reserve of 2 blue units per gram of liver. On the basis of the average daily weight and the total number of units of vitamin A given during the test period, it averages 114 U.S.P. units per 100 gm. of body weight per day.

Loss of appetite was one of the first signs of vitamin A depletion. Eye infections appeared in the animals given sub-minimum doses. A peculiar divergent strabismus was noted in several of the depleted animals which was definitely improved but not completely cured by the minimum amount of vitamin A that permitted resumption of growth. Ataxia was noted in one animal. Nervous running around the cage in circles appeared in some of the depleted animals. This was definitely reduced when sufficient vitamin A for growth was given. This was not cured by giving additional vitamin B complex in the form of brewers' yeast. Autopsy showed no evidence of otitis media or brain lesions. Skin lesions and corneal opacities appeared in a few of the animals. Dr. C. C. Higgins of The Cleveland Clinic autopsied one of the animals that had been depleted and then given a curative dose sufficient to produce a growth response. A calculus was found composed of calcium and magnesium phosphate with traces of calcium-carbonate and no oxalates or urates.

8339 C

An Attempt to Formulate a Quantitative Theory of Membrane Permeability.

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The fundamental theories of electrolyte diffusion (Nernst,[1] Planck[2]) take into account the electrostatic forces that coöperate with the "osmotic" forces to cause the migration of ions. In these theories, however, no assumption has to be made as to the origin of the charge on the particles in the solution. Accordingly, we may expect that their predictions regarding ionic diffusion may be extended to include other cases of diffusion, where other charged elements are present, regardless of the constitution, shape, etc., of these elements.

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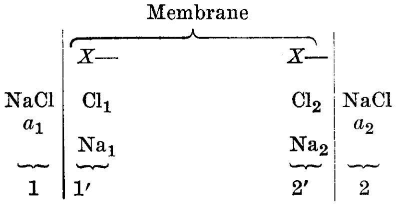
[1] Nernst, W., *Z. physiol. Chem.*, 1888, **2**, 617; 1889, **4**, 154.

[2] Planck, M., *Wied. Ann.*, 1890, **40**, 561.

Diffusion of an electrolyte through a membrane may be such a case. The membrane may be regarded as having a charge due either to "adsorption," "dissociation," or "polar character," etc., but it is not necessary to make any further assumptions as to its nature. The effect of the membrane is regarded as that of an "added ion."

In order to demonstrate the usefulness of treating permeability problems as cases of simple diffusion we shall—for the sake of clarity, in a highly simplified way—try to show that the so-called "concentration effect" when NaCl diffuses across a "negative" membrane is theoretically predictable:



From one side of the membrane, NaCl, having the activity a_1, diffuses to the other side where the activity is a_2. The membrane may be represented as consisting of negative, immobile ions of the activity X, which is assumed to be constant throughout the membrane. In the steady state the ionic activities in the membrane surface layers may be Na_1, Cl_1 and Na_2, Cl_2. For electroneutrality it may be assumed that $Na_1 = (Cl_1 + X)$ and $Na_2 = (Cl_2 + X)$. Although the concentration of Na in the membrane differs from that of Cl the flux will be equal because the forces ("osmotic" plus electrical) operating on them are not equal. If the diffusion from 1′ to 2′ is sufficiently slow, the ionic distribution across 1-1′ and 2-2′ respectively approaches a thermodynamic equilibrium and we may write as an approximation

$$a_1^{-2} = Na_1 \cdot Cl_1 = Na_1 \cdot (Na_1 - X) \tag{1}$$

and

$$a_2^{-2} = Na_2 \cdot (Na_2 - X) \tag{2}$$

Evidently there are 2 "boundary" potentials present here between 1-1′ and 2-2′, which sum up to

$$\text{Total boundary potentials} = 58 \log \left[(a_1 \cdot Na_2) \div (a_2 \cdot Na_1) \right] \tag{3}$$

Besides these we have a "diffusion" potential between 1′-2′. As X is constant along the distance in the diffusion layer, the "concentration" gradient of Cl also is linear, because, as shown by Planck, the *total* concentration (Na) must always fall off linearly. Under such conditions the 1′-2′ potential can be most simply expressed by Henderson's formula,[3] which here reduces to

$$\text{Diffusion potential} = [(u - v) \div (u + v)] \cdot 58 \log [\text{Na}_1(u + v) - X \cdot v] \div [\text{Na}_2(u + v) - X \cdot v] \quad (4)$$

u and v are the constant "mobilities" (inverse friction coefficients) of Na and Cl. The total E.M.F. of the membrane is the sum of equations 3 and 4:

$$\text{Total E.M.F.} = 58 \left[\log \frac{a_1 \cdot \text{Na}_2}{a_2 \cdot \text{Na}_1} + \frac{u - v}{u + v} \log \frac{\text{Na}_1 (u + v) - X \cdot v}{\text{Na}_2 (u + v) - X \cdot v} \right] \quad (5)$$

For calculations, Na_1 and Na_2 have to be expressed in terms of a_1 or a_2 and X, which is possible by means of equations 1 and 2.

If $X > 0$, it is found that the total E.M.F. is bound to vary with the absolute activities a_1 and a_2, even if the ratio $a_1 \div a_2$ is kept constant. This circumstance, however, is just what has been experimentally observed in a great many cases and has been called "concentration effect" (*cf.* Beutner,[4] Michaelis,[5] Osterhout[6]). Table I shows the numerical results of calculations according to equation 5 for this particular case.

TABLE I.

X or membrane "activity" = 1. Membrane negative. Mobility relation $u : v$ in the membrane the same as in water. (Signs refer to the dilute solution in the external circuit.)

a_1	a_2	Partial E.M.F. Boundary mv.	Partial E.M.F. Diffusion mv.	Total E.M.F. mv.
100	10	+ 1.1	—13.2	**—12.1**
10	1	+10.9	—12.1	**— 1.3**
5	0.5	+20.5	—12.0	**+ 8.5**
1	0.1	+46.2	— 5.4	**+41.8**

Using NaCl the sign of the total E.M.F. will depend upon the relation between X and the concentrations of the external solutions. In the comparable experiments of Beutner and of Michaelis, *et al.*, this relation seems to be such that only positive E.M.F. values are observed. These values, however, increase with decreasing con-

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[3] Henderson, P., *Z. physik. Chem.*, 1907, **59**, 118.

[4] Beutner, R., Physical Chemistry of Living Tissues and Life Processes, Baltimore, Williams and Wilkins Co., 1933.

[5] Michaelis, L., *Kolloid-Z.*, 1933, **62**, 1. Michaelis, L., Ellsworth, R. McL., and Weech, A. A., *J. Gen. Physiol.*, 1926-27, **10**, 671.

[6] Osterhout, W. J. V., and Harris, E. S., *J. Gen. Physiol.*, 1928-29, **12**, 761.

centration, as predicted by the present theory, and the limit + 58 mv. is approached according to both experiments and calculations.

Further discussions of this and other permeability problems, regarded as cases of "forced" diffusion, will, it is hoped, be presented in other communications.

8340 C

Apricot Seeds as a Source of Dehydrogenases.

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Increasing interest in various aspects of the mechanism of biological oxidation has developed a need for rich and reliable sources of dehydrogenases. An attempt was made to find such sources in appropriate plant material because of the possibility that such material might have an advantage in cheapness and in ease of handling. With the exception of yeasts, plants do not seem to have been much explored for dehydrogenases. Three samples of yeast from different manufacturers were found to be relatively poor sources for dehydrogenases, and samples from the same source varied greatly in such enzyme activity.

Preliminary search through representative available plant sources indicated the relative richness in dehydrogenases of the coatings of the seeds of various species of *Prunus*. With the skins removed, the seeds contain almost no dehydrogenases but are rich in lipases and emulsin. Such vegetables as beets and potatoes seem to be poor sources of dehydrogenases. Seeds of legumes and cereals are reported to be good sources of lactic dehydrogenase.[1] Representative assay data on dehydrogenase content are shown in Fig. 1 for extracts from beets, potatoes, yeast and seed coatings of almond, cherry, peach and apricot. Of these materials apricot seed coatings appear to be richest in dehydrogenases.

In extracting the dehydrogenases from fruit seeds, the seeds were first soaked for 24 hours in cold water to each liter of which one-half cc. of toluene was added. The skins were removed and extracted in a ball mill with disodium phosphate containing toluene, for 6 hours. To one liter of phosphate, 100 gm. of wet seed skins

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[1] Anderson, B., *Z. Physiol. Chem.*, 1932, **210**, 15.