there were pre-Ojibwa Algonkians in this region—probably the Cheyenne. Altogether, there is much good information and not a little speculation of a somewhat doubtful character in this volume. Some of the material deserves to be gone over again and made more of.

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SPECIAL ARTICLES

THE NATURE OF THE SUBSTANCES WHICH CAUSE THE BIOELECTRICAL POTENTIAL DIFFERENCES

In previous papers[1] we have shown that the potential differences at the junction of the *intact* surfaces of plants and aqueous salt solutions exhibit sharply defined and reversible changes with the change in the concentration of the salt solution. The sense of these changes is such that we can speak of a reversibility for kations and the order of magnitude corresponds nearly with that calculated by Nernst's formula. A similar change was observed on the *injured* surface of certain plants and on animal organs.

We found, moreover, that the potential difference becomes smaller if we substitute an equimolecular acid solution for the salt solution, and we pointed out that this difference is of the order of magnitude of the so-called current of injury found in living organs. Finally we observed that the bioelectrical potential difference approaches a limit for increasing concentrations of the salt solution.

These characteristics are so definite that we undertook an investigation of the nature of the substances which are responsible for the potential differences at the junction of living organs and aqueous solutions. It was first ascertained that solid proteins, like gelatine or coagulated white of egg, show none of the potential differences characteristic for living organs. These characteristics were shown, however, by certain fatty compounds, like phosphatides (lecithin and kephalin), oleic, stearic and palmitic acids, and to a lesser degree by triolein. For technical reasons it was necessary to dissolve these substances in guaiacol or kresol.[2]

At the junction of a soluble lecithin solution and aqueous solutions were found the same changes in E.M.F. with the change in the concentration of the salt solution as we had previously found at the junction of a living organ (*e. g.*, the leaf of *Ficus elasticus*) and the aqueous solution, and moreover we noticed also the characteristic acid effect. In order to show to what extent the electromotive behavior of a lecithin solution resembles that of

Salt Solution	10 Per Cent. Lecithin in m-kresol E.M.F.	Difference.	Leaf of *Ficus elasticus* E.M.F.	Difference
m/10 KCl	+ .050 volt			
m/1250 KCl	.141 volt	.023 volt	.099 volt	.031 volt
m/250 KCl	.118 volt	.034 volt	.068 volt	.002 volt
m/50 KCl	.084 volt	.035 volt	.036 volt	.024 volt
m/10 KCl	.049 volt	.031 volt	.012 volt	
m KCl	.018 volt			
m/10 NaCl	.064 volt			
m/1250 NaCl	.150 volt	.022 volt	.141 volt	.038 volt
m/250 NaCl	.128 volt	.030 volt	.103 volt	.036 volt
m/50 NaCl	.098 volt	.037 volt	.067 volt	.034 volt
m/10 NaCl	.061 volt	.031 volt	.043 volt	
m/2 NaCl	.030 volt			
	10 per cent. lecithin in guaiacol.			
m/10 KCl	+ .042 volt	.042 volt		
m/10 HCl	± .000 volt			

[1] Science, XXXIV., 884, 1911; XXXV., 970, 1912. *Biochem. Ztschr.*, 41: 1, 1912; 44: 303, 1912.

[2] Beutner, *Jour. Amer. Chemical Society*, 35: 344, 1913.

certain living plant organs, we will publish the results of two series of experiments, one on a 10 per cent. solution of lecithin in m-kresol and the other on the leaf of *Ficus elasticus*. In both experiments the E.M.F. at the junction of these bodies and aqueous solutions of various concentrations was measured.

The differences observed for the same degree of dilution are almost identical in both cases and the drop in potential, if we substitute *m*/10 HCl for *m*/10 KCl, corresponds for a 10 per cent. lecithin solution to the change observed in the case of the intact apple or leaf of *Ficus elasticus* under the same condition.

We obtained similar effects with chemically pure kephalin which Dr. Levene was kind enough to give us, and with triolein, oleic, stearic and palmitic acids dissolved in guaiacol or kresol. The kresol and the guaicol without these lipoids gave concentration effects of a much smaller order of magnitude. Cholesterin gave no concentration effects.

We then made experiments with extracts of the apple in guaiacol and this extract gave the same results as the apple itself.

We may therefore conclude that the concentration effects on the E.M.F. observed in certain plant organs are due to the fact that these organs possess a surface consisting of a phosphatide or some fatty substance. It would be wrong to conclude that the same is true for the surfaces of all cells or organs. In a number of organs, *e. g.*, the striped muscle, the concentration effects are extremly small and it requires further experiments to explain their electromotive behavior.

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METEOR DUST AS A MEASURE OF GEOLOGIC TIME

SOME years ago[1] I suggested a possible method of measuring the rate of formation of strata, and so of geologic time, by the proportion of meteor dust contained in the strata, which method seems, now, to be really practical. Meteorites are continually striking the earth. According to the Britannica, 20,000,000 visible meteorites strike the earth each day and the telescope might reveal twenty times as many. I then assumed that they weighed a gram and were 10 per cent. nickel. This would mean 28.6 grams of nickel per square kilometer, per year. Professor W. H. Pickering has shown reason to believe that the visible meteorites are 15 to 18 cm., or, at any rate, 5 to 7 cm. in diameter,[2] and Farrington[3] finds for the average specific weight 7.8 and for the average per cent. of iron and nickel, in a large number of meteorites, 72.06 and 6.5, respectively. Assume that the invisible meteorites make up for any exaggeration in Pickering's largest figure and that we have 7,300,000,000 meteors, weighing 23,700 grams each, striking the earth in a year, and we would have 340,000 grams per square kilometer of cosmic material per annum, of which 20,000 grams are nickel.

The .001 to .0001 grams per square meter of partly cosmic dust found on a 30-millimeter layer of granular snow by A. E. Nordenskjold,[4] Lat. 80° N., Long. 15° E., might be a small part of the year's accumulation.

The redness of the residual red clay may be due to the cosmic dust slowly added in this slow process. This should also be a large part of the abysmal red clay of the great depths of the ocean. Of this red clay one square kilometer, one meter thick, would make 2,500,000 tons, if the specific gravity is 2.5. It contains, according to Clarke,[5] 0.0077 per cent. more of nickel than the average igneous rock. Assuming the nickel of the

[1] Annual report Michigan Geological Survey, 1901, p. 243.

[2] *Astrophysical Journal*, 1909, p. 378; 1910, p. 89.

[3] Field Museum of Nat. Hist., Pub. 151, pp. 213–14.

[4] *Poggendorff's Annalen*, Bd. 151 (1874), p. 158. See also "Studien und Forschungen veranlasst . . . Norden," von A. E. Nordenskjold, Leipzig, 1885. *Journal f. prakt. Chemie*, N. F., Bd. 9 (1874), pp. 356–67.

[5] Data of Geochemistry, U. S. G. S. Bulletin 330, pp. 490 and 27 (.0307 and .023).