character of their environment. Whether the waters were warm or cold we do not know, and speculation upon that subject is hardly profitable. Whether the primeval ocean was fresh or saline is also uncertain, but we can assert that the composition and concentration of its dissolved salts have undergone great changes and are still changing. The enormous load of saline matter annually poured into the ocean by rivers is evidence that can not be ignored. Part of that load remains in solution, part is precipitated, either directly or through the agency of plants and animals, and so the changes are brought about. These changes in the environment

[1] Published with the permission of the Director of the U. S. Geological Survey.

of life must have affected the course of evolution, although with exceeding slowness. Every variation in the composition of the fluviatile or oceanic salts modified the conditions under which life developed. As living organisms multiplied, they in turn altered the composition of the waters, by just so much as they withdrew lime, or magnesia, or phosphoric oxide, or silica from solutions and used them in building up the sedimentary cherts, phosphorites, and limestones of today.

To trace these changes in detail would be difficult, if not impossible, but some of the ancient conditions can reasonably be inferred. The chemical reactions involved in the discussion are the same now as at the beginning, although the results produced by them have varied from time to time and place to place. The chemical elements are not uniformly distributed; at one point there is more silica, at another more lime; and organisms with siliceous, calcareous, or phosphatic shells or skeletons developed in accordance with their surroundings. Where the primeval waters were relatively rich in silica, siliceous organisms were most readily evolved; where lime predominated, the development of calcareous organisms was favored. So much seems to be clear.

It has already been stated that the land surface of the earth was at first composed of rocks such as form only one fourth of it today; that is, of igneous, plutonic, or crystalline rocks with no sedimentaries of organic origin. At present persilicic rocks of granitic or granitoid type are the most abundant of these, and they are relatively poor in lime. In this respect it is highly probable that the earliest rocks followed the same rule.

Many analyses of river waters have been made, some of them with reference to their geological relations. Waters emerging from areas of sedimentary rocks, or from basaltic regions, are quite unlike those which issue from granite and its congeners. The meteoric waters act differently upon different kinds of rock, and take up dissimilar loads of soluble substances. Waters from limestone or from certain ferromagnesian rocks are relatively rich in lime; those from dolomite contain a larger proportion of magnesia, and so on; the waters varying in composition as the rocks themselves vary. Each water at its point of origin has its own chemical characteristics, which are fixed by its lithologic parentage. This fact, which is almost self evident, has been verified by numerous analyses, which, however, have received less attention than they deserve.

Persilicic rocks, as I have already stated, are now the most abundant plutonics and, in all probability, have been so from the beginning. There is no reason for supposing that in this respect any important change has occurred. Such rocks consist mainly of quartz and feldspar, with only minor accessories. Waters issuing from them are low in salinity but relatively rich in silica and alkalies, the proportion of silica being especially high and much in excess of lime. The silica often approaches 40 per cent of the total inorganic matter in solution, and in some tropical rivers exceeds 50 per cent. Such waters offer a most favorable environment for the growth of siliceous organisms, all of which are low forms of life, like the radiolarians, diatoms, and siliceous sponges. They, or their ancestors, were probably among the earliest organisms to develop inorganic skeletons, and were in greater abundance than the calcareous forms. Doubtless there were local areas, basaltic for example, in which the waters carried much lime in solution, and here the conditions would be reversed. In every case, however, the chemical character of the environment determined the chemical character of the plants or animals which appeared. I speak now, of course, only of those organisms which built skeletons to support their tissues, or shells to house them; the simplest, earliest forms of life were hardly more than aggregations of protoplasm. How that originated and how it became endowed with life, that is, the ability to move about, to assimilate food, and to reproduce its kind, are questions on which only speculation is possible. Such problems I must leave to others.

ZOOLOGY.—*Six new genera of unstalked crinoids belonging to the families Thalassometridae and Charitometridae.*[1] AUSTIN H. CLARK, National Museum.

A recent survey of the comatulid families Thalassometridae and Charitometridae has shown that the following six systematic units are worthy of recognition as genera:

[1] Published with the permission of the Secretary of the Smithsonian Institution.

Oceanometra, new genus

Genotype.—*Thalassometra gigantea* A. H. Clark, 1908.

Diagnosis.—A genus of Thalassometrinae (Thalassometridae) in which the dorsal surface of the ossicles of the division series and of the arm bases is covered with numerous prominent spines, which become stouter and more prominent on the proximal and distal borders; there are from 15 to 28 arms; the IIBr series are all, or mostly, 4(3+4); the ossicles of the division series and first four brachials are strongly and evenly rounded dorsally, appearing relatively narrow; one or both of the elements of each of the pairs of ossicles in the division series, and of the first brachial pair, bears a more or less prominent median keel; the distal borders of the brachials are evenly rounded and very spinous; the centrodorsal is large, more or less conical, the cirrus sockets arranged in ten columns, two in each radial area; the cirri are of variable length, composed of from 55 to 79 segments.

Range.—Moluccas to the Philippine and Hawaiian Islands.

Bathymetrical Range.—From 54 to 858 meters.

Included Species.—*Oceanometra gigantea* (A. H. Clark), *Oceanometra magna* (A. H. Clark), and *Oceanometra annandalei* (A. H. Clark).

Crossometra, new genus

Genotype.—*Pachylometra investigatoris* A. H. Clark, 1909.

Diagnosis.—A genus of Charitometridae in which the centrodorsal is more or less conical, with the cirrus sockets arranged in ten definite columns, two in each radial area; the cirri are XX–XL, 19–26, stout; there are from 26 to 33 arms 125 mm. to 150 mm. long; the IIBr series are 4(3+4); the IIIBr series are 2(1+2), or 2, internally developed in 1–2–2–1 order; IVBr series, if present, resemble the IIIBr series; the ossicles of the division series and lower brachials are in close apposition and sharply flattened against their neighbors, evenly rounded dorsally, with the dorsal surface usually more or less uneven; the brachials are evenly rounded dorsally; the oral pinnules are more slender than those succeeding, though not appreciably longer; the genital pinnules are only slightly expanded, the expansion involving a considerable number of segments and dying away gradually distally.

Range.—Kei Islands to the Malay Archipelago, the Philippine Islands, and southern Japan.

Bathymetrical Range.—From 54 to 403 meters.

Included Species.—*Crossometra investigatoris* (A. H. Clark), *Crossometra helius* (A. H. Clark), and *Crossometra septentrionalis* (A. H. Clark).

Perissometra, new genus

Genotype.—*Antedon flexilis* P. H. Carpenter, 1888.

Diagnosis.—A genus of Charitometridae in which the centrodorsal is more or less conical, with the cirrus sockets arranged in ten definite columns, two in each radial area; the cirri are usually large and stout, XX–L (usually XX–XXX), 15–31; the arms are from 10 to 20 in number, from 75 mm. to 250 mm. (rarely less than 150 mm.) in length; the IIBr series, when present, are 4(3+4) or, less commonly, 2; the ossicles of the division series and the lower brachials are in close apposition and are sharply flattened against their neighbors; their dorsal surface is smooth or coarsely rugose, raised more or less sharply into a broad or narrow regular or irregular median tubercle, which may be longitudinally elongate; the division series usually make a relatively small angle with the dorsoventral axis, so that the lower part of the animal is relatively narrow; the brachials are evenly rounded dorsally, and the more proximal may bear a small rounded dorsal tubercle; the oral pinnules, though more slender than those succeeding, are not appreciably longer; the genital pinnules are only slightly expanded, the expansion always involving a number of segments and gradually tapering away distally.

Range.—Laccadive and Andaman Islands to Timor and the Kei Islands, and northward to the Philippines and southern Japan.

Bathymetrical Range.—From 73 to 1269 meters.

Included Species.—*Perissometra angusticalyx* (P. H. Carpenter), *Perissometra patula* (P. H. Carpenter), *Perissometra robusta* (P. H. Carpenter), *Perissometra selene* (A. H. Clark), *Perissometra gorgonia* (A. H. Clark), *Perissometra timorensis* (A. H. Clark), *Perissometra crassa* (A. H. Clark), *Perissometra lata* (A. H. Clark), *Perissometra flexilis* (P. H. Carpenter), *Perissometra invenusta* (A. H. Clark), and *Perissometra macilenta* (A. H. Clark).

Monachometra, new genus

Genotype.—*Pachylometra fragilis* A. H. Clark, 1912.

Diagnosis.—A genus of Charitometridae in which the centrodorsal is thick-discoidal or more or less columnar, with the cirrus sockets arranged in fifteen crowded columns; the cirri are XXX, 19; the arms are from 15 to 19 in number, 145 mm. long; all the division series are 2; the ossicles of the division series and the first two brachials are sharply flattened laterally, with the dorsal surface rising rather sharply into a blunt keel; the IBr_1 are produced inwardly, so that their inner apices nearly meet in the center of the calyx; the visceral mass rests on the ossicles of the IIBr series and first two brachials, and on the sharply flattened and almost horizontal inner face of the IBr_2 (axillary); the synarthrial articulations (between the elements of the division series and between the first two brachials) are extraordinarily brittle; the brachials have a faint and obscure median carination; the oral pinnules are of approximately the same length as those succeeding, though more slender; the genital pinnules are rather stout, but without a localized expansion.

Range.—Philippine Islands and the Moluccas.

Bathymetrical Range.—From 118 to 243 meters.

Included Species.—*Monachometra fragilis* (A. H. Clark).

Calyptometra, new genus

Genotype.—*Charitometra lateralis* A. H. Clark, 1908.

Diagnosis.—A genus of Charitometridae in which the proximal portion of the animal is robust, very broad, and well rounded, the profile of the division series and arm bases strongly convex; the ossicles of the division series and first four brachials which are in close apposition and sharply flattened against their neighbors, have the lateral borders strongly, the proximal and distal borders less strongly, everted, unmodified, finely tubercular, or crenulate, and possess each a narrow blunt median keel; the brachials are rounded dorsally, each usually with a prominent, though low, small rounded median tubercle, which beyond the middle of the arm gradually becomes obsolete; the 10 or 11 (only exceptionally more than 10) stout arms are 160 mm. to 180 mm. in length; the IIBr series, when present, are 2; the proximal pinnules are somewhat longer and more slender than their successors; the following pinnules are very stout in the basal half, thence tapering gradually to a slender tip, the expansion of the basal segments becoming less and less marked distally; the cirri are about XXX, 15–21 (usually 16–19), the component segments slightly constricted centrally with prominent ends.

Range.—Hawaiian Islands.

Bathymetrical Range.—From 574 to 812 meters.

Included Species.—*Calyptometra lateralis* (A. H. Clark).

Chondrometra, new genus

Genotype.—*Chlorometra robusta* A. H. Clark, 1911.

Diagnosis.—A genus of Charitometridae in which the 10 arms, from 75 mm. to 211 mm. in length, are stout at the base, becoming narrow and strongly compressed laterally in the outer portion; the mid-dorsal line of each brachial is elevated into a broad, high and blunt overlapping spine or tubercle; the ossicles of the division series and the first two brachials, which are in close apposition and are sharply flattened against their neighbors, have the central portion elevated in such a way that their dorsal surface is in the shape of a broadly V-shaped gable; the proximal pinnules are about as long as those succeeding, or at any rate no longer; the genital pinnules are only slightly expanded, the expansion involving a number of segments and tapering away evenly distally; the centrodorsal is large, sharply conical to more or less columnar, the cirrus sockets arranged in one irregular or two regular columns in each radial area; the cirri are XV–XXX, 18–28, stout, varying from short to very long.

Range.—Timor to the Meangis and Philippine Islands.

Bathymetrical Range.—From 520 to 1314 meters.

Included Species.—*Chondrometra rugosa* (A. H. Clark), *Chondrometra robusta* (A. H. Clark), and *Chondrometra aculeata* (P. H. Carpenter).

ETHNOLOGY.—*Some information from Spanish sources regarding the Siouan tribes of the East.* JOHN R. SWANTON, Bureau of American Ethnology.

The discovery of a group of tribes of the Siouan linguistic stock in the southeastern part of our country was in its day one of the great surprises in American Ethnology. The number and names of these, together with the relationships existing between them and the ethnological information regarding them furnished by early writers, were made the subject of a special study by Mr. James Mooney and the results appear in Bulletin 22, of the Bureau of American Ethnology, entitled *Siouan Tribes of the East.* Not much additional information bearing upon these peoples has since come to light and but very few alterations would be required in a new edition, so far as the Siouan tribes themselves are concerned. Nevertheless, as information regarding them is scanty it becomes proportionately more valuable, and for this reason I desire to call attention to one or two additional sources of information among Spanish writings.

The first of these, in a work long well known to students of American history but unfortunately overlooked by the ethnologist, is Peter Martyr's account of the province of Chicora, and the customs of its inhabitants, in his *De Orbe Novo.* The reason for this neglect is, no doubt, due in part to the dependence of investigators on Gomara's transcription of Peter Martyr's narrative, particularly because they were acquainted only with faulty translations of the latter, which contain grotesque and exaggerated statements tending to throw discredit upon the entire account, a discredit moreover which has ancient support from the historian Oviedo. The greater part of the information was derived by Peter Martyr from an Indian of Chicora, named by the Spaniards Francisco, who was carried to Spain and taught the Spanish language, but taken back as interpreter for Aylon's colony which came to such an inglorious end in 1526. The original narrative is contained in the Seventh Decade of Peter Martyr's work, where it occupies all of the third book and parts of the second and fourth; and if one goes back to this, instead of trying to depend on later transcriptions and translations, he will find little in it that can not be accounted for without impugning the honest intentions of the writer or his Indian informant. A close examination of the Ayllon narratives leads to the belief that Francisco of Chicora came from that part of the Atlantic coast of the Carolinas occupied by Siouan tribes, and in all probability from the neighborhood of the present Winyaw bay. Among several reasons for this belief may be cited the characteristic *r* sounds in the words, as in the name Chicora itself, which is so conspicuous among the Siouan dialects of this region. The material recorded by Peter Martyr contains some information regarding the economic lives of the people and their customs, some notes touching upon their myths, medical practice, etc., and particularly accounts of three of their ceremonies. Some trees also are mentioned and the native names borne by them. It should be noticed that most of this information concerns, not Chicora, but a neighboring province called Duhare or Duache.

A little further light is let in upon these people by documents in the Lowery collection, preserved in the Manuscripts Division of the Library of Congress, particularly by the narratives of two expeditions from St. Augustine under the command of Francisco Fernandes de Ecija, sent in search of an English colony reported to have been established somewhere to the north. The first of these was in the year 1605. The explorers passed along the coasts of Georgia and South Carolina until they came to the "barra de Cayegua," now Charleston harbor. Not far beyond was the bar of Joye, and twelve leagues beyond that a sandy point near which was the river Jordan. This latter (placed by the explorers in N. Lat. 33°11′) was, as we know well, the Santee, and the sandy point near by was evidently Cape Romain. It must be observed that the Cape San Roman of the Spaniards is not the Cape Romain of today, but probably Cape Fear, and we must not be surprised, therefore, to read immediately afterward that it was about 20 leagues from the River Jordan to Cape San Roman. We are informed that the chief of Joye ruled over all the land at the mouth of this river. The Indians told Ecija that it was large and that the interior people came down it in canoes with cloaks (*huapiles*) and many other things, including copper and silver, to exchange for fish and salt. They stated also that pearls were found near the mountains in a place called Xoada, described as very populous. The explorers met a Christian Indian in this region named Alonso, who acted as interpreter; his father-in-law, whose name was Panto, was head chief of the town of Sati (sometimes spelled Hati). One of these Indians had been as far on the trail to Xoada as a town called Guatari. On the direct road thither they said the following places were encountered: Guatari, Coguan-Guandu, Guacoguayn-Hati, Guaca-Hati-Animache, Lasi, Guasar, Pasque, Cotique. From the mouth of the Santee to Xoada was thirty days, "as Indians travel."

Ecija entered the Jordan on his second expedition July 8, 1609, and found some small houses and fields sowed with corn. He heard of a Frenchman living in the town of Sati and sent the Indians to fetch him. The Frenchman then told Ecija that he had heard from one of the natives that there was a town called Daxe four days' travel beyond Sati, and one and a half days' travel beyond that another, called Guandape, on an island near which the English had established themselves. One of the Indians from whom the Frenchman had derived this information was from a town called Guamuyhurto, the other two from a town called Quixis, and one had acted as interpreter for the English. It would seem that the settlement referred to must have been the Roanoke colony and not that at Jamestown, then only two years old. Four leagues up the Jordan Ecija met three chiefs, Sati, Gaandul, and Guatari. Another town in the interior was known as Ypaguano, and still another, five days' journey from Alonso's village, was called Guaño. A river ten leagues from Cape San Roman [Cape Fear] was called by the natives the river Barachoare. Somewhere east of the Jordan and Santee was a province known as Amy.

With the exception of the interesting note regarding trade there is little direct ethnological information in all this. It does, however, yield some important facts regarding the tribes of the section. In the first place there can be little doubt that the Sati of Ecija are identical with the Santee of the English. In native speech the *n* was probably nasalized, and the English chose to make a full *n* out of it while the Spaniards preferred to ignore it. It is equally evident that Guatari is the later Wateree, *gua* being a common Spanish equivalent of English *wa*. Joye is spelled in another place *Suye* and in still another *Xoye* or *Xoya*. As *x* was often employed by Spanish writers of this period to designate the *sh* sound, it is evident that the initial sound was either *sh* or *s;* and when we add to this the fact that the chief of Joye is represented as ruling over all of the land at the mouth of the Santee, the identity of Joye, Xuye, or Suye with the later Sewee becomes almost certain. If the name of one of the tribes mentioned by Ayllon and his chroniclers should be spelled Duache, as it appears in some places, instead of Duhare, it may be identical with Daxe, but no such tribe appears in later times. Xoada, the town near the mountains, is, as Mooney has shown, the tribe known to the English as Saraw, then living at the head of Broad river. If there has been a mistake in copying, Lasi may be intended for Issi, the old name of the Catawba. At any rate Guasar is undoubtedly Waxaw, while Pasque, although not found as a tribal name in the English period, is the Pasqui of Francisco of Chicora. On the authority of Lederer and some others Gregg and Mooney have expressed an opinion that in the latter part of the seventeenth century the Wateree were not on the river which now bears their name, but upon the Pedee or Yadkin.[1] Unless we suppose there were two divisions to the tribe, however, the statements just quoted indicate that this is a mistake, and that at least part of the Wateree were in their later well known historic seats almost at the beginning of the seventeenth century. In fact Ecija's testimony throughout is to the comparative permanence in location of the tribes in the area in question. The Sewee, Santee, Waxaw, and possibly Catawba are where the South Carolina settlers found them more than sixty years later. If there be an exception it is in the case of the Chicora, who may have been the Sugeree or the Shoccoree, found later by the Carolina colonists a considerable distance inland.

[1] Gregg, A., Hist. of the Old Cheraws, p. 7; Mooney, James, Bull. 22, Bur. Amer. Ethn., p. 81.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

ELECTRICITY.—*The international system of electric and magnetic units.* J. H. Dellinger. Bureau of Standards Scientific Paper No. 292 (Bull. Bur. Stds., **13**: 599–631). 1916.

A complete and distinct system of electric and magnetic units is in use, based on the international ohm and ampere, the centimeter, and the second. While these international units differ in their derivation from the electrostatic and electromagnetic units, they nevertheless represent very closely decimal multiples and submultiples of the theoretical electromagnetic units. The very slight differences are determined by absolute measurements made from time to time. One of the reasons why the international system is the most convenient and the most used electrical system is because it is centered around the phenomena of electric current. Electric current is more familiar and of vastly greater practical importance than electrostatic charges or magnetic poles, upon which the other two familiar systems are based. Another fortunate aspect of the international system is the convenience of its dimensional expressions. They are very simple, and directly suggest the ordinary relations of electrical theory and practice. Other systems, involving the definition of new units of certain quantities in such a way as to redistribute the factor 4π in the equations, have been proposed from time to time and some of these are now used to a limited extent. An attempt to redistribute the 4π's in an advantageous manner has been called a "rationalization" of the units. A careful study has been made to determine whether the advantages of these proposed systems are such as to justify the trouble and confusion incident to a general change of units. No such advantage has been found. A strong reason against a general change of units for the purpose of rationalization is the fact that a rationalized system is obtained merely by using the ampere-turn as the unit of magnetomotive force. D. J. M.

ELECTRICITY.—*A system of remote control for an electric testing laboratory.* P. G. Agnew, W. H. Stannard, and J. L. Fearing. Bureau of Standards Scientific Paper No. 291 (Bull. Bur. Stds., **13**: 581–597). 1916.

This paper describes a system of remote control which was developed primarily for use in testing electrical measuring instruments. Small multiple lever controllers, which may be operated in any one of several laboratory rooms, give complete control of the output of a group of motor-generator sets. For example, in testing a wattmeter, or an a.c. watthour meter on low power factor, the five levers of a controller give both a coarse and a fine adjustment of frequency, current, voltage, power factor, and an auxiliary d.c. voltage, respectively. The field rheostats are very long slide-wire resistances. They are tubular in form and are wound helically with the resistance wire. They are 32 mm. in outside diameter, and as much as 12 meters in length. When necessary they are cooled by circulating water through the tube. Special laminated brushes, which bear directly on the winding, are operated by small worm-geared motors which pull them along the tubes by means of cord and pulley. The phase relation of current to voltage is controlled by a motor-operated worm drive. A large, motor-operated, low voltage rheostat for currents up to 10,000 or 12,000 amperes is included in the system. P. G. A.

ELECTRICITY.—*A variable self and mutual inductor.* H. B. Brooks and F. C. Weaver. Bureau of Standards Scientific Paper No. 290 (Bull. Bur. Stds., **13**: 569–580). 1916.

The instrument consists of two pairs of fixed coils held in stationary hard rubber disks between which a third disk carrying two coils is arranged to be rotated. The form and the spacing of the coils were determined so as to secure the following advantages: (1) high ratio of inductance to resistance; (2) scale divisions of uniform length reading directly in units of inductance; (3) astatic arrangement of the coils, which reduces the liability of errors caused by the proximity of other instruments or of conductors carrying currents. Diagrams and data are given from which instruments of this type can be designed for given uses. Comparison is made of the new instrument and of some other older forms of variable inductor, including the Ayrton-Perry.

H. B. B.

GEOLOGY.—*Contributions to economic geology, 1915. Part I. Metal and non-metals except fuels.* F. L. Ransome, et al. U. S. Geological Survey Bulletin 620. Pp. 361, with illustrations. 1916.

This bulletin is made up of short reports by a number of different authors as listed herewith:

A gold-platinum-palladium lode in southern Nevada. Adolph Knopf.

Gold deposits near Quartzsite, Arizona. E. L. Jones, Jr.

A reconnaissance in the Kofa Mountains, Arizona. E. L. Jones, Jr.

A reconnaissance of the Cottonwood-American Fork mining region, Utah. B. S. Butler and G. F. Loughlin.

Notes on the fine gold of Snake River, Idaho. J. M. Hill.

Preliminary report on the economic geology of Gilpin County, Colorado. E. S. Bastin and J. M. Hill.

The Aztec gold mine, Baldy, New Mexico. W. T. Lee.

Iron Ore in Cass, Marion, Morris, and Cherokee counties, Texas. E. F. Burchard.

Iron-bearing deposits in Bossier, Caddo, and Webster parishes, Louisiana. E. F. Burchard.

Some cinnabar deposits in western Nevada. Adolph Knopf.

Quicksilver deposits of the Mazatzal Range, Arizona. F. L. Ransome.

Potash in certain copper and gold ores. B. S. Butler.

Recent alunite developments near Marysvale and Beaver, Utah. G. F. Loughlin.

Nitrate deposits in southern Idaho and eastern Oregon. G. R. Mansfield.

A reconnaissance for phosphate in the Salt River Range, Wyoming. G. R. Mansfield.

Cassiterite in San Diego County, California. W. T. Schaller.

E. S. B.

ENGINEERING.—*Surface water supply of the United States, 1914. Part IV. St. Lawrence Basin.* Nathan C. Grover, et al. U. S. Geological Survey Water-Supply Paper 384. Pp. 128, with 2 illustrations. 1916.

This volume is one of a series of reports presenting results of measurements of flow made on streams in the St. Lawrence River Basin during the year ending September 30, 1914. It includes also a list of the stream gaging stations and publications relating to water resources in this Basin. O. E. M.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors cooperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

ASTRONOMY

ABBOT, C. G., FOWLE, F. E., ALDRICH, L. B. *Confirmatory experiments on the value of the solar constant of radiation.* Proc. Nat. Acad. Sci., **1**: 331–333. 1915.

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BURTON, H. E. and WATTS, C. B. *Observations of Comet 1913 f (Delavan).* Astronomical Journal, **29**: 172, No. 693. 1916.

EICHELBERGER, W. S. *The distances of the heavenly bodies.* Journal Washington Academy of Sciences, **6**: 161–175. 1916; Science, **43**: 475–483. 1916.

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HOOGEWERFF, J. A. *Actual time of signals from the U. S. Naval Observatory.* Published each month in Popular Astronomy. 1916.

LITTELL, F. B. and HILL, G. A. *Determination of difference of longitude between Washington and Paris, 1913–1914.* Reprint of Publications of the United States Naval Observatory, Second Series, vol. 9, Appendix. 1916.

PETERS, GEORGE H. *Observations of asteroids with the photographic telescope.* Astronomical Journal, **29**: 147–148, No. 690. 1916.

ROSS, F. E. *The Sun's mean longitude.* Astronomical Journal, **29**: 152–156, No. 691. 1916.

ROSS F. E. *Investigations on the orbit of Mars.* Astronomical Journal, **29**: 157–163, No. 692. 1916.

ENGINEERING

MARSHALL, R. B. *Spirit leveling in Louisiana, 1903 to 1915, inclusive.* U. S. Geological Survey Bulletin 634. Pp. 101, with one illustration. 1916.

MARSHALL, R. B. *Primary traverse in Alabama and North Carolina, 1913–1915.* U. S. Geological Survey Bulletin 644-A. Pp. 12, with one illustration. 1916.

MARSHALL, R. B. *Triangulation in Arizona and New Mexico, 1913–1915.* U. S. Geological Survey Bulletin 644-B. Pp. 24, with one illustration. 1916.

MARSHALL, R. B. *Triangulation in California, 1913–1915.* U. S. Geological Survey Bulletin 644-C. Pp. 84, with one illustration. 1916.

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MATHEMATICS.—*Note on an integrating device.* M. D. HERSEY, Bureau of Standards. (Communicated by Louis A. Fischer.)

This note offers an approximate method for evaluating the integral

$$I = \int_{x_1}^{x_2} f(y)\, dx \tag{1}$$

in which $f(y)$ is stated analytically but in which the relation between y and x is available in the form of a curve only.

When $f(y)$ takes the form y, $\frac{y^2}{2}$, or $\frac{y^3}{3}$, the integral becomes, respectively, the area, the statical moment, or the moment of inertia, about the x-axis, of the plane figure bounded by the curve, the x-axis, and the limiting ordinates at x_1 and x_2. These three problems are familiar ones in machine design and naval architecture. They are frequently solved, with sufficient accuracy for the purpose, by plotting an auxiliary curve of squares or cubes if the case requires it, and then determining an area by cutting up the figure into strips of equal width, and applying some average ordinate rule. The present device is offered as a substitute for the latter method. It is equally accurate and more convenient. The applicability of the device is not limited to these particular functions.

The device consists of a templet, or plane figure, to be cut out of stiff paper, celluloid, or German silver. In its simplest form, the templet is bounded by two perpendicular lines and a curve. Call the two straight lines respectively the back and the base, and call the curve the front of the templet. The templet is to be placed on the drawing board right over the (x, y) curve so that it can be slid along with its base on the x-axis. Starting with the back at x_1, make a mark where the front of the templet crosses the (x, y) curve. Then slide it along until the back comes to the mark and make a second mark where the front now crosses the curve, and so on. Let n be the number of steps necessary to travel across from x_1 to x_2 in this manner. An approximate numerical value of the integral I will then be

$$I = nC \tag{2}$$

in which C is a known constant for a given templet.

In order to obtain the simple result (2), it is necessary only that the front of the templet be cut to the curve

$$f(Y) \cdot X = C \tag{3}$$

Here X and Y are respectively the abscissa and ordinate of any point on the templet curve, relative to the back and the base as axes.

To prove (2), let the variable Δx denote the width of each step along the x-axis. When the templet is in any one of the successive positions marked on the (x, y) curve, $X = \Delta x$ and $Y = y$. Hence by (3)

$$f(y) \cdot \Delta x = C \tag{4}$$

Integrating (1) between x and $x + \Delta x$ gives for the contribution which the strip of width Δx makes to the integral I, approximately

$$\Delta I = f(y) \cdot \Delta x \tag{5}$$

Comparing (4) and (5),

$$\Delta I = C \tag{6}$$

Thus every strip contributes the same amount C; therefore the whole integral is

$$I = \Sigma \Delta I = nC \tag{7}$$

The accuracy of the result is enhanced if the device be made up of two such templets, back to back in one piece. The working formula will then be

$$I = nK \tag{8}$$

in which

$$K = 2C \tag{9}$$

Any number may be chosen for K, and the templet cut accordingly. It is desirable that K be a multiple of 10, provided this does not make the device inconveniently large or small. It is immaterial where the extremities are cut off. Further expedients for simplifying the work, such as the use of templets of graded sizes, or auxiliary base lines for the (x, y) curve, will suggest themselves upon examining each particular problem.

The equilateral hyperbola has the property that the rectangle formed under any point has a constant area. This property has been utilized in various ways for determining the areas of plane figures. One such device is known as Beauvais' hyperbolic triangle.[1] The present contribution is nothing other than a generalization of the hyperbolic triangle so that it will determine any function, and not simply areas.

The statical moment and moment of inertia have been cited as functions which can be evaluated by the new device. Another function, which the writer has met both in barometric altitude calculations and in studying the effect of pressure on viscosity, is the integral of the reciprocal of the ordinate of an empirical curve,

$$\int_{x_1}^{x_2} \frac{dx}{y}$$

The templet needed for stepping off this integral is simply an inverted triangle.

To integrate any function $F(x)$ which can be written $f[\phi(x)]$, it is necessary only to evaluate $\int f(y)dx$ along an auxiliary curve $y = \phi(x)$. The result will be $\int F(x)dx$. For example, let it be required to find $\int_{x_1}^{x_2} e^{-x^2}dx$. Here

$$\left.\begin{aligned} F(x) &= e^{-x^2} \\ \phi(x) &= x^2 \\ f(y) &= e^{-y} \end{aligned}\right\} \tag{10}$$

[1] Engineering News, **66**: 340, 628. 1911.

Cut out a double faced templet to the curve $e^{-Y} \cdot X$ = const., i.e., to the curve

$$Y = \log \frac{2}{K} + \log X \tag{11}$$

in which K is chosen at pleasure. If n is the number of steps needed for traversing the curve

$$y = x^2 \tag{12}$$

from x_1 to x_2 with this templet,

$$\int_{x_1}^{x_2} e^{-x^2}\, dx = nK \tag{13}$$

The device therefore is not limited to problems involving empirical curves to start with. It is applicable also to cases in which the integrand is given analytically. It will be practically useful in such cases, whenever $F(x)$ is sufficiently complicated to warrant the trouble of dealing separately with the two functions $\phi(x)$ and $f(y)$.

PHYSICS.—*Note on a relation connecting the derivatives of physical quantities.*[1] M. D. HERSEY, Bureau of Standards. (Communicated by E. Buckingham.)

Statement of the problem. Given the fact that some relation of unknown form

$$Q_0 = f\,(Q_1,\ Q_2,\ \ldots\ Q_{N-1}) \tag{1}$$

subsists between N physical quantities Q_0, Q_1, Q_2, . . . Q_{N-1}, no others being involved, it is required to deduce a relation of known form

$$\frac{\partial Q_0}{\partial Q_1} = F\left(\frac{\partial Q_0}{\partial Q_2},\ Q_0,\ Q_1,\ Q_2,\ \ldots\ Q_{N-1}\right) \tag{2}$$

such that at any point whose generalized coordinates, Q_0, Q_1, Q_2, etc., are given, the value of any one of the N-1 partial derivatives of Q_0 can be computed from any other. Thus, it is required to calculate one of the component slopes of the generalized sur-

[1] This work was done at the Jefferson Physical Laboratory, Harvard University.

face (1) from a knowledge of another, although the equation of the surface is not available. The interest of the problem to the physicist lies in the fact that he may wish to learn the value of a derivative not readily accessible to experiment, in a case where some other derivative of the same quantity can easily be observed. It will be shown that a definite solution can always be obtained, provided certain dimensionless products of the N quantities are held constant.

Other classes of relations among derivatives. The proposition, that relations may be found connecting the derivatives of quantities in the absence of a primitive equation, is not new. There are two other classes of such relations. One consists of mathematical identities, applicable to any set of related quantities, whether physical or not. To this class belongs the identity

$$\frac{\partial}{\partial Q_1}\frac{\partial Q_0}{\partial Q_2} = \frac{\partial}{\partial Q_2}\frac{\partial Q_0}{\partial Q_1} \tag{3}$$

as well as the triple product relation

$$\frac{\partial Q_0}{\partial Q_1}\cdot\frac{\partial Q_1}{\partial Q_2}\cdot\frac{\partial Q_2}{\partial Q_0} = -1 \tag{4}$$

The other class comprises relations requiring the explicit use of physical laws, such as the two laws of thermodynamics, or Hamilton's principle. To this class belong Maxwell's four thermodynamic relations, and the reciprocal relations of generalized dynamics.[2] The relations to be presented here are of a nature intermediate between the other two classes, in that they require a knowledge only of the dimensions of the quantities.

Derivation of the new relation. The present result depends upon and is a corollary to Buckingham's Π-theorem,[3] according to which any complete physical equation is reducible to the form

$$\text{funct.}(\Pi_1, \Pi_2, \quad . \quad . \quad . \quad \Pi_i) = 0 \tag{5}$$

[2] J. J. Thomson, Applications of dynamics to physics and chemistry, Chap. V.

[3] This Journal, **4**: 347–353. 1914; Phys. Rev., **4**: 345–376. 1914; Trans. Am. Soc. Mech. Engs., **37**: 263–296. 1915. Any one who can sufficiently visualize the meaning of the Π-theorem will be able to treat each concrete problem by itself, dispensing with the formulas of the present paper save as a check.

in which the Π's are all the independent dimensionless products which can be built up by combining in any way the N physical quantities involved. Further, the total number of such products, or dimensionless arguments, will always be the same, no matter how the quantities are grouped. This number will be

$$i = N - k \tag{6}$$

if k is the number of fundamental units needed for measuring the N quantities.[4]

Let Π_0 and Π designate any two of the i products in (5) which contain between them the three quantities Q_0, Q_1, and Q_2 in which we are interested. Let Q_0 appear to the first power in Π_0 and not at all in any other product. This can always be done, for Buckingham has shown that a certain standard arrangement is possible in which each product contains to the first power some one quantity of type P which occurs nowhere else.[5] We shall then have

$$\Pi_0 = Q_1^{\alpha_0} Q_2^{\beta_0} \cdot \cdot \; Q_k^{\kappa_0} \cdot Q_0 \tag{7}$$

and

$$\Pi \;= Q_1^{\alpha} \, Q_2^{\beta} \; \cdot \cdot \; Q_k^{\kappa} \; \cdot Q_{k+1} \tag{8}$$

The exponents are abstract numbers fixed by the dimensions of the N quantities; in any particular problem some of them may be zero. If we now agree to keep the remaining $i-2$ products constant, (5) becomes

$$\Pi_0 = \phi(\Pi) \tag{9}$$

in which the form of ϕ is unknown. The restriction to constant products can always be fulfilled in theory, but it may lead to difficulties in practice; it will be discussed in a later section. Differentiating (9) and then (8) gives in succession

$$\frac{\partial \Pi_0}{\partial Q_1} = \frac{d\phi}{d\Pi} \cdot \frac{\partial \Pi}{\partial Q_1} = \frac{d\phi}{d\Pi} \frac{\alpha \Pi}{Q_1} \tag{10}$$

From (7)

$$\frac{\partial \Pi_0}{\partial Q_1} = \frac{\partial Q_0}{\partial Q_1} \frac{\Pi_0}{Q_0} + \frac{\alpha_0 \Pi_0}{Q_1} \tag{11}$$

[4] The question of the number of fundamental units needed has been discussed by Riabouchinsky, Rayleigh, and Buckingham; see Nature, **96**: 396–397. 1915.

[5] Trans. Am. Soc. Mech. Engs., **37**: 291–292; note eq. (11) and its discussion.

Comparing (10) and (11)

$$\Pi \frac{d\phi}{d\Pi} = \frac{Q_1 \Pi_0}{\alpha} \left(\frac{1}{Q_0} \frac{\partial Q_0}{\partial Q_1} + \frac{\alpha_0}{Q_1} \right) \tag{12}$$

Similarly

$$\Pi \frac{d\phi}{d\Pi} = \frac{Q_2 \Pi_0}{\beta} \left(\frac{1}{Q_0} \frac{\partial Q_0}{\partial Q_2} + \frac{\beta_0}{Q_2} \right) \tag{13}$$

Comparing (12) and (13)

$$\frac{\partial Q_0}{\partial Q_1} = \left(\frac{\alpha}{\beta} \beta_0 - \alpha_0 \right) \frac{Q_0}{Q_1} + \frac{\alpha}{\beta} \frac{Q_2}{Q_1} \frac{\partial Q_0}{\partial Q_2} \tag{14}$$

Hence the desired relation (2) has the linear form

$$\frac{\partial Q_0}{\partial Q_1} = a + b \frac{\partial Q_0}{\partial Q_2} \tag{15}$$

in which the coefficients

$$a = \left(\frac{\alpha}{\beta} \beta_0 - \alpha_0 \right) \frac{Q_0}{Q_1} \tag{16}$$

and

$$b = \frac{\alpha}{\beta} \frac{Q_2}{Q_1} \tag{17}$$

involve none of the N quantities save Q_0, Q_1, and Q_2.

Evidently (14) can be written also

$$\frac{\partial \log Q_0}{\partial \log Q_1} = \left(\frac{\alpha}{\beta} \beta_0 - \alpha_0 \right) + \frac{\alpha}{\beta} \frac{\partial \log Q_0}{\partial \log Q_2} \tag{18}$$

in which the coefficients are independent of the coordinates. Thus the relation connecting the logarithmic derivatives is the same all over the generalized surface.

Extension to higher derivatives. Differentiating (14) with respect to Q_1 and using the identity (3) gives

$$\frac{\partial^2 Q_0}{\partial Q_1^2} = A + B \frac{\partial Q_0}{\partial Q_2} + C \frac{\partial^2 Q_0}{\partial Q_2^2} \tag{19}$$

in which the coefficients are

$$A = \frac{Q_0}{Q_1^2} \left(\frac{\alpha}{\beta} \beta_0 - \alpha_0 \right) \left(\frac{\alpha}{\beta} \beta_0 - \alpha_0 - 1 \right) \tag{20}$$

$$B = \frac{Q_2}{Q_1^2}\frac{\alpha}{\beta}\left(\frac{\alpha}{\beta} - 1\right)(1 + 2\alpha_0) \tag{21}$$

and

$$C = \left(\frac{Q_2}{Q_1}\frac{\alpha}{\beta}\right)^2 \tag{22}$$

Thus the curvature with respect to Q_1 can be calculated from the slope and the curvature with respect to Q_2.

Integral form of the relation.[6] Integrating (14) at the point $(Q_0 = q_0,\ Q_1 = q_1,\ Q_2 = q_2)$ over an interval so short that $\frac{\partial Q_0}{\partial Q_2}$ may be treated as constant, and denoting its value by the symbol $\frac{\partial q_0}{\partial q_2}$, gives for the primitive equation of an element of the surface

$$\frac{Q_0}{q_0} = \left(\frac{Q_1}{q_1}\right)^h \tag{23}$$

in which

$$h = \frac{\alpha}{\beta}\left(\frac{q_2}{q_0}\frac{\partial q_0}{\partial q_2} + \beta_0\right) - \alpha_0 \tag{24}$$

The use of (23) would permit a direct comparison of any new results obtained by the present method with empirical results previously published in one-term, constant-exponent formulas.

Discussion of the constant-product restriction. Let Π_c denote any one of the $i-2$ arguments which we have agreed to hold constant, and let Q stand for either Q_1 or Q_2. Then, unless Π_c can be so chosen that it does not contain Q, it must be so chosen that it will contain some additional quantity Q_c not occurring

[6] If instead of an isolated value of $\frac{\partial Q_0}{\partial Q_2}$ we were furnished with the entire curve $Q_0 = f_2(Q_2)$, the direct use of the Π-theorem would be preferable, and would give the whole curve $Q_0 = f_1(Q_1)$. If successively furnished with additional curves, $Q_0 = f_3(Q_3)$ and so on, we could gradually build up generalized cross sections of the surface (1) until, when N-k independent curves had been given, we should have the whole of it. The problem of developing empirical equations synthetically has not been treated in the available papers. That problem is a general one, of which the problem of the present paper is a special case; this situation is illustrated by the fact that our final result (23) applies only to an infinitesimal piece of the curve $Q_0 = f_1(Q_1)$.

in any other product. The rule for keeping Π_c constant will then be: Vary Q_c simultaneously in such a manner as to compensate the changes due to Q.

If Q enters Π_c to the n^{th} power and Q_c enters it to the first, the derivatives in (15) and elsewhere are subject to one or more conditions of the type $Q_c \propto Q^{-n}$. For such a derivative let us adopt from now on the notation $\left(\frac{\partial Q_0}{\partial Q}\right)_{Q_c \propto Q^{-n}}$. There are two experimentally independent methods for getting its numerical value: First, by directly observing the change in Q_0 with Q while simultaneously changing Q_c in the prescribed manner; second, by calculating it from separate observations on the change in Q_0 with Q at constant Q_c, and the change in Q_0 with Q_c at constant Q. Expanding the conditioned derivative into the form $\left(\frac{\partial Q_0}{\partial Q}\right)_{Q_c} + \left(\frac{\partial Q_0}{\partial Q_c}\right)_Q \frac{dQ_c}{dQ}$ and taking account of the fixed relation between Q_c and Q leads to the working formula

$$\left(\frac{\partial Q_0}{\partial Q}\right)_{Q_c \propto Q^{-n}} = \left(\frac{\partial Q_0}{\partial Q}\right)_{Q_c} - n\frac{Q_c}{Q}\left(\frac{\partial Q_0}{\partial Q_c}\right)_Q \tag{25}$$

for the second method. In the most general case where there are $i-2$ arguments to be kept constant, the second term on the right of (25) will be replaced by $-\frac{1}{Q}$ times the summation of $i-2$ terms of the type $nQ_c\left(\frac{\partial Q_0}{\partial Q_c}\right)_Q$.

While the procedure outlined in this section is always possible and sufficient, it is not always necessary or even desirable. For example: if the number of quantities, N, does not exceed the number of fundamental units, k, by more than 2, there will be no other arguments than Π_0 and Π; again, if the remaining $i-2$ arguments do not involve Q (i.e., Q_1 or Q_2), their constancy will not be disturbed at all by the fact that Q_1 and Q_2 do vary. Further expedients for simplifying the work will suggest themselves upon examining each particular case by itself.

Some illustrative examples. For reference in solving problems it is convenient to rewrite (5) in the form

$$Q_1^{\alpha_0} Q_2^{\beta_0} \cdots Q_k^{\kappa_0} \cdot Q_0 = \text{funct.}\ (Q_1^{\alpha} Q_2^{\beta} \cdots Q_k^{\kappa} \cdot Q_{k+1}, \text{ and other } \Pi\text{'s}) \quad (26)$$

The values of α, β, etc, can now be read off directly by identifying them with the corresponding numerical exponents in the equation, of type (26), afforded by the particular example in hand.

I. In the case of a journal bearing, under certain restrictions, we may expect a relation of type (1) to connect the coefficient of friction f, with the viscosity of the lubricant μ, the revolutions per unit time n, the bearing pressure p, the journal diameter D, and the volume of oil V forced through the bearing in unit time. Let it be required to calculate the effect of altering the size of the machine from a test in which nothing is varied but the rate of pumping oil through the bearing. By the Π-theorem,

$$f = \text{funct.}\left(\frac{D^3 n}{V}, \frac{\mu n}{p}, \text{shape}\right) \quad (27)$$

Let f, D and V serve respectively as Q_0, Q_1, and Q_2. Comparing (27) with (26), $\alpha_0 = 0$, $\beta_0 = 0$, $\alpha = 3$, $\beta = -1$; hence, by (16) and (17), $a = 0$ and $b = -3\frac{V}{D}$, or

$$\frac{\partial f}{\partial D} = -3\frac{V}{D}\frac{\partial f}{\partial V} \quad (28)$$

Also, by (20) and (22), $A = 0$, $B = 12\frac{V}{D^2}$, and $C = 9\left(\frac{V}{D}\right)^2$; therefore

$$\frac{\partial^2 f}{\partial D^2} = 12\frac{V}{D^2}\frac{\partial f}{\partial V} + 9\left(\frac{V}{D}\right)^2\frac{\partial^2 f}{\partial V^2} \quad (29)$$

Equations (28) and (29) enable us to predict the bearing losses of any slightly larger or smaller machine in the same geometrically similar series. This requirement of geometrical similarity is an instance of the constant-product restriction. The products in this case are the length ratios fixing the shape.

II. Let it be required to find the effect of gravity on a rolling ball viscosimeter in terms of the effect produced by changing the size of the instrument. Let D, l, and θ denote, respectively, the diameter and length of the tube and its angle of inclination to the horizontal, d and ρ_0 the diameter and density of the ball, ρ and μ the density and viscosity of the liquid, and t the roll-time[7] in a locality[8] of gravity g. Assuming that a complete relation does subsist among these quantities, the Π-theorem shows that any equation describing that relation, whether obtained theoretically or experimentally, must be reducible to the form

$$\frac{\mu}{\rho D^2} t = \text{funct.} \left(\frac{\rho_0}{\rho}, \frac{g\rho^2 D^3}{\mu^2}, \text{shape} \right) \tag{30}$$

the shape, in turn, being fixed by the arguments $\frac{d}{D}$, $\frac{l}{D}$, and θ. Taking t, g, and D respectively for Q_0, Q_1, and Q_2 gives $\alpha_0 = 0$, $\beta_0 = -2$, $\alpha = 1$, and $\beta = 3$; so that by (18)

$$\frac{g}{t}\frac{\partial t}{\partial g} = -\frac{2}{3} + \frac{1}{3}\frac{D}{t}\frac{\partial t}{\partial D} \tag{31}$$

An interesting check on (31) is afforded by differentiating the empirical equation for such an instrument.[9] The equation has been presented in the form $y = a + bx$, in which x denotes $\tau \sqrt{Dg\left(\frac{\rho_0}{\rho} - 1\right)}$ and y denotes $\nu / \sqrt{D^3 g\left(\frac{\rho_0}{\rho} - 1\right)}$, τ being the roll-time per unit length $\frac{t}{l}$, ν the kinematic viscosity $\frac{\mu}{\rho}$, and a and b particular numerical values fixed by a particular choice of $\frac{d}{D}$ and θ. Recast in the form (30) it becomes

[7] That is, the time required for the ball to roll down. This instrument, proposed by Flowers (Proc. Am. Soc. Test. Mat., **14**: 565. 1914), is further discussed by the writer in this Journal, **6**: 527. 1916.

[8] Having set up such a viscosimeter in Cambridge, the question arose whether there would be any sensible change upon taking it to Washington, where gravity is 0.3 per cent less. The conclusion is that the roll-time in a very viscous liquid will be 0.3 per cent greater in Washington; and that the effect of gravity diminishes when the fluidity of the liquid increases, falling to 0.2 per cent for water.

[9] This Journal, **6**: 528, eq. (6). 1916.

$$\frac{\mu}{\rho D^2} t = \frac{1}{b} \cdot \frac{1}{\frac{\rho_0}{\rho} - 1} \left(1 - a \sqrt{\frac{\rho_0}{\rho} - 1} \sqrt{\frac{g\rho^2 D^3}{\mu^2}}\right) \frac{\mu^2}{g\rho^2 D^3} \cdot \frac{l}{D} \tag{32}$$

or

$$t = \frac{A}{gD}\left(1 + B\sqrt{gD^3}\right) \tag{33}$$

in which A and B (both intrinsically positive) do not involve g at all, nor D except in a shape factor. The values of $\frac{g}{t}\frac{\partial t}{\partial g}$ and $\frac{D}{t}\frac{\partial t}{\partial D}$ found by differentiating (33) do satisfy (31).

III. Without knowing the empirical equation let it be required to predict the change in roll time due to any small change in liquid density, such as would occur upon using the tube under pressure, by reference to an observation on the effect of changing the ball density. Since an expression for $\frac{\partial t}{\partial \rho}$ in terms of $\frac{\partial t}{\partial \rho_0}$ is sought, t, ρ, and ρ_0 are selected for Q_0, Q_1, and Q_2 respectively. If (30) were to be used as it stands there would be a restriction on the derivative $\frac{\partial t}{\partial \rho}$, which is hardly to be desired. An equivalent result in a more convenient form can evidently be obtained by confining ρ to a smaller number of arguments. This is done by replacing (30) by one of the alternative forms provided by the Π-theorem, such as

$$\sqrt{\frac{g}{D}}\, t = \text{funct.}\left(\frac{\rho_0}{\rho}, \frac{g\rho_0^2 D^3}{\mu^2}, \text{shape}\right) \tag{34}$$

Comparing this with (26), $\alpha_0 = 0$, $\beta_0 = 0$, $\alpha = 1$, $\beta = -1$; hence by (14)

$$\frac{\partial t}{\partial \rho} = -\frac{\rho_0}{\rho}\left(\frac{\partial t}{\partial \rho_0}\right)_{\mu \propto \rho_0} \tag{35}$$

or by (25)

$$\frac{\partial t}{\partial \rho} = -\frac{1}{\rho}\left(\rho_0 \frac{\partial t}{\partial \rho_0} + \mu \frac{\partial t}{\partial \mu}\right) \tag{36}$$

In the last transformation μ took the part of Q_c and ρ_0 of Q, while n had the value -1.

The following observations afford an experimental illustration of (36). They were made with a tube 59 cm. long and 1 cm. in diameter, containing a $\frac{1}{4}$ inch (0.635 cm.) ball, ordinarily of steel ($\rho_0 = 7.7$ g./cm.³). The tube was filled with lard oil ($\mu = 0.74$ c. g. s. units, $\rho = 0.92$ g./cm.³). The slope $\frac{\partial t}{\partial \mu}$ was found to be 31 c. g. s. units. Substituting now a brass ball ($\rho_0 = 8.6$ g./cm.³) for the steel one, the roll-time dropped from 27.9 to 24.7 seconds, making $\frac{\partial t}{\partial \rho_0}$ equal to -3.6 c. g. s. units. From these data, in conjunction with (36), the value $\frac{\partial t}{\partial \rho} = 5.2$ c. g. s. units would be predicted. From (32), the actual value is found to be 5.7 c. g. s. units. Since $\frac{\partial t}{\partial \rho}$ is itself a correction term, the agreement is sufficient.

BOTANY.—*Ammocodon, a new genus of Allioniaceae, from the southwestern United States.*[1] PAUL C. STANDLEY, National Museum.

The genus *Selinocarpus* was proposed by Gray, in 1853,[2] in a paper dealing with the plants of the family Allioniaceae[3] collected by Charles Wright during his explorations of western Texas, southern New Mexico and Arizona, and northeastern

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] Amer. Journ. Sci. II. **15**: 262.

[3] Dr. Gray used the family name Nyctaginaceae, a term more widely employed by botanists than the earlier Allioniaceae. The designation of this family is not based, as some suppose, upon the genus *Nyctaginia*, but upon *Nyctago*, an early name for the four-o'clocks, to which Linnaeus assigned the generic term *Mirabilis*, which is universally used today. Consequently the term Nyctaginaceae is objectionable, as applied to a family, since it is based upon a generic name nowhere accepted as valid.

An example of mistaken ideas concerning the source of the word Nyctaginaceae and certain related forms is found in *Catalogue of the Flowering Plants and Ferns of Connecticut* (Connecticut Geol. and Nat. Hist. Surv. Bull. 14, p. 172. 1910). In explanation of the specific name of *Oxybaphus nyctagineus* (Michx.) Sweet

Mexico, which extended from 1849 to 1852. Two species were described, *S. diffusus* and *S. chenopodioides*. There is no indication that the genus was based primarily upon either species; consequently the first, *S. diffusus*, may be taken as the type.

Selinocarpus is related to the large genus *Boerhaavia*, being distinguished chiefly by the broad, thin wings of the fruit. In the latter, it is true, the fruit is sometimes winged, but the wings are narrow, thick, and usually veined. No one, apparently, has questioned the claims of *Selinocarpus* to generic rank, for the plants are decidedly different in their general aspect from the group of species comprised in *Boerhaavia*, as restricted by the present writer.[4]

Since 1853 five species of *Selinocarpus* have been published, the genus now being known to range from Nevada and southern Utah to western Texas and southward to Coahuila, Mexico. Upon close inspection of the seven species it is evident that one of the two original ones, *S. chenopodioides*, differs in certain floral characters from the genotype and the five subsequent additions to the genus. Its perianth is campanulate and conspicuously constricted above the ovary, while in *S. diffusus* and the other species the perianth is tubular-funnelform and not at all constricted. In the case of the latter group of species the perianth varies markedly, however, in shape and size, being only 1 cm. long and with a short tube in *S. angustifolius* Torr., and 2.5 to 4.5 cm. long, with a slender, elongate tube, in the other species. In *S. chenopodioides* the perianth is 4 to 5 mm. long. In the last, moreover, the stamens are 2 or rarely 3, their filaments free from the perianth, while in *S. diffusus* and its allies the stamens are 5 or 6, their filaments adherent to the perianth tube. These striking differences in the perianth and androecium are accompanied by habital differences, also: In *S. chenopodioides* the flowers are aggregated in many-flowered, umbelliform cymes,

(*Allionia nyctaginea* Michx.) the statement is made that it signifies "like *Nyctaginia*, a genus of this family." As a matter of fact, Michaux's species was published many years before the generic name *Nyctajinia*. His specific name doubtless alludes to the resemblance of the leaves of the *Allionia* to those of the common four-o'clock, *Mirabilis jalapa*, the *Nyctajo* of pre-Linnaean botanists.

[4] Contr. U. S. Nat. Herb., **12**: 372–387. 1909.

each flower subtended by one or rarely 2 bracts, while in the other species the few flowers are solitary or geminate in the leaf axils, each subtended by 2 or 3 bracts.

In 1913 Dr. Anton Heimerl, an eminent Austrian botanist well known for his studies of this family of plants, pointed out[5] these differences and used them as a basis for the division of *Selinocarpus* into two sections, *Breviflori* and *Tubiflori*. To the writer, however, it seems that the section *Breviflori* deserves generic rank, and the name *Ammocodon* is accordingly proposed for it. The primary characters upon which the genus is based are those of the flower and androecium, and they are certainly of greater significance than the quantitative fruit characters which are used to separate *Selinocarpus* and *Boerhaavia*.

Ammocodon Standley, gen. nov.

Erect or decumbent perennial herbs with thick roots and dichotomous pubescent stems. Leaves opposite, petiolate, those of a pair often unequal, the blades succulent. Flowers umbellulate, the umbellules in open cymes, each flower subtended by a minute subulate bract, or a second smaller bract rarely also present; perianth campanulate, purplish red, constricted above the ovary, shallowly 5-lobed, the lobes plicate. Stamens 2 or rarely 3; filaments filiform, short-connate at the base, free from the perianth. Ovary narrowly oblong; style filiform, exserted; stigma peltate, smooth. Fruit a compressed anthocarp, broadly 5-winged vertically, the wings hyaline. Testa of the seed adherent to the pericarp; embryo conduplicate, the cotyledons enclosing the farinaceous endosperm; radicle elongate, descending.

Type species, *Selinocarpus chenopodioides* Gray.

Ammocodon chenopodioides (Gray) Standley.

Selinocarpus chenopodioides Gray, Amer. Journ. Sci. II. **15:** 262. 1853.

The type was collected by Charles Wright in valleys from Providence Creek to the Rio Grande, western Texas. The species ranges from western Texas through southern New Mexico to southeastern Arizona, and southward into Chihuahua. It is very abundant in the region about El Paso, growing chiefly in the loose sandy soil of the mesas, usually along with creosote bush (*Covillea glutinosa*). The flowers are not very showy, but bright-colored and borne in great profusion. Like those of most, if not all, of the herbaceous members of the family, they open late in the evening and close about noon or earlier the following day.

[5] Oesterr. Bot. Zeitschr., **63:** 351–355.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TECHNOLOGY.—*An investigation of cartridge enclosed fuses. Report of the Bureau of Standards in the case of Economy Fuse and Manufacturing Co. vs. Underwriters' Laboratories (Inc.) concerning the fire and accident hazard of the Economy Refillable Fuse as compared with approved fuses.* E. B. Rosa, H. B. Brooks, B. McCullom, W. J. Canada, and F. W. Gladding. Bureau of Standards Technologic Paper No. 74. Pp. 199. 1916.

This report represents the results of the investigation carried out by the Bureau of Standards acting as referee on the joint request of the Economy Fuse and Mfg. Co. and Underwriters' Laboratories, Inc., on the question of the relative fire and accident hazard of Economy Refillable fuses and fuses at present listed as standard by Underwriters' Laboratories, Inc. The evidence on which the finding of the Bureau was based includes a large number of tests of fuses under widely different conditions, as well as inspections of numerous fuse installations in practice, personal interviews with many fuse users, evidence and arguments submitted by the Economy Fuse and Mfg. Co. and Underwriters' Laboratories both at a public hearing and by correspondence, and evidence and arguments submitted by a number of manufacturers of fuses at present listed as standard by Underwriters' Laboratories. The investigation disclosed that the experience with the present type of Economy fuse is not yet sufficient to determine whether the total hazard is greater or less than it is with approved fuses as they are actually used in practice. The report contains numerous tables and 110 oscillographic records showing the performance of both Economy and approved fuses under various short circuit conditions.

B. McC.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 775th meeting was held on May 27, 1916, at the Cosmos Club. President BRIGGS in the chair; 47 persons present. The minutes of the 774th meeting were read in abstract and approved.

The evening was devoted to a symposium on the atom. Mr. H. L. CURTIS presented a paper on *The atom as a miniature solar system.* The author briefly sketched the history of atomic theory from Dalton's work in 1803 to the recent work of J. J. Thomson, Rutherford, Nicholson, Bohr, Van der Brock, Zeeman, and others. Two types of nucleus atom are possible, viz, the planetary type and the Saturnian type. In the planetary type each electron has an orbit different from that of any other electron, as is the case of the planets rotating about the sun, but different from this in that they repel each other while the planets attract. In the Saturnian type, which is most generally accepted, the electrons rotate in rings around the nucleus. Bohr's assumptions of the laws holding at atomic dimensions and the results from his hypothesis were given in detail. The present trend of thought is towards accepting the Saturnian type of the nuclear atom. It is generally conceded that the forces which bind the parts of the atom together are different from those with which we are accustomed to deal. The radiation giving the lines of the visible spectrum is concerned with the outer rings of the atomic system, while X-rays are produced by vibrations of the inner rings of electrons. Radioactive phenomena and chemical affinity appear to be concerned with the nucleus.

Discussion. Mr. AGNEW referred to experiments in magnetization which indicate the validity of the Saturnian or planetary-type theory. Bohr's theory predicted that certain lines of the spectrum of helium were due to hydrogen. Mr. BAUER referred to the looseness of terms found in writings on the atomic theories; for example, 8 out of 10 will use "rotation" instead of "revolution." In many theories of astronomy it is not necessary to take account of rotation, but no astronomer would attempt to explain all facts and phenomena only by revolution; it, therefore, appears that the time may come when it may be necessary to consider both rotation and revolution in connection with atomic theories. Mr. SOSMAN referred to the recent work on the valence of atoms in chemical compounds. Mr. WRIGHT referred to studies in crystal structure in which particular directions within an atom find expression in atomic arrangement of crystals.

Mr. SWANN referred to conflicting theories between the chemist and the physicist with reference to the structure of the atom. He thought that perhaps some part of the apparent excellent agreement of constants might be due to a juggling of the 2π-factor in the computations. Mr. DELLINGER thought that Mr. Swann's last remark explained some agreements found in recent contributions.

Mr. W. J. HUMPHREYS presented a paper on *The magnetic field of an atom.* Recent investigations by Weiss, Ritz, Humphreys, Oxley, and Merritt of atomic phenomena and structure were reviewed. These investigations all give varied evidence in favor of the assumption that atoms have powerful magnetic fields which are of the order 10^8 gauss, and which are due, presumably, to orbital revolutions of electrons. It might seem that atoms with such strong magnetic fields would collapse; the author's calculations, however, show that the electric forces between the portions of atomic models of the Saturnian type would be more than sufficient to prevent collapse through the interaction of their powerful magnetic fields.

Mr. SWANN thought the indicated order of magnitude of the atomic fields is large, judging, for example, from computations, assuming a field of 10^8 gauss, of the moment of the equivalent magnet and of the deflection that would be produced in shooting α-particles through a thin piece of magnetic iron.

The 776th meeting was held on October 14, 1916, at the Cosmos Club. Vice-President BUCKINGHAM in the chair; 65 persons present. The minutes of the 775th meeting were read in abstract and approved.

Mr. A. L. DAY presented a communication, illustrated by lantern slides, on *Do volcanoes offer evidence in regard to the interior of the earth?* Recent studies are helping to emphasize more and more sharply the conclusion that volcanoes are local phenomena of very limited significance in affording information concerning the interior of the earth. This view is supported by the differences in chemical composition between lava outflows in different parts of the world, by the differences in altitude of the points of outflow even in neighboring volcanoes, by the apparently complete independence of one another of volcano vents which are immediately contiguous, as at Stromboli, Hawaii, and other places, and by the fact that most of the volcanic phenomena appear to derive their energy from gas reactions in which only the gases appear to be of deep-seated origin. The formation of vertical conduits, under this view, is then simply the result of gas reactions ("gas fluxing") which generate sufficient heat to melt the adjacent rock masses and to form more or less vertical outlets for gaseous or liquid products. Neighboring conduits of this kind often show complete independence of action in time, in pressure (as shown by the lava level), and in character of explosive or other activity at the mouth, all of which point to the independence of the local supply chambers to which the vents serve as outlets. Of course, a great rift like the one on the south flank of Mauna Loa, from which two lava streams recently flowed to a distance of 8 miles, indicates a basin of much larger magnitude than those at Stromboli, but still vanishingly small when compared with the magnitude of the earth or even with the magnitude of the volcanic island (Hawaii) of which it forms a part. In fact, the complete absence in the geological record, of any really great outpouring of lava, and the absence of evidence of extreme temperatures in those outlets which have been accessible to study, point to the conclusion that all are local and probably not even deep-seated phenomena.

Discussion. Mr. WASHINGTON called attention to the characteristics of the volcanic rocks from the continent of Africa which are quite different from those, for example, from Vesuvius and Etna. Mr. CLARKE referred to the pioneer work of Herbert Spencer regarding the condition of the interior of the earth. Mr. FARQUHAR made inquiry regarding the temperature gradients determined from borings and the relation of such gradients to Chamberlin's hypothesis. Mr. DAY stated that, judging from the temperature gradient determined from borings, the interior temperature may reach 20,000° which Chamberlin admits in his hypothesis. He stated that bore-hole temperature records must always be carefully used since conditions are generally not typical; determinations of temperature gradients from different sources vary by 100 per cent.

Mr. L. A. BAUER presented a communication, illustrated by lantern slides, entitled *Concerning the origin of the earth's magnetic field.* The various recent theories regarding the origin of the Earth's magnetic field were reviewed with particular reference to their bearings on the general topic of the evening: the constitution of the earth's interior. The hypothesis of chief interest in this connection, namely, that of an iron core being the cause of terrestrial magnetism, has inherent in it many difficulties, which, however, may not be insuperable. Should experiments decisively show that increased pressure elevates the critical temperature of magnetization, then the depth of 10 to 12 miles, now supposed to limit the presence of materials in the magnetic stage, would be increased. However, the few experiments available indicate that increased pressure lowers the critical temperature of magnetization. The various hypotheses as to the earth's magnetic field being caused by electric currents within the earth's crust, or as to its connection in some manner with the speed and direction of rotation of the earth, were briefly discussed. The exceedingly small effect to be observed renders conclusive laboratory experiments, if not a hopeless task, certainly a very difficult one with present appliances. The author reiterated a belief, already expressed on a former occasion, that our chief hope at present of determining the origin of the earth's magnetic field appears to lie in the direction of determining what causes the field to vary in the remarkable manner it does. The definite limitations imposed by the variations in the earth's magnetic field, both of the periodic and aperiodic kind, and the departures of the field from the simple uniform type, are too frequently overlooked by theorists. Most theories, for example, are found inadequate when the attempt is made to explain, besides the origin of the field, the secular variation as it is actually observed.

In conclusion it was pointed out that the solution of some of the questions entering into the problem of the origin of the earth's magnetic field must be deferred until the completion of the magnetic survey of the earth now in progress under the auspices of the Carnegie Institution of Washington.

Discussion. Mr. BURGESS discussed the question of the effect of pressure on magnetic properties of iron. Our knowledge of variations in the magnetic conditions of ferrous materials is at present insufficient to give much help. Mr. SWANN referred to the difficulty associated with the assumption of electric currents as the origin of the earth's magnetic field primarily in the explanation of the e. m. f. to which these currents owe their origin; this difficulty is not, however, as great as may appear, for it is not improbable that the state of equilibrium in the rotating earth might involve relative motion between the electrons and the ordinary matter as a condition for the absence of degradation into heat of such motion as exists. It is a known fact that the intensity of magnetization produced in a sphere of infinite permeability when placed in a magnetic field is only four times the intensity which would be produced were the permeability only two; the reason for this is to be found in the demagnetizing force which a magnetic sphere produces in its own substance. It appears that the principle inherent in the phenomenon is not limited to the case where the magnetizing influence is an ordinary magnetic field but is of wide application, so that we may say in general that it is impossible to produce, no matter what the material of the sphere may be, an appreciable magnetization in a sphere by feeble influence. J. A. FLEMING, *Secretary.*

BOTANICAL SOCIETY OF WASHINGTON

The 112th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club, Tuesday, April 4, 1916. Fifty-two members and five guests were present. HARRY R. FULTON, GEORGE L. KEENAN, LESTER A. ROUND, J. F. CLEVENGER, C. E. TEMPLE, A. E. ALDOUS, VICTOR BIRCKNER, and FORREST S. HOLMES were elected to membership. The following papers were presented.

Botanical explorations in South America: J. N. ROSE.

Plants domesticated in Peru: O. F. COOK. Mr. Cook gave a brief account of the agriculture of the Incas, with their wonderful terraces and system of irrigation. Among the plants domesticated by them were maize, beans, lima beans, peanuts, quinoa (*Chenopodium quinoa*), red peppers (*Capsicum*), mandioca, tomatoes, passion fruits, sweet potatoes, tuberous *Tropaeolum* and *Oxalis*, arracacha (a celery-like plant), squashes and pumpkins, gourds; and among the fruits were chirimoyas, lucumas, and pepinos. The narcotic coca, from which cocaine is now prepared, was also grown. Mr. Cook's paper is embodied in an article since published in the National Geographic Magazine, **29**: 474–534. June, 1916.

W. E. SAFFORD, *Corresponding Secretary.*

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GEOPHYSICS.—*A theory of terrestrial volcanoes and the geography of the moon.*[1] Stanislas Meunier, Museum of Natural History, Paris. (Communicated by Arthur L. Day.)

Long-continued studies have led me to develop a new theory in regard to the phenomenon of volcanoes, a theory which, it seems to me, harmonizes with the best-established facts of geodynamics, differing therein from all preceding theories. A necessary sequel has been a study of the consequences to which the theory leads as regards the future of eruptive activity itself.

In making that study, I adopted the method of the mathematician, who proceeds to the solution of a given problem by varying the elements of the problem in order to discover the corresponding special cases. Accordingly I have assumed hypotheses regarding the geologic consequences that result from modifying the variables of the problem. I shall not try to conceal the satisfaction I felt on finding that one of the suppositions examined explains completely the circumstances of lunar economy.

The discussion involves three main consequences:

1. It tightens in an unexpected manner the geologic bonds existing between the earth and the moon. This result is so conformable to the ingenious cosmologic conception of Laplace as to constitute a veritable confirmation of it, by furnishing definitive proof of the similarity of the physical constitution of our

[1] Translated from the French.

globe and its satellite, as well as of the identity of their behavior in the course of sidereal evolution, in which they represent two successive stages.

2. In the second place, the relation of the history of the moon to the history of the earth, so different at first sight as regards the phenomena of volcanism, includes the verification, the tangible verification so to speak, of the eruptive theory, although the latter had been established on purely geologic considerations at the very moment when I felt compelled to postpone the selenographic study, which seemed to require a combination of special conditions.

3. Finally, by means of a correlation which *a priori* seemed hazardous, my results furnish a new support for that great chapter of science which is yet far from being fully understood, but which nevertheless has so often and so strongly fascinated me from the very beginning of my career, namely, the chapter of comparative geology.

This may seem a bold program, and in laying it before the reader I feel that it may arouse a certain skepticism. Nevertheless I feel confident that my undertaking will benefit the work on which I am engaged, namely, the building-up of a body of arguments which will naturally group themselves into one of the chapters of the geologic harmonies of the physical universe.

In order readily to understand the bearing of the statements just made, it is necessary to call briefly to mind the nature of the proposed volcanic theory and what, in my opinion, it is capable of explaining.

According to this theory, *volcanic activity* is a normal and therefore inevitable result of the regular evolution of our globe. It therefore determines, on the one hand, all the details of the earth's constitution, that is to say, of its *anatomy*, and, on the other, all the details of its activity, that is to say, of its *physiology*. According to this theory, also, volcanic activity is a natural and frequent result of the formation of mountains, being in fact its epiphenomenon, so to speak.

We have to recall the circumstances accompanying the beginning of planetary history and to assume, with Laplace, that the earth is but a drop of the chaotic substance separated from the sun, like the other globules of the same nature, which, before or after it, have taken on the condition of autonomous bodies. The sun represents the enormous residue of primordial matter from which these successive products were derived.

The globular form assumed by the mass that was to be our planet results from the dominant property possessed by the molecules of all mobile matter to attract one another and thus to become grouped around their common center of gravity. Laplace has shown how this attraction causes the heating of the whole mass and at the same time its general movement of rotation around its own axis. We need add nothing to the conception of the author of the *Exposition du Système du Monde* in order to understand in outline the successive stages of our globe, all due to the spontaneous cooling caused by its position in space, the temperature of which is far below that of the earth itself.

The first effect of cooling was to deprive the chaotic matter of any homogeneity which it might have had at the start, the result being a solid crust forming a partition between the uncooled fluids that constitute the nucleus of the globe and the far less dense fluids forming the ocean and the atmosphere.

Ever since the crust began to form and to grow thicker by additions on the inside, owing to the progressive solidification of the nucleus, it has tended to accommodate itself to the ever-changing conditions arising from the steady diminution in volume of the enclosed mass. While that mass contracts during cooling without changing its form, which remains spherical while its diameter decreases, the crust, which is not contractile, responds in a different way. As the support furnished by the fluid nucleus is withdrawn because of its contraction, the crust has to follow it and hence becomes increasingly corrugated, with attendant faults (geoclases) and tangential thrusts.

This is the well-known cause of topographic relief, the cause of continents and oceanic basins. The water, instead of covering the globe as a uniform sheet, has collected in the oceanic basins, to which, by a ceaseless circulation, it always returns after falling as rain and flowing over the land as storm water and running water—aside from the large amount that seeps into the ground, of which we will speak later on.

Without entering into details which every one knows, I will merely add, for the sake of clearness, that the deformations of the earth's crust, constantly diminishing the diameter of the planet, consist essentially in the transformation of a centripetal action into a tangential compression, as is shown by the great mountain ranges, whose natural escarpments so often and so clearly reveal to us the internal structure. In these mountain ranges beds of a great variety of rocks are seen resting one on the other, which may be correlated with the strata of the plains, but which have been modified in their mineral composition by metamorphism and in their relative position by orogenic forces.

As regards the last-mentioned point, the essential fact is that geologically old strata commonly rest on geologically younger strata, which is exactly the reverse of what prevails in undisturbed sedimentary regions. When, for example, we climb the Alps we first pass over very recent beds, such as the Tertiary conglomerates of the Righi, next over Mesozoic deposits, such as the Cretaceous and Jurassic marbles of Mount Pilatus, next over Paleozoic sediments, such as the Carboniferous shales of the Mcëde, etc., and only when we arrive at the top do we find the primitive rocks, such as the gneisses of the Jungfrau.

There can be no doubt that these strata were pushed along nearly horizontal planes of fracture, with the result that they now occupy a much smaller area than they did originally, while their thickness has increased by superposition, as has just been pointed out. Thus there has been a transfer of deep-seated material over younger strata. It is necessary to recall this commonplace notion, because it suffices to give us the viewpoint needed for the present subject as regards everything relating to the structure of mountain ranges, which for that matter varies widely.

Summarizing this first point, we see that the spontaneous cooling of the globe gives rise to a tangential compression of the crust, which at any given moment is too wide for its contents, and that this is the sole cause of the characteristic superpositions observed in mountains.

This, however, does not yet suffice to explain completely the origin of mountains, and it is proper to note that the process just described is strictly confined to the underground regions. In order that a mountain may be formed another thing is necessary: the block that has been compressed in the underground region has to be raised by tangential reactions, causing a protuberance that rises above the general surface of the planet. The gigantic tuberosity of Thibet, in the heart of the Asiatic continent, is a type.

Space will not admit of presenting the arguments which prove that the compression and transfer on the incline planes of geoclases can take place only in a certain portion of the crust. The deeper portions are still too hot to admit of the production and maintenance of gliding planes in their plastic substance, while in the outer parts the porosity and compressibility of the rocks constituting the substratum, opposing their inertia to the propagation of vibrations, protect the superficial strata against excessive mechanical shocks, which would constitute an insuperable obstacle to the development of external phenomena, such as the manifestations of organic life.

Without dwelling on this subject let us note merely that the mechanical deformations of the crust are not the only inevitable consequences of the spontaneous cooling of the globe.

Another fact of equal importance, and without which volcanism would be impossible, develops parallel with the first. We have already noted that the lowering of the surface temperature has led to the condensation of water, the fall of rain, and the development of rivers, whose waters accumulate in the ocean basins. Part of the water penetrates into the crust not only by constant infiltration but by the burial of wet sediments under later sediments, whereby water and other volatilizable matter are imprisoned in the solid mass at constantly increasing depths and are incorporated in a large part of the thickness of the crust.

This being premised, we must next observe that the overthrusting just described, whereby the rock masses are superposed (often in inverted order) acquires a new meaning from the very presence of water. The water-soaked zone thus forms an envelope around the deeper zone which is as yet too hot to admit the entrance of water. At many points the orogenic compression, taking advantage of geoclases, carries hot waterless strata over less hot water-soaked strata. The latter are thus subjected to *reheating* under circumstances which are particularly interesting. We know the effects that are likely to be produced by such reheating under the influence of water incorporated in deeply buried rock masses having no communication with the surface. On this point Sénarmont has made experiments of which I am unable for lack of space to mention more than the results. He has shown that in *superheated* water, as he called it, that is to say, water subjected to a temperature of several hundred degrees in a closed vessel, the ordinary rocks take on all the characters of metamorphic and volcanic rocks. The water, strongly compressed and having reached the condition when it assumes the mineralizing function, becomes incorporated with the rock particles, and thus in the state of occlusion it endows them with the expansive property.

Suppose next that a mass of rocks thus charged with occluded water under high pressure is put into communication with the atmosphere through a fissure, for example. The occluded vapor, no longer held back by a resistance equal to its expansive force, will seek to attain equilibrium of pressure with the atmosphere; it will issue from its confinement and carry with it the rock magma in which it is dissolved, ejecting it through the vent, and thus will produce the volcanic phenomenon in all its details. Without attempting any detailed proof, let us note that this line of reasoning explains all the incidents of the volcanic phenomenon, from the ejection of ashes, vesicular pumice, and scoriae to the rise and overflow of lava and even the formation and reaction of fumaroles.

Volcanism as a whole, as has just been found to be the case with seismism, is an epiphenomenon of the production of mountains. This is why intrusions of igneous rocks in all their forms play such a prominent part in all complete mountain ranges.

Summarizing, we may say that eruption results from the collaboration of two processes, seemingly quite unrelated:

1. The *progressive penetration of water* and other volatile substances to a depth within the earth's crust which is strictly dependent at every instant on the degree of spontaneous cooling;

2. The *tangential compression of the rocks*, due to the contraction of the nucleus and also to the tendency of the crust to founder into deeper and deeper regions where the horizontal space grows narrower and narrower.

Thus the crust of our planet forms a kind of weaver's loom, producing the volcanic tissue, the *warp* being represented by the descending network of threads of water, while the *woof* is represented by the tangential network of heated material, due to the orogenic superposition of intrusive masses over water-soaked sediments.

Harking back to the point from which we started, we may here adopt the practice of the mathematician who devotes himself to the discussion of a given problem. We may inquire what special results would follow from modifying one or the other of the two factors of the eruptive phenomenon.

Let us note, first of all, that the volcanic phenomenon could only have appeared after a long evolution of the terrestrial globe, because it requires a crust, and not only this but the superposition of two concentric zones: the one deep down and very hot, the other at less depth, impregnated with water and of moderate temperature.

However, to dwell on this point would be to enter into the domain of comparative geology. Suffice it to say that from the moment when the crust was formed, and long before, eruptions had taken place, different no doubt from, but yet comparable in certain respects and belonging to, the class now represented by the majestic spectacle of the solar eruptions.

Hervé Faye recently established the synthetic theory of the sunspots and of the red protuberances accompanying them, and showed that these phenomena represent an incessant radial circulation of the material constituting the epidermic zone of the sun; we might almost say the *cortical* zone, for the photosphere represents as it were a rudimentary crust, situated, like the earth's crust, between the atmosphere and the nucleus, but as yet in an unstable condition because of its extreme thinness. It exhibits one of the stages through which the lithosphere of our own globe must necessarily have passed.

The circulation, which (like the circulation of water in the earth's organism) is radial, results from conditions no longer found on our globe, conditions due to the extreme mobility of all the solar elements. Faye notes the production of whirlwinds in the sidereal mass, and he does not hesitate to compare their course and cause to those of the eddies in rapid rivers. The solar eddies, like those of rivers, carry into the depths of the moving fluid the material derived from the peripheral zone, and their descent, though effected in quite a different way, reminds us of the progressive soaking of the rocks by water, for, like this soaking, it results in producing the mechanical force that is the cause of eruption. Once this relatively cool material derived from the solar surface has been carried to the proper depth, it is heated, expands, and yields to an enormous pressure tending to shoot it out into the atmosphere, where it forms the rose-colored flames. Evidently it cannot burst forth in this way without carrying with it material derived from relatively lesser depths, especially from the photosphere. This process shows that the solar explosion is an agent for the mixing of substances which by the diversity of their physical properties seemed destined to be forever separated, just as happens in the case of volcanic eruptions on the earth.

We are not yet in a position to give an exact account of the details exhibited by the volcanic phenomenon at its first appearance, as soon as the necessary conditions were realized on our globe. However, observations of a purely geologic nature show that the upheavals of rocks since the oldest sedimentary epochs are so closely comparable to the work of modern eruptions as to suggest that the appearance of volcanoes was virtually instantaneous. To gain a clearer view on this point we should have to consider successively the consequences that would flow from the various possible combinations of temperature distribution along one and the same terrestrial radius, under the complications that would arise from the fact of the freezing of water at the surface and also at greater and greater depths. We should also have to make the same inquiry as regards the distribution of the water soaking into the deep strata, which would necessarily carry with it the zone of volcanic activity. All these subjects, and various other subjects besides, suggest discussions, some of which promise definite conclusions. It may suffice here to suggest them, while awaiting fuller data from the progress of science. We can merely attempt to set up a few hypotheses as regards the future of eruptive activity.

First of all, we may turn our attention to the relations between the cooling process and the stock of infiltrated water. The quantity of water available in the superficial regions of the earth is evidently limited, and the progress of cooling constantly tends to diminish the amount of water in seas, lakes, air, and even in the interstices of rocks. The tentative estimates made on this point at various times, by totally different methods, have invariably led to the conclusion that the quantity of water already absorbed by the crust is several times larger than the total volume of water still remaining on the surface in the liquid state; and that this remainder is only a small fraction of the amount that would be needed to saturate the entire crust to the degree of humidity observed in moist rocks, described by the expressive term of *quarry-water*. A time will come, therefore, when the earth will be completely dried up, because all its water will have disappeared, by infiltration, in the beds of rock.

On the other hand the globe, growing cooler all the time, will some day arrive at a state of equilibrium with the temperature of space. Thus the two factors of volcanism will disappear independently of each other, and not necessarily at one and the same time.

Several suppositions may be based on this consideration. Suppose, first of all, that the time necessary for the complete absorption of the water by the crust is exactly equal to the time required for the complete cooling of the globe. In that case it may be that the volcanic phenomenon may gradually fade away and disappear without any important modification of the exterior of the planet.

Suppose, in the second place, that the quantity of water were much larger than it actually is on the earth. In that case, when the cooling has been completed, the whole planet will still be impregnated with water, a surplus of which will even remain on the surface. Long before that time, of course, the water will be frozen, and ice will be a rock like the other petrographic species.

Let us, however, take the opposite case, supposing that the quantity of water is insufficient to moisten the entire rock mass during the process of cooling. In that case the volume of the seas and of all the other liquid water bodies of the surface will diminish until it disappears, and the globe will be completely dried up while still warm. But—and this is the essential point—the drying up will not necessarily cause the disappearance of the volcanic phenomenon. That phenomenon is not a superficial reaction; on the contrary, its focus is situated at a great depth, and that depth is consantly increasing as the absorption of liquid water continues. Thus the conditions necessary for an eruption may continue long after the drying of the surface is completed. For example, the water that active volcanoes emit nowadays no doubt represents a contribution from the ocean going back to very ancient geologic periods. The orogenic superposition of moist subterranean regions by hot rocks driven tangentially over the roof of the great geoclases may continue for long geologic periods, which means that water of impregnation will continue to be occluded in the substance of ancient sediments, which will take advantage of the smallest fissure communicating with the upper, less dense regions to inject themselves into them by expansion. The feebleness of the atmospheric pressure, dwindling little by little to zero, will increase the number and energy, perhaps also the volume, of the outbursts, and will especially affect the *relief* of the material ejected upon the surface as cones of lapilli and ashes, needles, chaotic accumulations of scoriae, and lava flows. In addition the superficial water, except the volcanic rains, having little by little disappeared, erosion, formerly so active, will cease, and consequently the products of eruption will persist without much alteration. Meantime the centers of eruption will constantly increase in number, until they may eventually cover the entire surface of the planet. By a singular contrast the planet destined to perish by progressive cooling will don as its final garment a shroud woven by volcanic energy.

The picture thus drawn of the effects of a prolongation of volcanic activity after the complete absorption of the surface water is closely analogous to the most essential features of lunar geography. Without going into detail, I will content myself with expressing my satisfaction on finding that the volcanic theory outlined at the beginning of this article is completely borne out by an object-lesson, the moon.

Let us suppose that this theory really expresses the facts, and that the earth at the dawn of the Tertiary epoch had reached a condition where all its surface water had been absorbed, while the volcanic activity was still in full blast. It is easy to see what would have happened. Volcanic eruptions would have continued, and their products would have been spread over the surface; but there would have been this essential difference, the volcanic outflows would no longer have been exposed to the destructive action of rain and seas. They would have accumulated side by side without perceptible change. To form an idea of the morphologic effect on the earth's surface it may suffice to point out that the previous sediments would have disappeared, more or less completely, beneath this sheet of volcanic material.

The importance of this fact will be appreciated if we cast a glimpse at the condition in which Europe, for example, would be if all the eruptive formations poured out since the beginning of Tertiary time had remained intact, side by side.

From Iceland, with Hecla and its companions, from the British isles, with Skye, the Hebrides, the Faroes, and Ireland, with Antrim, to the Mediterranean basin, with Sicily, continental Italy, Elba, and Santorin, the Tertiary and Quaternary eruptive centers follow one another without any wide gaps. All central Europe was volcanic: Hungary and Transylvania are dappled with trachytes and rhyolites; Bohemia rests on vast and highly varied outflows; in the Höhgau, basalts are associated with phonolites; the Siebengebirge around Bonn, the Drachenfels, Mount Meissner in Hesse, the so-called Kaiserstuhl region in the Breisgau, the vicinity of Mainz and of Cassel, the Eifel, and above all the vicinity of the Laacher See, are made up of outflows, and their analogues occur throughout the central plateau of France, in Puy-de-Dôme, Mont-Dore, Cantal, Velay and Vivarais, and also in Catalonia, near Olot and Castel-Follit. The Carpathians, the Caucasus, the region of the Great Ararat, and Allagöz belong to the list, which we may here bring to a close, long before it is complete.

If we remember that the other parts of the world are not less rich in volcanic manifestations than Europe, and if we recall that the ocean basins also are dotted with them—the Indian Ocean as well as the Pacific and Altantic showing everywhere eruptive centers, most of them as yet imperfectly known; if, finally, we remember that in the absence of rain and wind the pulverulent ejections of the volcanoes would cover the earth's surface around every fiery vent in such a way as to mask all the anterior formations under this volcanic snow, we shall arrive at the conclusion that the earth would exhibit all the characteristics shown so clearly and sharply on the disk of the moon. So far as I am aware, this is the first time, since observers have been busy with the lunar problem, that its explanation crops out of itself as a logical consequence of a hypothesis elaborated independently of any astronomic considerations.

In conclusion I may be allowed to dwell on the last remark, which suggests a reflection in the line of comparative geology: That science has grown up on the common frontier of geology (or science of the earth) and physical astronomy (or science of the heavens), exactly as comparative anatomy has grown up on the common frontier of human anatomy (or science of the human body) and animal anatomy (or science of the bodies of animals). The resemblance extends even to the increase of knowledge and to the philosophic generalizations by which both of the compared sciences benefit. The great general laws of animal organization, revealed to us by the science of comparative anatomy, are an earnest of those which we may discover in regard to the economy of the celestial bodies as a result of the progress of comparative geology. We know that astronomy proceeds not only by purely morphologic investigations of the celestial bodies, but that several other means of study have been opened to it successively by physics and chemistry; spectroscopy, which is based on the prismatic analysis of the light emanating from the heavenly bodies or reflected by them, has demonstrated the chemical unity of the heavens, just as telescopy had shown their mechanical coordination. On the other hand, through a piece of good luck which no one could have foreseen or hoped for, bits of substance derived from the cosmic regions and precipitated on our planet in the form of meteorites, have supplemented the spectroscopic evidence by a large number of extraterrestrial minerals, enabling still closer comparisons to be made. A geologic relationship has thus been revealed, and the legitimacy of synthetic suppositions of the widest scope can now no longer be called in question. It does seem as if we were now in position to say that all conceptions that hold that the physical constitution of heavenly bodies differs from the constitution of the earth are erroneous. I may be permitted to express the hope that the present paper may serve to reinforce this conclusion by showing that the moon, which has inspired so many hypotheses, in reality presents morphologic features that are not only compatible with those of the earth but also harmonize completely with the proposed volcanologic theory of the earth, an agreement as neat as it was unforeseen. It furnishes the most valuable confirmation of that theory, while in return it receives not less decisive confirmation from geologic studies.

It is a rare pleasure to find such complete agreement between two lines of study which at first sight seem so unrelated. I may even be permitted to express a sort of gratitude, somewhat superstitious perhaps, to the Unknown Cause which reveals to our minds some of the harmonies, hitherto so jealously hidden, of the natural mechanism. A glimpse of these harmonies sometimes bursts on the mind so suddenly that one has the feeling of an astonished spectator rather than of an originator.

PHYSICAL CHEMISTRY.—*Thermoelectric measurement of the critical ranges of pure iron.*[1] GEORGE K. BURGESS and H. SCOTT, Bureau of Standards.

The methods hitherto employed for the determination of the thermoelectric properties of conducting materials possess the characteristic, which is particularly disadvantageous in the case of a substance such as iron which has two critical ranges, of

TABLE 1

THERMOELECTRIC POWER OF IRON AGAINST PLATINUM

TEMPERATURE CENTIGRADE t	MICROVOLTS PER DEGREE dE/dt		PELTIER EFFECT TdE/dt		THOMSON EFFECT d^2E/dt^2	
0	19.5		5,320		−0.010	
100	18.1		6,750		−0.027	
200	15.4		7,280		−0.035	
300	11.7		6,700		−0.033	
400	9.5		6,390		−0.010	
500	9.1		7,030		+0.009	
600	10.8		9,430		+0.026	
700	14.3		13,910		+0.036	
780	18.1		18,980		+0.045	
800	18.4		19,740		+0.014	
880	19.4		22,350		+0.010	
	Heating	Cooling	Heating	Cooling	Heating	Cooling
900	19.7	17.5	23,100	20,510	0.000	−0.400
910	19.4	10.8	22,940	12,770	−0.050	−0.040
920	16.6	10.9	19,800	13,000	−0.575	+0.010
930	11.4	11.1	13,710	13,350	−0.023	+0.017
1,000	12.6		16,030		+0.017	

requiring a length of the material in question to have a temperature distribution extending from the maximum to the lowest temperature. There may then be ambiguity or superposition of thermoelectric effects.

Using a length of pure iron wire (Fe = 99.968 per cent) of some 7 cm. length and 0.05 cm. diameter and joined between the hot

[1] To appear in detail as Bureau of Standards Scientific Paper No. 296 (Bull. Bur. Stds., vol. 14).

junctions of two Le Chatelier thermocouples within a furnace 60 cm. long, several series of accurate observations in vacuo of the thermoelectric power of the couple iron-platinum have been taken, at 2° intervals, over the temperature range 0° to 1000°C.

In the thermoelectric power vs. temperature curve the critical point A_3 is marked by a discontinuity of considerable magnitude at about 915°C. on heating, and at 900°C. on cooling. At A_2 there is a change in shape of the curve. The thermal effect at A_2 is superimposed upon the thermoelectric and manifests itself as a slight protuberance or dent at 768°C.

In Table 1 are given the thermoelectric power (dE/dt), Peltier effect (TdE/dt), and Thomson Effect (d^2E/dt^2) for iron-platinum from 0° to 1000°C.

These thermoelectric observations give further evidence of the distinct character of the critical points A_2 and A_3 delimiting the regions of alpha, beta, and gamma iron.

BOTANY.—Severinia buxifolia, *a Citrus relative native to southern China.* WALTER T. SWINGLE, Bureau of Plant Industry.

In southern China, Tonkin, and Annam, and in the adjacent islands of Formosa, Hongkong, and Hainan, there occurs not uncommonly a much-branched thorny shrub which has shiny box-like leaves and small, black, berry-like fruits, 1–1.5 cm. in diameter. This plant is commonly called *Atalantia bilocularis* (Roxb.) Wall., or *Atalantia buxifolia* (Benth.) Oliv. in recent botanical works. In connection with a survey of the plants related to *Citrus* this plant has been studied, with the result that it seems necessary to recognize it as constituting the type of a distinct genus, for which, fortunately, there is a valid name, *Severinia*, established in 1840 by Tenore.

The nomenclatorial history of this plant has been a checkered one. The earliest reference to it by a European botanist seems to have been in 1757, when Osbeck, one of Linnaeus's pupils, published the original Swedish edition of his diary of a voyage to the East Indies. On October 20, 1751, he found on Danish Island, near Canton, China, a plant of which he says "*Buxoides aculeata*, what the Chinese call *Sau-pann-gipp*, is like our box-tree, but thorny. I did not see its parts of fructification."[1] Although a Latin binomial name is apparently assigned to this plant, it is very unlikely that it was intended as a true botanical name, inasmuch as Osbeck's teacher, Linnaeus, strongly objected to generic names ending with *-oides*.[2] At any rate the description is insufficient to identify the plant, of which Osbeck did not see the flowers or fruits. So far, the Cantonese name *Sau-pann-gipp* cannot be traced, but Loureiro gives for his *Limonia monophylla* a similar Cantonese name, *Săo peng lâc*,[3] "lâc" being perhaps the common Cantonese word *lak*, meaning thorn.

In 1798 Poiret described in the *Encyclopédie méthodique* of Lamarck, as *Citrus buxifolia*, a plant which had been found in China by Sonnerat. The latter had forwarded specimens of it to Citizen Lamarck, in whose herbarium Poiret had examined them.

Already in 1790 Loureiro in his *Flora Cochinchinensis* had described this same plant, but had referred it erroneously to *Limonia monophylla* L.

In 1825 David Don in his Flora of Nepaul described, as a new species, *Limonia retusa*. Although the description is very short and the writer has had no opportunity of examining Don's specimens, it seems very probable that Don's diagnosis refers to the plant in question.

Another obscure name, *Limonia microphylla*, published in 1828 by Voigt, would seem to belong here. Voigt's article is a description of the plants cultivated in the Jena Botanic Garden and the descriptive phrase following the name reads merely "folia Buxi apice emarginata, crenata." This phrase, however, seems to warrant considering Voigt's plant identical with the one in question.

[1] *Buxoides aculeata.* Obs. kallas på Chinesiska Sau-pann-gipp; och liknar wår Buxbom; men är taggig. Fructificationen blef jag aldrig warse.—Osbeck, Pehr. Dagbok öfwer en Ostindisk Resa, p. 242. Stockholm, 1757.

[2] "Nomina generica in *oides* desinentia, e foro Botanico releganda sunt." Linnaeus, C. Philosophia Botanica, §226. 1751.

[3] Loureiro, J. Flora Cochinchinensis, **1**: 271. 1790.

Desfontaines, in the third edition (1829) of the catalogue of plants of the Paris Botanic Garden, describes as a new species *Citrus emarginata*, which is undoubtedly the same plant.

While Don seems to have been the first to record this species from India, Wallich and Roxburgh again report it from that country (1832), but under a different name. This time it figures as *Limonia bilocularis* Roxb. or *Atalantia? bilocularis* Wall.

In 1834 Wight and Arnott described this species as *Sclerostylis atalantioides*, referring to it as synonyms *Atalantia? bilocularis* Wall. and *Limonia bilocularis* Roxb. These authors add that no one except Dr. Berry, who had sent it to the Botanic Garden in 1807, seemed to have found this plant in India.

The first botanist to recognize this plant as belonging to a distinct genus was Tenore, who in 1840 published a new genus *Severinia*, transferring to it *Citrus buxifolia* of the gardeners as *Severinia buxifolia*. Tenore seems to have overlooked the fact that *Citrus buxifolia* was no mere gardener's name, but had been properly published by Poiret in 1798. In the following year Tenore submitted this and two other of his new genera to the Third Convention of the Italian Scientists held at Florence in September, 1841, for their approval. The President of the Section, Professor Moris, appointed three distinguished foreign botanists—Robert Brown, Heinrich Link and Charles Morren—present at the meetings, on a committee to report on the matter. Robert Brown, chairman, reported a few days later that *Severinia* seemed to the committee to be a good new genus of the orange family.[4]

However, George Bentham, in 1851, took exception to Tenore's new genus, stating that specimens sent him by the latter had enabled him to identify this as "a not uncommon Chinese plant," and transferring Tenore's species to *Sclerostylis* as *Sclerostylis buxifolia* Benth. Ten years later Bentham in-

[4] "Che la *Severinia*, pianta della famiglia delle Auranziacee sembragli ancor essa poter con buona ragione fornare un genere nuovo. Per i suoi caratteri somigliare essa la *Bergera*, ma da questa differirne per avere le foglie semplici, mentre che quella le ha impari pennate. Esser poi ben distinta in grazia del suo ovario biloculare dalla *Limonie*, le quali lo hanno uniloculare." Brown, Robt., in Atti della terza rinuione degli scienzati ital., p. 533. 1841.

cluded this plant in his *Flora Hongkongensis* under the name *Atalantia buxifolia* Oliv. MS., and in the same year Oliver himself described it in his treatise on the Aurantiaceae. In his paper he doubts the Indian station for this plant, saying [Introd. p. 11]: "*Atalantia buxifolia* I believe to be an Eastern Asiatic species only, and not a Coromandel plant, as stated in Roxburgh's 'Flora Indica,'" and [p. 26] "I consider this alleged Indian station to have originated in some garden mistake . . ."

Roemer,[5] the indefatigable but uncritical compiler, described the plant in 1846 under three different names: (1) *Atalantia Loureiriana*, based on the *Limonia monophylla* of Loureiro, not of Linnaeus; (2) *Helie atalantioides*, based on *Sclerostylis atalantioides* W. & A., and having *Limonia bilocularis* Roxb. as a synonym; and (3) *Citrus buxifolia* Poir. Under the latter name, he remarks that this may be a variety of *Citrus sinensis* Risso.

The best and fullest account of the plant as yet published, giving both the morphological and anatomical characters, is that by Penzig.[6] As it was the only species of *Atalantia* studied by him, he did not have opportunity to note how widely it differs from the typical species, *Atalantia monophylla* (Roxb.) DC., and its congeners.

As a matter of fact it is very unlike the true Atalantias, differing in having a berry-like fruit becoming very dark red or nearly black, as it ripens, through the softening and darkening of the ovarial walls. The pulp vesicles remain very rudimentary, mere blunt papillae lining the ovary walls, quite unlike the pulp vesicles of the true Atalantias. Two or three large oil glands develop in the mesocarpic tissues of the young ovary.

The leaves are shiny above, very strongly veined below and emarginate (see fig. 1). The flowers are smal and the stamens are free, with rather broad filaments. The seeds are green, large and subglobose, with thin teguments, and germinate from buried cotyledons; the first post-cotyledonary leaves are cataphylls, as in *Eremocitrus* and *Poncirus* (see fig. 2).

[5] Roemer, M. J. Fam. Nat. Reg. Veg. Syn. Monogr., Fasc. 1, p. 37, 42, 52. 1846.

[6] Penzig, Otto. *Studi bot. sugli agrumi*, in Annal. di. Agric. 1887, no. 116, p. 149–163; Atlas, pl. 11, figs. 6–17, pl. 12, figs. 1–21. 1887.

The fruit characters are so different that the plant cannot be considered to be a congener of *Atalantia* and must be considered to be a distinct genus, for which the oldest available name is *Severinia* of Tenore. The oldest name for this plant becomes, therefore, *Severinia buxifolia*, with the following synonyms:

Severinia buxifolia (Poir.) Tenore, Ind. Sem. Hort. Bot. Neapol., 1840, p. 3 (?) [not seen]; Atti della terza riunione degli scienzati ital., 501–3. 1841.

(?) *Buxoides aculeata* Osb. Dagbok Ostindisk Resa, p. 242. 1757 [nom. subnud.].
Limonia monophylla Lour. Fl. Cochin. **1**: 271. 1790. [err. det.]
Citrus buxifolia Poir. in Lam. Encycl. **4**: 580. 1798.(?)
Limonia bilocularis R. Hort. Bengal. 32. 1814. [nom. nud.]
(?) *Limonia retusa* Don. Prod. Fl. Nepal. 224. 1825.
(?) *Limonia microphylla* Voigt, Syll. Pl. Ratisb. 53. 1828.
Citrus emarginata Desf. Cat. Hort. Paris, ed. 3, 235, 406. 1829.
Atalantia? bilocularis Wall. Cat. no. 6356. 1831. [nom. nud.]
Limonia bilocularis Roxb. Fl. Indica, **2**: 377. 1832.
Sclerostylis atalantioides Wight & Arn. Prodr. **1**: 93. 1834.
Atalantia Loureiriana Roem. Syn. Hesperid. 37. 1846.
Helie atalantioides Roem. Syn. Hesperid. 42. 1846.
Sclerostylis buxifolia Benth. in Hook. Journ. Bot. **3**: 326. 1851.
Atalantia buxifolia Oliv. Proc. Linn. Soc. **5**, Suppl. 2: 26. 1861 (ex Benth. Fl. Hongkong. 51. 1861).

Illustrations: Seeman, Bot. Voy. Herald, pl. 81, 1852–7; Penzig, O., Studi bot. sugli agrumi, Atlas, pl. 11, figs. 6–17, pl. 12, figs. 1–21, 1887.

Type Locality: "Cette plante est originaire de la chine, & y a eté observé par Sonnerat" [in the vicinity of Canton, China].

Distribution: Southern China (Hongkong, Kwangtung, Hainan), Tonkin, Annam, Formosa.

The writer examined in 1911 the type specimen in Lamarck's herbarium in the Muséum d'histoire Naturelle at Paris. It consists of a single leafy twig about 20 cm. long with three short branches. The branch still bears a few flower buds. There can be no possible doubt of its being the plant common in southern China. The original label in Lamarck's handwriting reads: "Citrus—de la chine." A later label in Poiret's handwriting reads: "*Citrus buxifolia*, Dict. No. —."

In the Kew herbarium is a flowering branch of *Severinia buxifolia* collected by Tenore in the botanic garden at Naples and probably a merotype of the plant upon which the genus *Severinia* was based. This specimen is undoubtedly congeneric and doubtless conspecific with the type specimen of *Citrus buxifolia* Poir.

In the Rijks Herbarium at Leyden there is an apparently authentic specimen of *Citrus emarginata* Desf., possibly a merotype, which is undoubtedly *Severinia buxifolia.*

RELATIONSHIPS

Severinia, in spite of its being referred to *Atalantia* by all recent botanical writers, is not at all closely related to the typical species of that genus. In its fruit characters it resembles *Tri-*

Fig. 1. *Severinia buxifolia.* Twig bearing flowers and fruits, and showing emarginate leaves and sharp spines. Scale $\frac{1}{3}$.

phasia, but it has very different flowers, leaves, and twigs. Possibly *Severinia* may prove to be related to the aberrant Atalantias, *A. disticha* (Bl.) Merr., *A. linearis* (Bl.) Merr., *A. maritima* Merr., etc. Its affinities are certainly with *Triphasia* and other members of the tribe Citreae, rather than with *Claucena* or *Micromelum.* It is, however, distinctly not one of the true citrous fruits constituting the subtribe *Citrinae,—Citrus, Fortunella, Microcitrus, Eremocitrus, Poncirus,* and *Citropsis.*

USES OF SEVERINIA

The Severinia is a handsome shrub, readily propagated from cuttings and suitable for hedges, if care be taken to select for multiplication the very thorny forms which are common in this species. Some forms have sharp spines two to three inches long. *Severinia* has proved useful in Louisiana for hedges.

Experiments have shown that *Severinia* can withstand unusually large amounts of salt in the soil. It may prove of interest as a stock for citrous fruits in regions having alkali in the soil or having salty irrigation water.

Fig. 2. *Severinia buxifolia.* Seedling, showing the cataphylls succeeded by foliage leaves. The scar of one of the cotyledons shows near the base. Natural size.

BOTANY.—*Moreh oak, a new name for* Quercus morehus *Kellogg.*[1] W. H. Lamb, Forest Service.

The name Moreh oak is proposed as a standard common name for *Quercus morehus* Kellogg, a tree of the Sierra Nevada foothills and the north coast ranges of California.

The tree is one which has presented many problems to the botanist. It is most frequently regarded as a form of hybrid origin, one parent being the California black oak (*Quercus californica* or *Quercus kelloggii*), the other the canyon live oak (*Quercus wislizenii*).[2] The discoverer, Dr. Albert Kellogg, called the tree Abram's oak, giving it at the same time the scientific name of *Quercus morehus.* For many years, however, the meaning and derivation of the scientific name and the significance of the common name were matters of much futile speculation among botanists, and although the species was described

[1] Published with the permission of the Secretary of Agriculture.

[2] Greene, E. L. Illustrations of West American oaks from drawings by the late Albert Kellogg, M.D., pl. 2. 1889. Sargent, C. S. Manual of the trees of North America, p. 255. 1905. Jepson, W. L., *Silva of California.* Memoirs of the University of California, 2: 46–49. 1910.

in 1863[3] it was not until 1887[4] that the derivations of the names were fully understood. It was the custom of Dr. Kellogg to express his veneration for Biblical characters and places by naming his botanical discoveries in their honor, just as other writers have sought to commemorate the name of friends or localities intimately associated with their experiences. In this instance it was desired by the author to recall the dwelling place of Abram, by honoring the newly discovered tree with its name. Anticipating perhaps that Moreh might not be recognized as the inspiration of his name, he called the tree "Abram's oak." But notwithstanding his precaution, the name "morehus oak" has appeared in forestry literature as the common name of this interesting tree.[5] This name has no meaning, is grammatically incorrect, and only perpetuates the fact that Dr. Kellogg's name has not been understood. The name "Abram's oak" is sometimes used;[6] but on account of the fact that the erroneous name "morehus oak" has been so widely circulated, it seems advisable to replace it with the correct English equivalent of the scientific name. It is proposed, therefore, that *Quercus morehus* Kellogg be uniformly designated as Moreh oak.

CERAMICS.—*The constitution and microstructure of porcelain.*[1] A. A. Klein, Bureau of Standards. (Communicated by S. W. Stratton.)

A petrographic microscopical study of porcelains prepared in the laboratory of the Bureau of Standards, of commercial porcelain, as well as of various combinations of the raw materials which enter into porcelain, has led to results which are interesting and important both scientifically and technically.

Bodies and mixtures of the following types were examined: kaolin, feldspar-kaolin, feldspar-quartz, and feldspar-clay-quartz.

[3] Proceedings of the California Academy of Science, **2**: 36. 1863.

[4] Greene, E. L. *Biographical notice of Dr. Albert Kellogg.* Pittonia, **1**: 145. 1887.

[5] Sudworth, G. B. *Nomenclature of the arborescent flora of the United States.* Bull. 14, U. S. Department of Agriculture, Division of Forestry. 1897.

[6] Britton, N. L. North American Trees, p. 308. 1908.

[1] To appear in detail as Bureau of Standards Technologic Paper No. 80.

These were burned at various known temperatures. The commercial bodies investigated represented the practices of the following countries: United States, England, Germany, France, Austria, Denmark, and Japan. The end in view was to obtain data concerning the changes involved by burning porcelain at various temperatures; for bodies whose composition lay within the limits of whiteware and hard fired porcelains it was found possible to correlate to a certain degree the constitution and microstructure with the burning temperature.

The result of this investigation leads to the following conclusions: Kaolin appears homogeneous microscopically when heated up to 1200°. At about this temperature a trace of dissociation occurs. As the temperature is raised above 1200° the dissociation increases very slowly at first, then at an increasing rate until at 1400° it seems to be complete. The products of dissociation are silica and aluminium silicate. The latter compound has been identified as an amorphous phase of sillimanite from the following facts: it shows no crystalline form, has an index of refraction above 1.60, and by heating at a higher temperature (about 1450°) it inverts to minute needle crystallites corresponding to sillimanite in all determinable optical properties.

Up to 1340°, in mixtures of quartz and feldspar, the quartz dissolves to only a small extent in the feldspar glass. At 1460° the quartz is practically completely dissolved in specimens having as high a quartz content as 50 per cent quartz to 50 per cent feldspar.

In specimens containing kaolin and feldspar the kaolin dissociates entirely at 1340°. The amount of crystallized and amorphous sillimanite increases with an increased content of kaolin, at least to a concentration of 50 per cent kaolin to 50 per cent feldspar.

At 1460°, apparently 10 per cent kaolin is entirely soluble in the feldspar glass. With higher concentrations of kaolin the amount of crystallized sillimanite increases. The needle crystals are well developed and comparatively large.

At 1310°, in quartz-clay-feldspar bodies, the feldspar is present as a glass; the clay shows almost complete dissociation with the formation of amorphous sillimanite mainly and but little crystallized sillimanite, while the quartz is undissolved and the grains may still be of considerable size, up to 0.2 mm. or more, depending upon the fineness of grinding.

By burning these bodies at 1380° to 1400° the feldspar glass dissolves considerable quartz, there being only a comparatively small amount of residual quartz remaining. The quartz grains are much rounded and etched and they seldom show a length over 0.06 mm. The clay is dissociated with the formation of crystallized sillimanite, although an extremely small amount of amorphous sillimanite may be present.

The changes involved by burning commercial bodies are identical with those of laboratory prepared bodies. The quartz grains observed in whiteware and in low-fired vitreous ware are large and angular, showing a size of 0.2 mm., or more, whereas in the hard porcelains, due to solution, the quartz grains are rounded and etched, and seldom exceed 0.05 mm. in length.

The constitution and the microstructure of porcelain depend upon the temperature of burning, and change as this temperature changes. This has served as a basis for the estimation of the probable burning temperatures of the commercial bodies, a fact which was accomplished with success, the error involved being within 25°. It appears that the time-of-burning factor is by no means as important as that of the burning temperature in determining the constitution and microstructure of the ware.

No cristobalite or tridymite has been definitely observed in any of the laboratory or commercial bodies examined. It appears that the quartz dissolves in the feldspar glass more readily than it inverts to the other modifications of silica.

In conclusion, it may be stated that the petrographic microscopic study of porcelain has led to interesting and, it is to be hoped, important technical results. It has placed the chemical and physical processes involved in the formation of porcelain on a more quantitative thermal basis. Furthermore it has offered a means of estimating the burning temperature of a ware by an examination of a fragment much too small in size to be satisfactory for even a chemical analysis.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*On the results of some magnetic observations during the solar eclipse of August 21, 1914.* L. A. Bauer and H. W. Fisk. Journ. Terr. Mag., **21**: 57–86. 1916.

In response to a circular letter issued by the Director of the Department of Terrestrial Magnetism, several observatories made observations during the eclipse of August 21, 1914, and forwarded their data to Washington. The present paper comprises a compilation of abstracts of the reports of the various institutions which supplied data, and a discussion of the results.

At the four stations, Eskdalemuir, Stonyhurst, Kew, and Rude Skov, the maximum phase of the eclipse occurred at about the time when the declination needle was approaching its maximum westerly position for the day, and on examining the curves for these stations it appeared that at each one of them a bay occurred a few minutes before the time of maximum obscuration. As the result of this bay the customary progression towards a westerly extreme was interrupted, and a retrograde movement occurred, which continued for some time. Of the above stations, the bay was most developed at Rude Skov, the nearest one of the four to the belt of totality.

On plotting a vector diagram for Rude Skov, with the north and west components of the field as derived from the observed declinations and horizontal intensities, it was found that during the eclipse the regular course of the curve was interrupted and a loop was described. The occurrence of this loop, which appeared also in the vector diagrams for Eskdalemuir and Kew, is in harmony with the similar effect found at Rocky Mount, North Carolina, during the total eclipse of May 28, 1900.

Atmospheric-electric observations were furnished by Kew, Eskdalemuir, and the Department of Terrestrial Magnetism. The conductivity gave no reliable evidence of any effect attributable to the eclipse, and, while the diurnal variation curves for the potential-gradient showed depressions at the time of maximum obscuration, this effect was not sufficiently pronounced, in relation to other variations, to render its connection with the eclipse a certainty. W. F. G. S.

GEOLOGY.—*Notes on some mining districts in eastern Nevada.* James M. Hill. U. S. Geological Survey Bulletin 648. Pp. 207, with 6 plates and 18 figures. 1916.

This reconnaissance report describes 29 mining districts in eastern Nevada, extending from the line of the Southern Pacific Railroad to the Colorado River and comprising parts of Elko, White Pine, Lincoln, Nye, Clark, and Lander counties. Details of the mining development in the various camps are given, as well as information concerning the production of those districts for which figures are available. The report discusses briefly the grouping of the copper, lead, gold, and silver deposits about or near masses of granitic rocks which are intrusive into Paleozoic sediments ranging in age from Cambrian to Permian, and of gold veins in the probably pre-Cambrian schists near the Colorado River. It includes notes on the tungsten deposits in the Kern Mountains of northeastern White Pine County, and on gold deposits associated with Tertiary volcanic rocks at Atlanta, Lincoln County, in which carnotite is found. Most of the deposits discussed are either replacements or veins. Contact metamorphic deposits, though of some importance, are not as common in this region as would be expected from the wide distribution of intrusive rocks. J. M. H.

GEOLOGY.—*Geology and ground waters of northeastern Arkansas, with a discussion of the chemical character of the waters.* L. W. Stephenson, A. F. Crider, and R. B. Dole. U. S. Geological Survey Water-Supply Paper 399. Pp. 315, with 11 plates and 4 figures. 1916.

The report describes the physiography, geology, and ground water resources of that part of Arkansas lying northeast of Arkansas River and east of the Ozark hills. Much information compiled from scattered previously published sources is incorporated, together with a large amount of new data gathered by the authors in the field and by correspondence. Emphasis is laid on the availability of the vast quantities of water contained in the Pleistocene alluvial deposits for the irrigation of the extensive tracts of land that are suitable for rice culture.

The section on geologic history describes the interesting succession of events that resulted in the formation of the alluvial lowlands composing the greater part of the area treated. The chapter of the chemistry of the waters contains in addition to the discussion of the character of the Arkansas ground waters, much general information on the mineral constituents of water, the character of water suitable for boiler use, irrigation, and domestic use, and methods of purifying water.

L. W. S.

GEOLOGY.—*The Pliocene Citronelle formation of the Gulf coastal plain and its flora.* George Charlton Matson and Edward Wilber Berry. U. S. Geological Survey Professional Paper 98-L. Pp. 167–208, with 16 plates and 3 figures. 1916.

This report describes the character and areal distribution of the Pliocene deposits, chiefly non-marine, occurring near the seaward margin of the Gulf coastal plain from Florida to eastern Texas. These are called the Citronelle formation, which is made to include portions of the deposits formerly classified as "drift," "Orange sand," "Lafayette," and "Grand Gulf." The fossil plants, by means of which the age determinations are made, are represented by 18 species. Three of these are Pleistocene and Recent forms and 15 are extinct, the latter embracing 2 West Indian and one non-American type. The plants are, without exception, coastal forms and they indicate climatic conditions very similar to those prevailing at the present time along the Gulf coast, and a physiography of barrier beaches and coastal lagoons, with gum swamps and cypress ponds near the coast. It is concluded that this flora flourished in the latter half of the Pliocene. E. W. B.

GEOLOGY.—*The Lower Eocene floras of southeastern North America.* Edward Wilber Berry. U. S. Geological Survey Professional Paper 91. Pp. 481, with 117 plates and 16 figures. 1916.

This report describes a small flora of early Eocene age from Texas, tentatively referred to the Midway formation, and gives an exhaustive discussion of the large flora of the Wilcox Group. The character, succession, areal distribution, and stratigraphic relations of the Wilcox deposits are described, and it is shown that the Wilcox is separated by a hitherto unrecognized time interval from the underlying basal Eocene, or Midway, and from the overlying middle Eocene, or Claiborne.

The Wilcox flora, which comprises over 300 species, is fully described and figured, and its composition, distribution, relations, and environment are discussed in great detail. The Wilcox flora is one of the most extensive American fossil floras known from a single horizon in a single area, and it includes a large number of types hitherto unknown from North America and more than 200 species new to science. It contains 'arge numbers of figs, lauraceae, and leguminosae and is prevailingly a strand flora, subtropical in character, which invaded southeastern North America from the equatorial region at a time when the Mississippi Gulf reached northward to southern Illinois and covered nearly all of the states of Mississippi and Louisiana as well as a large area in Alabama, Tennessee, Arkansas, and Texas. The Wilcox deposits are definitely correlated with the Sparnacian and Ypresian stages of the European lower Eocene section. E. W. B.

GEOLOGY.—*The Catahoula sandstone and its flora.* GEORGE CHARLTON MATSON and EDWARD WILBER BERRY. U. S. Geological Survey Professional Paper 98-M. Pp. 209–259, with 13 plates and 7 figures. 1916.

The Catahoula sandstone is redefined and its lithology, topography, structure, thickness, origin, and stratigraphy are discussed. It is shown that in central Louisiana this formation is interbedded with lower Oligocene limestones and marls of the Vicksburg formation, while near the Texas line it replaces all of the marine lower Oligocene. Across Mississippi the Catahoula lies above the Vicksburg, and eastward in Alabama and western Florida it merges into the marine beds of the Chattahoochee formation.

TECHNOLOGY.—*The density and thermal expansion of American petroleum oils.* H. W. BEARCE and E. L. PEFFER. Bureau of Standards Technologic Paper No. 77. Pp. 26. 1916.

This paper gives an account of the experimental work on which are based the expansion tables of Bureau of Standards Circular No. 57, *United States standard tables for petroleum oils.* It gives a detailed description of the methods and apparatus employed in the determination of the density and thermal expansion of petroleum oils from the various oil fields of the United States. H. W. B.

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MATHEMATICS.—*Note on relativity: The geometric potential.* EDWIN BIDWELL WILSON, Massachusetts Institute of Technology. (Communicated by Arthur L. Day.)

1. In our treatment[1] of the principle of relativity Lewis and I introduced as fundamental the extended (i.e., four-dimensional) vector **m** of which the space and time components, when once a time-axis has been arbitrarily selected, are the ordinary retarded vector potential **a** and the retarded scalar potential φ. We called the vector **m** the extended vector potential, and by its differentiation we obtained the electromagnetic field equations. This is the converse of the usual procedure, which is to regard the field equations as fundamental and to introduce the retarded potentials as "certain auxiliary functions on which the electric and magnetic forces may be made to depend."[2]

We built up the potential for a distributed charge from that for a point charge and reduced the potential of a point charge to the product of the charge and a vector **p**, which may be called a geometric potential because of its definition solely by geometric means. To find the potential **p** at a point Q (of the four-dimensional manifold) and due to a curve δ which is the space-time locus of a moving charge, the first step is to draw the backward singular cone with vertex Q and determine its intersection O with the curve δ; then draw at O the forward unit tangent **w** to the curve, and let the perpendicular from Q

[1] WILSON, EDWIN B., and LEWIS, GILBERT N., *The space-time manifold of relativity; the non-euclidean geometry of mechanics and electromagnetics,* Proc. Amer. Acad. Arts Sci., **48**: 389–507. 1912.

[2] See, for example, LORENTZ, The Theory of Electrons, p. 19. What Lorentz here calls electric and magnetic forces are what we call field intensities.

to this tangent be R. If then $\mathbf{l}$ denotes the vector OQ, the singular vector from the acting point to the point at which the potential is desired, the potential[3] $\mathbf{p}$ is

$$\mathbf{p} = \frac{\mathbf{l}}{R} = -\frac{\mathbf{l}}{\mathbf{l}\cdot\mathbf{w}} \tag{1}$$

The vector $\mathbf{p}$ satisfies the two fundamental conditions

$$\Diamond \cdot \Diamond\, \mathbf{p} = 0, \quad \Diamond \cdot \mathbf{p} = 0, \tag{2}$$

of which the first is the wave equation needed to represent the fact of the propagation of an electromagnetic disturbance, and the second is the condition usually imposed upon the auxiliary functions $\mathbf{a}$ and φ to make their determination complete.[4]

To validate the selection of (1) as definition of the potential, a definition which thus far apparently has nothing but simplicity in its favor, we may cite our proof that (1) is, apart from a numerical multiplier, the only possible form for the potential $\mathbf{p}$ which satisfies (2) and depends only on $\mathbf{l}$ and $\mathbf{w}$, that is, on the retarded position and velocity but not on the acceleration.

2. I wish now to remove from the hypotheses the condition $\Diamond \cdot \mathbf{p} = 0$ and to state the theorem:

The only possible choice for the geometrical potential $\mathbf{p}$, dependent only on $\mathbf{l}$ and $\mathbf{w}$ but not on the derivatives of $\mathbf{w}$, and subject to satisfying the wave equation $\Diamond \cdot \Diamond \mathbf{p} = 0$, is $\mathbf{p} = A\mathbf{l}/R$, where A is a constant.[5]

When we have proved this theorem we have, from the point of view of relativity, a completely rational basis for the theory of the potential and field of the point charge,[6] and through it,

[3] This is the definition given by MINKOWSKI in his *Raum und Zeit*, Gesammelte Werke, vol. 2, p. 442.

[4] See, for example, LORENTZ, loc. cit., p. 239.

[5] PAGE, L., in *Relativity and ether*, Amer. J. Sci., **37**: 169–187, 1914, apparently reaches a similar conclusion in a totally different way; but it is difficult to compare the arguments.

[6] Even if we believe that electricity always occurs in continuous distributions, that is, that electrons are continuous surface or volume spreads of electricity with appropriate densities, it is convenient to have a rational theory of the point charge for those investigations in which the size of the electron is negligible, and particularly as the density within or upon the electron is unknown.

by integration, for the theory of continuous distributions of electricity.

Before we can give the proof, we must make precise the meaning of the statement that **p** is dependent only on **l** and **w**. Geometrically[7] speaking, **l** and **w** determine a plane, and thus also a second plane completely perpendicular to their plane, but they determine no particular vector in this second plane or in their own plane.[8] Hence, if a vector **p** is to depend on **l** and **w** alone, it must lie in their plane. The scalar products of **l** and **w** by themselves are

$$\mathbf{l}\cdot\mathbf{l} = 0, \quad \mathbf{l}\cdot\mathbf{w} = -R, \quad \mathbf{w}\cdot\mathbf{w} = -1.$$

Hence the function **p** must take the form

$$\mathbf{p} = \varphi(R)\,\mathbf{w} + f(R)\,\mathbf{l}. \tag{3}$$

To show that **p** reduces to the form $A\,\mathbf{l}/R$, we have merely to substitute the general form (3) in the equation $\Diamond\cdot\Diamond\,\mathbf{p} = 0$ and see that the only possibilities are $\varphi(R) = A/R$, $f(R) = 0$. Now if f is a scalar and **u**, **v** are two vectors,

$$\Diamond\cdot\Diamond(f\mathbf{v}) = (\Diamond\cdot\Diamond f)\mathbf{v} + 2\Diamond f\cdot\Diamond\mathbf{v} + f\,\Diamond\cdot\Diamond\mathbf{v}$$
$$\Diamond\cdot\Diamond(\mathbf{u}\cdot\mathbf{v}) = \mathbf{v}\cdot(\Diamond\cdot\Diamond\mathbf{u}) + 2\Diamond\mathbf{u}:\Diamond\mathbf{v} + \mathbf{u}\cdot(\Diamond\cdot\Diamond\mathbf{v})$$
$$\Diamond\cdot\Diamond f(R) = f''(R)\,\Diamond R\cdot\Diamond R + f'(R)\,\Diamond\cdot\Diamond R$$

With the formulas that we have established (§44, loc. cit.), namely

$$\Diamond\,\mathbf{w} = \frac{1}{R}\mathbf{l}\mathbf{c} \qquad \Diamond\,\mathbf{c} = -\frac{1}{R}\frac{d\mathbf{c}}{ds}$$
$$\Diamond\,\mathbf{l} = I + \frac{1}{R}\mathbf{l}\mathbf{w} \qquad \Diamond R = -\mathbf{w} + \frac{1 + \mathbf{l}\cdot\mathbf{c}}{R}\mathbf{l}$$

where **c** is the retarded curvature $d\mathbf{w}/ds$ of the space-time locus

[7] We might discuss this question more in detail as H. BURKHARDT does the corresponding general problem for three dimensional vector analysis in *Ueber Functionen von Vectorgrössen, welche selbst wieder Vectorgrössen sind. Eine Anwendung invariantentheoretischer Methoden auf eine Frage der mathematischen Physik.* Math. Ann., **43**: 197–215. 1893. For our present purposes this seems hardly necessary.

[8] The plane of **l** and **w** and the plane completely perpendicular to it cut the singular cone in pairs of lines which are respectively real and imaginary, but no vectors along these directions are determined.

of the charge, and I is the idemfactor, it is easy to show that

$$\diamondsuit \cdot \diamondsuit \mathbf{p} = -2\mathbf{c}\left(\varphi' + \frac{\varphi}{R}\right) + \mathbf{w}\left[\frac{2f}{R} + \left(\varphi'' + \frac{2\varphi'}{R}\right)(1 + 2\,\mathbf{l}\cdot\mathbf{c})\right]$$
$$+\mathbf{l}\left[\left(f'' + \frac{2f'}{R}\right)(1 + 2\,\mathbf{l}\cdot\mathbf{c}) + 2f'(1 + \mathbf{l}\cdot\mathbf{c})\right]$$

If this is to vanish, $\varphi' + \varphi/R = 0$, that is

$$\varphi = \frac{A}{R} \qquad f = 0$$

3. As the potential has turned out homogeneous of degree zero in $\mathbf{w}$, we may write

$$\mathbf{p} = -\frac{\mathbf{w}}{\mathbf{l}\cdot\mathbf{w}} = -\frac{\mathbf{u}}{\mathbf{l}\cdot\mathbf{u}}$$

where $\mathbf{u}$ is any tangent to the curve δ. If we define dq by the relation $d\mathbf{r} = \mathbf{u}\,dq$, where $d\mathbf{r}$ is the increment along the curve, we have determined a parametric representation of the curve so that $\mathbf{u} = d\mathbf{r}/dq$, which is analogous to $\mathbf{w} = d\mathbf{r}/ds$, but more general in that it would be applicable to curves of zero length.

The equations for the derivatives would now become

$$\diamondsuit\,\mathbf{u} = \frac{\mathbf{l}\mathbf{c}^1}{\mathbf{l}\cdot\mathbf{u}} \qquad \diamondsuit\,\mathbf{l} = I - \frac{\mathbf{l}\mathbf{u}}{\mathbf{l}\cdot\mathbf{u}}$$

$$\diamondsuit\,(\mathbf{l}\cdot\mathbf{u}) = (\diamondsuit\,\mathbf{l})\cdot\mathbf{u} + (\diamondsuit\,\mathbf{u})\cdot\mathbf{l} = \mathbf{u} - \frac{\mathbf{u}\cdot\mathbf{u}}{\mathbf{l}\cdot\mathbf{u}}\mathbf{l} + \frac{\mathbf{l}\cdot\mathbf{c}^1}{\mathbf{l}\cdot\mathbf{u}}\mathbf{l}$$

where
$$\mathbf{c}^1 = d\mathbf{u}/dq$$

Then

$$\diamondsuit\,\mathbf{p} = \frac{\mathbf{u}\mathbf{u}}{(\mathbf{l}\cdot\mathbf{u})^2} - \frac{\mathbf{u}\cdot\mathbf{u}}{(\mathbf{l}\cdot\mathbf{u})^3}\mathbf{l}\mathbf{u} + \frac{\mathbf{l}\cdot\mathbf{c}^1}{(\mathbf{l}\cdot\mathbf{u})^3}\mathbf{l}\mathbf{u} - \frac{\mathbf{l}\mathbf{c}^1}{(\mathbf{l}\cdot\mathbf{u})^2}$$

and

$$\diamondsuit \times \mathbf{p} = -\frac{\mathbf{u}\cdot\mathbf{u}}{(\mathbf{l}\cdot\mathbf{u})^3}\mathbf{l}\times\mathbf{u} + \frac{\mathbf{l}\cdot\mathbf{c}^1}{(\mathbf{l}\cdot\mathbf{u})^3}\mathbf{l}\times\mathbf{u} - \frac{\mathbf{l}\times\mathbf{c}^1}{(\mathbf{l}\cdot\mathbf{u})^2}$$

$$\mathbf{P} = \diamondsuit \times \mathbf{p} = -\frac{\mathbf{u}\cdot\mathbf{u}}{(\mathbf{l}\cdot\mathbf{u})^3}\mathbf{l}\times\mathbf{u} + \frac{\mathbf{l}\times[\mathbf{l}\cdot(\mathbf{u}\times\mathbf{c}^1)]}{(\mathbf{l}\cdot\mathbf{u})^3}$$

The vector $\mathbf{P}$, of the second sort, is the (geometric) field[9] set

[9] WILSON and LEWIS, loc. cit., p. 460.

up by the potential; the first term varies inversely as the square of the interval of $\mathbf{l}$, and the second term inversely as the interval itself. When $\mathbf{u} = \mathbf{w}$ the result reduces to that previously found.[10] The interest attaching to the present form is that it is applicable to the case in which the curve is a singular curve, that is, to the path of a particle of light, whereas the previous form was applicable only to curves that could be described by electrons or material particles.

If we consider the vector $\mathbf{u}$ as a singular vector, the first term in $\mathbf{P}$ drops out by virtue of $\mathbf{u}.\mathbf{u} = 0$. We have therefore the following result:

In the (geometric) field of a particle of light that portion which corresponds to Coulomb's law for the field of an ordinary particle vanishes identically.

The field $\mathbf{P}$ vanishes entirely unless the particle of light (assumed to be moving with the normal velocity of light in free space) travels in a curved path so that $\mathbf{c}^1$ is not parallel to $\mathbf{u}$.

MINERALOGY.—*Lorettoite, a new mineral.*[1] ROGER C. WELLS and ESPER S. LARSEN, Geological Survey.

A specimen, furnished by Mr. Frank L. Hess of the United States Geological Survey and received by him from Mr. I. N. Wilconson of Loretto, Tennessee, proved on analysis to differ chemically from any known mineral. A specimen labeled "massicot," without a location, in the collections of the University of California, differs in its optical properties from any known mineral, and a later optical examination of the Loretto mineral showed the essential identity of the two. The name lorettoite is proposed for the mineral, from its occurrence near Loretto, Tennessee.

Physical properties. The mineral is in flat, compact pieces, up to an inch thick, and apparently occurs in thin seams. It has a bladed structure and a very perfect cleavage along these blades. The blades commonly extend across the specimen and

[10] WILSON and LEWIS, loc. cit., p. 464.

[1] Published with the permission of the Director of the U. S. Geological Survey.

are about half a millimeter in width. The specific gravity of the Loretto specimen, as determined by the picnometer method, is 7.39; that of the University of California specimen, as determined with a Joly balance, is 7.65. The cloudiness of the Loretto specimen is due to minute gas cavities which may account for the apparently low specific gravity. The Loretto specimen fuses readily in the flame of a candle (F = 1) to a mass which on cooling is a yellow, crystalline bead. It has a hardness of about 3. Its luster is adamantine, its color honey-yellow, and its streak pure yellow.[2] It is optically negative, sensibly uniaxial, and the optic axis is normal to the cleavage. The indices of refraction as measured in sulphur-selenium melts are, for the Loretto specimen:

$$\omega_{Li} = 2.40 \pm 0.02$$
$$\epsilon_{Li} = 2.37 \pm 0.02$$

and for the specimen at the University of California:

$$\omega_{Li} = 2.35 \pm 0.02$$
$$\epsilon_{Li} = 2.33 \pm 0.02$$

The specimen from the University of California is less clouded than that from Loretto, and basal sections show a delicate cross-grating at 90° due to the minute gas inclusions collected along certain planes. The mineral is therefore probably tetragonal with very perfect basal cleavage.

Chemical properties. Lorettoite dissolves easily in hot dilute nitric acid, leaving only a very slight residue. It dissolves slowly in hot dilute hydrochloric acid, and lead chloride separates from the solution on cooling. Sulfuric acid decomposes it very slowly. It is not appreciably soluble in hot water. The slight effervescence of the Loretto specimen with acids is due to a small amount of carbonate.

A microscopic examination of the powder analyzed showed a little impurity, estimated at 2 per cent, consisting chiefly of carbonate and a little of an opaque mineral, lead gray in reflected

[2] Following Ridgway's Color Standards and Nomenclature, 1912, the color is honey-yellow (19″—), and the streak strontium-yellow (23′—).

light, probably galena or metallic lead. The results of a chemical analysis of lorettoite are given in Table 1. The material on which the second chlorine determination was made contained very little impurity.

TABLE 1

COMPOSITION OF LORETTOITE FROM LORETTO, TENNESSEE

(R. C. Wells, analyst)

	1	2
Insoluble	0.58	
PbO	93.98	
Cl	3.98	4.09
P_2O_5	0.11	
CaO	0.48	
MgO	0.56	
Al_2O_3	0.08	
ZnO	0.31	
CO_2	0.20	
Br, I, F	None	
H_2O	0.03	
	100.31	
Less O eq. of Cl	0.90	
	99.41	

Chlorine was determined by gently fusing the mineral with sodium carbonate and, after carefully neutralizing the cold aqueous extract of the melt with nitric acid, precipitating and weighing the chlorine as silver chloride. A determination of chlorine in selected material, almost entirely homogeneous, from the California specimen gave 4.94 per cent.

If all the constituents except chlorine, lead, and oxygen in the complete analysis are regarded as extraneous, the composi-

TABLE 2

	(a)	(b)	(c)
PbO	83.72	80.62	82.80
$PbCl_2$	16.28	19.38	17.20
	100.00	100.00	100.00

tion reduces to (*a*), Table 2. If the California specimen is assumed to contain only lead, oxygen, and chlorine, the composition would be as shown under (*b*). Under (*c*) is given the theoretical percentage for the formula $6PbO.PbCl_2$.

It would, perhaps, be rash to claim that the evidence at hand establishes the existence of a definite chemical compound with the formula $6PbO.PbCl_2$, but the composition of the lorettoite approaches more nearly to the requirements of this than of any other simple formula.

Summary. Lorettoite occurs in honey-yellow masses made up of rather coarse fibers or blades. It is probably tetragonal in crystallization and has a very perfect basal cleavage. Its specific gravity is about 7.6, its hardness about 3, and its fusibility about 1. Its luster is adamantine and its streak is pure yellow. It is sensibly uniaxial, optically negative, and its indices of refraction are: $\omega_{Li} = 2.40$, $\epsilon_{Li} = 2.37$. It dissolves readily in acid and has the approximate composition $6PbO.PbCl_2$.

SOIL CHEMISTRY.—*A chemical study of the habitat of the walking fern,* Camptosorus rhizophyllus (*L.*) *Link.*[1] EDGAR T. WHERRY, National Museum.

A problem that often confronts the field geologist is the determination of the calcareous or non-calcareous nature of a given ledge of rock, and while a bottle of acid can be carried along and actual tests of the rock for carbonates performed, the existence of an easily recognizable index-plant, which might be found growing only on calcareous rocks, would be a great advantage. In order to ascertain the possible value in this connection of the plants classed by botanists as calciphilous, the writer decided to make a chemical study of the rocks associated with such a plant. For this purpose the walking fern, *Camptosorus rhizophyllus,* was selected, as it is a fairly common and readily recognized plant and is stated in all of the well known botanical treatises to prefer a calcareous habitat.

Samples of the rocks and soils on which colonies of the plant

[1] Published by permission of the Secretary of the Smithsonian Institution.

were growing were collected at some twenty places in Pennsylvania, Maryland, Virginia, and West Virginia. It is a pleasure to acknowledge the assistance in locating these stations received from Mr. Harold W. Pretz, of Allentown, Pa., Prof. Glenn V. Brown and Prof. N. F. Davis of Bucknell University, Lewisburg, Pa., and Dr. T. C. Stotler and Prof. H. T. McDonald, of Harpers Ferry, W. Va.

The walking fern was found not only on limestone, but also on various rocks not ordinarily classed as calcareous, comprising granite, schist, shale, sandstone, and quartzite, as well as on tree trunks, both living and dead. To make certain that these rocks were actually low in lime, analyses were made on samples collected as near as possible to the roots of the fern plants. Standard methods of analysis were employed, involving decomposition of the rock by evaporation with hydrofluoric acid or by fusion with sodium carbonate, removal of the iron and aluminium by ammonium hydroxide, and precipitation of the calcium as oxalate, followed by ignition and weighing as lime. For completeness, several undoubtedly calcareous rocks were also analyzed, being first dissolved in hydrochloric acid and the lime separated as above outlined. The several rocks were found to vary in lime content from 53.8 per cent down to less than 0.1 per cent; details are given in Table 1, below.

At the outset, then, it was apparent that the walking fern could not be depended on as an index of calcareous rocks. From a theoretical viewpoint, however, plants would be expected to respond not so much to the rock upon which they grow as to the soil which clothes that rock, since it is from the soil that their mineral nutriment is directly obtained. Analysis showing from 30 to 40 per cent of lime in the ash of the plant, it was decided to extend the investigation so as to determine whether the walking fern might perhaps be limited to highly calcareous soils.

That the soil supporting plant growth is not necessarily closely related in composition to the underlying rock has been repeatedly pointed out,[2] yet is not always recognized in studies

[2] Compare, Coville, Frederick V. *The formation of leafmold.* Journ. Wash. Acad. Sci., **3**: 77. 1913; Ann. Rept. Smithsonian Inst., 1913, 333. 1914.

of plant habitats; attention is therefore again called to it here. The soil may contain: (1) less lime than the underlying rock if (a) it originated on a non-calcareous rock, but has been transported to a more calcareous one, or (b) lime has been leached from it by the rain; (2) more lime than the underlying rock if (a) it originated on a calcareous rock, but has been transported to a less calcareous one, or (b) lime has become concentrated in it by long continued decay of vegetable matter.

To determine which of the above relations holds in the case of the walking fern, samples of the several soils were dried at 105°C., so that they could be more easily handled, and shaken from the network of roots. The soils in almost every case were found to be filled with rock fragments of all sizes, so that some arbitrary classification, on the basis of size, into "rock" and "soil" particles was unavoidable. A sieve with 40 meshes to the centimeter was adopted for this purpose, and the various soils were gently sifted through it, the chips of rock and coarse vegetable matter being thereby removed. The particles passing through this sieve were finely powdered in an agate mortar and used for the analytical work. Two-tenth gram samples of the soils were weighed out into platinum crucibles, and ignited over complete-combustion burners to drive off volatile matter; this varied between 20 and 80 per cent in the several soils studied. The residues were then fused with sodium carbonate, and analyzed for total lime in the usual way; the results are given in Table 1.

The total lime is, however, probably not so important in this connection as the soluble lime, for it is conceivable that even in soils high in total lime only a very minute amount may be present in such a form as to be available to the plants. It was, therefore, decided to test the soils for soluble lime.

It is, of course, impracticable to determine the amount of lime in the natural soil liquid when dealing with such small quantities of material as are available in this case. An excess of water must be added, so that a volume of liquid sufficient for analysis can be obtained. The complexity of soils is so great, and the factors involved so numerous, that it can not be assumed that the composition of a solution obtained by adding an excess of water to a soil will bear any simple relation to that of the original soil liquid, nor that it will contain any definite fraction of the total soluble lime. Although the analytical results will, therefore, have no absolute numerical significance, their general order of magnitude should show in a rough way the extent to which lime is available to the plant. In order that the results should represent as nearly as possible the natural condition of the soil, the samples to be used for determination of soluble lime were not dried, finely sifted, or pulverized. For the same reason water saturated with carbon dioxide was used for extracting, and the amount of this water was reduced to the smallest possible quantity consistent with convenient analytical operation.

One-gram samples of soil were carefully separated from the roots and placed in centrifuge tubes, 3 cc. of distilled water saturated with carbon dioxide being added; the tubes were shaken gently to insure uniform moistening, stoppered, allowed to stand one hour, and centrifuged for a few minutes, and the lime in the liquid was determined in the usual way. The results obtained are given, along with the others, in Table 1.

Still another feature of the soils, their acidity or alkalinity, seemed worth determining, since there is evidence that some plants are sensitive to relatively slight changes in these factors. The acidity or alkalinity of soils is often expressed in terms of "normality," the equivalent weight of soil being taken as 1000 and water extracts being titrated with standard alkali or acid, using phenolphthalein as indicator; and such normality determinations were made as described below. In addition, to determine the *true* acidity (or alkalinity), the soils were examined by the colorimetric method developed by Dr. L. J. Gillespie of the Bureau of Soils, U. S. Department of Agriculture.[3] The results obtained by this method are presented in two forms, in the last three columns of the table. First the P_H value is given, this being the negative exponent of 10 corresponding to the concentration of hydrogen ions present in the solution. Then, as the P_H figures do not express clearly the relative strengths

[3] Journ. Wash. Acad. Sci., **6**: 7. 1916.

of the acids (or alkalies) to persons not accustomed to thinking in such terms, actual numerical intensities of acid and alkali are also given. These have been obtained by subtracting 7, the P_H value of a neutral solution, from each P_H value in turn, making the sign +, and raising 10 to the power indicated; the figures derived from P_H values less than 7 going in the acid, and from P_H values greater than 7 in the alkaline column.

For the two preceding determinations, 2-gram samples of the soils, in their natural condition, were treated in 50 cc. centrifuge tubes with 10 cc. of distilled water which had been boiling for some time in a resistance-glass flask to remove carbon dioxide. The tubes were stoppered, allowed to stand for several hours, and then centrifuged. Five cc. of the liquid, which represents the soluble matter in 1 gram of soil, was titrated in a resistance-glass vessel, using phenolphthalein as an indicator, carbon dioxide being continually boiled out. The remainder of the liquid was used for the color comparison, phenolsulfonephthalein and rosolic acid being found to be the most convenient indicators. The solutions of standard concentration required were tested electrometrically by Dr. Gillespie, to whom the writer's hearty thanks are herewith extended for this courtesy, as well as for much valuable advice in connection with the methods of procedure.

Because of the fact that phenolphthalein changes color only in a somewhat alkaline solution, the true alkalinity is always greater than the alkalinity inferred from the normality values; indeed, when the solution is only weakly alkaline, as in soils Nos. 3, 7, 13, 14, and 19, the two methods give apparently conflicting results, in that the reaction is acid toward phenolphthalein yet alkaline when compared to a truly neutral solution. It seems probable that the true alkalinity (or acidity) is of more significance than the normality, with reference to the growth of plants, and the normality determinations are given merely to permit comparison of the results with those which have been obtained in other similar investigations.

The rocks on which the walking fern was observed to grow are listed in Table 1 in order of decreasing lime content. Only the first 5 are of types to which the term calcareous is generally applied, lime being present as carbonate, so that the rocks effervesce when acid is applied. The remainder comprise igneous,

TABLE 1

Results of Analyses

NO.	LOCALITY[a]	ROCK		SOIL						
		Name	Per cent lime	Per cent total lime	Per cent sol. lime	Normality Alk.	Normality Acid	P_H	Intensities Alk.	Intensities Acid
1	3.5 mi. n. w. of L..	Limestone	53.8	5.4	0.21	0.006		8.5	30	
2	3.0 mi. s. w. of A..	Dolomite-limestone	29.0	10.5	0.05	0.011		9.0	100	
3	12.2 mi. s. w. of A..	Limestone-conglomerate	8.5	3.6	0.08		0.004	7.5	3	
4	12.3 mi. s. w. of A..	Limestone-conglomerate	8.3	2.3	0.06	neut	ral	8.0	10	
5	2.0 mi. s. of L.....	Argillaceous limestone	7.5	2.5	0.08		0.009	6.5		3
6	6.0 mi. s. w. of H..	Mica schist	7.5	6.3	0.04		0.006	7.0	neu	tral
7	10.7 mi. s. of A.....	Gneissoid granite	7.5	5.1	0.14		0.003	7.5	3	
8	3.0 mi. s. e. of A...	Gneissoid granite	7.2	4.3	0.03		0.007	7.0	neu	tral
9	1.3 mi. s. e. of H...	Mica schist	5.9	2.5	0.04		0.018	5.5		30
10	10.0 mi. n. w. of W.	Granitic gneiss	5.0	4.8	0.09		0.010	6.5		3
11	6.1 mi. s. w. of H..	Mica schist	4.1	2.0	0.07		0.017	5.5		30
12	11.0 mi. n. w. of A.	Shale	2.9	1.5	0.04		0.013	6.0		10
13	1.1 mi. s. e. of H. .	Granite	2.0	4.3	0.04		0.004	7.5	3	
14	1.8 mi. n. of H.....	Mica schist	1.4	1.2	0.02		0.002	7.5	3	
15	12.5 mi. n. w. of A.	Sandstone	0.8	3.7	0.07		0.011	6.5		3
16	2.5 mi. s. of L.....	Shale	0.4	4.0	0.11		0.009	6.5		3
17	3.0 mi. s. of A......	Jasperoid quartzite	0.1	5.1	0.10		0.018	5.5		30
18	0.2 mi. s. e. of H..	Quartzite	tr.	3.2	0.06		0.010	6.5		3
19	Same as 6.	Hemlock trunk		5.1	0.04		0.002	7.5	3	
20	Same as 1.	Hemlock stump		10.0	0.30	0.004		8.5	30	
Average for walking fern soils		....	....	4.4	0.08		0.008	7.0	neu	tral
Average for several field soils		....	....	0.8	0.01		0.015	6.0		10

[a] In this column the capital letters stand for the following localities: A. = Allentown, Pa., H. = Harpers Ferry, W. Va., L. = Lewisburg, Pa., and W. = Washington, D. C.

metamorphic, and sedimentary rocks. Even though in some cases fairly high in lime, these are not ordinarily classed as calcareous, their lime being united with silica and other constituents in relatively insoluble form; several, indeed, contain only extremely small amounts of lime. When the total lime contents of the soils are compared to those of the rocks, however, wide divergences are shown. The several soils vary in total lime from 1.2 to 10.5 per cent, containing in some cases less and in others more lime than the rocks upon which they occur; in other words, in so far as this one constituent is concerned, the composition of the soil bears no relation whatever to that of the underlying rock. Soil transportation on any considerable scale is virtually excluded; but it is evident that leaching out of lime by the rain and its concentration by accumulation and decay of vegetable matter are both effective processes. Which is dominant depends on circumstances, such as exposure to rain, opportunity for leaves to fall in, etc., but the net result is that in cases where the rock is high in lime the soil usually contains less lime than the rock, whereas with rocks low in lime the reverse is usually true; and the average lime content of the soil is slightly more than 4 per cent. If a calcareous soil is defined as one containing more lime than the average field soil (0.8 per cent or less), then the soils supporting the growth of walking fern are certainly highly calcareous.

The percentage of soluble lime bears no recognizable relation to that of total lime, but it is also on the average many times as great as the figure for ordinary field soils. The habitat of the walking fern is thus calcareous with reference to both total and soluble lime. It is not claimed that the plant grows in these calcareous soils merely because of the presence of abundant lime; more probably the lime acts indirectly by favoring the accumulation of humus or the growth of beneficial microorganisms; no doubt the physical condition of the soils, the amount of moisture, the degree of drainage, etc., have an important bearing on the question also; but as this phase of the subject lies entirely outside of the scope of the present investigation it will not be further discussed.

The results in the last five columns, and more particularly the last two, show that some of the soils are alkaline, some neutral, and some acid. The chief sources of the alkalinity are, no doubt, calcium and potassium salts of weak organic acids; of the acidity, these acids in a free state; but the amount of soil available is too limited to permit of isolation or identification of these substances. At any rate it is evident that the walking fern is not especially sensitive to variations in the reaction of the soil.

Summary.—It has been shown by chemical analysis that the rocks supporting the growth of walking fern (*Camptosorus rhizophyllus*) are by no means necessarily calcareous, but that the soils in which this fern grows are rather high in both total and soluble lime. Rocks high in lime suffer leaching during soil formation, and those low in this constituent gain it through decay of vegetable matter, the ultimate amount varying widely with the conditions, but averaging about 4 per cent. The above results indicate that the view often held, that the occurrence of calciphilous plants necessarily indicates the presence of lime in the underlying rock strata, is untenable, except in cases where circumstances preclude the accumulation and decay of vegetable matter, and the resulting accumulation of lime in the soil.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METALLURGY.—*The failure of brass.—1. Microstructure and initial stress in wrought brasses of the type 60 per cent copper and 40 per cent zinc.* P. D. Merica and R. W. Woodward. Bureau of Standards Technologic Paper No. 82. Pp. 72. 1916.

This paper gives an account of an investigation of the cause of failure of a number of articles, particularly bolts, of wrought brass of the type 60 : 40 (i.e. of such material as naval brass and manganese bronze) with particular reference to the microstructure of the material and the presence in it of initial stress. In the course of this investigation the physical properties, microstructure, and initial stress distribution have been studied in some 250 materials, some of which had been in service (in the Catskill Aqueduct construction, in the Filtration Plant of the City of Minneapolis, in the U. S. Navy Department, and in the Panama Canal construction) and some of which was new material, rods having been kindly furnished by several manufacturers. It was shown that the initial stresses in rods could be relieved by annealing for one or two hours at low temperatures, 300°C. to 400°C., at which the physical properties of the rods were not appreciably affected.

P. D. M.

METALLURGY.—*The failure of brass.—2. The effect of corrosion on the ductility and strength of brass.* Paul D. Merica. Bureau of Standards Technologic Paper No. 83. Pp. 7. 1916.

Investigations of a homogeneous alpha brass have shown that the electrolytic solution potential of this material is increased by the application of a tensile stress. This measured increase amounts to approximately 0.1 millivolt for 10,000 lbs. per sq. in. of stress.

On this fact can be based an explanation of the decrease of strength and of ductility of brasses when corroded while under stress. Over a roughened surface of a bar the tensile stress will vary in value, being greatest at the bottom of furrows and depressions and least, almost zero indeed, at the tops of the ridges. The e.m.f. will therefore, other things being equal, be greater (i.e., more electropositive) at the bottoms of the furrows than elsewhere; corrosion will set in here most rapidly, forming a crack which will grow narrower and sharper, its rate of growth being greater the sharper it is. In time the cross section of such a bar is so reduced by these cracks that fracture occurs, the brass exhibiting only slight elongation (ductility) and failing at a stress value apparently less than the ultimate strength. This explanation is borne out by the examination of a number of brass failures which have occurred under such conditions. P. D. M.

METALLURGY.—*The failure of brass.—3. Initial stress produced by the "burning-in" of manganese bronze.* Paul D. Merica and C. P. Karr. Bureau of Standards Technologic Paper No. 84. Pp. 7. 1916.

In connection with the failure, by cracking, of a number of manganese bronze valve castings in the Catskill Aqueduct at or near areas repaired by "burning-in," an investigation has been made of the initial stress produced in a manganese bronze double bar casting by the burning-in of a constrained portion. The stresses measured were in each case about 8000 to 10,000 pounds per square inch (i.e., the true elastic limit of the material) and the material within the burned-in area was of course in tension. The microstructure of the portion adjacent to the burned-in metal was not altered; the burned-in metal was in all cases of finer grain than that of the casting.

The conclusion is reached that, although distortion of a burned-in casting may partially relieve the initial stresses set up by this operation, such castings will, in all probability, generally contain local stresses of dangerous magnitude, i.e., near the elastic limit of the material. Castings repaired in this manner should either be thoroughly preheated or subsequently annealed in order to eliminate these stresses.

P. D. M.

GEOLOGY.—*Some Paleozoic sections in Arizona, and their correlation.* F. L. Ransome. U. S. Geological Survey Professional Paper No. 98-K. Pp. 133–166, with 8 plates and 4 figures. 1916.

A comparison is made of ten stratigraphic sections from Bisbee, near the Mexican border, to the Grand Canyon. Attention is called to the thickness of the Cambrian beds in the Globe-Ray region in contrast with those of the Grand Canyon section and to the exposure in the Mazatzal Range and Sierra Ancha of a thick series of quartzites, shales, and conglomerates unconformably beneath the Cambrian.

The observations presented in this paper indicate that in Cambrian time a land barrier existed in the region now adjacent to Tonto Basin, between the depositional basin of central and southern Arizona and that now corresponding to the Arizona Plateau, or at least to that part of the plateau between Payson and the Grand Canyon. It follows that while the whole Apache group of the Globe-Ray region and its stratigraphic equivalents in eastern and southern Arizona were deposited at probably about the same time as the beds of the Tonto group, the beds of the two groups were probably never continuous within the Tonto region of Arizona. It can not be said that any particular sandstone or quartzite of the Apache group is identical with the Tapeats sandstone.

Although the evidence from fossils is lacking, it appears to be fairly well established that the entire Apache group is Cambrian, or possibly in part younger, and, so far as can be seen over a wide region, is conformably overlain by the Devonian, while in the northern parts of the Mazatzal Range and Sierra Ancha the Paleozoic beds overlie with conspicuous unconformity a series of shales, quartzites, and conglomerates, which is probably equivalent to the Grand Canyon series.

The marked difference in the Carboniferous sections of the two geographic provinces in north-central Arizona suggests that the natural barrier supposed to exist in Cambrian time may have persisted in some form, possibly as a submarine ridge, throughout the Paleozoic era.

F. L. R.

BOTANY.—*Fungi of New Mexico.* Paul C. Standley. Mycologia, 8: 142–177. 1916.

But little attention has been given by collectors to the lower plants of New Mexico. The only previous list of fungi of the state, enumerating 46 species, was published by Prof. T. D. A. Cockerell in 1904. The present paper is based chiefly on material collected by the author in connection with his work upon the phanerogamic plants. Two hundred and ten species are listed, 113 of which are rusts. There is included a description of a new rust, *Aecidium cockerellii* Arthur, on *Chamaesaracha coronopus* (Dunal) Gray. P. C. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY OF WASHINGTON

The 113th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Tuesday, May 2, 1916. Mr. Frank N. Meyer, geographical explorer of the U. S. Department of Agriculture, was elected to membership. The program consisted of the following papers.

Dr. Edward L. Greene, an appreciation: H. H. Bartlett. As it was impossible for Mr. Bartlett to be present at the meeting, the paper was read by title. It has since been published in Torreya.[1]

Winter rape and adulterants of this seed (with lantern): Edgar Brown. Five types of plants raised from seed imported into the United States under the name of rape were briefly described and illustrated. The Dutch and German sources of the winter rape seed normally used in this country for the production of forage having been shut off, seed was imported from other sources, including winter rape from England, France, and Japan, annuals of no forage value from Argentina, France, China, and Japan, and biennials of no forage value from France and Japan.

An economic Amaranthus of ancient America (with exhibition of specimens and lantern): W. E. Safford. Among the tributes paid to Montezuma by the pueblos of Mexico was a certain grain of ivory whiteness and more minute than a mustard seed, called by the Aztecs *huauhtli*. Eighteen imperial granaries were filled with it each year, each having a capacity of about 9000 bushels. In some parts of Mexico, at times when maize was scarce this seed was used in its stead and along the Pacific coast it was an important food staple. Cabeza de Vaca noticed it in Sonora in 1536. Its most important use was in religious ceremonies, when a paste, called *tzoalli*, was made of it together with maguey syrup, and images of the god Uitzilipuztli were molded of it. After having been adorned with beautiful ornaments and carried in procession, the image was carried to the top of the pyramidal temple in the city of Mexico. Sacrifices were made to it, including human beings, and the next day it was broken up into fragments and served as communion to the people. For a long time the botanical identity of this seed was unknown. The late Edward Palmer, while making col-

[1] **16**: 151–175, with portrait. July, 1916

lections in the states of Sinaloa and Jalisco, found an *Amaranthus* growing both in cultivation and spontaneously. Its ivory-white seeds, resembling fish-eggs, corresponded exactly with the *huauhtli* as described by early writers. Moreover its local name, "guauto," is only a variation of the Nahuatl *huauhtli*. Near Guadalajara Dr. Palmer found a paste made of this seed and sugar offered for sale in the form of strings of dumplings enveloped in corn husks, under the name of "suale," a corruption of the Nahuatl *tzoali*. He collected botanical specimens of the plant producing the seed, which proved to be an *Amaranthus*, evidently a white-seeded form of *A. paniculatus*. Although Dr. Palmer did not realize that he had rediscovered an important economic plant of the Aztecs, his botanical specimens together with his field notes, found by the writer in the U. S. National Herbarium, have served to establish the identity of the sacred *huauhtli*. The possibility of cultivating this *Amaranthus* in suitable situations in the southwestern United States was suggested by the writer. Very closely allied plants, also producing white seeds, are cultivated as grain crops in India, Thibet, South America, and Africa. Of the existence of this particular form in pre-Columbian America there can be no doubt. It remains to be determined whether or not the Asiatic and African plants were endemic in the countries where they are now cultivated, or were introduced there after the discovery of America. Mr. Safford's paper will appear in full in the Proceedings of the Ninth Congress of Americanists.

Fungus fairy rings in eastern Colorado and their effect on vegetation (with lantern): H. L. Shantz and R. L. Piemeisel. (To be published by the U. S. Department of Agriculture.)

Report on the local flora: A. S. Hitchcock.

W. E. Safford, *Corresponding Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VI DECEMBER 19, 1916 No. 21

MINERALOGY.—*Hopeite from the H. B. mine, Salmo, B. C.*

T. L. WALKER, Royal Ontario Museum of Mineralogy.

The mineral hopeite, a hydrous zinc phosphate, occurs very sparingly along with smithsonite, calamine, hydrozincite, spencerite, hibbenite, and cerusite at the H. B. mine near Salmo, B. C. It is remarkable that the ore as mined and shipped is almost entirely free from sulphides even on the 300-foot level. From this mine two new zinc phosphates, spencerite and hibbenite, have been recently described. The phosphates occurred in considerable quantity in a cave from which almost 100 tons were sent to the smelter. Calamine and smithsonite appear to be less prominent in this ore than the phosphates, which in places occurred in very pure stalactitic masses weighing at least ten pounds. In the stalactitic growths the central core is always spencerite, while the outer zone is principally calamine. There is often a solution zone between these two, and in these solution cavities small bright crystals of hopeite are found attached to the spencerite by which they were at one time completely enclosed. In general these crystals do not exceed 3 mm. in length, although some attain a length of 1 cm.

Chemical properties. As the amount available was insufficient for a quantitative analysis the mineral was subjected to qualitative tests and found to respond in all respects to the reactions of hopeite. Heated in the closed tube it yields water. In the forceps it fuses quietly to a clear glass, which is not yellow when hot.

Physical properties. The specific gravity, determined by means of a solution of potassic mercuric iodide, is 3.03. Under the microscope the crystals exhibit parallel extinction in the prismatic zone. There are three cleavages corresponding to the three pinacoids. The luster is vitreous except on the macropinacoid, which is pearly.

Crystallographic properties. The three crystals measured were similar as to habit and forms present. The macropinacoid is generally the predominant form. The prism (120) is usually well developed, while of the terminal faces the most prominent are the unit pyramid (111) and the unit macrodome (101). The other terminal faces are usually quite small, but, considering their size, remarkable for the accuracy with which they can be measured. The measurements on the two large crystals, while satisfactory, are somewhat less concordant than those obtained from the third crystal, which is only 2 mm. in length. The following forms were observed:

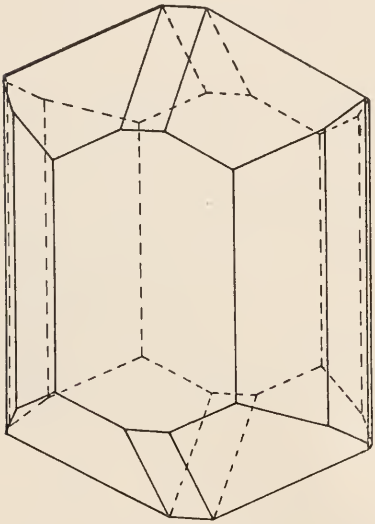

Fig. 1. Hopeite from British Columbia.

(a) Pyramids..(111) and (133)
(b) Brachydomes....................................(011) and (021)
(c) Macrodomes...............................(103), (101), and (201)
(d) Prisms............(670), (120), (5.11.0), (130), (3.11.0), and (160)
(e) Pinacoids..(010) and (100)

The above list contains all the forms observed by Spencer on crystals from Rhodesia except the pyramid (233). The form (201) observed by Lévy in 1837 on material from Aix-la-Chapelle is represented by one face on crystal No. 2. The following forms have not been previously observed:

(021) represented by five faces out of a possible six on the three crystals measured,
(670) observed on two crystals,
(3.11.0) shown on one crystal.

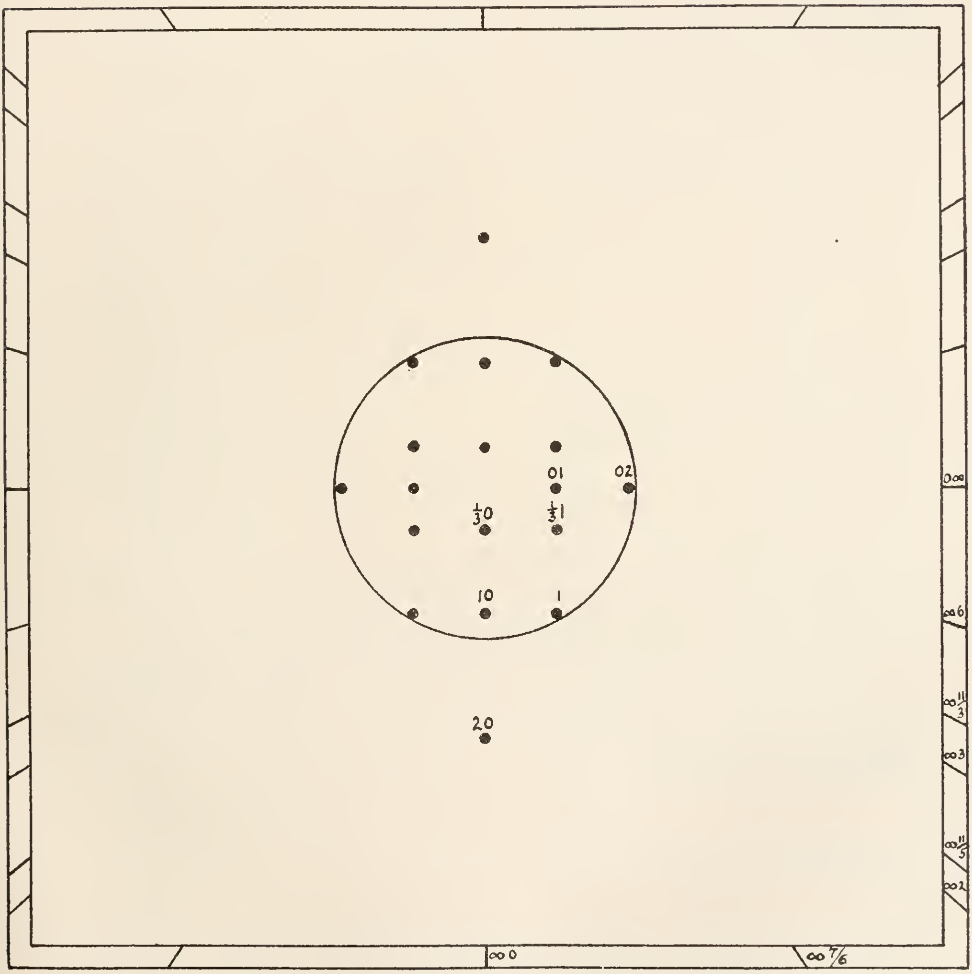

Fig. 2. Gnomonic projection of hopeite from British Columbia.

From crystal No. 1 the polar elements were found to be $p_0 = 0.8277$; $q_0 = 0.4720$, corresponding to the axial ratios a : b : c : : 0.5703 : 1 : 0.4720. These ratios are slightly lower than those obtained by previous observers, though they are very near the values of Lévy—a : b : c : : 0.5723 : 1 : 0.4718.

The details of the measurements given in the following table were obtained from crystals 1 and 2 except the values for the form (103), which are from the third.

NO.	FORM	NO. 1 OBSERVED			NO. 2 OBSERVED			CALCULATED	
		Faces	ϕ	ρ	Faces	ϕ	ρ	ϕ	ρ
1	111	4	60° 17′	43° 37′	4	59° 51′	43° 20′	60° 18′	43° 37′
2	133	2	30° 07′	28° 35′	4	30° 22′	28° 52′	30° 19′	28° 40′
3	011				2	0° 35′	25° 51′	0°	25° 16′
4	021	1	0° 10′	43°	2	0° 20′	43° 28′	0°	43° 21′
5	103	2	89° 37′	15° 26′				90°	15° 26′
6	101	1	89° 55′	39° 40′	1	88° 55′	39° 30′	90°	39° 36′
7	201				1	89° 29′	59° 04′	90°	58° 52′
8	670				3	56° 19′	89° 32′	56° 22′	90°
9	120	4	40° 42′	90°	4	40° 49′	89° 19′	41° 15′	90°
10	5.11.0	1	38° 44′	90°				38° 33′	90°
11	130	3	29° 34′	90°	4	29° 13′	89° 05′	30° 53′	90°
12	3.11.0	1	25° 48′	90°				25° 34′	90°
13	160				1	16° 02′	89° 55′	16° 20′	90°
14	010	1	0° 05′	90°				0°	90°
15	100	2	90°	89° 42′				90°	90°

The principal faces are shown in figure 1, while all the forms observed appear on the gnomonic projection in figure 2.

Hopeite has been found in the zinc mines near Aix-la-Chapelle and at the Broken Hill mine in Rhodesia. The occurrence at the H. B. mine near Salmo, B. C., is the first recorded for the American continent.

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An * denotes an abstract of a printed paper. A † denotes an abstract of a paper presented before the Academy or an affiliated society.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

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Vol. VI

No. 1

January 4, 1916

JOURNAL

OF THE

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BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
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Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Thursday, January 6: The Entomological Society, at the Saengerbund Hall, at 8 p. m. Program:

A. N. Caudell: *Address of the retiring President.*

Wednesday, January 12: The Geological Society, at the Cosmos Club, at 8 p. m.

Thursday, January 13: The Washington Academy of Sciences, at the Cosmos Club, at 8 p. m.

Annual meeting for the reports of officers, etc.

This will be followed by a joint meeting with the Chemical Society. Program:

C. L. Alsberg: *Address of the retiring President of the Chemical Society.*

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the first and fifteenth days of each month.

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Wednesday, January 19: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m. Program:

Motion picture films (beginning promptly at 8 p. m.) showing construction work on the Central Railway of Brazil.

THOMAS RIGGS, JR., member of the Alaska Engineering Commission: *The work of the Alaska Railroad.* Lantern slides and motion pictures.

Saturday, January 22: The Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

C. G. ABBOT: *New proofs of the variability of solar radiation.* Illustrated, 30 minutes.

L. A. BAUER: *Corresponding changes in the Earth's magnetic field and the solar radiation.* Illustrated, 30 minutes.

Wednesday, January 26: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

G. F. LAUGHLIN: *Faulting in the Tintic District, Utah.* 20 minutes.

P. S. SMITH: *Geology of the Lake Clark-Iditarod region, Alaska.* 15 minutes.

F. W. CLARKE: *The inorganic constituents of marine invertebrates and their bearing on the origin of dolomite and phosphatic rock.* 30 minutes.

Tuesday, February 1: The Anthropological Society, in the west study room of the District Public Library, at 8 p. m.

Wednesday, February 2: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m. Program:

Dr. C. M. COBURN, Professor of Archaeology, Alleghany College: *The work of the Ancients, with special reference to Engineering.*

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the first and fifteenth days of each month.

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, February 5: The Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

EUGENE C. BINGHAM (by invitation): "*Plastic Flow.*" Illustrated, 30 minutes.

E. BUCKINGHAM: *Notes on the theory of Efflux viscosimeters.* 30 minutes.

Wednesday, February 9: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

CHARLES BUTTS: *Faults of unusual character in central Pennsylvania.* Illustrated, 20 minutes.

LAURENCE LA FORGE: *Résumé of the geology of southeastern New England in the light of field work done since 1908.* Illustrated, 20 minutes.

A. H. BROOKS: *Physiographic provences of Alaska.* Illustrated, 15 minutes.

Tuesday, February 15: The Anthropological Society, in the west study room of the District Public Library, at 8 p. m.

Wednesday, February 16: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m. Program:

H. W. HUDSON, of New York City: *The Hell Gate arch bridge and approaches of the New York Connecting Railroad.* Illustrated.

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Vol. VI

February 19, 1916

No. 4

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Saturday, February 19: The Philosophical Society, at the Cosmos Club, at 8 p. m. Program:

WILLIAM BOWIE: *Determination of the intensity of gravity on land in the United States.* Illustrated, 30 minutes.

L. J. BRIGGS: *Measurement of the acceleration of gravity at sea.* Illustrated, 30 minutes.

Saturday, February 19: The Medical Society of the District of Columbia is invited to meet with the George Washington University Medical Society, at the Medical Department of George Washington University, 1325 H Street N.W., at 8 p. m. Program:

DR. JOHN R. WILLIAMS, of Rochester, N. Y.: *Recent developments in the study and treatment of diabetes mellitus.* Illustrated.

Wednesday, February 23: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

CHARLES BUTTS: *Faults of unusual character in central Pennsylvania.* Illustrated, 20 minutes.

LAURENCE LA FORGE: *Resume of the geology of southeastern New England in the light of field work done since 1908.* Illustrated, 20 minutes.

A. H. BROOKS: *Physiographic provinces of Alaska.* Illustrated, 15 minutes.

NOTE: The meeting of February 9, for which this program was originally announced, assembled and immediately adjourned out of respect to the memory of C. Willard Hayes, former President of the Society.

Wednesday, March 1: The Washington Society of Engineers, at the New Willard Hotel Ball Room, at 8 p. m. Program:

WILLIAM BARCLAY PARSONS, Consulting Engineer, New York City: *The Engineer Reserve Corps.*

Saturday, March 4: The Philosophical Society, at the Cosmos Club, at 8 p. m.

Address of the retiring president, W. S. EICHELBERGER.

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, March 7: The Anthropological Society, in the west study-room of the District Public Library, at 8 p. m. Program:

C. L. G. Anderson: *Old Panama.*

Wednesday, March 8: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

C. F. Bowen: *Review of the stratigraphy and structure of the Hanna Basin, Wyoming.* 20 minutes.

C. H. Wegemann: *The discovery of Wasatch fossils in the so-called Fort Union beds of Powder River Basin, Wyoming, and its bearing in the stratigraphy of the region.* 20 minutes.

C. J. Hares: *Stratigraphic relation of some of the Upper Cretaceous and Tertiavy formations of the Hanna and Powder River Basins, with those of the Wind River Basin.* 25 minutes.

Saturday, March 18: The Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

H. C. Dickinson: *Thermal conductivity through air spaces.* 30 minutes.

L. H. Adams: *The thermo-electric power of pure metals.* 20 minutes.

Asaph Hall: *The micrometer screws of the equatorial telescope of the U. S. Naval Observatory.* 15 minutes.

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March 19, 1916

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, March 21: The Anthropological Society, in the lecture room of the District Public Library, at 8 p. m. Program:

Miss Frances Densmore: *Mandan music.* Mr. Heinrich Hammer will play some of his compositions based upon Miss Densmore's records.

Wednesday, March 22: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

R. B. Sosman and J. C. Hostetter: *Zonal growths in hematites and their bearing on the origin of certain iron ores.* Illustrated. 20 minutes.

R. W. Pack: *Structural features of the San Joaquin Valley oil field, California.* Illustrated. 20 minutes.

C. T. Lupton: *Notes on the stratigraphic and structural relations in the southern and portions of the Big Horn Basin, Wyoming.* 20 minutes.

Thursday, March 23: The Washington Academy of Sciences, in the Auditorium of the New National Museum, at 8.30 p. m. Program:

Dr. L. H. Baekeland, member of the Naval Consulting Board. *Chemistry in relation to the war.* Illustrated.

Saturday, April 1: The Philosophical Society, at the Cosmos Club, at 81.5 p. m. Program:

R. S. Woodward: *The extraction of square roots of numbers.* 20 minutes.

Wm. W. Fraser: *Vectors and Quaternions: What has been done and what can be done.* 20 minutes.

W. J. Spillman: *A graphic method for the determination of the average interval between departures from the mean greater than a given departure.* 15 minutes.

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APRIL 4, 1916

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

The Washington Academy of Sciences announces a series of illustrated lectures on nutrition open to the public to be given on Friday afternoons in April 1916 at 4:45 o'clock in the auditorium of the new National Museum (Tenth street entrance). The lecturers are men distinguished for their contributions to this important subject in which great advances have recently been made.

The lecturers and the subjects of their addresses are as follows:

April 7: Dr. EUGENE F. DUBOIS, Medical Director, Russell Sage Institute of Pathology, New York: *The basal food requirement of man.*

April 14: Dr. GRAHAM LUSK, Professor of Physiology, Cornell University Medical College: *Nutrition and food economics.*

April 21: Dr. E. B. FORBES, Chief, Department of Nutrition Ohio Agricultural Experiment Station: *Investigations on the mineral metabolism of animals.*

April 28: Dr. CARL VOEGTLIN, U. S. Public Health Service, Washington: *The relation of the vitamines to nutrition in health and disease.*

Wednesday, April 12: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

J. S. DILLER: *The geology of the Lassen Peak region, California.* Illustrated, 20 minutes.

ARTHUR L. DAY: *The volcanic phenomena of Lassen Peak.* Illustrated, 40 minutes.

Friday, April 14: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m. Program:

Lieut.-Col. GEORGE P. HOWELL, Corps of Engineers: *The selection, laying out and preparation of camps and cantonments; the service of general construction, and the special services, including all public work of an engineering nature which may be required in a territory under military control.*

Tuesday, April 18: The Anthropological Society, in the west study-room of the District Public Library, at 8 p. m. Program:

Annual meeting for the election of officers, etc. Address of the President JOHN R. SWANTON: *The influence of inheritance on human culture.*

Wednesday, April 19: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m. Program:

JOHN F. HAYFORD, Dean of the Engineering School of Northwestern University: *Engineering Education.*

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

The two remaining lectures of the series on nutrition previously announced by the Washington Academy of Sciences will be given on Friday afternoons at 4:45 o'clock in the auditorium of the new National Museum (Tenth street entrance) as follows:

April 21: Dr. E. B. FORBES, Chief, Department of Nutrition, Ohio Agricultural Experiment Station: *Investigations on the mineral metabolism of animals.*

April 28: Dr. CARL VOEGTLIN, U. S. Public Health Service, Washington: *The relation of the vitamines to nutrition in health and disease.*

Thursday, April 20: Special meeting of the Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

DR. R. A. MILLIKAN, Professor of Physics in the Universisy of Chicago: *On some recent aspects of the radiation problem.*

Saturday, April 22: The Biological Society, at the Cosmos Club, at 8 p. m.

Wednesday, April 26: The Geological Society, at the Cosmos Club, at 8 p. m., jointly with the Washington Academy of Sciences.

The program will consist of a symposium on limestone deposition. Papers will be presented by KARL F. KELLERMAN, JOHN JOHNSTON, and H. E. MERWIN.

Saturday, April 29: The Philosophical Society, at the Cosmos Club, at 8.15 p. m.

The program will consist of a symposium on X-rays and crystal structure. Papers will be given by C. W. KANOLT and F. E. WRIGHT.

Tuesday, May 2: The Botanical Society, at the Cosmos Club, at 8 p. m.

[1] The programs of the meetings of the affiliated socities will appear on this page if sent to the editors by the first and fifteenth days of each month.

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Vol. VI

No. 9

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Wednesday, May 10: The Geological Society, at the Cosmos Club, at 8 p. m. Program:

W. C. Alden: *The Iowan stage of glaciation; a review of the evidence, based on field studies in 1914 and 1915 by the U. S. Geological Survey and the Iowa Geological Survey.* 25 minutes. Illustrated.

F. C. Schrader: *Ore deposits of the Rochester district, Nevada.* 20 minutes.

H. S. Washington: *The Persistence of the volcanic vents at Stromboli, Italy.* 15 minutes. Illustrated.

Thursday, May 11: The Washington Society of Engineers.

Members of the Society and their friends, with ladies, will visit the plant of the Newport News Ship Yard and Dry Dock Company, Newport News, Va., on Friday, May 12. The party will leave on the regular Norfolk boat at 6.45 p. m., Thursday, May 11, reaching Old Point Comfort Friday morning. Breakfast will be served at Hotel Chamberlain, after which the party will go by trolley to Newport News and visit the plant during the forenoon by invitation of the Company. After luncheon at Hotel Warwick in Newport News, the party will disband, to return by the regular boat on Friday, Saturday, or Sunday night, as desired. Orders for tickets should be in the hands of the Treasurer not later than May 4.

Saturday, May 13: The Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

C. W. Hewlett (Johns Hopkins University): *An apparatus for the analysis of sound waves.*

J. A. Anderson (Johns Hopkins University): *Diffraction gratings, their preparation and use.*

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Wednesday, May 24: The Philosophical Society, at the Cosmos Club, at 8:15 p. m. The program will consist of a symposium on the atom:

H. L. CURTIS: *The atom as a miniature solar system.* 35 minutes. (Discussion will be led by P. G. AGNEW.)

W. J. HUMPHREYS: *The magnetic field of an atom.* 25 minutes. (Discussion will be led by W. F. G. SWANN.)

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Saturday, October 21: The Biological Society, at the Cosmos Club, at 8 p. m.

Wednesday, October 25: The Geological Society, at Cosmos Club, at 8 p. m.

Wednesday, October 25: The Medical Society, at the Medical Department of George Washington University, 1325 H Street N. W., at 8 p. m.

Saturday, October 28: The Philosophical Society, at the Cosmos Club, at 8 p. m. Program:

E. C. Crittenden, F. K. Richtmyer, and A. H. Taylor: *A normal eye for the photometry of lights of different colors.* Illustrated. 30 minutes.

W. W. Coblentz and W. B. Emerson: *The relative sensibility of the average eye to lights of different colors.* Illustrated. 30 minutes.

Wednesday, November 1: The Medical Society, at the Medical Department of George Washington University, 1325 H Street N. W., at 8 p. m.

Thursday, November 2: The Entomological Society, at the Saengerbund Hall, 8 p. m.

Saturday, November 4: The Biological Society, at the Cosmos Club, at 8 p. m.

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REPRINT OF NUTRITION LECTURES

A series of four public lectures by Dr. E. F. DuBois, Dr. Graham Lusk, Dr. E. B. Forbes, and Dr. Carl Voegtlin, dealing with various phases of human and animal nutrition, was given under the auspices of the Washington Academy of Sciences during April, 1916, at the New National Museum, Washington, D. C. In view of the wide-spread interest in the lectures and the importance of the subject, and in response to numerous requests, the Academy has reprinted in collected form a limited edition of the lectures as published in the JOURNAL. It has seemed desirable also to include, as a fitting introduction to the series, the address of the retiring president of the Chemical Society of Washington, Dr. C. L. Alsberg, which was presented in January, 1916, before a joint meeting of the Chemical Society and the Academy.

Copies of the brochure, substantially bound in flexible cloth covers, may be purchased of the Treasurer, Mr. William Bowie, Coast and Geodetic Survey, Washington, D. C., at fifty cents each (postage included).

LYMAN J. BRIGGS,
Chairman, Committee on Meetings.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, November 7: The Anthropological Society, at the Public Library, at 8 p. m.

Tuesday, November 7: The Botanical Society, at the Cosmos Club, at 8 p. m.

Wednesday, November 8: The Geological Society, at the Cosmos Club, at 8 p. m.

Thursday, November 9: The Chemical Society, at the Cosmos Club, at 8 p. m.

Saturday, November 11: The Philosophical Society, at the Cosmos Club, at 8.15 p. m.

Saturday, November 18: The Biological Society, at the Cosmos Club, at 8 p. m.

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NIEL M. JUDD: *Some newly discovered ruins in western Utah.*

Tuesday, November 21: The Washington Society of Engineers, at the Cosmos Club, at 8 p. m.

Wednesday, November 22: The Geological Society, at the Cosmos Club, at 8 p. m.

Thursday, November 23: The Chemical Society, at the Cosmos Club, at 8 p. m. Members of the Botanical Society are especially invited to attend. Program:

FREDERICK B. POWER: *The aims and developments of phyto-chemical research.*

Saturday, November 25: The Philosophical Society, at the Cosmos Club, at 8.15 p. m. Program:

W. P. WHITE: *Specific heats at high temperatures.* Illustrated, 30 minutes.

N. S. OSBORNE. *A calorimeter for the determination of latent and specific heats of fluids.* Illustrated, 30 minutes.

Saturday, December 2: The Biological Society, at the Cosmos Club, at 8 p. m.

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William H. Holmes: *Outlines of American Aboriginal History.* Illustrated by lantern slides.

Tuesday, December 5: The Botanical Society, at the Cosmos Club, at 8 p.m. The program will consist of *a symposium on the behavior of hybrids in different groups of plants.* The speakers will be Messrs. G. N. Collins, O. F. Cook, Frederick V. Coville, H. V. Harland, C. E. Leighty, J. B. Norton, W. A. Orton, C. V. Piper, W. J. Spillman, and W. T. Swingle.

Saturday, December 9: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

Annual meeting for the reports and election of officers.

Wednesday, December 13: The Geological Society, at the Cosmos Club, at 8 p.m. Program:

Annual meeting for the election of officers. Address by the retiring President.

Thursday, December 14: The Chemical Society, at the Cosmos Club, at 8 p.m. Program:

D. M. Buck: *The manufacture of sheet tin and tin plate.* Illustrated by motion pictures.

Saturday, December 16: The Biological Society, at the Cosmos Club, at 8 p.m.

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Tuesday, December 19: The Washington Society of Engineers, at Rauscher's, 1034 Connecticut Ave., N. W., at 8 p.m.

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