A MODEL OF THE POTASSIUM EFFECT

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The protoplasm of certain cells has to a marked degree the power to distinguish electrically between Na\(^+\) and K\(^+\). This ability has been called the "potassium effect."

It is clearly seen when we replace\(^1\) 0.01 m KCl in contact with a Nitella cell by 0.01 m NaCl. We then observe a change of P.D. in a positive direction by an amount which varies from 30 to 95 mv.\(^2\)

We find a pronounced potassium effect in Valonia\(^3\) and in Halicystis.\(^5\) Such an effect has long been known in muscle\(^6\) and is also found in nerve.\(^7\)

The potassium effect can be removed from Nitella by leaching in distilled water and thus removing a substance which for convenience has been called R. This substance can be recovered from the water and applied to the cell and this restores\(^8\) its ability to distinguish electrically between K\(^+\) and Na\(^+\). To do this we remove the water from the cells and shake it with petroleum ether which is then drawn off and evaporated to dryness: the residue is then taken up in a relatively small quantity of distilled water which is applied to the cell. The potassium effect is promptly restored.

It would therefore appear that the Nitella cell contains a substance which is soluble in petroleum ether and which is responsible for the potassium effect.

A variety of organic substances has been investigated with a view to making a model of the potassium effect. The most interesting thus far encountered is nitrobenzene. When this is shaken with m/1 KCl and allowed to stand in

\(^1\) Replacing 0.01 m NaCl by 0.01 m KCl may produce an action current and thus make the interpretation more difficult.

\(^2\) I.e., the spot in contact with 0.01 m NaCl becomes positive (in the external circuit) to a spot in contact with 0.01 m KCl.


contact with it we find that replacement of m/1 KCl at any spot by m/1 NaCl causes a change of potential in a positive direction (as in Nitella)\(^9\) amounting to about 67 mv. This compares favorably with the values found for Nitella and is higher than that of 49 mv. reported by Beutner\(^9\) for m-nitrobenzene dissolved in nitrobenzene.

When nitrobenzene, previously shaken with m/1 aqueous KCl, is placed in contact with aqueous m/1 KCl on one side and with aqueous m/1 NaCl on the other we may assume that the situation resembles that shown in Scheme 1. Here B' and C' are very thin layers on each side of the phase boundary and the customary assumption is made that they at once come into approximate equilibrium with each other. This involves a movement of KCl from B" to C' and a movement of NaCl from C' to B".

**Aqueous**

<table>
<thead>
<tr>
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<th>Non-aqueous</th>
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<tbody>
<tr>
<td>A</td>
<td>A'</td>
<td>B'</td>
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<tr>
<td>KCl</td>
<td>KCl</td>
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<tr>
<td>m/1</td>
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<tr>
<td>P1</td>
<td>P2</td>
<td>P3</td>
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**Scheme 1**

At the other phase boundary the corresponding layers A' and B' are in equilibrium from the start: the concentration of KCl in B' is probably less than m/10\(^6\) but as it is not definitely known it has been designated as m/X.

Evidently KCl will diffuse from B into C and NaCl will diffuse from C into B. Hence we may expect diffusion potentials at P2 and P4.

If C' contained m/1 KCl and no NaCl and the adjacent region of C contained m/1 NaCl and no KCl the potential might be computed from the formula\(^11\) (for 25°C.)

\[
P_4 = 59 \log \frac{\Lambda_{KCl}}{\Lambda_{NaCl}}
\]

in which \(\Lambda_{KCl}\) and \(\Lambda_{NaCl}\) are the equivalent conductivities of m/1 KCl and m/1 NaCl in aqueous solution. Lacking a satisfactory value for \(\Lambda_{KCl}\) +

\(^9\) The spot in contact with NaCl is positive in the external circuit to the spot in contact with KCl.


\[ \Delta_{\text{NaCl}} \text{ at } 25^\circ \text{C}, \text{ we may use the value at } 18^\circ \text{C, which must be almost the same.} \]

We then have

\[ P_4 = 59 \log \frac{98.08}{74.19} \]

\[ = 7.2 \text{ mv.} \]

Evidently the actual value is much less since \( C' \) must contain a good deal of NaCl.

We may say that \( P_1 + P_2 + P_3 + P_4 = 67 \text{ my.} \) and if \( P_4 \) is less than 7.2 mv. the value of \( P_1 + P_2 + P_3 \) must be more than 60 my, since the potential at \( P_4 \) makes NaCl more positive to KCl in the external circuit and thus has the same direction as the total potential of 67 mv.

\[
\begin{array}{cccccc}
\text{Aqueous} & & & \text{Non-aqueous} & & \text{Aqueous} \\
\text{A} & \text{A'} & \text{B} & \text{B'} & \text{C} & \text{C'} \\
\text{KCl} & \text{KCl} & \text{KCl} & \text{KCl} & \text{KCl} & \text{KCl} \\
\text{m/1} & \text{m/1} & \text{m/X} & \text{m/X} & \text{<m/X} & \text{>m/10} \text{ m/10} \\
\text{P}_1 & \text{P}_4 & \text{P}_4 & \text{P}_4 & \text{P}_4 \\
\end{array}
\]

\text{Scheme 2}

At \( P_2 \) we have a diffusion potential in the nitrobenzene whose value depends on the mobilities and activities of the ions involved. In order to get information regarding mobilities measurements were made of the concentration potentials.

For this purpose nitrobenzene was shaken with \( \text{m/1 KCl} \) and placed in contact with aqueous \( \text{m/1 KCl} \) on one side and with aqueous \( \text{m/10 KCl} \) on the other. We may assume that the situation is like that in Scheme 2. The observed p.d. is 25 ± 0.5 mv. (4 observations) with the dilute solution positive in the external circuit.

The maximum possible value of \( P_4 \) would occur if \( C' \) contained \( \text{m/1 KCl} \) and the adjacent region of \( C \) contained \( \text{m/10 KCl} \). We should then have

\[ P_4 = 59 (2\log a + 1) \log \frac{a_1}{a_1} \]

\[ = 25 \text{ mv.} \]

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\[ \text{For this purpose nitrobenzene was shaken with m/1 KCl and placed in contact with aqueous m/1 KCl on one side and with aqueous m/10 KCl on the other. We may assume that the situation is like that in Scheme 2. The observed p.d. is 25 ± 0.5 mv. (4 observations) with the dilute solution positive in the external circuit.} \]

\[ \text{The maximum possible value of } P_4 \text{ would occur if } C' \text{ contained m/1 KCl and the adjacent region of } C \text{ contained m/10 KCl. We should then have at } 25^\circ \text{C.} \]

\[ P_4 = 59 (2\log a + 1) \log \frac{a_1}{a_1} \]

\[ = 25 \text{ mv.} \]
where \( t_K \) is the transference number of \( K^+ \) and \( a_1 \) and \( a_2 \) are the mean ionic activities of the two solutions of KCl. The average transference number\(^{16} \) of KCl at 25°C. between \( \mu/1 \) and \( \mu/10 \) is 0.4885. Inserting this value and putting for convenience activities equal to concentrations we have

\[
P_4 = 59(2[0.4885] - 1) \log \frac{1.0}{0.1}
\]

\[= -1.4 \text{ mv.}\]

This would tend to make the total potential less and hence we might correct for it by adding 1.4 mv. but the value is undoubtedly less than 1.4 mv. and it may well be neglected.

In experiments with guaiacol it has been found\(^{17} \) that the value of the phase boundary potentials \( P_1 + P_3 \) could be neglected. If, for purposes of calculation, we assume that this is the case here we may say that \( P_2 \) equals 25 mv. We then have\(^{17} \) for 25°C.

\[
P_4 = 25 = 59 \frac{\mu_K - \mu_{Cl}}{\mu_K + \mu_{Cl}} \log \frac{a_1}{a_2}
\]

where \( \mu_K \) is the mobility of \( K^+ \) and \( \mu_{Cl} \) that of \( Cl^- \) in nitrobenzene, and \( a_1 \) and \( a_2 \) are the mean ionic activities corresponding to the two concentrations of KCl in nitrobenzene. In view of results previously obtained with guaiacol\(^{17} \) we may assume that \( a_1 + a_2 = 1.0 + 0.1 \); i.e., is equal to the ratio of the aqueous concentrations.

For convenience we may put the mobility of \( Cl^- \) equal to unity and designate it as \( \overline{\mu}_{Cl} \) and the corresponding value of \( K^+ \) as \( \overline{\mu}_K \). We then have

\[
P_4 = 25 = 59 \frac{\overline{\mu}_K - 1}{\overline{\mu}_K + 1} \log \frac{1.0}{0.1}
\]

whence \( \overline{\mu}_K = 2.5 \). This means that in nitrobenzene \( \mu_K : \mu_{Cl} = 2.5 \).

Proceeding in the same way with NaCl we shake nitrobenzene with \( \mu/1 \) NaCl and place it in contact with \( \mu/1 \) NaCl on one side and with \( \mu/10 \) NaCl on the other and obtain 31 ± 1.5 mv. (4 observations) with the dilute solution positive in the external circuit. In this case we may expect a larger value at \( P_4 \). The maximum possible value would occur if \( C' \) contained \( \mu/1 \) NaCl and the adjacent region of \( C \) contained \( \mu/10 \) NaCl. In that case we should have\(^{18} \) (putting for convenience activities equal to concentrations)

\[
P_4 = 59(2[0.379] - 1) \log \frac{1.0}{0.1}
\]

\[= 59(2[0.379] - 1)
\]

\[= -14.3 \text{ mv.} \]


\(^{17}\) Osterhout, W. J. V., \textit{J. Gen. Physiol.}, 1942-43, \textbf{26}, 293.

\(^{18}\) The value of \( t_{Na} = 0.379 \) is the average of \( t_{Na} \) at \( \mu/10 = 0.385 \) (MacInnes,\(^{11} \) p. 85) and \( t_{Na} \) at \( \mu/1 = 0.373 \) (MacInnes, personal communication).
Here $t_{Na}$ is the average transference number of Na$^+$. This value of $P_4$ is undoubtedly much larger than the actual value since the concentration in C' would fall off rapidly because NaCl would diffuse away from C' faster than it diffused into it. The diffusion in the nitrobenzene is relatively slow both because of the very low concentration gradient and the higher viscosity.

This potential would be in the opposite sense to that in the nitrobenzene, i.e., it would tend to make the dilute solution negative since in aqueous solutions $u_{Na}$ is less than $u_{Cl}$, and if a correction were made it would involve an addition to the observed value of 31 mv.

These results appear to indicate that in nitrobenzene $u_{Na}$ may be somewhat greater than $u_{K}$. Hence the fact that KCl is negative to NaCl in the external circuit cannot be due to the difference in ionic mobilities for this would make KCl positive. But it would seem that this result should be accepted with reserve in view of the fact that in guaiacol, where the situation appears to be quite clear, $u_{K}$ is greater than $u_{Na}$ (but the opportunity of the ion to surround itself with water is greater in guaiacol since it contains much more water).

The observed result might be explained if the ionic activity of KCl in nitrobenzene were very much greater than that of NaCl. An attempt was accordingly made to ascertain the relative concentrations but the solubility of KCl and of NaCl in nitrobenzene is too small to admit of satisfactory determination.

Since the salicylates are more soluble in nitrobenzene some measurements were made with them. The partition coefficient $S$ (where $S$ = concentration of K$^+$ or Na$^+$ in nitrobenzene divided by that in the aqueous solution) is about 0.000012 for $1/10$ Na-salicylate and about 0.00014 for $1/10$ K-salicylate; i.e., the latter is about 11.7 times as great. This would not account for the potential.

In C' and C the maximum possible concentration gradient would occur if C' contained a little less than $1/10$ NaCl: in this case the concentration gradient in nitrobenzene would be nearly zero.

The viscosity of nitrobenzene is more than twice that of water. According to Landolt-Börnstein's Physikalisch-Chemische Tabellen, 1912, I, 132, $\eta$ for nitrobenzene at 25°C is 0.01834 and for water 0.00895 (p. 135). Cf. International Critical Tables, 1930, 7, 217 and 1929, 5, 10.

In the case of a Nitella cell treated first with 0.01 M NaCl and then with 0.001 M NaCl somewhat similar considerations may apply.

The value obtained in this case is usually about 25 mv. (Osterhout, W. J. V., J. Gen. Physiol., 1939-40, 23, 429) which does not differ much from that found with nitrobenzene. The value with Nitella for 0.01 M NaCl ranges from 25 mv. (Osterhout, W. J. V., J. Gen. Physiol., 1939-40, 23, 429) to about 50 mv. (Osterhout, W. J. V., J. Gen. Physiol., 1929-30, 13, 715).

K-salicylate and Na-salicylate act much like KCl and NaCl with Nitella.

These values are for K$^+$ and Na$^+$: the values for total salicylate are higher since salicylic acid is taken up in addition to K-salicylate and Na-salicylate.

This is evident when we employ Henderson's equation. Cf. Osterhout, W. J. V., and Hill, S. E., J. Gen. Physiol., 1938-39, 22, 139.
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tential of m/1 K-salicylate vs. m/1 Na-salicylate with nitrobenzene, which is 56 ± 3 mv. (6 observations) even if we regard $u_{Na}$ and $u_{K}$ as equal.

It would take a much greater difference in partition coefficients to account for the 67 mv. found for m/1 KCl vs. m/1 NaCl. The actual value of the partition coefficient is not known but it was found that the conductivity of nitrobenzene when shaken with m/1 KCl is much higher than when shaken with m/1 NaCl. The interpretation is complicated by the possibility that the amount of water taken up may not be equal in both cases.

It may be asked whether KCl in nitrobenzene produces proportionally more ions than NaCl, possibly by the formation of complex ions of the type $(KX)_{1}^{+}$, $(KX)_{11}^{+}$, etc. Such ions have been postulated in certain cases by Fuoss and by Kraus. To account for the observed value of 67 mv. by the formation of simple ions the dissociation constant of KCl in nitrobenzene would have to be much greater than that of NaCl.

To what extent phase boundary potentials may enter into the observed values cannot be determined at present.

An interesting parallel between the model and Nitella is seen in the effect of guaiacol. In the model when nitrobenzene is replaced by guaiacol (arranged as in Scheme 1, page 92) the potassium effect is only 16 mv. It is therefore not surprising that an admixture of guaiacol with nitrobenzene in the model causes the potassium effect to fall off markedly. The application of guaiacol to Nitella and to Valonia also causes a falling off in the potassium effect.

There is still another resemblance between Nitella and the model. If in Scheme 1 we substitute various chlorides in the model we find that the mobilities fall off in the following order

$$Cs > Rb > K > Na > Li$$

As with the chloride, K$^+$ is negative in the external circuit to Na$^+$.

The concentration effect of K-salicylate and Na-salicylate with nitrobenzene (m/1 vs. m/10 in each case) is about 13 mv. (set up as in Scheme 2). The interpretation is rendered doubtful because we do not know the value of $P_4$ and because the total salicylate taken up by the nitrobenzene is more than twice as great as the amount of K-salicylate or Na-salicylate.

The taking up of water increases the conductivity though to a much less extent than in guaiacol (regarding guaiacol see Shedlovsky, T., and Uhlig, H. H., J. Gen. Physiol., 1933–34, 17, 549).

The dissociation in nitrobenzene is evidently less than in water since the dielectric constant of nitrobenzene at 20°C is 36.1 (International Critical Tables, 1929, 6, 92).


CsCl is more negative to KCl than it is to RbCl and KCl is less negative to NaCl than it is to LiCl. The values cannot be accounted for by the potentials in the aqueous solutions.
This is the order of mobilities in water. The same order is found in Nitella except that Rb and K are equal and Cs comes at the bottom of the list instead of at the top; a somewhat similar behavior of Cs is not unusual in living cells. NH₄ comes between K and Na, as in Nitella. (In water it comes between Rb and K.)

In comparing the model with Nitella we must bear in mind that the changes of potential due to the application of salt solutions are very rapid and therefore affect only the outer non-aqueous surface layer of the protoplasm. We suppose that when this layer is allowed to stand for a short time in contact with KCl it comes into equilibrium with it since it is less than a micron in thickness. Hence the effect is much the same as when the layer of nitrobenzene is shaken with KCl. When KCl in contact with Nitella is replaced by NaCl we suppose that the changes which occur in this layer are similar to those discussed in connection with Scheme 1 (page 92).

Methods

Nitrobenzene (Eastman Kodak Company No. 387) was shaken with 5 per cent NaOH solution and washed with distilled water. Then followed washings with 5 per cent H₂SO₄ and finally several washings with distilled water. The sample was then carefully distilled and the fraction coming over at 208.5°C. (757 mm. of Hg) was collected. It had a very pale amber color.

In preparing the equilibrium mixtures for the concentration effect of KCl about 500 cc. of molar KCl solution were shaken with 25 cc. of nitrobenzene on a shaking machine for 3 hours. A like volume of 1/10 KCl solution was shaken with a few cubic centimeters of nitrobenzene at the same time to insure saturation with nitrobenzene.

The solutions were shaken at a temperature of 25 ±1°C. and kept at this temperature overnight. The nitrobenzene was then drawn off, filtered through glass wool and then through a high grade of filter paper to remove droplets of the aqueous solution. It was then ready for use.

A similar procedure was used in studying the concentration effect of NaCl. In studying the chemical effect (molar KCl vs. molar NaCl) the nitrobenzene was shaken with the molar KCl solution.

A similar procedure was followed with the salicylates. The salicylate stock solutions were prepared only as needed and were protected from direct light. The salicylates used were supplied by the Monsanto Chemical Company and Merck and Company. There was no great difference in the values obtained with the two samples nor with samples which were purified by recrystallization three times from ethyl alcohol.

Measurements of potential were made in a variety of ways including (a) U-tubes

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with nitrobenzene at the bottom and aqueous solutions above, and (b) curved Pyrex tubes closed at the ends by fusing on porous fritted disks of Pyrex glass; these tubes were filled with aqueous solutions and placed in beakers filled with nitrobenzene so that the porous glass disks were parallel in a vertical position and only a few millimeters apart, thus reducing the resistance.

The most reproducible results were obtained by using glass tubes with open ends dipping in nitrobenzene as described in a previous paper. In each tube was a stopcock which was kept closed during the measurements in order to keep the aqueous solution in place. These tubes were connected by means of calomel electrodes to a Compton electrometer. All the results reported here were obtained in this way.

The aqueous solutions were saturated with nitrobenzene in all cases (and contained guaiacol when this was added to the nitrobenzene).

The calomel electrodes were made up with 3.5 M KCl and a very pure electrolytic calomel. They were tested for asymmetry potential before each experiment. If the asymmetry potential was more than 0.5 mv. the pair was not used. In most cases no asymmetry potential was detectable.

All measurements were made with the Compton electrometer (Cambridge Instrument Co.) used as a null instrument and a potentiometer (Leeds and Northrup student type). The standard cell used for the reference E.M.F. and calibration was a Weston Model 4 standard cell. This cell was checked at 25°C. against a precision laboratory standard cell. The voltage was 1.01833 volts. The working battery consisted of storage cells in series. The potentiometer was checked against the standard cell at the start and at the finish of each set of experiments.

The electrometer switch was a rebuilt Leeds and Northrup single pole-double throw switching. The metal contact arms were removed and mounted on a thick piece of clear Bakelite and mounted by stand-off insulators on another piece of Bakelite. The switch handle was replaced by a 6-inch length of lucite rod. In this manner surface leakage was reduced to a minimum and erratic movements of the electrometer were eliminated. The switch, potentiometer, and rheostat were all mounted in a shielded box and worked from without by means of extension controls. The cables to the cells and electrometer were Belden crystal microphone shielded cable, the shield being grounded at several points wherever it was more than 4 feet in length. All cables were grounded at both ends. The insulation resistance of this wire was checked on the General Radio Type 544-B megohm bridge and gave a resistance of “infinity” measured from the inner conductor to a point on the outer insulation.

The cells were set up in a grounded metal cabinet maintained by a thermometer relay at 25 ±0.1°C, although experiments in which the temperature was allowed to change as much as 5°C. showed no marked degree of change in E.M.F. due to thermal change. The conductivity measurements were made at the same temperature.

If a cell behaved erratically, its resistance was checked on the General Radio megohm bridge. In practically all cases of erratic behavior, the cell showed a resistance of the order of 300 or 400 megohms or higher. The cause was usually poor

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36 No stopcock grease was employed. It may be noted that stopcocks in nitrobenzene should be avoided.
contact around the stopcock junction. (A check of the potential across the stopcocks using a symmetrical chloride cell, \( \text{m/1 NaCl vs. m/1 NaCl} \), showed the potential to be negligible.)

The average resistance for the chloride cells was about 20 megohms; for the salicylates about 800,000 ohms.

If the measurement of potential changed more than 5 millivolts in the course of an hour the measurement was rejected.

In determining the distribution of sodium and potassium salicylates between water and nitrobenzene the following reagents were employed.

Potassium salicylate (Eimer and Amend, "pure"); recrystallized from ethanol, washed with ether, and dried at room temperature under reduced pressure.

Sodium salicylate (Merck's reagent grade).

HCl 0.1 M; prepared from redistilled c.p. acid.

The solutions were shaken for about 3 hours in a mechanical shaker, at 25°C., allowed to stand overnight, separated, and the nitrobenzene layer filtered through washed and dried Pyrex glass wool.

Determination of Na and K.—Since the chlorides are much less soluble than the salicylates in nitrobenzene the cation in the nitrobenzene phase was extracted by shaking with 0.1 M HCl. The aqueous extract was evaporated to dryness in a platinum dish, dried overnight at 110°C. to drive off salicylic acid and excess HCl. The dried residue was dissolved in a small volume of water and any excess acid was determined by titration with dilute alkali; then the chloride was determined by potentiometric titration, using AgNO₃. The cation concentration was assumed to be equal to the corrected chloride concentration. A check determination was made by evaporating the aqueous extract, drying at 110°C., igniting at about 400°C., and weighing the residue on a micro balance.

The cation in the aqueous phase was determined by conversion of the salicylate to the chloride and weighing.

Salicylate was determined by means of the colored solution produced by the reaction between ferric ion and salicylic acid. To 10.0 ml. of the neutral salicylic solution was added 0.4 ml. of a solution containing 0.2 \( \times \text{Fe}_2(\text{SO}_4)_3 \) + 0.1 \( \times \text{H}_2\text{SO}_4 \) and the concentration determined by means of a photoelectric photometer with a filter having a maximum transmission at 5600 Å. The color intensity did not vary appreciably between 5 and 60 minutes from the time of mixing.

The salicylate in the nitrobenzene was determined after extraction with dilute NaOH (0.001 to 0.002 N).

The conductivity of the nitrobenzene was measured in a Wheatstone bridge with a conductivity cell, having electrodes of platinized platinum. Alternating current at 1000 cycles was employed.

All measurements were made at 25 ±0.1°C.

(Since the vapor of nitrobenzene is toxic good ventilation was provided so that the odor of nitrobenzene did not become noticeable.)

I wish to express my thanks to Mr. Donald J. DeCain and Mr. Harry Bodner for the care and skill with which they have made the measurements.
SUMMARY

The protoplasm of certain cells is able to distinguish electrically between K⁺ and Na⁺. This has been called the potassium effect.

This is illustrated by experiments with Nitella. When 0.01 M KCl which has stood in contact with Nitella is replaced by 0.01 M NaCl the p.d. changes in a positive direction by an amount which varies between 30 and 95 mv. This ability to distinguish between K⁺ and Na⁺ disappears with the removal of an organic substance from the cell. The amount of this substance is doubtless too small to make it possible to obtain enough for analysis. An attempt has therefore been made to find an organic compound which can produce similar effects.

It is found that when m/1 KCl in contact with nitrobenzene (previously shaken with m/1 KCl) is replaced by m/1 NaCl the potential changes in a positive direction to the extent of 67 mv. which compares favorably with the values found in Nitella.

This is not due to a greater mobility in nitrobenzene of K⁺ as compared with Na⁺: this is evident from measurements of concentration effects with nitrobenzene (m/1 KCl vs. m/10 KCl and m/1 NaCl vs. m/10 NaCl). It might be brought about if KCl produced in nitrobenzene a sufficient preponderance of ions (simple or complex) as compared with NaCl. Whether this occurs could not be determined but it was found that nitrobenzene shaken with m/1 KCl has a higher conductivity than when shaken with m/1 NaCl.

Measurements with salicylates showed that K-salicylate has a partition coefficient about 11.7 times as great as that of Na-salicylate. It was also found that when m/1 K-salicylate in contact with nitrobenzene (previously shaken with m/1 K-salicylate) is replaced by m/1 Na-salicylate there is a change of potential in a positive direction amounting to 56 mv.

To what extent phase boundary potentials may enter into the observed values cannot be determined at present.

The model resembles the Nitella cell in that RbCl and KCl are negative to NH₄Cl which in turn is negative to NaCl and still more so to LiCl (in the model CsCl is negative to KCl but in Nitella it is positive).

It likewise resembles Nitella in that the potassium effect is lessened by the addition of guaiacol.