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STUDIES ON OXIDATION-REDUCTION.

V. ELECTRODE POTENTIALS OF SIMPLE INDOPHENOLS, EACH IN EQUILIBRIUM WITH ITS REDUCTION PRODUCT.

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Introduction.

Our interest in dyes of the indophenol series is multifold. After Ehrlich (1885) introduced them to biochemistry they became favorite reagents in the investigation of biochemical oxidation-reduction; but they were often used without a clear distinction between conditions which control their synthesis in the cell and the conditions which determine whether they shall remain oxidized or reduced. In this series of papers we are trying to make plain only the conditions which determine equilibria between an oxidant and its reductant. The data on 1-naphthol-2-sulphonate indophenol, described in the third paper, show in terms of electrode potentials and pH the intensity factors governing the ratio of total oxidant to total reductant. Although the numerical values will differ with different indophenols, the principles revealed should be significant to those who have hitherto had to deal with the conduct of the cell toward indophenols without any quantitative exposition of equilibrium conditions.

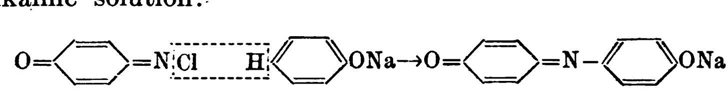
We have already shown that 1-naphthol-2-sulphonate indophenol in equilibrium with its reduction product gives much more electropositive equilibrium potentials than those of the systems described by Clark (1920). This suggests that a physiologically important zone of comparatively positive oxidation-reduction intensity can be covered by a series of oxidation-reduction indicators of indophenol structure. To proceed logically in the synthesis of such a series we need information upon the effects of substitution. In itself, a knowledge of these effects should be of considerable value to the better understanding of the forces with which we are dealing. Incidentally, the pursuit of accurate data in pH regions of no physiological importance with the sole purpose of satisfying the demands of the theoretical equations outlined in the second paper has revealed data bearing upon the essential feature of the oxidation-reduction process; and the conclusions drawn will, we believe, necessitate a broader outlook upon biological reduction than that current in the literature.

We shall confine this paper to the more complete data on a series of simple indophenols and shall describe in a subsequent paper incomplete data on a variety of substitution products.

Preparation of Indophenols.

Since some of the indophenols we have prepared are new and therefore require detailed description, and since the preparation of certain of the compounds revealed peculiarities which demand further study, it has seemed best to postpone to a separate paper these aspects of our studies. After over two years of labor we are still uncertain regarding inorganic impurities present and therefore doubt the suitability of some of the preparations for elementary analysis; but we have assured ourselves that the impurities present are of minor significance for the oxidation-reduction studies here reported, and we are confident of the essential reproducibility, both of the preparations used and of the electrometric data. There seems to be, therefore, no good reason to withhold longer the electrometric data, provided the reader will keep in mind the reservations we imply.

The preliminary measurements reported by Cohen and Clark (1921) were made with compounds prepared by Heller's (1912) method—the condensation of p-amino phenol and a phenol with sodium hypochlorite at low temperature. We found the method unsatisfactory for definite reasons which will be detailed later. We then had recourse to the method of Hirsch (1880), which consists in the reaction between quinone chloroimide and sodium phenolate in alkaline solution:



The resulting sodium salt of the indophenol was salted out with sodium chloride, redissolved and resalted, dried, taken up in a minimal amount of absolute ethanol, and precipitated with anhydrous ethyl ether. This will be called procedure 1. In some instances the free acids were prepared by precipitating them with acids from solutions of the sodium salts purified by procedure 1. Such preparations will be said to have been made by procedure 2. Again the leuco-compounds were prepared by reducing solutions of the sodium salts with potassium sulphide and recrystallizing from acid solutions protected by hydrogen sulphide against oxidation. This will be called procedure 3.

The following is a condensed summary of the sources of the preparations used in determining the electrometric data:

Phenol indophenol from quinone chloroimide and phenol:
- Sample (O) by procedure 1.
- Sample (G) by procedure 3.

o-Cresol indophenol from quinone chloroimide and o-cresol:
- Sample (D) by procedure 1.
- Sample (E) by procedure 2.
- Sample (G) by procedure 3.

m-Cresol indophenol from quinone chloroimide and m-cresol:
- Sample (C) by procedure 1.
- Sample (E) by procedure 2.

Thymol indophenol from quinone chloroimide and thymol:
- Sample (G) by procedure 2.

Carvacrol indophenol from quinone chloroimide and carvacrol:
- Sample (C) by procedure 2.

o-Bromo phenol indophenol from quinone chloroimide and o-bromo phenol:
- Sample (A) by procedure 1.

m-Bromo phenol indophenol from quinone chloroimide and m-bromo phenol:
- Sample (A) by procedure 1.

o-Chloro phenol indophenol from quinone chloroimide and o-chloro phenol:
- Sample (D) by procedure 1.

Hydrogen Electrode Measurements.

To save space, the compositions of the buffer solutions used are given in Table I and will be referred to subsequently by number. In subsequent tables solution numbers containing ½ refer to buffers made by mixing equal volumes of solutions having adjacent numbers. Thus solution No. 21½ was prepared by mixing equal volumes of solution No. 21 and solution No. 22.

Since the desired accuracy of pH measurement was higher than could be guaranteed by ordinary reproduction of solutions, hydrogen electrode measurements were made in each case and within a reasonable period before or after the use of the buffer solutions in the oxidation-reduction measurements. In general, these hydrogen electrode measurements, made with the apparatus described by Clark (1922, fig. 19), were reproducible to within 0.1 millivolt. As in the oxidation-reduction measurements, the liquid junctions were made with saturated potassium chloride solution, and liquid junction potential differences were neglected. The standard potential difference was that of a hydrogen electrode under one atmosphere hydrogen in M/20 acid potassium phthalate solution. To this was assigned the value −0.2386 at 30° C. (*cf.* Clark, 1922).

Oxidation-Reduction Electrode Measurements.

The measurements of electrode potential differences were made with the equipment described in previous articles of this series. No essential modification was made, except the complete elimination of rubber tubing from the nitrogen system.

All measurements were made at 30° C.

The data briefly reported in a preliminary paper by Cohen and Clark (1921) were obtained by the titanium reduction method (*cf.* Clark, 1920 and the 3d paper of this series). Because of difficulties in estimating the pH values of the complex solutions used and in estimating pH changes during titration, these data were too inaccurate for certain purposes which will presently be revealed. Furthermore, we were dissatisfied with the organic preparations made according to Heller (1912) and used in this preliminary survey. Therefore, all these older data were rejected when comparison with the present series of measurements made it highly probable that discrepancies were due to experimental difficulties in the older methods.

In the description of measurements with 1-naphthol-2-sulphonate indophenol (3d paper, this series) we showed that the equation which is applicable at 30° C. is

$$E_h = E_o - 0.03006 \log \frac{[S_r]}{[S_o]} + 0.03006 \log [K_r K_2 [H^+] + K_r [H^+]^2 + [H^+]^3] - .03006 \log [K_o + [H^+]] \qquad (1)$$

Here, E_h is the observed electrode potential, E_o the electrode potential when $\frac{[S_r]}{[S_o]} = 1$ and $[H^+] = 1$ (K_r, K_2, and K_o being negligibly small at $[H^+] = 1$). $[S_r]$ is the concentration of total reductant. $[S_o]$ is the concentration of total oxidant, K_o is the acid dissociation constant of the oxidant, K_r is the acid dissociation constant of the hydrogen in the reductant to which K_o applies in the oxidant, K_2 is the acid dissociation constant of the phenolic group created by reduction, and $[H^+]$ is the hydrion concentration.

The symbol E'_o is used for E_h at any definite value of $[H^+]$ when $\frac{[S_r]}{[S_o]} = 1$.

We shall show that equation (1) applies to the indophenols now under consideration.

Since earlier papers of this series have described the general procedure in determining the constants of an equation such as (1), only the special features of the present investigation need be mentioned.

Acid solutions of the simple indophenols precipitate slowly and therefore are unsuited for measurement. This fact precluded titrations at values of $[H^+]$ sufficiently high to leave the dissociation constants of negligible magnitude. Consequently E_0 could not be determined directly as in other studies. E_0 was combined with the second term on the right of (1) at a definite value of $\frac{[S_r]}{[S_o]}$ to form a temporary constant, and $[H^+]$ was varied to furnish data for calculating the dissociation constants.

These constants are so close that the calculation must be approached by the method of trial values. In this, the graphic method is of aid only in the first approximations.

With K_o, K_r, and K_2 determined, the type curve can be plotted and then one or more determinations of E'_0 permit the calculation of E_0.

In the tables showing the relation of pH and potential we have reduced the potential data to E'_0 values. In some instances the agreement between calculated and observed values of E'_0 at different values of pH can be improved by altering the several constants a unit or two in the second decimal place; but as a matter of fact the apparent agreement is probably better in some instances than the experimental data permit. Within any one system of buffers there is a very decided shift in buffer power as we progress from the middle of the series to either end; and as we proceed from a solution of one pH to another the several acidic groups in the dye system are thrown in or out of play. Consequently, our hydrogen electrode measurements of the dye-free buffer solutions, accurate as they are and reproducible to 0.1 millivolt, can give but approximations of the true pH of the buffer-dye mixtures. The corrections are unknown, but probably amount to a millivolt in many instances.

Again in the present series we meet the drift in potential occurring immediately after adding the mixture of oxidant and reductant to the buffer. In a few instances it has been necessary to use the initial potentials, or those taken after a definite period, but in most instances we have used the so-called plateau values, values to which the potentials came gradually and at which they remained for periods varying from 30 to 60 minutes before a subsequent slower drift.

This troublesome drift and the acidity corrections will have to be understood before data such as we are presenting can define the several dissociation constants with high accuracy. From the point of view of estimating errors, it is best to state the constants in terms of pK values, pK being $\log \frac{1}{K}$. The pK values given are probably accurate to within one or two units in the first decimal place.

In all cases the concentration of dye in buffer solutions was of the order of 0.0006—0.001 molar.

In preparing a partially reduced solution for the measurements outlined above, reduction was accomplished by hydrogen and platinized asbestos. For a reason to be mentioned presently, this reduction was made slowly with weakly active, platinized asbestos (compare Paper III, footnote 3) and was seldom allowed to approach completion at the last stage of filtration. These precautions were suggested by an apparent slight destruction of reductant in experiments designed to provide a known concentration of reductant by complete reduction of oxidant. Because of this, it was considered unsafe to prepare known mixutres of oxidant and reductant by the method of mixtures used in previous studies where vigorous reduction was permissible. Titrations were therefore used exclusively for the determination of E'_0 values.

In titrating the oxidant a mild reducing agent, leuco indigo carmine, was used. The proper weight of indigo carmine (indigo disulphonate) was dissolved in a buffer solution which had been diluted to the concentration to be found in the solution of oxidant. It was reduced with hydrogen and platinized asbestos and then filtered into a protected reservoir with calibrated burette attached. The oxidant was dissolved in water and an aliquot added to a portion of the same buffer solution used for the reductant. This mixture of oxidant and buffer solution was deaerated in the electrode vessel and then titrated with the buffered leuco indigo carmine. Leuco indigo carmine is not an ideal reducing agent for the indophenols because the zone of its oxidation-reduction equilibria lies rather close the zone of the indophenols. There is a slight overlapping which causes difficulty in the precise estimation of end points. No better reagent, so easily handled from the point of view of acid-base equilibria, was found.

We have already mentioned the difficulties of preparing the sodium salts of the oxidants in pure state. But titrations indicated so clearly that the impurities are inert as oxidants or reductants within the zones of potential of the indophenols themselves that there seemed to be no objection to using the salts for the main measurements. The salts were preferred because they were easier to handle. Check measurements were made not only with the free indophenols, which are somewhat impure, but also with the free reduced substances, which in many cases can be prepared in a state of high purity. In operating with the reduced compounds a charge was weighed upon a glass spoon, and this was inserted in the electrode vessel out of contact with the buffer solution. Nitrogen was then run through the vessel, and when it was believed that all the oxygen was displaced, the spoon was lowered into the liquid. Ample time was allowed for solution and then the colorless solution of the reductant was titrated with buffered, potassium ferricyanide solution.

In previous papers we have described our method of estimating the change in pH which occurs in ferricyanide titrations by reason of the conversion of K_3FeCy_6 to the acid HK_3FeCy_6. In titrations with leuco indigo carmine no such correction is necessary, for the oxidant is supposed to have an inappreciable effecton acid-base equilibrium. The change occurring on reduction is cancelled on reoxidation.

In either case there is a troublesome change in pH, due to the fact that titrations had to be made in a region where both the indophenol and its reduction product are but partially dissociated and possess different dissociation constants. For instance, there is created in phenol indophenol an acidic group so little dissociated that its effect in solution No. 21 can be neglected; but the hydrogen to which K_o applies in the oxidant and K_r applies in the reductant becomes 66 per cent less dissociable when the system is reduced.

The effect is as if a *comparatively* strong acid were being removed from the buffer system, and it should become apparent in a change of the E'_0 values calculated for different stages of the reduction. Since subtraction of an acid component in small quantities produces an almost linear increase in the pH value of the buffer and consequently in the hypothetical hydrogen electrode potential, the change in E'_0 mentioned above should be almost linear with respect to added reductant.

Now in most of the cases we discover such a linear change, but the attempt to correct for it experimentally has been vitiated by the following facts:

In the first place it is difficult to determine with very great precision the end point when an indophenol is titrated with leuco indigo carmine. This is because the two systems, indophenol-leuco indophenol and indigo carmine-leuco indigo carmine overlap sufficiently to produce a noticeable *poising*[1] effect in the titration curve near the estimated end point. It is easy to misjudge the end point by one or even two per cent.

Let us then consider the case of o-chloro phenol indophenol (Table 21). It was judged that 100 per cent reduction came at an addition of 20.25 c.c. reduced indigo carmine. Were the true end point at 20.05 c.c., the end-point error of about 1 per cent would cause an apparent deviation of approximately 0.3 millivolt between 20 per cent and 70 per cent reduction. Because of experimental errors, the increments of deviation between these points might appear to lie on a straight line. But such a deviation of 0.3 millivolt between 20 per cent and 70 per cent reduction is 50 per cent of the deviation found in Table 21. It is therefore at once evident that precision in judging an end point is necessary before it can be said that a series of E'_0 values does not deviate because of such an error, and that the observed deviation is due entirely to the pH changes.

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[1] See Paper I. (Reprint No. 823, U. S. Public Health Service, p. 11.)

In the second place, control experiments in which the dye-free buffer solution is titrated with alkali in an attempt to find the magnitude of pH change, can give only an approximation of the change occurring in the dye-buffer mixture. We have estimated in the case of o-chloro phenol indophenol that an acidity change, corresponding to approximately 0.2 millivolt, should occur between 20 per cent and 70 per cent reduction because of the change of 34 per cent in the dissociation of the indophenol system. The actual effect may well be twice this and an added error of 0.5 per cent in judging the end-point would then account for the observed deviation of 0.6 millivolt.

Because of these uncertainties we have adopted a procedure which probably gives the proper correction in most cases. A *slight* error in end point gives a curve the *first* section of which is almost straight, and which if projected back to 0 per cent reduction will cut the E'_0 axis of an E'_0: per-cent-reduction diagram within 0.1 or 0.2 millivolt of the true E'_0 value. Any change in potential due to change in acidity will give apparent deviations of E'_0 which are almost linear with respect to percentage reduction. A straight line projected through such varying E'_0 values to zero percentage reduction will cut the E'_0 axis at the point where least change has occurred and where the pH is probably closest to that of the dye-free buffer mixture which is assumed to be that of the dye-buffer mixture.

Accordingly, we have plotted our calculated E'_0 values against percentage reduction, and, finding in most cases a linear variation, we have projected through the data a straight line as a "best curve." The E'_0 at which this line intersects the zero-percentage-reduction ordinate has been considered the true E'_0 With each increment of reduction the increment of E'_0 read along this straight line has been considered the correction to apply, and the corrected E'_0 values are given in those tables where the method seemed applicable. In some cases we have extended this method of correction to ferricyanide titrations.

These corrections are in the direction called for by theory; they are of the order of magnitude demanded by theory and by such control experiments as were made; but they lack experimental confirmation of their exactness. We wish to emphasize this last statement lest important facts be overlooked. In the following tables we shall designate by α those corrections determined by experimental control, and by β those corrections estimated by the procedure outlined above. In all cases the uncorrected E'_0 values are included for the use of those who feel that the β corrections are of uncertain justification.

Discussion.

Having four experimentally determined constants for each system, the components of which may be regarded as substitution products of the simplest indophenol, we have quantitative expressions of the effects of substitution. The constants are assembled in Table 23. For some purposes it is desirable to use pK values for dissociation constants, pK being defined as $\log \frac{1}{K}$. Such values are given in Table 24.

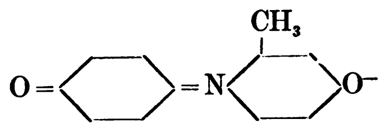
A rational interpretation meets three serious difficulties. The first is the absence of a rigid method for the allocation of the dissociation constants. The electrometric data simply reveal the constants. However, with a fair degree of certainty they may be allocated as follows: The value of one of the revealed constants agrees with colorimetric measurements of the "apparent" dissociation constant of the oxidant. It can easily be shown that although an acid-base indicator-constant is called "apparent" to signify that it may be a complex involving a hypothetical "true" acid dissociation constant and hypothetical tautomer equilibria constants, still it is "real" in the sense that it is the constant directly determined either by electrometric or colorimetric measurement of acid-base equilibria. The agreement between the so-called "apparent" dissociation constant of the oxidant and one of the constants determined by the electrometric data, is presumptive evidence for a definite allocation. Our K_o we shall, therefore, assume to be the acid dissociation constant of the oxidant. But this K_o would not be revealed in a pH:E'_o curve unless there were a change in value of the ionization constant when the dye becomes reduced. Then there appears evidence not only of K_o but of a second constant, K_r, which applies to that hydrogen in the reductant to which K_o applies in the oxidant. (See Paper II, this series, Reprint No. 826, page 12 and figure 8.) Among the indophenol systems we obtain just such a relation as was predicted for the case in which a dissociation constant is lowered by reduction at other points. It is therefore reasonable to allocate a second constant, K_r, as already suggested.

Beyond this, the argument becomes less certain but still probable. In a compound such as leuco indophenol (p,p–hydroxy–diphenylamine) it is highly probable that the first and second dissociation constants relate to the phenolic groups. The third detected constant has therefore been allocated to the second phenolic group of the reductant, the anion of which is created by the reduction process.

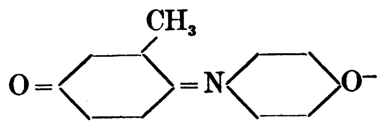
In the isolated reductant are three displaceable hydrogens. One of these is supposed to be attached to the nitrogen. If this does not dissociate within the region of pH studied, the curve of E'_0: pH will have a slope of $\frac{-dE'_0}{dpH} = 0.03$ in alkaline regions as was found.

It is possible that we are overlooking the basic nature of the nitrogen. However, the allocations of constants described above give a satisfactory account of facts so far known, and at this writing we have been unable to formulate an equation which will fit the data and at the same time allow the allocation of a detected constant to the nitrogen.

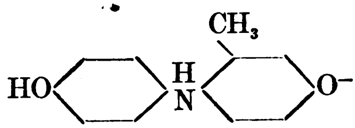
If these arguments be valid, they make the first difficulty in the interpretation of the data on substitution a minor one when considered by itself; but granted that we know what we mean by K_o, K_r, and K_2, there remains a second difficulty. Is, for instance, a substituted methyl group near to, as in I, or distant from, as in II, the ionizing hydrogen of the oxidant; and is it near the first or the second ionizing hydrogen in a reductant such as III or IV?



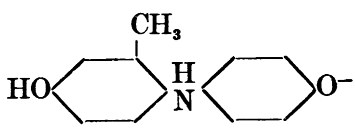
I



II



III



IV

Heller (1912) prepared sodium salts of compounds which, by the method of preparation, were presumably I and II, and stated that, while one may be inclined to call them tautomers, experiments on their splitting showed them to be isomers. He prepared one by condensing 6–amino–3–hydroxy–1–methyl benzene with phenol and the other by condensing m–cresol with p–amino phenol. We have prepared cresol indophenols in one case (C) by condensing quinone chloroimide with m–cresol, and in a second case (G–B) by condensing m–cresol quinone chloroimide with phenol. The sodium salts of the two preparations were titrated under the same conditions with leuco indigo carmine, giving the data in Tables 25 and 26. The uncorrected E'_0 values agree within the limits expected, and when corrected are identical. With the constants in Table 9 there is calculated $E'_0 = 0.1015$ for the pH value used as against $+0.1020$ found in Tables 25 and 26.

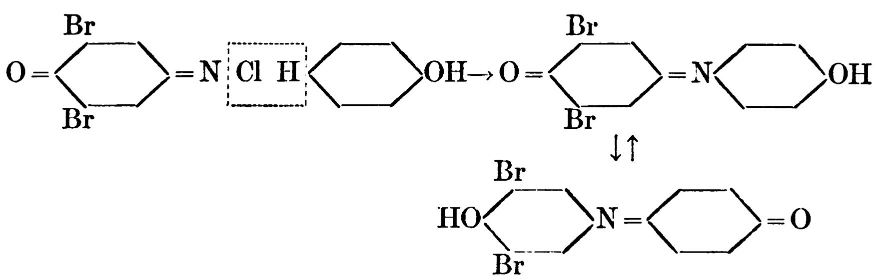
Colorimetric measurements by Salm's method gave the following values of pK_0:

	pK_0.
(C) Compound from quinone chloroimide and m-cresol	8. 52
(G–B) Compound from m-cresol quinone chloroimide and phenol	8. 47

The discrepancy is slightly more than the experimental error of differential precision but within the experimental error of accuracy. It may be due to colored impurities.

It is highly improbable that two systems having other and distinctly different constants should coincide as closely as (G–B) and (C) at the points selected for measurement; but it should be noted that substitution may have comparatively small effects upon the characteristics we are measuring, and the greatest caution will be necessary in drawing conclusions. With this in mind, we may tentatively conclude that I and II are tautomers.

A further suggestion (not proof) of tautomers among indophenols is the fact that condensation of 2–6 dibromo quinone chloroimide and phenol gives an indophenol, the K_0 value of which is comparatively very high, as would be expected if the bromine atoms were adjacent to a phenolic group. This indicates a rearrangement as follows:



This system will be described in a subsequent paper.

It is entirely possible that slight changes in conditions allow splitting of an indophenol molecule now in one way and again in another. It was this sort of experimentation upon which Heller depended. This will reveal the presence of tautomers and isomers but not the relative proportions of tautomers at equilibrium. Our electrometric methods *alone* will not even reveal their presence (*cf.* second paper, this series). There is, then, implicit in our methods no rigid basis for determining the dominant position of the methyl group in I and II.

The third difficulty we shall illustrate by means of a hypothetical series of simple cases of Group A, class 1 (see second paper). In Figure 1 assume that curve 1 represents a simple member of a series of substitution products. Let substitution increase both the potential of the half-reduced system of fully ionized components and the acid dissociation constant to give curve 2. The *increases* postulated are apparent at every point, although differences in E'_0 values are

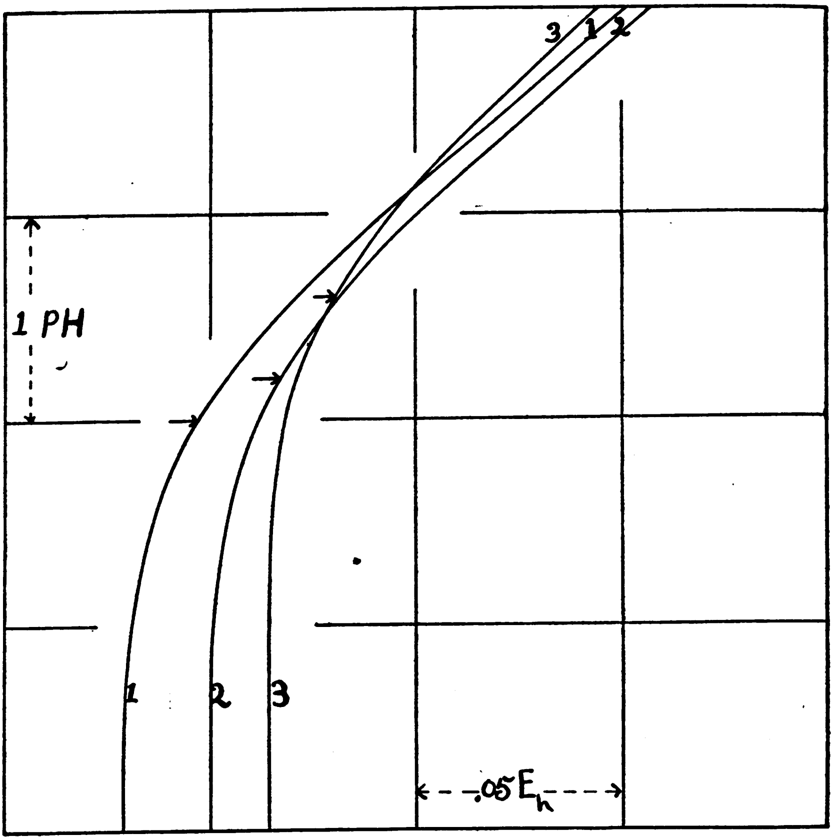


FIG. 1.

quantitatively different in different regions of pH. Let a second substitution again increase both the dissociation constant and the potential of the half-reduced system of fully ionized components. In curve 3 the *increases* postulated, have, in the region of low pH, changed the original order

$$1 < 2 < 3 \text{ to } 3 < 1 < 2.$$

Let it be well understood that this illustration is given not to detract from the intrinsic importance of any particular region of pH, but to show that a simple order *may* be revealed in one region and obscured in another. It would be interesting to know whether a simple order in the effects of substitution would appear if Conant and Fieser (1923) had carried their studies in chloroquinones to alkaline regions.

It will be noted that our experimental conditions have not reached dissociation of a remaining hydrogen in each of our indophenols. Consequently the curves do not attain $\frac{-dE}{dpH}=0$. Would a higher order of uniformity appear if we could compare the fully ionized systems? Upon what shall we base a choice in selecting one region or another for the comparison of data? A suggestion will appear presently.

For purposes of comparison it seems best to have before us data on the hypothetical normal potentials of the systems classified in Table 27. The several equations are built up by adapting equation (3) of Paper II to the case at hand as in (2).

$$E_h = C - \frac{RT}{2F}\, ln \frac{[\bar{\bar{\bar{R}}}ed]}{[O\bar{x}]} \tag{2}$$

The equilibrium equations for acid dissociations are:

$$\frac{[\bar{\bar{\bar{R}}}ed][H^+]}{[H\bar{\bar{R}}ed]} = K_3 \qquad {}^2(3)$$

$$\frac{[H\bar{\bar{R}}ed][H^+]}{[H_2\bar{R}ed]} = K_2 \tag{4}$$

$$\frac{[H_2\bar{R}ed][H^+]}{[H_3Red]} = K_r \tag{5}$$

$$\frac{[O\bar{x}][H^+]}{[HOx]} = K_o \tag{6}$$

Utilizing the sums—

$$S_r = H_3Red + H_2\bar{R}ed + H\bar{\bar{R}}ed + \bar{\bar{\bar{R}}}ed \tag{12}$$

$$S_o = HOx + \bar{O}x \tag{13}$$

and combining (12) and (13) with equations (2) to (6) we have (14),

$$E_h = C + \frac{RT}{2F}(pK_3 + pK_2 + pK_r - pK_o) - \frac{RT}{2F}\, ln \frac{[S_r]}{[S_o]} + \frac{RT}{2F}\, ln \Big[K_r K_2 K_3 + K_r K_2 [H^+] + K_r [H^+]^2 + [H^+]^3\Big] - \frac{RT}{2F}\, ln\, [K_o + H^+] \tag{14}$$

[2] For simplicity the hydrogen attached to nitrogen is treated as acidic. If the nitrogen be treated as substituted ammonium there will be introduced another constant, which, like K_3, we presume to be not revealed in the experimental data.

Equation (14) was simplified to (1) page 384 by letting $E_o = C + \frac{RT}{2F}(pK_3 + pK_2 + pK_r - pK_o)$ and neglecting the product $K_r\,K_2\,K_3$ in the 4th term at the right as of negligible magnitude within the range of the experimental conditions used.

Having determined pK_2, pK_r, and pK_o and E_o in each case, we have $C + \frac{RT}{2F}\,pK_3$ for each case. As we pass from one substitution product to another, both C and K_3 may change equally or unequally and in the same or different directions. This is a restatement of the possibilities illustrated geometrically by Figure 1 for a simpler set of cases.

A geometric illustration of equation (14) when $\frac{[S_r]}{[S_o]} = 1$ is shown in Figure 2 by the full line. It is evident that at the higher alkalinities $\frac{[H\overline{Red}]}{[O\bar{x}]}$ is equal to $\frac{[S_r]}{[S_o]} = 1$. By utilizing equations (2) to (4) we can build up the equation given under B (8), Table 27, which is applicable to the case. The projection of the curve representing equation (8) at $\frac{[H\overline{Red}]}{[O\bar{x}]} = 1$ to its intersection with pH = 0 gives what may be called the hypothetical normal potential of the B system. In a similar manner and by the utilization of equations (2) to (6) the other normals of the systems in Table 27 can be determined graphically or by use of the equations. In Table 28 are listed these several normals for each substitution product.

We shall now elaborate upon a fundamental fact mentioned in the third paper of this series. The data collected by Clark (1920), Granger and Nelson (1921), Biilmann (1921), LaMer and Baker (1922), and Conant, Kahn, Fieser, and Kurtz (1922) as well as the data reported in this and previous papers of this series, have demonstrated not only that two electrochemical equivalents are concerned in the reversible oxidation-reduction of quinone-quinol systems but also that these two electrochemical equivalents are paired.

The E'_o:pH curves show that each hydrogen enters the reductant at a distinctly different intensity level. If now pH is kept constant so that on the statistical average the ratio of ionized to nonionized reductant is constant, the electrochemical equivalents are added or withdrawn at the same intensity level. Were it not so, the E_h: percentage reduction curves should show either two distinct sections or, if continuous, should show a distinctive slope different from that found; just as, in the titration of a polyacid, the distinctly different energy levels at which hydrogens ionize are apparent in the several sections of, or the distinctive slopes of, the titration curves. Such composite curves are not found in any of the investigations mentioned above, and in this paper there are reported cases where the accuracy of measurement and the reliability of applied corrections indicate the very close pairing of the electrochemical equivalents. For instance, in Figure 3 the experimentally corrected values of E_h,

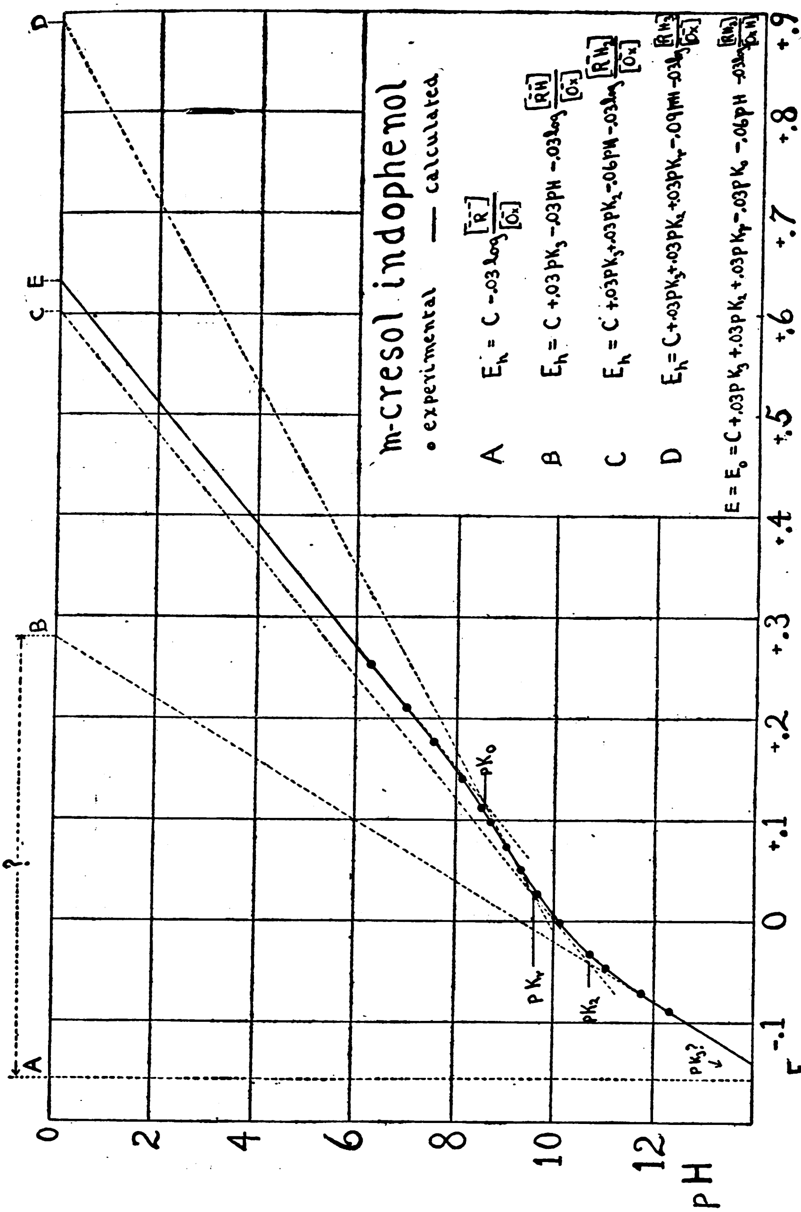


FIG. 2.

taken from Table 7, fall so near the type curve of two, paired, electrochemical equivalents that the deviation in most instances is less than the thickness of the line as drawn. While this precision is more than the accuracy we claim, it indicates very clearly the paired equivalence phenomenon.

Now there is nothing inherent in the energy relations, expressed by the equations in use, which permits us to say what these electrochemical equivalents are. In the first and second papers we adopted a basic formulation in terms of electron-transfer simply for convenience, and one should not be misled into assuming that the experimental confirmation of the final working-equations justifies the original postulate; for, as was indicated at the beginning, the same relations will be reached through a variety of channels. This aspect

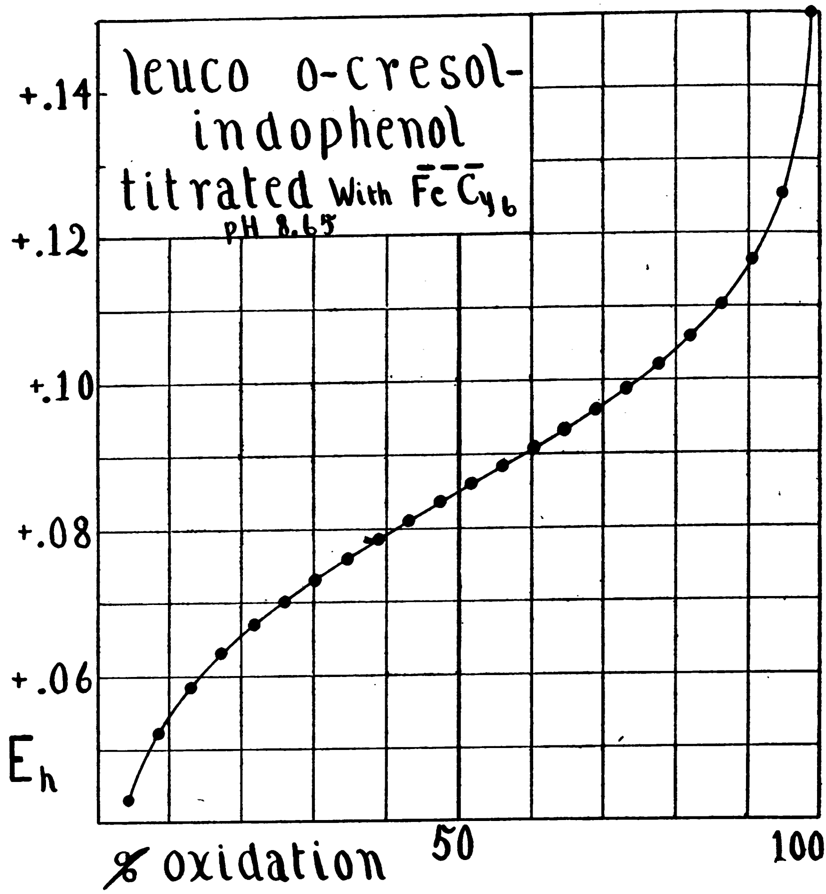


FIG. 3.

would be clearer had we adopted a more purely thermodynamic treatment. On the other hand, the pursuit of definite numerical data has led to some significant results which can hardly be ignored, however dangerous may be the entrance into discussions of mechanism.

Having chosen the "normal hydrogen electrode" as an arbitrary standard of reference, we find our numerical data to refer to a hydrogenating reaction. We shall make use of this presently, but it should be clearly understood that in examining the question of the mechanism of oxidation-reduction we are not compelled to deal with the particular hydrogenation reaction in the cell to which our numerical data relate. If we could agree on what is meant by an absolute potential difference and could find a reliable method of measuring single potential differences, we undoubtedly would find the course of the change in absolute potential difference of our half-cells strictly parallel to that found by the method of relative measurement.

Let it therefore be imagined that we are dealing with the oxidation-reduction half-cell alone. There something is being received by the electrode in the maintenance of a stable potential governed by the ratio of oxidant to reductant and the pH of the solution.

Mixtures of oxidant and reductant in buffer solutions give stable potentials quickly readjusted on addition of oxidant or reductant. The equilibrium is therefore not necessarily dependent upon the participation of reagents used in titration. On addition of one component or of titrating agent, the attainment of a new position of equilibrium is so rapid that we have wondered whether our mixing device could be so efficient. While we have no reason to think that there is an inductive action spreading from the region where the reagent enters, our imagining such an action will indicate our surprise at the very great rapidity in attainment of equilibria. This suggests that if there is involved the participation of other *material* components of the solutions, these must be present in sufficient concentration, else there would be at any instant insufficient numbers of reacting molecules to account for the rapidity of action and the stability of the potential in the equilibrated system.

What might the intermediaries be?

Now it is not entirely clear that we are justified in extending to actual conditions the calculated hydrogen and oxygen pressures at oxidation-reduction electrodes as presented in the second paper of this series. But, if the theoretical basis be granted, we reach some interesting results. The values for m-bromo phenol indophenol give a hypothetical hydrogen pressure of $10^{-22.3}$ atmosphere. It is thus obvious that the electrode in the mixture of this oxidant and reductant is not functioning as an *actual* hydrogen electrode, as Fredenhagen (1902) and others have assumed in comparable cases. If there be postulated a chain of reactions whereby the electrode is made an oxygen electrode, we run against the fact that the calculated oxygen pressure in the instance mentioned is $10^{-37.3}$ atmosphere.

An elementary fact to which we may be inclined to revert is that the reductant as isolated from solution and the oxidant as isolated from solution differ by two hydrogens. If we try to deal with this without taking account of other experimental facts, we may be grossly misled. *The displaceable hydrogens of the reductant ionize at very* *different energy levels.* How is this to be reconciled with the paired equivalence phenomenon?

A concept with which many facts harmonize may be built up as follows:

1. In the older symbolism of organic structure the binding of atoms was depicted by a dash. In the Lewis (1923) theory this is equivalent to an electron pair. In Langmuir's (1920) treatment, the completion of an octet of electrons in the outer shell of each atom by the sharing of electron pairs at "bonds" is the essential of organic structure. Using the older symbolism with its new interpretation and com-

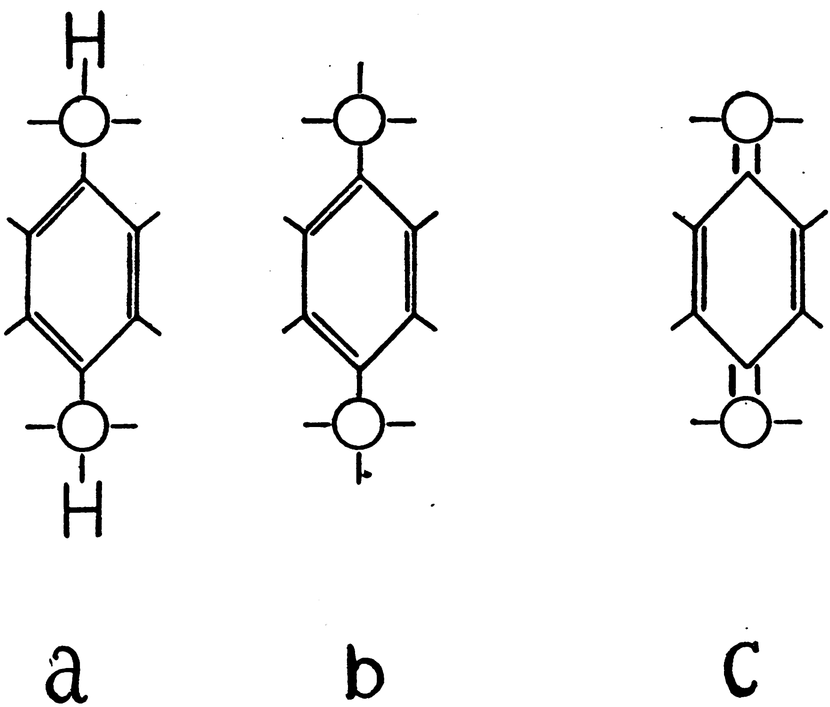


FIG. 4.

pleting octets we have as an instance the formulas (a) and (c), Figure 4, of hydroquinone and quinone, respectively.

The ionization of H^+ from (a) to give the anion (b) leaves the octets complete and the structure not essentially altered. In (c) there is one less electron pair than in (a) or (b). In short, the essential difference between a quinol and a quinone structure, as depicted by the organic chemist, is the difference of an *electron pair.* The above applies to the indophenols.

This description is in harmony with the view of Lewis (1923) that "the tendency to form pairs and the tendency to form groups of eight we shall find to be the essential features in the arrangement of valence electrons in compound molecules."

2. Experimentally, the primary fact detected by the electrical measuring system is the exchange of electrons, through some means or other, between electrode and solution and the pairing of the electrochemical equivalents exchanged between oxidant and reductant.

3. The electron-escaping tendency should be greater in the more highly charged anions than in the undissociated acids. Therefore, while undissociated molecules may still react, the ratio of most highly ionized oxidant and reductant should *determine* the charge of electrons picked up by the electrode. Experimentally, the highest negative potentials are found in alkaline solutions and the course of the change in potential with change in pH occurring with a fixed ratio of *total* oxidant to *total* reductant is the course predicted on the assumption that the completely dissociated oxidant and reductant are the *most active* components.

4. If a group substituted for hydrogen pulls electron pairs toward itself more than hydrogen pulls electron pairs toward itself, the escaping tendency of an electron pair should be lowered at least in the immediate neighborhood. This should become evident in an increased ionization of hydrogen and a more positive electrode potential. The converse of both effects should be noted if the substituent group tends to repel electron pairs. If alkyl groups be considered repellant and halogen attractive, the predicted effects on acid dissociation constants are found in Table 23, and the predicted effects on potentials are found in Table 28, where the most comparable "normals" are the B normals.

Because of the comparatively slight effects of substitution, the E'_0: pH curves of all the compounds studied would be massed if plotted together. In Figure 5 are shown the curves for thymol indophenol, phenol indophenol, and m-bromo phenol indophenol, illustrating the effects of the substitution of "positive" and "negative" groups.

On the above assumption the differences between "A" normal potentials, which we can not estimate in the present cases, should be the most significant in comparing the effects of substitution. Differences here represent the change in escaping tendency of electron pairs uncomplicated by the effect of pH upon relative concentrations of *most active* oxidant and *most active* reductant.

Differences in pK constants represent only relative energies of H^+ escape at one or another point, leaving an octet still complete; and at present we see no quantitative relation between these differences and the energy necessary for readjusting electron pairs from different levels of escaping tendency to their final elimination; although, of course, the energy of hydrogen ionization enters into the numerical data for the hydrogenation reactions.

We have already mentioned the tendency of methyl substitution to increase pK values and to give more negative "normals," and of halogen substitution to decrease pK values and to give more positive "normals." The explanation of differences between meta and ortho substitution is much more difficult. An order in the observed

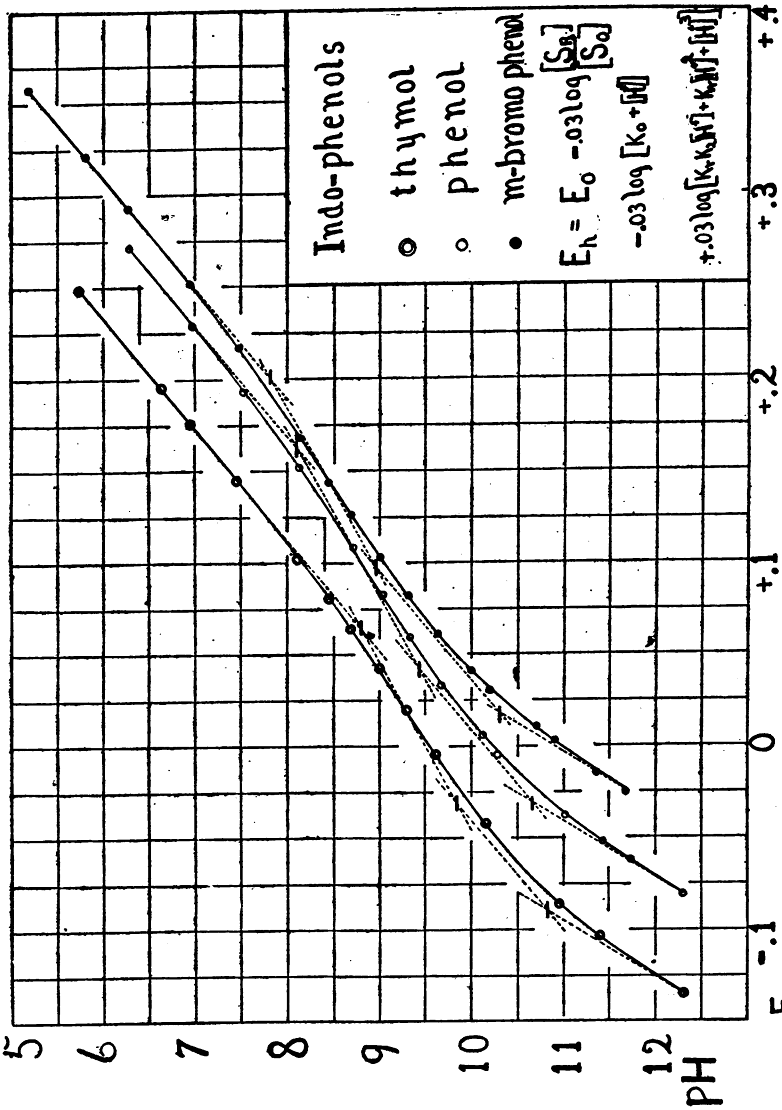


FIG. 5.

effects can be shown if we assume that groups nearer to ionizing hydrogen have the greater effect on pK values and assume for each case a predominant tautomer in accordance with the first assumption. Logically this reduces to the possibility of explaining everything if enough variables are assumed. We must therefore refrain from an attempt to explain the effects of ortho and meta substitutions till lines of evidence supplementing the present data can be secured.

We believe that the determination of distinct affinity constants of the dissociable hydrogens of the compounds studied, the demonstration of the paired equivalence phenomenon, the qualitative explanation of the gross effects of substitution, and the calculations which show that the electrode can not be functioning as an oxygen or hydrogen electrode point rather conclusively to a direct transfer of electron pairs between oxidant and reductant and to and from electrode and solution. There has been no difficulty with this view applied to certain inorganic systems. We see no difficulty in the present instance. Hydrogenation to the compounds found on isolation then becomes merely the repression of acid ionization.

LaMer and Baker (1922) give the "normal potentials" of systems of substituted quinones. These normals correspond to our E_0. The following is an interesting comparison:

	E_0 at 30°		E_0 at 25°
Phenol indophenol	0. 649	Benzoquinone	0. 699
o-Cresol indophenol	. 616	Toluquinone	. 645
Thymol indophenol	. 592	Thymoquinone	. 588
o-Bromo phenol indophenol	. 659	Bromquinone	. 715
o-Chloro phenol indophenol	. 663	Chlorquinone	. 712

While not strictly comparable, the differences from the prototypes in each case are—

	Methyl.	Isopropyl-methyl.	Bromo.	Chloro.
Indophenol	−0. 033	−0. 057	+0. 010	+0. 014
Quinone	− . 054	− . 111	+ . 016	+ . 013

In conclusion we may note several important facts:

As shown in the preliminary papers from this laboratory (Cohen and Clark 1921, Sullivan and Clark 1921), as shown by the studies of Biilmann (1921), LaMer and Baker (1922), and Conant and his coworkers (1922), and as more accurately detailed in the present and preceding papers of this series, simple substitutions have effects which are slight in comparison with the effect of a fundamental change in the type of compound.

The most positive system we have so far recorded is that of m-bromo phenol indophenol. As an indicator of oxidation-reduction it therefore shows the least reducing intensity of any *indicator* so far known.

If the conclusions regarding the direct transfer of electron pairs are accepted, they will necessitate revision of views expressed in the literature regarding the mechanism of certain dye reductions by cellular activity.

Summary.

The oxidation-reduction equilibria, measured in terms of electrode potential difference and pH, have been determined for mixtures of certain simple indophenols and their reduction products.

The compounds studied were phenol indophenol, o-cresol indophenol, m-cresol indophenol, thymol indophenol, carvacrol indophenol, o-bromo phenol indophenol, m-bromo phenol indophenol, and o-chloro phenol indophenol.

The equation applicable in all cases at 30° C. is—

$$E_h = E_o - .03006 \log \frac{[S_r]}{[S_o]} + .03006 \log [K_r K_2 + K_r [H^+] + [H^+]^2] + .03006 \log [H^+] - .03006 \log [K_o + [H^+]]$$

E_h is the electrode potential difference referred to the normal hydrogen electrode standard, E_o is a constant for a particular system, $[S_r]$ is the concentration of total reductant, $[S_o]$ is the concentration of total oxidant, $[H^+]$ is the hydrion concentration, and K_o, K_r, and K_2 are acid dissociation constants.

These acid dissociation constants and E_o have been determined, giving four constants for each system and thus providing quantitative data on the effects of substitution. These effects are discussed.

The quantitative data, especially on the pairing of electro-chemical equivalents exchanged, and on separate ionization of hydrogens, have suggested certain difficulties in the customary interpretation of the mechanism of dye reduction; and it is concluded that the essential feature of dye reduction is direct transfer of electron pairs. Hydrogenation is then in these cases suppression of acidic ionization.

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Tables.

TABLE 1.—*Composition of buffer solutions.*

[See text.]

Solution No.	
7	250 c. c. M/5 KH Phthalate+0 M/5 KOH+250 c. c. M/5 KCl+500 c. c. water.
9	250 c. c. M/5 KH Phthalate+150 c. c. M/5 KOH+100 c. c. KCl+500 c. c. water.
10	250 c. c. M/5 KH Phthalate+215 c. c. M/5 KOH+35 c. c. KCl+500 c. c. water.
13	250 c. c. M/5 KH_2PO_4+60 c. c. M/5 KOH+190 c. c. M/5 KCl+500 c. c. water.
14	250 c. c. M/5 KH_2PO_4+150 c. c. M/5 KOH+100 c. c. M/5 KCl+500 c. c. water.
15	250 c. c. M/5 KH_2PO_4+210 c. c. M/5 KOH+40 c. c. M/5 KCl+500 c. c. water.
19	250 c. c. M/5 H_3BO_3+16 c. c. M/5 KOH+234 c. c. M/5 KCl+500 c. c. water.
20	250 c. c. M/5 H_3BO_3+30 c. c. M/5 KOH+220 c. c. M/5 KCl+500 c. c. water.
21	250 c. c. M/5 H_3BO_3+80 c. c. M/5 KOH+170 c. c. M/5 KCl+500 c. c. water.
22	250 c. c. M/5 H_3BO_3+160 c. c. M/5 KOH+90 c. c. M/5 KCl+500 c. c. water.
23	250 c. c. M/5 H_3BO_3+240 c. c. M/5 KOH+10 c. c. M/5 KCl+500 c. c. water.
25	250 c. c. M/5 KOH+240 c. c. M/5 KH_2PO_4+10 c. c. M/5 KCl+500 c. c. water.
26	250 c. c. M/5 KOH+200 c. c. M/5 KH_2PO_4+50 c. c. M/5 KCl+500 c. c. water.
27	250 c. c. M/5 KOH+120 c. c. M/5 KH_2PO_4+130 c. c. M/5 KCl+500 c. c. water.
28	250 c. c. M/5 KOH+0 c. c. M/5 KH_2PO_4+250 c. c. M/5 KCl+500 c. c. water.
29	250 c. c. M/5 KOH+750 c. c. water.
30	250 c. c. M/5 KOH+250 c. c. water.

TABLE 2.—*Phenol indophenol (O): Relation of E'_0 to pH.*

[E_0=0.6494; K_0=8.0×10^{-9}; K_r=3.6×10^{-10}; K_2=2.3×10^{-11}.]

Solution No.	pH	π_h	E'_0 calculated.	E'_0 found.	Deviation.
13	6.286	−0.3778	+0.2713	+0.2713	0.0000
14	6.972	− .4190	.2293	.2289	− .0004
15	7.527	− .4524	.1938	.1931	− .0007
20	8.122	− .4882	.1514	.1512	− .0002
21	8.710	− .5235	.1067	.1080	+ .0013
21½	9.036	− .5426	.0810	.0824	+ .0014
22	9.329	− .5607	.0585	.0586	+ .0001
22½	9.678	− .5817	+ .0337	+ .0328	− .0009
23	10.277	− .6176	− .0030	− .0051	− .0021
25	10.118	− .6081	+ .0058	+ .0054	− .0004
26	11.016	− .6621	− .0373	− .0382	− .0009
26½	11.424	− .6866	− .0522	− .0524	− .0002
27	11.733	− .7051	− .0625	− .0626	− .0001
28	12.305	− .7396	− .0805	− .0807	− .0002

TABLE 3.—*Phenol indophenol (O) titrated with leuco indigo carmine at pH 8.702.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (β).	Deviation from 0.1075.
C. c.	*Per cent.*					
1	4.46	−0.0400	+0.1465	+0.1065	0.1066	−0.0009
2	8.93	− .0303	.1373	.1070	.1072	− .0003
3	13.39	− .0244	.1314	.1070	.1073	− .0002
4	17.86	− .0199	.1270	.1071	.1075	.0000
5	22.32	− .0163	.1232	.1069	.1074	− .0001
6	26.79	− .0131	.1199	.1068	.1074	− .0001
7	31.25	− .0103	.1170	.1067	.1074	− .0001
8	35.71	− .0077	.1144	.1067	.1075	.0000
9	40.18	− .0052	.1118	.1066	.1075	.0000
10	44.64	− .0028	.1093	.1065	.1075	.0000
11	49.11	− .0005	.1070	.1065	.1076	+ .0001
12	53.57	+ .0019	.1046	.1065	.1077	+ .0002
13	58.04	+ .0042	.1021	.1063	.1076	+ .0001
14	62.50	+ .0067	.0995	.1062	.1076	+ .0001
15	66.96	+ .0092	.0969	.1061	.1076	+ .0001
16	71.44	+ .0120	.0940	.1060	.1076	+ .0001
17	75.90	+ .0150	.0909	.1059	.1076	+ .0001
18	80.36	+ .0184	.0873	.1057	.1075	.0000
19	84.82	+ .0224	.0831	.1055	.1074	− .0001
20	89.28	+ .0277	.0777	.1054	.1074	− .0001
21	93.76	+ .0354	.0699	.1053	.1074	− .0001
22.4	100	....	....	....	....	....

$E'_o = 0.1075$ (orienting datum) calculated by constants of Table 2.

TABLE 4.—*Leuco phenol indophenol (G) titrated with K_3FeCy_6 at pH 8.682.*

K_3FeCy_6	Oxidation.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E_h corrected (α).	E'_o	Deviation from +0.1084.
C. c.	*Per cent.*					
2	9.80	+0.0290	+0.0788	+0.0782	+0.1072	−0.0012
4	19.61	+ .0184	+ .0909	+ .0896	.1080	− .0004
6	29.41	+ .0114	+ .0989	+ .0968	.1082	− .0002
8	39.22	+ .0057	+ .1055	+ .1027	.1084	.0000
10	49.02	+ .0005	+ .1114	+ .1079	.1084	.0000
12	58.83	− .0047	+ .1172	+ .1131	.1084	.0000
14	68.64	− .0102	+ .1233	+ .1185	.1083	− .0001
16	78.44	− .0169	+ .1305	+ .1250	.1081	− .0003
18	88.24	− .0263	+ .1404	+ .1342	.1079	− .0005
20.5	100	....	....	....	....	....

E'_o found .... +0.1084
E'_o calculated with constants of Table 2 .... + .1090

TABLE 5.—*o-Cresol indophenol (D): Relation of E_o' to pH.*

[$E_o = +0.6160$; $K_o = 4.2 \times 10^{-9}$; $K_r = 3.0 \times 10^{-10}$; $K_2 = 1.3 \times 10^{-11}$.]

Solution No.	pH	π_h	E'_o calculated.	E'_o found.	Deviation.
13	6.286	−0.3778	+0.2380	+0.2383	+0.0003
14	6.972	− .4190	.1964	.1962	− .0002
15	7.452	− .4479	.1666	.1670	+ .0004
15	7.527	− .4524	.1618	.1609	− .0009
20	8.122	− .4882	.1224	.1226	+ .0002
20½	8.456	− .5082	.0984	.0991	+ .0007
21	8.682	− .5218	.0814	.0821	+ .0007
21	8.710	− .5235	.0792	.0797	+ .0005
21½	8.996	− .5406	.0572	.0589	+ .0017
22	9.329	− .5607	.0317	.0325	+ .0008
22½	9.678	− .5817	+ .0065	+ .0060	− .0005
23	10.158	− .6105	− .0248	− .0238	+ .0010
25½	10.728	− .6446	− .0561	− .0570	− .0009
26	11.024	− .6625	− .0698	− .0707	− .0009
26½	11.397	− .6850	− .0847	− .0850	− .0003
27	11.716	− .7041	− .0961	− .0955	+ .0006
28	12.295	− .7398	− .1148	− .1147	+ .0001

TABLE 6.—*o-Cresol indophenol (D) titrated with leuco indigo carmine at pH 8.702.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (β).	Deviation from +0.0799.
C. c.	*Per cent.*					
2	8.18	−0.0315	+0.1114	+0.0799	+0.0801	+0.0002
3	12.27	− .0257	.1054	.0797	+ .0799	.0000
4	16.36	− .0213	.1010	.0797	.0800	+ .0001
5	20.45	− .0177	.0973	.0796	.0799	.0000
6	24.54	− .0147	.0941	.0794	.0798	− .0001
7	28.63	− .0119	.0913	.0794	.0799	.0000
8	32.72	− .0094	.0888	.0794	.0799	.0000
9	36.81	− .0070	.0864	.0794	.0800	+ .0001
10	40.90	− .0048	.0840	.0792	.0799	.0000
11	44.99	− .0026	.0819	.0793	.0800	+ .0001
12	49.08	− .0005	.0796	.0791	.0799	.0000
13	53.17	+ .0017	.0775	.0792	.0800	+ .0001
14	57.27	.0038	.0752	.0790	.0799	.0000
15	61.35	.0060	.0729	.0789	.0799	.0000
16	65.44	.0083	.0705	.0788	.0798	− .0001
17	69.53	.0108	.0680	.0788	.0800	+ .0001
18	73.62	.0134	.0654	.0788	.0800	+ .0001
19	77.71	.0163	.0624	.0787	.0800	+ .0001
20	81.80	.0196	.0589	.0785	.0799	.0000
21	85.89	.0236	.0550	.0786	.0800	+ .0001
22	89.98	.0287	.0498	.0785	.0800	+ .0001
23	94.07	.0361	.0422	.0783	.0798	− .0001
24.45	100					

E'_o calculated by the constants of Table 5 .... +0.0799
E'_o found (orienting value) .... + .0799

TABLE 7.—*o-Cresol indophenol (E) titrated with leuco indigo carmine pH 8.702.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (β).	Deviation from +.0795.
C. c.	*Per cent.*					
2	7.90	−0.0321	+0.1110	+0.0789	+0.0790	−0.0005
3	11.86	− .0262	.1054	.0792	.0793	− .0002
4	15.81	− .0218	.1011	.0793	.0795	.0000
5	19.76	− .0183	.0975	.0792	.0795	.0000
6	23.72	− .0152	.0944	.0792	.0795	.0000
7	27.67	− .0125	.0916	.0791	.0795	.0000
8	31.62	− .0100	.0891	.0791	.0795	.0000
9	35.57	− .0078	.0867	.0789	.0794	− .0001
10	39.52	− .0055	.0844	.0789	.0794	− .0001
11	43.48	− .0034	.0824	.0790	.0796	+ .0001
12	47.43	− .0013	.0802	.0789	.0795	.0000
13	51.39	+ .0007	.0781	.0788	.0795	.0000
14	55.34	+ .0028	.0760	.0788	.0795	.0000
15	59.29	+ .0049	.0738	.0787	.0795	.0000
16	63.24	+ .0071	.0716	.0787	.0795	.0000
17	67.20	+ .0094	.0693	.0787	.0796	+ .0001
18	71.15	+ .0118	.0668	.0786	.0795	.0000
19	75.10	+ .0144	.0641	.0785	.0795	.0000
20	79.05	+ .0173	.0611	.0784	.0794	− .0001
21	83.01	+ .0207	.0578	.0785	.0796	+ .0001
22	86.96	+ .0248	.0536	.0784	.0795	.0000
23	90.92	+ .0301	.0482	.0783	.0795	.0000
24	94.86	+ .0380	.0399	.0779	.0791	− .0004
25.3						

E_o' calculated with constants of Table 5 .... +.0799
E_o' found .... .0795

TABLE 8.—*o-Cresol indophenol (G) titrated with ferricyanid at pH 8.652.*

K_3FeCy_6	Oxidation.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (α).	Deviation from +0.0837.
C. c.	*Per cent.*					
1	4.31	+0.0405	+0.0432	+0.0837	0.0836	−0.0001
2	8.62	+ .0308	.0526	.0834	.0833	− .0004
3	12.93	+ .0249	.0587	.0836	.0834	− .0003
4	17.24	+ .0205	.0633	.0838	.0835	− .0002
5	21.55	+ .0169	.0671	.0840	.0836	− .0001
6	25.86	+ .0137	.0702	.0839	.0835	− .0002
7	30.17	+ .0110	.0732	.0842	.0836	− .0001
8	34.48	+ .0084	.0759	.0843	.0836	− .0001
9	38.79	+ .0059	.0785	.0844	.0836	− .0001
10	43.10	+ .0036	.0809	.0845	.0837	.0000
11	47.42	+ .0014	.0834	.0848	.0839	+ .0002
12	51.73	− .0009	.0858	.0849	.0839	+ .0002
13	56.04	− .0032	.0882	.0850	.0839	+ .0002
14	60.35	− .0055	.0904	.0849	.0837	.0000
15	64.66	− .0079	.0929	.0850	.0837	.0000
16	68.97	− .0104	.0955	.0851	.0838	+ .0001
17	73.28	− .0132	.0984	.0852	.0838	+ .0001
18	77.59	− .0162	.1016	.0854	.0840	+ .0003
19	81.90	− .0197	.1054	.0857	.0842	+ .0005
20	86.21	− .0240	.1097	.0857	.0841	+ .0004
21	90.52	− .0295	.1154	.0859	.0843	+ .0006
22	94.83	− .0380	.1242	.0862	.0845	+ .0008
23	99.14	− .0620	.1486	.0866	.0848	+ .0011
23.2	100					

E_o' calculated with constants of Table 5 .... +.0837
E_o' found .... +.0837

TABLE 9.—*m-Cresol indophenol (C): Relation of E_o' to pH.*

[$E_o = +0.6316$; $K_o = 2.8 \times 10^{-9}$; $K_r = 2.7 \times 10^{-10}$; $K_2 = 2.2 \times 10^{-11}$.]

Solution No.	pH	π_h	E'_o calculated.	E_o' found.	Deviation.
13	6.286	−0.3778	+0.2535	+0.2530	−0.0005
14	6.972	− .4190	+ .2120	+ .2120	.0000
15	7.527	− .4524	+ .1779	+ .1759	− .0020
20	8.122	− .4675	+ .1395	+ .1380	− .0015
20½	8.456	− .5082	+ .1163	+ .1149	− .0014
21	8.710	− .5235	+ .0979	+ .0980	+ .0001
21½	9.036	− .5426	+ .0734	+ .0736	+ .0002
22	9.325	− .5607	+ .0514	+ .0521	+ .0007
22½	9.678	− .5817	+ .0264	+ .0252	− .0012
25	10.118	− .6061	− .0019	− .0016	+ .0003
25½	10.712	− .6438	− .0329	− .0334	− .0005
26	11.024	− .6625	− .0461	− .0461	.0000
27	11.733	− .7051	− .0712	− .0700	+ .0012
28	12.305	− .7396	− .0892	− .0891	+ .0001

TABLE 10 (a).—*m-Cresol indophenol (E) titrated with leuco indigo carmine at pH 8.702.*

Indigo	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o
C. c.	*Per cent.*			
2	7.94	−0.0320	+0.1260	+0.0940
4	15.87	− .0218	.1188	.0970
6	23.81	− .0152	.1133	.0981
8	31.75	− .0100	.1085	.0985
10	39.68	− .0055	.1042	.0987
12	47.62	− .0013	.1000	.0987
14	55.56	+ .0029	.0959	.0988
16	63.50	.0072	.0916	.0988
18	71.44	.0120	.0867	.0987
20	79.39	.0176	.0810	.0986
22	87.30	.0252	.0733	.0985
24	95.24	.0391	.0584	.0975
25.2	100			
Average				0.0980

TABLE 10 (*b*).—*Recalculation of Table 10* (*a*).

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from +0.0989.
C. c.	*Per cent.*				
2	7.98	−0.0319	0.1260	0.0941	−0.0048
4	15.97	− .0217	.1188	.0971	− .0018
6	23.95	− .0151	.1133	.0982	− .0007
8	31.93	− .0099	.1085	.0986	− .0003
10	39.92	− .0053	.1042	.0989	.0000
12	47.90	− .0011	.1000	.0989	.0000
14	55.89	+ .0031	.0959	.0990	+ .0001
16	63.87	+ .0074	.0916	.0990	+ .0001
18	71.86	+ .0122	.0867	.0989	.0000
20	79.84	+ .0179	.0810	.0989	.0000
22	87.82	+ .0258	.0733	.0991	+ .0002
24	95.81	+ .0409	.0584	.0993	+ .0004
25.05	100				

TABLE 11.—*m-Cresol indophenol* (*C*) *titrated with leuco indigo carmine at pH 8.706.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from +0.0983.
C. c.	*Per cent.*				
2	9.88	−0.0289	+0.1249	+0.0960	−0.0023
4	19.75	− .0183	.1160	.0977	− .0006
5	24.69	− .0145	.1126	.0981	− .0002
6	29.63	− .0113	.1094	.0981	− .0002
7	34.57	− .0083	.1066	.0983	.0000
8	39.50	− .0056	.1039	.0983	.0000
9	44.44	− .0029	.1012	.0983	.0000
10	49.38	− .0003	.0987	.0984	+ .0001
11	54.32	+ .0023	.0962	.0985	+ .0002
12	59.26	+ .0049	.0935	.0984	+ .0001
13	64.20	+ .0076	.0907	.0983	.0000
14	69.14	+ .0105	.0878	.0983	.0000
15	74.08	+ .0137	.0846	.0983	.0000
16	79.02	+ .0173	.0809	.0982	− .0001
17	83.95	+ .0216	.0766	.0982	− .0001
18	88.89	+ .0271	.0712	.0983	.0000
19	93.82	+ .0355	.0631	.0986	+ .0003
20.25	100				

TABLE 12.—*Thymol indophenol* (*G*): *Relation of E'_o to pH.*

[E_o= +.5923; K_o=1.6×10^{-9}; K_r=1.4×10^{-10}; K_2=1.5×10^{-11}.]

Solution No.	pH	π_h	E'_o calculated.	E'_o found.	Deviation.
10	5.733	−0.3445	+0.2480	+0.2478	−0.0002
13½	6.629	− .3984	.1941	.1945	+ .0004
14	6.943	− .4173	.1751	.1750	− .0001
15	7.452	− .4479	.1441	.1437	− .0004
20	8.105	− .4871	.1032	.1016	− .0016
20½	8.446	− .5076	.0806	.0801	− .0005
21	8.685	− .5219	.0639	.0640	+ .0001
21½	8.996	− .5403	.0411	.0423	+ .0012
22	9.294	− .5586	+ .0186	+ .0197	+ .0011
22½	9.618	− .5781	− .0058	− .0055	+ .0003
23	10.158	− .6105	− .0435	− .0431	+ .0004
26	10.950	− .6581	− .0861	− .0865	− .0004
26½	11.397	− .6850	− .1039	− .1041	− .0002
29	12.312	− .7400	− .1342	− .1346	− .0004

TABLE 13.—*Thymol indophenol (G) titrated with leuco indigo carmine at pH 9.617.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from −0.0058.
C.c.	*Per cent.*				
2	6.47	−0.0349	+0.0294	−0.0055	+0.0003
4	12.94	− .0249	+ .0191	− .0058	.0000
7	22.65	− .0161	+ .0103	− .0058	.0000
8	25.89	− .0137	+ .0079	− .0058	.0000
10	32.36	− .0096	+ .0038	− .0058	.0000
12	38.84	− .0059	+ .0002	− .0057	+ .0001
14	45.30	− .0025	− .0033	− .0058	.0000
16	51.77	+ .0009	− .0067	− .0058	.0000
18	58.25	+ .0044	− .0102	− .0058	.0000
20	64.72	+ .0079	− .0137	− .0058	.0000
22	71.18	+ .0118	− .0176	− .0058	.0000
24	77.66	+ .0163	− .0221	− .0058	.0000
26	84.14	+ .0218	− .0277	− .0059	− .0001
28	90.63	+ .0296	− .0355	− .0059	− .0001
30.9	100	....	....	....	....

E'_o calculated with constants of Table 12.. −0.0058 (orienting value).

TABLE 14.—*Carvacrol indophenol (C): Relation E'_o to pH.*

[$E_o = +.5931$; $K_o = 1.4 \times 10^{-9}$; $K_r = 1.4 \times 10^{-10}$; $K_2 = 1.8 \times 10^{-11}$.]

Solution No.	pH	π_h	E'_o calculated.	E'_o found.	Deviation.
10	5.733	−0.3445	+0.2485	+0.2472	−0.0013
13	6.268	− .3767	.2163	.2158	− .0005
14	6.913	− .4173	.1757	.1760	+ .0003
15	7.452	− .4479	.1447	.1434	− .0013
20	8.105	− .4871	.1040	.1021	− .0019
20½	8.446	− .5076	.0816	.0806	− .0010
21	8.685	− .5219	.0651	.0654	+ .0003
21½	8.996	− .5406	.0427	.0428	+ .0001
22	9.294	− .5586	+ .0203	+ .0216	+ .0013
22½	9.618	− .5781	− .0039	− .0039	.0000
23	10.158	− .6105	− .0411	− .0397	+ .0014
26	10.959	− .6581	− .0828	− .0829	− .0001
26½	11.307	− .6850	− .1002	− .0986	+ .0016
29	12.312	− .7400	− .1301	− .1302	− .0001

TABLE 15.—*Carvacrol indophenol (C) titrated with leuco indigo carmine at pH 9.617.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from −0.0039
C.c.	*Per cent.*				
1	3.63	−0.0428	+0.0398	−0.0030	+0.0009
2	7.26	− .0333	+ .0300	− .0033	+ .0006
3	10.89	− .0274	+ .0239	− .0035	+ .0004
4	14.52	− .0232	+ .0196	− .0036	+ .0003
5	18.15	− .0197	+ .0160	− .0037	+ .0002
6	21.78	− .0167	+ .0130	− .0037	+ .0002
7	25.41	− .0140	+ .0103	− .0037	+ .0002
8	29.04	− .0117	+ .0078	− .0039	.0000
9	32.67	− .0094	+ .0056	− .0038	+ .0001
10	36.30	− .0073	+ .0034	− .0039	.0000
11	39.93	− .0053	+ .0014	− .0039	.0000
12	43.56	− .0034	− .0005	− .0039	.0000
13	47.19	− .0014	− .0024	− .0038	+ .0001
14	50.82	+ .0004	− .0043	− .0039	.0000
15	54.45	+ .0023	− .0063	− .0040	− .0001
16	58.08	+ .0043	− .0083	− .0040	− .0001
17	61.71	+ .0062	− .0102	− .0040	− .0001
18	65.34	+ .0083	− .0123	− .0040	− .0001
19	68.97	+ .0104	− .0145	− .0041	− .0002
20	72.60	+ .0127	− .0168	− .0041	− .0002
21	76.23	+ .0152	− .0193	− .0041	− .0002
22	79.86	+ .0173	− .0221	− .0048	− .0009
23	83.49	+ .0212	− .0254	− .0042	− .0003
25	90.74	+ .0298	− .0341	− .0043	− .0004
26	94.37	+ .0368	− .0413	− .0045	− .0005
27.55	100	....	....	....	....

E'_o calculated with constants of Table 14....................−0.0039.

Table 16.—*o-Bromo phenol indophenol (A): Relation of* E'_0 *to pH.*

[$E_0=0.6586$; $K_0=7.8\times10^{-8}$ $K_r=3.0\times10^{-9}$ $K_2=5.8\times10^{-11}$.]

Solution No.	pH	π_h	E'_0 calculated.	E'_0 found.	Deviation.
10	5.814	−0.3495	+0.3084	+0.3081	−0.0003
13	6.286	− .3778	.2788	.2794	+ .0006
14	6.970	− .4189	.2328	.2328	.0000
15	7.524	− .4522	.1907	.1896	− .0011
20	8.117	− .4878	.1433	.1429	− .0004
20½	8.464	− .5087	.1167	.1180	+ .0013
21	8.702	− .5230	.0994	.1004	+ .0010
21½	9.007	− .5413	.0786	.0790	+ .0004
22	9.305	− .5592	.0598	.0602	+ .0004
22½	9.593	− .5766	.0429	.0417	− .0012
25	9.998	− .6009	.0211	.0196	− .0015
23	10.263	− .6168	+ .0086	+ .0082	− .0004
25½	10.696	− .6428	− .0092	− .0095	− .0003
26	11.005	− .6614	− .0204	− .0194	+ .0010
27	11.725	− .7047	− .0437	− .0436	+ .0001

Table 17.—*o-Bromo phenol indophenol (A) titrated with reduced indigo carmine at pH 8.702.*

Indigo.	Reduction.	$0.03006 \log\frac{[S_r]}{[S_o]}$	E_h	E'_0	E'_0 corrected (β).	Deviation from +0.1004.
C. c.	*Per cent.*					
1	5.56	−0.0370	+0.1306	+0.0936	+0.0936	−0.0068
2	11.11	− .0271	.1244	.0973	.0974	− .0030
3	16.67	− .0210	.1198	.0988	.0990	− .0014
4	22.22	− .0164	.1158	.0994	.0996	− .0008
5	27.78	− .0125	.1122	.0997	.1000	− .0004
6	33.33	− .0091	.1089	.0998	.1001	− .0003
7	38.89	− .0059	.1059	.1000	.1004	.0000
8	44.44	− .0029	.1029	.1000	.1004	.0000
9	50.00	.0000	.1000	.1000	.1005	+ .0001
10	55.55	+ .0029	.0970	.0999	.1005	+ .0001
11	61.11	+ .0059	.0941	.1000	.1006	+ .0002
12	66.67	+ .0091	.0908	.0999	.1006	+ .0002
13	72.23	+ .0125	.0868	.0993	.1000	− .0004
14	77.78	+ .0164	.0832	.0996	.1004	.0000
15	83.33	+ .0210	.0778	.0988	.0996	− .0008
16	88.89	+ .0271	.0719	.0990	.0999	− .0005
17	94.45	+ .0370	.0614	.0984	.0994	− .0010
18	100.	....	....	....	....	....

E'_0 calculated with constants of Table 16 (orienting value) .... +0.1004

Table 18.—*m-Bromo phenol indophenol (A): Relation of* E'_0 *to pH.*

[$E_0=+0.6700$; $K_0=1.5\times10^{-8}$; $K_r=1.1\times10^{-9}$; $K_2=5.0\times10^{-11}$.]

Solution No.	pH	π_h	E'_0 calculated.	E'_0 found.	Deviation.
9	5.191	−0.3120	+0.3579	+0.3579	0.0000
10	5.814	− .3495	+ .3203	.3206	+ .0003
13	6.271	− .3773	+ .2927	.2925	− .0002
14	6.952	− .4178	+ .2504	.2508	+ .0004
15	7.479	− .4495	+ .2158	.2164	+ .0006
20	8.122	− .4881	+ .1690	.1679	− .0011
20½	8.439	− .5072	+ .1445	.1432	− .0013
21	8.686	− .5220	+ .1256	.1256	.0000
21½	9.003	− .5411	+ .1023	.1023	.0000
22	9.318	− .5600	+ .0805	.0813	+ .0008
22½	9.639	− .5793	+ .0505	.0504	− .0001
23	10.199	− .6130	+ .0304	.0296	− .0008
25	9.998	− .6009	+ .0404	.0404	.0000
25½	10.696	− .6428	+ .0099	.0102	+ .0003
26	10.898	− .6550	+ .0013	.0022	+ .0009
26½	11.353	− .6823	− .0143	− .0157	− .0014
27	11.681	− .7020	− .0246	− .0263	− .0017

TABLE 19 (a).—*m-Bromo phenol indophenol (A) titrated with leuco indigo carmine at pH 8.702.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (β).	Deviation from +0.1244.
C. c.	*Per cent.*					
2	9.43	−0.0296	0.1540	+0.1244	+0.1245	+0.0001
4	18.87	− .0190	.1434	.1244	.1246	+ .0002
6	28.30	− .0121	.1363	.1242	.1246	+ .0002
8	37.74	− .0065	.1306	.1241	.1246	+ .0002
10	47.17	− .0015	.1253	.1238	.1244	.0000
12	56.61	+ .0035	.1203	.1238	.1245	+ .0001
14	66.04	+ .0087	.1149	.1236	1244	.0000
16	75.48	+ .0147	.1087	.1234	.1244	.0000
18	84.91	+ .0225	1006	.1231	.1244	.0000
20	94.34	+ .0368	.0865	.1235	.1247	+ .0003
21.2	100					

TABLE 19 (b).—*Recalculation of Table 19 (a).*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from +0.1244.
C. c.	*Per cent.*				
1	4.81	−0.0390	+0.1634	+0.1244	0.0000
2	9.62	− .0293	.1540	.1247	+.0003
3	14.42	− .0233	.1479	.1246	+.0002
4	19.23	− .0187	.1434	.1247	+.0003
5	24.04	− .0150	.1396	.1246	+.0002
6	28.85	− .0118	.1363	.1245	+.0001
7	33.65	− .0089	.1333	.1244	.0000
8	38.46	− .0061	.1306	.1244	.0000
9	43.27	− .0035	.1279	.1244	.0000
10	48.08	− .0010	.1253	.1243	−.0001
11	52.88	+ .0015	.1229	.1244	.0000
12	57.70	+ .0040	.1203	.1243	−.0001
13	62.50	+ .0067	.1177	.1244	.0000
14	67.31	+ .0094	.1149	.1243	−.0001
15	72.12	+ .0124	.1119	.1243	−.0001
16	76.93	+ .0157	.1087	.1244	.0000
17	81.74	+ .0196	.1050	.1246	+.0002
18	86.54	+ .0243	.1006	.1249	+.0005
19	91.35	+ .0308	.0949	.1257	+.0013
20.8	100				

TABLE 20.—*o-Chloro phenol indophenol (D): Relation of E'_o to pH.*

[E_o=+0.6627; K_o=1.0×10^{-7}; K_r=3.6×10^{-9}; K_2=5.0×10^{-11}.]

Solution No.	pH	π_h	E'_o calculated.	E'_o found.	Deviation.
7	4.079	−0.2451	+0.4175	+.04269	[a] [+0.010]
9	5.169	− .3107	.3518	.3520	+ .0002
10	5.740	− .3450	.3169	.3176	+ .0007
13	6.269	− .3768	.2837	.2842	+ .0005
13½	6.629	− .3984	.2599	.2592	− .0007
14	6.943	− .4173	.2375	.2374	− .0001
15	7.452	− .4479	.1985	.1966	− .0019
20	8.083	− .4858	.1479	.1482	+ .0003
20½	8.446	− .5076	.1203	.1202	− .0001
21	8.685	− .5219	.1030	.1031	+ .0001
21	8.652	− .5200	.1053	.1053	.0000
21½	8.996	− .5406	.0821	.0817	− .0004
22	9.294	− .5586	.0634	.0631	− .0003
22½	9.618	− .5781	.0443	.0436	− .0007
23	10.158	− .6105	+ .0130	+ .0136	+ .0006
26	10.950	− .6581	− .0166	− .0169	− .0003
26½	11.393	− .6850	− .0318	− .0303	+ .0015
29	12.312	− .7400	− .0603	− .0620	− .0020

[a] Precipitates because of high acidity.

TABLE 21.—*o-Chloro phenol indophenol (D) titrated with leuco indigo carmine at pH 8.702.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected (β).	Deviation from 0.1012.
C. c.	*Per cent.*					
1	4.94	−0.0386	+0.1391	+0.1005	0.1006	−0.0006
2	9.88	− .0288	.1298	.1010	.1011	− .0001
3	14.81	− .0227	.1239	.1012	.1014	+ .0002
4	19.75	− .0183	.1193	.1010	.1012	.0000
5	24.69	− .0146	.1155	.1009	.1012	.0000
6	29.63	− .0113	.1121	.1008	.1012	.0000
7	34.57	− .0083	.1091	.1008	.1012	.0000
8	39.50	− .0056	.1063	.1007	.1012	.0000
9	44.44	− .0029	.1036	.1007	.1012	.0000
10	49.38	− .0003	.1009	.1006	.1012	.0000
11	54.32	+ .0023	.0983	.1006	.1013	+ .0001
12	59.26	+ .0049	.0956	.1005	.1012	.0000
13	64.20	+ .0076	.0928	.1004	.1012	.0000
14	69.14	+ .0105	.0899	.1004	.1012	.0000
15	74.08	+ .0137	.0866	.1003	.1012	.0000
16	79.02	+ .0173	.0829	.1002	.1012	.0000
17	83.95	+ .0216	.0785	.1001	.1011	− .0001
18	88.89	+ .0271	.0730	.1001	.1012	.0000
19	93.83	+ .0356	.0647	.1003	.1014	+ .0002
20.25	100					

TABLE 22.—*o-Chloro phenol indophenol (D) titrated with leuco indigo carmine at pH 9.609.*

(Acidity change negligible.)

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	Deviation from 0.0436.
C. c.	*Per cent.*				
1	4.37	−0.0403	+0.0844	0.0441	+0.0005
2	8.73	− .0307	+ .0743	.0436	.0000
3	13.10	− .0247	+ .0682	.0435	− .0001
4	17.47	− .0203	+ .0638	.0435	− .0001
5	21.83	− .0166	+ .0601	.0435	− .0001
6	26.20	− .0135	+ .0570	.0435	− .0001
7	30.57	− .0107	+ .0542	.0435	− .0001
8	34.93	− .0081	+ .0516	.0435	− .0001
9	39.30	− .0057	+ .0492	.0435	− .0001
10	43.67	− .0033	+ .0469	.0436	.0000
11	48.04	− .0010	+ .0446	.0436	.0000
12	52.40	+ .0013	+ .0423	.0436	.0000
13	56.77	+ .0035	+ .0402	.0437	+ .0001
14	61.14	+ .0059	+ .0378	.0437	+ .0001
15	65.50	+ .0084	+ .0354	.0438	+ .0002
16	69.87	+ .0110	+ .0327	.0437	+ .0001
17	74.24	+ .0138	+ .0298	.0436	.0000
18	78.60	+ .0170	+ .0266	.0436	.0000
19	82.77	+ .0205	+ .0228	.0433	− .0003
20	87.34	+ .0253	+ .0179	.0432	− .0004
21	91.70	+ .0314	+ .0113	.0427	− .0009
22.7	100.		+ .03		

E'_o .... +0.0436

TABLE 23.—*Indophenols: E_o and dissociation constants.*

System.	E_o	K_o	K_r	K_2
Phenol indophenol	+0.640	8.0×10^{-9}	3.6×10^{-10}	2.3×10^{-11}
o-Cresol indophenol	.616	4.2×10^{-9}	3.0×10^{-10}	1.3×10^{-11}
m-Cresol indophenol	.632	2.8×10^{-9}	2.7×10^{-10}	2.2×10^{-11}
Thymol indophenol	.592	1.6×10^{-9}	1.4×10^{-10}	1.5×10^{-11}
Carvacrol indophenol	.593	1.4×10^{-9}	1.4×10^{-10}	1.8×10^{-11}
o-Bromo phenol indophenol	.659	7.8×10^{-8}	3.0×10^{-9}	5.8×10^{-11}
m-Bromo phenol indophenol	.670	1.5×10^{-8}	1.1×10^{-9}	5.0×10^{-11}
o-Chloro phenol indophenol	.663	1.0×10^{-7}	3.6×10^{-9}	5.0×10^{-11}

TABLE 24.—*Indophenols: E_0 and pK values.*

System.	E_0	pK_o (colorimetric).	pK_o	pK_r	pK_2
Phenol indophenol	+0.649	8.1	8.1	9.4	10.6
o-Cresol indophenol	+ .616	8.4	8.4	9.5	10.9
m-Cresol indophenol	+ .632	8.5	8.6	9.6	10.7
Thymol indophenol	+ .592	8.7	8.8	9.9	10.8
Carvacrol indophenol	+ .593	8.8	8.9	9.9	10.7
o-Bromo phenol indophenol	+ .659	7.15	7.1	8.5	10.2
m-Bromo phenol indophenol	+ .670	7.7	7.8	9.0	10.3
o-Chloro phenol indophenol	+ .663	7.0	7.0	8.4	10.3

TABLE 25.—*m-Cresol indophenol (C) from quinone chloroimide and m-Cresol titrated with leuco indigo carmine at pH 8.664.*

Indigo.	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected. (β)	Deviation from +0.1020.
C. c.	*Per cent.*					
1	3.65	−0.0427	+0.1457	0.1030	+0.1030	+0.0010
2	7.29	− .0332	.1356	.1024	.1025	+ .0005
3	10.94	− .0274	.1296	.1022	.1023	+ .0003
4	14.59	− .0231	.1251	.1020	.1021	+ .0001
5	18.23	− .0196	.1215	.1017	.1019	− .0001
6	21.88	− .0166	.1184	.1018	.1020	.0000
7	25.53	− .0140	.1157	.1017	.1019	− .0001
8	29.18	− .0116	.1133	.1017	.1020	.0000
9	32.82	− .0094	.1110	.1016	.1018	− .0002
10	36.47	− .0072	.1088	.1016	.1020	.0000
11	40.12	− .0052	.1068	.1016	.1020	.0000
12	43.77	− .0032	.1048	.1016	.1020	.0000
13	47.42	− .0014	.1029	.1015	.1020	.0000
14	51.06	+ .0006	.1009	.1015	.1020	.0000
15	54.71	.0025	.0989	.1014	.1020	.0000
16	58.36	.0044	.0969	.1013	.1019	− .0001
17	62.00	.0064	.0949	.1013	.1019	− .0001
18	65.65	.0085	.0928	.1013	.1020	.0000
19	69.29	.0106	.0906	.1012	.1019	− .0001
20	72.94	.0129	.0882	.1011	.1019	− .0001
21	76.59	.0155	.0858	.1013	.1021	+ .0001
22	80.24	.0183	.0829	.1012	.1020	.0000
23	83.88	.0215	.0797	.1012	.1021	+ .0001
24	87.53	.0255	.0757	.1012	.1021	+ .0001
25	91.17	.0305	.0706	.1011	.1021	+ .0001
26	94.83	.0380	.0630	.1010	.1020	.0000
27.42	100					

TABLE 26.—*m-Cresol indophenol (G-B) from m-cresol quinone chloroimide and phenol titrated with leuco indigo carmine at pH 8.664.*

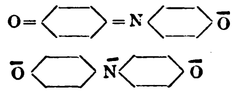
Indigo	Reduction.	$0.03006 \log \frac{[S_r]}{[S_o]}$	E_h	E'_o	E'_o corrected. (β)	Deviation from +0.1020.
C. c.	*Per cent.*					
1	4.88	−0.0388	0.1418	0.1030	0.1031	+0.0011
2	9.76	− .0290	.1312	.1022	.1024	+ .0004
3	14.62	− .0230	.1249	.1019	.1022	+ .0002
4	19.51	− .0185	.1202	.1017	.1023	+ .0003
5	24.39	− .0148	.1163	.1015	.1020	.0000
6	29.27	− .0115	.1129	.1014	.1020	.0000
7	34.15	− .0086	.1098	.1012	.1019	− .0001
8	39.02	− .0058	.1070	.1012	.1020	.0000
9	43.90	− .0032	.1043	.1011	.1020	.0000
10	48.78	− .0006	.1016	.1010	.1020	.0000
11	53.66	+ .0019	.0990	.1009	.1020	.0000
12	58.54	.0045	.0963	.1008	.1020	.0000
13	63.42	.0072	.0935	.1007	.1020	.0000
14	68.30	.0100	.0906	.1006	.1020	.0000
15	73.17	.0131	.0874	.1005	.1020	.0000
16	78.05	.0166	.0838	.1004	.1020	.0000
17	82.93	.0206	.0795	.1001	.1018	− .0002
18	87.81	.0258	.0743	.1001	.1019	− .0001
19	92.68	.0332	.0668	.1000	.1019	− .0001
20.5	100					

TABLE 27.

A.

System: $O\bar{x} + 2e \rightleftharpoons \overline{\overline{Red}}$

Example:



($O\bar{x}$)

($\overline{\overline{Red}}$)

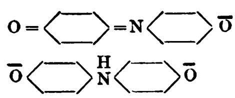
Equation: $E_h = C - \frac{RT}{2F} \ln \frac{[\overline{\overline{Red}}]}{[O\bar{x}]}$ (7)

Curve A, Figure 2.

B.

System: $O\bar{x} + 2e + H^+ \rightleftharpoons H\overline{\overline{Red}}$

Example:



($O\bar{x}$)

($H\overline{\overline{Red}}$)

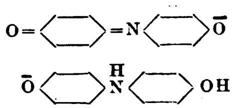
Equation: $E_h = C + \frac{RT}{2F} pK_3 - \frac{RT}{2F} \ln \frac{[H\overline{\overline{Red}}]}{[O\bar{x}]} - \frac{RT}{2F} pH$ (8)

Curve B, Figure 2.

C.

System: $O\bar{x} + 2e + 2H^+ \rightleftharpoons H_2\overline{Red}$

Example:



($O\bar{x}$)

($H_2\overline{Red}$)

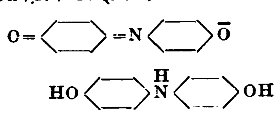
Equation: $E_h = C + \frac{RT}{2F}(pK_3 + pK_2) - \frac{RT}{F} pH - \frac{RT}{2F} \ln \frac{[H_2\overline{Red}]}{[O\bar{x}]}$ (9)

Curve C, Figure 2.

D.

System: $O\bar{x} + 2e + 3H^+ \rightleftharpoons H_3Red$

Example:



($O\bar{x}$)

(H_3Red)

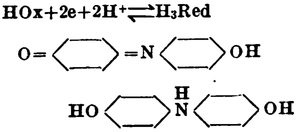
Equation: $E_h = C + \frac{RT}{2F}(pK_3 + pK_2 + pK_r) - \frac{3}{2}\frac{RT}{F} pH - \frac{RT}{2F} \ln \frac{[H_3Red]}{[Ox]}$ (10)

Curve D, Figure 2.

E.

System: $HOx + 2e + 2H^+ \rightleftharpoons H_3Red$

Example:



(HOx)

(H_3Red)

Equation: $E_h = C + \frac{RT}{2F}(pK_3 + pK_2 + pK_r - pK_o) - \frac{RT}{F} pH - \frac{RT}{2F} \ln \frac{[H_3Red]}{[HOx]}$ (11)

Curve E, Figure 2.

81739°—24——3

TABLE 28.—"*Normal potentials.*"

System.	A	B	C	D	$E = E_0$
Phenol indophenol	(?)	0.292	0.610	0.893	0.6494
o-Cresol indophenol	(?)	.255	.583	.869	.6160
m-Cresol indophenol	(?)	.280	.602	.890	.6316
Thymol (o-C_3H_7-m-CH_3) indophenol	(?)	.235	.559	.857	.5923
Carvacrol (o-CH_3-m-C_3H_7) indophenol	(?)	.241	.563	.861	.5931
o-Bromophenol indophenol	(?)	.310	.617	.872	.6586
m-Bromophenol indophenol	(?)	.327	.636	.905	.6700
o-Chlorophenol indophenol	(?)	.310	.619	.873	.6627

THE HEALTH SECTION OF THE LEAGUE OF NATIONS.

Work Being Done by the Service of Epidemiological Intelligence and Public Health Statistics.

In a report dated January 10, 1924, made to the medical director of the Health Section of the League of Nations, an outline of the work of the Service of Epidemiological Intelligence and Public Health Statistics was presented in some detail. Progress already made in this work has been due to the aid and cooperation of the various public health services and ministries of health, and it is hoped that the work can be continued and further developed on this cooperative basis.

The scope of the activities of the Service of Epidemiological Intelligence and Public Health Statistics are set forth as follows:

I. Epidemiological intelligence, including—
   1. Current epidemiological reports and publications, and
   2. Special epidemiological studies.

II. Reports on health organization and current activities in the various countries.

III. The study of official vital statistics and statistical procedure, including—
   1. Preparation of handbooks on official vital statistics, and
   2. Studies on the comparability of statistics.

IV. Collective studies on vital and public health statistics.

I. EPIDEMIOLOGICAL INTELLIGENCE.

A distinction in this field is drawn between current epidemiological information (such as weekly, monthly, and annual summaries) and special scientific studies (such as world distribution of certain diseases, comparative epidemiology in different countries, periodicity, etc.).

1. CURRENT EPIDEMIOLOGICAL INFORMATION.

Sources of information.—(1) Through the public health services and statistical offices reports from the different countries. Current reports on the prevalence of notifiable diseases are received from the following countries:

EUROPE.

Austria.
Belgium.
Bulgaria.
Czechoslovakia.
Danzig.
Denmark.
England and Wales.
Esthonia.
Finland.
France.
Germany.
Greece.
Hungary.
Ireland (Northern).
Italy.
Latvia.
Lithuania.
Netherlands.
Norway.
Poland.
Rumania.
Russia.
Scotland.
Kingdom of the Serbs, Croats, and Slovenes.
Spain.
Sweden.
Switzerland.
Turkey (Constantinople).

AFRICA.

Algeria.
Basutoland.
Egypt.
Gold Coast
Kenya and East African Protectorate.
Mauritius Island.
Morocco, French zone.
Nigeria.
Nyasaland.
Northern Rhodesia.

AFRICA—continued.

Southern Rhodesia.
Siarra Leone.
Tanganyika Territory.
Protectorate of Tunis.
Uganda.
Union of South Africa.
Zanzibar.

AMERICA.

Brazil (Rio de Janeiro).
Costa Rica.
Cuba.
Ecuador.
British Guiana.
Republic of Haiti.
Mexico (Mexico City).
Panama Canal Zone.
Republic of Salvador.
San Domingo.
United States.
Uruguay.
West Indies (British).
Saint Lucia.
Saint Vincent.
Grenada.
Trinidad and Tobago.

ASIA.

Aden Protectorate (Arabia).
Ceylon.
China (Hongkong).
British India.
Iraq (Mesopotamia).
Malay States (federated).
Malay States (unfederated).
Palestine.
Siam.
Straits Settlements.

AUSTRALASIA.

Australia.
New Zealand.

(2) A constant effort is being made to secure special epidemiological reports and also summaries of reports on infectious diseases, natality, mortality, and population.

(3) Public health and medical periodicals.

(4) Telegraphic information from the daily press.

Recording the epidemiological information.—All information relating to the occurrence of and deaths from notifiable diseases is recorded, as soon as received, on record blanks, separate sheets being used for each disease in each country and civil subdivision, so that the course of the disease and the latest report may be immediately available. The data for previous years are summarized for comparative purposes. Special data and epidemiological observations are indexed for reference, as are also statistical morbidity and mortality reports and medical intelligence of especial interest.

Publication of epidemiological information.—Two current summaries are being published regularly, namely, the Monthly Epidemiological Report and an Annual Summary of notifiable diseases. To these should also be added the special epidemiological reports, which are issued at irregular intervals, whenever conditions warrant.

The chief purpose of the Monthly Epidemiological Report is to provide public health services, epidemiologists, and other persons interested, current information of the course of the important communicable diseases in countries other than their own.

The Annual Summaries, as the title implies, summarize the current reports of notifiable diseases for the calendar year, and are presented with tables, charts, and text.

2. SPECIAL EPIDEMIOLOGICAL STUDIES.

The special epidemiological studies report detailed epidemiological investigations of such questions as world distribution of a particular disease, comparative epidemiology in different countries, periodicity of epidemics, and special analyses of epidemiological data.

II. REPORTS ON HEALTH ORGANIZATION AND CURRENT ACTIVITIES IN THE VARIOUS COUNTRIES.

It was early considered essential for the Health Section to have data on health organization and administration in the different countries, and a systematic collection of such information was begun. Reports on the following countries had been completed at the time of this report to the medical director: Albania, Austria, Belgium, Czechoslovakia, Denmark, Finland, Germany, Hungary, Italy, Netherlands, Norway, Spain, and Sweden. The reports on the following six countries were in preparation: France, Poland, Portugal, Rumania, Kingdom of the Serbs, Croats, and Slovenes, and Switzerland.

Arrangements were being made to develop a liaison between the public health services and the health organization of the League, whereby it is expected that current information relative to the various health activities in the several countries will be made available for the health section.

III. THE STUDY OF OFFICIAL VITAL STATISTICS AND STATISTICAL PROCEDURE.

Because of the great differences between the countries in the method of registering deaths and births, in diagnosing diseases causing death, in classifying these causes, etc., and the wide variations in accuracy and completeness of the reports, no comparisons or accurate scientific use of the data can be made without a thorough understanding of these differences and shortcomings. It is essential, therefore, that a careful study should be made of the medical statistics of each country by competent medical statisticians, and such a study has been carried out for 13 countries, and partially completed for 6 more. The information secured covers the following points for each country:

A. Legislation and procedure as regards—
   (*a*) Registration of population (including census), births, deaths, and stillbirths.
   (*b*) Certification of causes of death.
   (*c*) Notification of diseases.

B. Procedure in the compilation and tabulation of the data referred to above.

C. Official statistics, showing the distinction made as to sex, age, race (and nationality), civil condition, occupation, etc., of data on population, natality, morbidity, and mortality.

1. HANDBOOKS ON OFFICIAL VITAL STATISTICS.

Preliminary drafts on the vital statistics of three countries, the Netherlands, Spain, and Portugal, were submitted to the Health Section in 1923, and it was decided that in addition to the data on vital statistics, these handbooks should also include information on statistical procedure and organization, and deal more in detail with the laws governing registration of population, births, deaths, and the notification of diseases. It is hoped that about two of these handbooks can be issued every half year, and it is planned to issue the next two on Great Britain and Belgium. Before publication, the handbooks, in every instance, will be approved by the public health services and the statistical departments of the countries concerned.

2. STUDIES ON THE COMPARABILITY OF STATISTICS.

The question of the best procedure in making a comparative study of the statistics of the different countries has been given special consideration, and the present report to the Medical Director makes the recommendation that special committees of technical statisticians be appointed to advise and collaborate in the study of the following subjects:

(1) On statements of the causes of death in the different countries, and on the procedure in classification of deaths in the different countries;

(2) On uniformity in statistical presentation of mortality, with special reference to the sex and age groups in tables of mortality from all causes, as well as for specific causes;
(3) On the definition of stillbirths;
(4) On a standard population for use in the standardization of mortality rates;
(5) On notification of disease for statistical purposes and morbidity statistics.

IV. COLLECTIVE STUDIES ON VITAL AND PUBLIC HEALTH STATISTICS.

The Provisional Health Committee outlined a scheme for the work on collective studies of vital and public health statistics in the following terms:

(*a*) Bringing medical statisticians into closer relations with each other and with the Service of Epidemiological Intelligence and Public Health Statistics; and
(*b*) Affording a means by which various important differences between countries with respect to vital statistics and epidemiological records can be studied and a greater uniformity secured.

Since the project was, in many respects, an entirely new one, plans for its operation were at first naturally largely experimental. With the concurrence of the chairman of the committee, the following general plan was considered:

1. To institute a series of "interchanges" or group conferences at Geneva, and possibly at one or two other convenient points, in which vital statisticians and epidemiologists occupying administrative positions in their respective governments would participate for periods of two to three months.
2. To hold a series of conferences with medical statisticians in connection with certain phases of the work of the Service of Epidemiological Intelligence and Public Health Statistics, and on the study of specific statistical procedures in which uniformity and comparability are most important.
3. To provide the opportunity for a limited number of officers to be selected by the various Governments from their public health services, to study the application of statistical methods and practices at selected institutions and public record offices.

In accordance with this plan, a group of statisticians and epidemiologists gathered at Geneva in October, 1923, for a collective study of vital statistics. The work of the group was divided into three general steps: First, a collective study of vital statistics at Geneva (about six weeks); second, visits to statistical and epidemiological offices in Switzerland, Paris, The Hague, and London (about one month); third, a series of final conferences in Geneva (about 10 days).

In general, the work of this group at Geneva covered the following subjects:

(1) Registration of deaths, with particular reference to the procedure and factors governing the completeness and accuracy of statements of causes of death.

(2) Mortality statistics, with a study of the various methods of census enumeration, population, registration, and details of population statistics from the point of view of their use in vital statistics.

(3) Methods of making intercensal estimates of population.

(4) Standardization of rates and methods of adjusting death rates to standard populations.

(5) Registration of births, with particular reference to the definition of stillbirths.

(6) Statistics of births and of infantile mortality.

(7) Statistics of disease prevalence and epidemiological intelligence.

A detailed report on the proceedings of this work of collective study has been prepared.

It is proposed to have two such studies made during 1924, which will undoubtedly profit by the experience gained last year.

Statisticians have been invited to come to Geneva for conferences with members of the staff on the study of vital statistics of various countries and their comparability; and from them valuable suggestions and advice will be had which will contribute materially to the furtherance of this work.

It may be of interest here to make mention of the recent meeting of the Permanent Health Organization of the League of Nations in Geneva, the first held since the amalgamation of the International Bureau of Public Health in Paris with the Provisional Health Committee.

An extensive program was presented at this meeting, which included reports on the sanitary arrangements at the world's seaports and progress of the fight against cancer, malaria, and the opium evil. The report of a committee sent to the Far East suggests the establishment there of a central bureau of epidemiological intelligence, preferably at Singapore, and recommends that far eastern countries conclude a sanitary convention.

Plans have been drawn up to bring about greater coordination of the health administration of all countries to enable a more effective world-wide fight against disease.

TRICHINOSIS AND TYPHOID CARRIERS IN NEW YORK STATE.

The following notes are taken from a recent issue of the Health News, a weekly bulletin published by the New York State Department of Health:

TRICHINOSIS.

Three outbreaks of trichinosis have recently been reported in the State, with a total of 19 cases and 3 deaths. Of these, 7 cases with 3 deaths occurred at Rochester, 10 cases in Yonkers, and 2 cases in Patterson, a small village in Putnam County.

The Rochester cases occurred in one family, all of whom ate raw pork which had been purchased in a public market about Christmas time. In Yonkers, four of the cases were in one family, two in another family, and one case each in four families. It was not possible to trace the source of the pork eaten by these people. The Patterson cases were a mother and a 21-month old baby who ate home-produced pork. No other cases were found in the neighborhood.

Laboratory confirmation was obtained in all cases.

The bulletin warns health officers to be on the lookout for cases of trichinosis, as the physician who attended the cases in Yonkers states that he is convinced that there were many cases in Westchester County diagnosed as grippe.

In view of the fact that the United States Department of Agriculture states that no system of meat inspection is sufficiently certain in its application to prevent the sale of pork infected with trichinæ, the health commissioner of New York State cautions against eating pork which has not been thoroughly cooked, and advises that a temperature of 160° F. is necessary to destroy the infecting organism.

TYPHOID BACILLUS CARRIERS.

The division of communicable diseases reports that on January 1, 1924, it had 90 persons on its list of typhoid bacillus carriers, as against 71 carriers on January 1, 1923. During the year 1923, 4 carriers died, 1 moved out of the State, 3 were returned to the list, and 21 new carriers were discovered. In addition to these, there are now 18 carriers in State hospitals as against 16 in 1923.

Of the 21 new carriers, 4 are male and 17 are female. Four of the new carriers were working on dairy farms, and one of them was responsible for 25 cases of typhoid fever.

In all, 69 cases of typhoid are attributed to these 21 carriers; but not all of the cases occurred during the past year.

The history of one woman covers 12 years, during which time she has been responsible for 16 cases. Two others, a man and wife, have been responsible for 6 cases occurring among relatives whom they have visited from time to time during the past 18 years. The youngest of the carriers was 23 years of age; the oldest, 74.

DEATHS DURING THE WEEK ENDED FEBRUARY 16, 1924.

Summary of information received by telegraph from industrial insurance companies for week ended Feb. 16, 1924, and corresponding week of 1923. (From the Weekly Health Index, Feb. 19, 1924, issued by the Bureau of the Census, Department of Commerce.

	Week ended Feb. 16, 1924.	Corresponding week, 1923.
Policies in force	56, 318, 460	52, 140, 069
Number of death claims	10, 615	11, 271
Death claims per 1,000 policies in force, annual rate	9. 8	11. 3

Deaths from all causes in certain large cities of the United States during the week ended Feb. 16, 1924, infant mortality, annual death rate, and comparison with corresponding week of 1923. (From the Weekly Health Index, Feb. 19, 1924, issued by the Bureau of the Census, Department of Commerce.)

City.	Week ended Feb. 16, 1924.		Annual death rate per 1,000, corresponding week, 1923.	Deaths under 1 year.		Infant mortality rate, week ended Feb. 16, 1924.[2]
	Total deaths.	Death rate.[1]		Week ended Feb. 16, 1924.	Corresponding week, 1923.	
Total	8,180	14.0	17.5	1,057	1,243	....
Akron	31	7.8	7.8	4	5	42
Albany[3]	32	14.1	25.8	3	4	66
Atlanta	97	22.2	17.1	16	14	....
Baltimore[3]	249	16.5	21.3	28	41	81
Birmingham	70	18.2	11.2	11	5	....
Boston	252	16.9	22.7	33	52	92
Bridgeport	39	14.2	14.9	3	4	47
Buffalo	127	12.1	16.7	24	33	102
Cambridge	31	14.4	14.5	3	4	52
Camden[3]	41	16.9	21.0	4	7	63
Canton	12	6.1	12.1	2	5	42
Chicago[3]	684	12.1	15.7	113	146	104
Cincinnati	138	17.6	22.5	20	10	126
Cleveland	219	12.5	14.3	38	44	99
Columbus	82	16.0	24.4	7	14	67
Dallas	61	16.9	11.2	7	8	....
Dayton	40	12.3	15.8	3	7	50
Denver	74	14.0	20.5	10	14	....
Des Moines	31	11.1	15.2	4	4	....
Detroit	257	13.5	16.0	55	56	102
Duluth	28	13.5	12.3	2	3	43
Erie	33	14.9	19.9	7	9	144
Fall River[3]	37	15.9	15.5	9	10	127
Flint	28	11.8	19.0	8	5	138
Fort Worth	23	8.1	8.0	1	5	....
Grand Rapids	31	10.9	21.1	1	7	16
Houston	33	10.8	9.7	8	5	....
Indianapolis	96	14.3	19.2	10	16	76
Jacksonville, Fla	33	16.8	16.7	4	5	....
Jersey City	95	15.9	18.1	14	13	101
Kansas City, Kans	47	20.8	14.4	6	5	120
Kansas City, Mo	108	15.7	18.1	9	11	....
Los Angeles	229	17.0	17.3	17	17	53
Louisville	83	16.7	24.1	16	19	154
Lowell	29	13.1	18.1	3	4	54
Lynn	15	7.5	14.7	3	3	76

[1] Annual rate per 1,000 population.
[2] Deaths under 1 year per 1,000 births—an annual rate based on deaths under 1 year for the week and estimated births for 1923. Cities left blank are not in the registration area for births.
[3] Deaths for week ended Friday, Feb. 15, 1924.

Deaths from all causes in certain large cities of the United States during the week ended Feb. 16, 1924, infant mortality, annual death rate, and comparison with corresponding week of 1923. (From the Weekly Health Index, Feb. 19, 1924, issued by the Bureau of the Census, Department of Commerce)—Continued.

City.	Week ended Feb. 16, 1924.		Annual death rate per 1,000, corresponding week, 1923.	Deaths under 1 year.		Infant mortality rate, week ended Feb. 16, 1924.
	Total deaths.	Death rate.		Week ended Feb. 16, 1924.	Corresponding week, 1923.	
Memphis	69	20.9	19.3	4	6	....
Milwaukee	108	11.4	17.1	22	20	101
Minneapolis	83	10.4	14.4	10	12	54
Nashville [3]	58	24.5	17.0	7	6	....
New Bedford	31	12.2	12.8	7	9	109
New Haven	44	13.0	18.1	6	3	78
New Orleans	196	25.0	22.4	11	14	....
New York	1,492	12.9	17.5	191	207	77
Bronx Borough	174	10.4	17.0	15	20	53
Brooklyn Borough	517	12.3	15.8	67	68	72
Manhattan Borough	650	15.0	19.6	92	100	90
Queens Borough	92	8.6	15.5	11	16	60
Richmond Borough	59	23.5	21.7	6	3	109
Newark, N. J	113	13.2	18.2	13	17	61
Norfolk	34	10.8	10.5	9	4	164
Oakland	68	14.4	14.3	3	4	38
Oklahoma City	28	14.0	....	3	....	....
Omaha	55	13.8	16.6	6	10	64
Paterson	42	15.6	19.1	1	7	16
Philadelphia	576	15.4	19.0	65	73	83
Pittsburgh	193	16.1	24.5	32	32	109
Portland, Oreg	62	11.6	13.3	4	8	41
Providence	79	16.9	23.0	9	15	73
Richmond	59	16.7	21.0	8	5	94
Rochester	71	11.4	16.8	10	8	78
St. Louis	233	14.9	17.9	15	25	....
St. Paul	44	9.4	19.6	6	11	52
Salt Lake City [3]	42	17.0	10.3	4	6	66
San Antonio	59	16.1	15.5	13	9	....
San Francisco	159	15.1	15.1	14	12	84
Schenectady	28	14.5	17.4	4	2	113
Seattle	50	8.3	11.2	9	7	87
Somerville	22	11.4	15.3	3	4	82
Spokane	23	11.5	13.0	1	1	21
Springfield, Mass	43	15.1	18.4	2	6	34
Syracuse	46	12.8	17.5	6	6	74
Tacoma	23	11.6	12.8	4	3	92
Toledo	65	12.3	15.7	8	3	76
Trenton	36	14.5	22.9	4	7	66
Utica	28	13.9	25.7	3	5	65
Washington, D. C	145	17.3	25.4	10	27	58
Waterbury	23	12.0	10.6	3	3	67
Wilmington, Del	35	15.2	19.9	6	7	130
Worcester	31	8.3	18.2	2	7	24
Yonkers	25	11.9	14.1	6	2	131
Youngstown	44	17.3	12.6	7	7	101

[3] Deaths for week ended Friday, Feb. 15, 1924.

PREVALENCE OF DISEASE.

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditions cases are occurring.

UNITED STATES.

CURRENT STATE SUMMARIES.

These reports are preliminary, and the figures are subject to change when later returns are received by the State health officers.

Reports for Week Ended February 23, 1924.

ALABAMA.

	Cases.
Cerebrospinal meningitis	2
Chicken pox	45
Diphtheria	12
Influenza	116
Malaria	9
Measles	806
Mumps	57
Pellagra	5
Pneumonia	224
Scarlet fever	8
Smallpox	29
Tuberculosis	47
Typhoid fever	16
Whooping cough	64

ARIZONA.

Chicken pox	7
Diphtheria	1
Measles	63
Mumps	1
Pneumonia	1
Scarlet fever	4
Smallpox	2
Typhoid fever	1
Whooping cough	3

ARKANSAS.

Chicken pox	29
Diphtheria	5
Influenza	253
Measles	460
Mumps	13
Paratyphoid fever	2
Pellagra	3
Scarlet fever	15
Smallpox	24
Trachoma	2
Tuberculosis	14
Typhoid fever	11
Whooping cough	54

CALIFORNIA.

	Cases.
Cerebrospinal meningitis:	
San Francisco	1
San Mateo County	1
Diphtheria	184
Influenza	19
Lethargic encephalitis:	
Berkeley	1
Los Angeles County	1
San Joaquin County	1
Measles	829
Poliomyelitis—Crescent City	2
Scarlet fever	152
Smallpox:	
Compton	37
Fullerton	11
Long Beach	45
Los Angeles	145
Los Angeles County	35
Orange County	15
Scattering	58
Typhoid fever:	
Santa Ana	12
Scattering	11

COLORADO.

(Exclusive of Denver.)

Chicken pox	17
Impetigo contagiosa	2
Influenza	3
Measles	190
Mumps	38
Pneumonia	14
Scarlet fever	31
Smallpox	3
Tuberculosis	59
Typhoid fever	4

CONNECTICUT.

Chicken pox	80
Conjunctivitis (infectious)	2

CONNECTICUT—continued.

	Cases.
Diphtheria	52
German measles	11
Influenza	13
Lethargic encephalitis	1
Measles	120
Mumps	111
Pneumonia (lobar)	38
Scarlet fever	163
Septic sore throat	1
Smallpox	1
Tetanus	1
Tuberculosis (all forms)	26
Typhoid fever	1
Whooping cough	31

DELAWARE.

Chicken pox	4
Diphtheria	4
Influenza	4
Measles	6
Mumps	1
Pneumonia	5
Scarlet fever:	
Wilmington	8
Scattering	2
Tuberculosis	2
Whooping cough	3

DISTRICT OF COLUMBIA.

Chicken pox	71
Diphtheria	6
Influenza	3
Measles	7
Scarlet fever	34
Smallpox	4
Tuberculosis	24
Typhoid fever	1
Whooping cough	10

FLORIDA.

Cerebrospinal meningitis	1
Diphtheria	22
Influenza	7
Malaria	6
Pneumonia	11
Scarlet fever	1
Smallpox	3
Typhoid fever	10

GEORGIA.

Chicken pox	35
Diphtheria	5
German measles	12
Hookworm disease	1
Influenza	75
Malaria	8
Measles	280
Mumps	12
Pneumonia	38
Rabies	1
Scarlet fever	6
Septic sore throat	2
Smallpox	135
Tuberculosis (pulmonary)	16
Typhoid fever	1
Whooping cough	175

ILLINOIS.

	Cases.
Diphtheria:	
Cook County	75
Pike County	9
Scattering	54
Influenza	69
Lethargic encephalitis—Saline County	1
Measles	486
Pneumonia	389
Poliomyelitis—Cook County	1
Scarlet fever:	
Cook County	114
DeKalb County	13
Kane County	18
Lake County	12
Macon County	12
Peoria County	8
Stephenson County	8
Scattering	92
Smallpox:	
Cook County	7
Scattering	2
Tuberculosis	262
Typhoid fever	18
Whooping cough	152

INDIANA.

Chicken pox	95
Diphtheria:	
Hamilton County	13
Marion County	12
Marshall County	9
Scattering	34
Influenza:	
Clark County	12
Scattering	13
Measles	482
Pneumonia	20
Scarlet fever:	
Allen County	9
Delaware County	14
Lake County	28
Marshall County	9
Scattering	61
Smallpox:	
Marion County	20
Marshall County	9
Rush County	10
Scattering	13
Tuberculosis:	
Marion County	20
Scattering	13
Typhoid fever	8
Whooping cough	85

IOWA.

Diphtheria	23
Scarlet fever	75
Smallpox	14
Typhoid fever	1

KANSAS.

Chicken pox	125
Diphtheria	28
German mealses	21
Influenza	2
Measles	1,083

KANSAS—continued.

	Cases.
Mumps	154
Pellagra	2
Pneumonia	58
Scarlet fever	69
Septic sore throat	1
Smallpox	45
Tuberculosis	50
Typhoid fever	3
Whooping cough	97

LOUISIANA.

Diphtheria	38
Hookworm disease	37
Influenza	45
Measles	380
Pneumonia	52
Scarlet fever	7
Smallpox	15
Tuberculosis	39
Typhoid fever	13

MAINE.

Chicken pox	55
Diphtheria	6
German measles	7
Influenza	6
Measles	39
Mumps	19
Pneumonia	12
Scarlet fever	36
Tuberculosis	14
Whooping cough	49

MARYLAND.[1]

Cerebrospinal meningitis	1
Chicken pox	167
Conjunctivitis	1
Diphtheria	24
Dysentery	2
German measles	14
Influenza	51
Lethargic encephalitis	1
Measles	167
Mumps	25
Pneumonia (all forms)	139
Scarlet fever	112
Septic sore throat	1
Smallpox	1
Tuberculosis	41
Typhoid fever	6
Whooping cough	45

MASSACHUSETTS.

Cerebrospinal meningitis	4
Chicken pox	235
Conjunctivitis (suppurative)	19
Diphtheria	122
German measles	25
Influenza	9
Lethargic encephalitis	3
Measles	790
Mumps	238
Ophthalmia neonatorum	15

[1] Week ended Friday.

MASSACHUSETTS—continued.

	Cases.
Pneumonia (lobar)	113
Scarlet fever	441
Septic sore throat	2
Smallpox	1
Trichinosis	5
Tuberculosis (all forms)	143
Typhoid fever	11
Whooping cough	69

MICHIGAN.

Diphtheria	142
Measles	411
Pneumonia	153
Scarlet fever	356
Smallpox	165
Tuberculosis	31
Typhoid fever	4
Whooping cough	49

MINNESOTA.

Cerebrospinal meningitis	1
Chicken pox	39
Diphtheria	66
Influenza	1
Measles	384
Pneumonia	12
Scarlet fever	345
Smallpox	73
Tuberculosis	60
Typhoid fever	2
Whooping cough	14

MISSISSIPPI.

Diphtheria	10
Smallpox	11
Typhoid fever	12

MISSOURI.

Chicken pox	41
Diphtheria	73
Influenza	20
Measles	432
Mumps	79
Pneumonia	24
Scarlet fever	133
Septic sore throat	7
Smallpox	12
Tetanus	1
Trachoma	4
Tuberculosis	34
Typhoid fever	3
Whooping cough	67

MONTANA.

Chicken pox	25
Diphtheria	11
Measles	416
Pneumonia	2
Scarlet fever	38
Smallpox	31
Tuberculosis	4
Typhoid fever	2
Whooping cough	20

NEBRASKA.

	Cases.
Chicken pox	20
Diphtheria	8
Measles	405
Mumps	12
Pneumonia	8
Scarlet fever	32
Typhoid fever	1
Whooping cough	9

NEW JERSEY.

Cerebrospinal meningitis	4
Chicken pox	270
Diphtheria	83
Influenza	30
Measles	539
Pneumonia	183
Scarlet fever	146
Smallpox	7
Typhoid fever	5
Whooping cough	90

NEW MEXICO.

Chicken pox	12
Conjunctivitis	3
Diphtheria	18
Influenza	1
Measles	104
Mumps	3
Pneumonia	15
Scarlet fever	8
Septic sore throat	1
Smallpox	1
Tuberculosis	24
Typhoid fever	2
Whooping cough	4

NEW YORK.

(Exclusive of New York City.)

Cerebrospinal meningitis	2
Diphtheria	119
Influenza	60
Lethargic encephalitis	2
Measles	1,248
Pneumonia	329
Poliomyelitis	2
Scarlet fever	387
Smallpox	14
Typhoid fever	17
Whooping cough	259

NORTH CAROLINA.

Chicken pox	173
Diphtheria	30
German measles	7
Measles	1,950
Scarlet fever	46
Septic sore throat	1
Smallpox	213
Typhoid fever	2
Whooping cough	342

OREGON.

Chicken pox	20
Diphtheria:	
Portland	19
Scattered	8

[1] Deaths.

OREGON—continued.

	Cases.
Influenza	1
Measles	220
Mumps	15
Pneumonia	[1] 6
Scarlet fever	15
Smallpox:	
Portland	19
Scattered	10
Trichinosis	5
Tuberculosis	5
Typhoid fever	1
Whooping cough	5

SOUTH DAKOTA.

Chicken pox	37
Diphtheria	4
Measles	213
Mumps	30
Pneumonia	11
Scarlet fever	38
Smallpox	1
Whooping cough	16

TEXAS.

Chicken pox	29
Dengue	3
Diphtheria	7
Influenza	49
Lethargic encephalitis	1
Measles	617
Mumps	33
Pneumonia	24
Scarlet fever	27
Smallpox	6
Tuberculosis	11
Typhoid fever	19
Whooping cough	7

VERMONT.

Chicken pox	29
Diphtheria	5
Measles	119
Mumps	12
Pneumonia	2
Scarlet fever	20
Smallpox	3
Whooping cough	53

WASHINGTON.

Chicken pox	46
Diphtheria	31
Measles	1,273
Mumps	35
Pneumonia	6
Scarlet fever:	
Seattle	11
Spokane	18
Scattering	14
Smallpox:	
Spokane	25
Scattering	12
Tuberculosis	2
Typhoid fever	2
Whooping cough	20

WEST VIRGINIA.

	Cases.
Diphtheria	8
Scarlet fever	16
Typhoid fever	8

WISCONSIN.

	Cases.
Milwaukee:	
Chicken pox	54
Diphtheria	14
Measles	8
Pneumonia	4
Scarlet fever	24
Tuberculosis	12
Typhoid fever	2
Whooping cough	43
Scattering:	
Chicken pox	136
Diphtheria	55
German measles	1
Influenza	28

WISCONSIN—continued.

	Cases.
Scattering—Continued.	
Measles	582
Pneumonia	47
Scarlet fever	313
Smallpox	18
Tuberculosis	41
Typhoid fever	6
Whooping cough	103

WYOMING.

	Cases.
Chicken pox	1
Diphtheria	1
Influenza	1
Measles	63
Pneumonia	1
Scarlet fever	7
Tuberculosis	1
Whooping cough	2

Reports for Week Ended February 16, 1924.

NORTH DAKOTA.

	Cases.
Chicken pox	18
Diphtheria	18
Measles	290
Pneumonia	41
Scarlet fever	74
Smallpox	4
Trachoma	2
Tuberculosis	3
Whooping cough	35

SUMMARY OF CASES REPORTED MONTHLY BY STATES.

The following summary of monthly State reports is published weekly and covers only those States from which reports are received during the current week:

State.	Cerebrospinal meningitis.	Diphtheria.	Influenza.	Malaria.	Measles.	Pellagra.	Poliomyelitis.	Scarlet fever.	Smallpox.	Typhoid fever.
December, 1923.										
Minnesota	3	524	2		758		6	1,243	221	36
January, 1924.										
Alabama	3	71	526	75	2,102	15	2	51	[1] 107	47
Arizona		11			206			59	7	3
Delaware	1	46	9	2	6			88		7
Georgia		50	177	15	785	3	2	34	293	10
Idaho		14		0		0	0	33	12	2
Illinois	11	1,007	104	1	2,475		12	1,435	37	159
Louisiana	3	122	205	10	1,008	5		28	70	32
Maine	4	57	18	1		0		120	0	12
Maryland	0	226	260	4	393	0	2	482	3	43
Michigan		961	19		2,247		3	1,617	543	27
Minnesota	2	473	8	0	1,275	0	0	1,349	242	25
New Jersey	11	607	130	0	1,417		5	746	101	28
North Carolina	3	202			6,014			245	569	20
Ohio	4	1,257	48	1	532		4	1,715	291	60
Rhode Island		100	2		26			411		8
South Carolina		124	99	5	954	11		22	68	5
South Dakota	3	42	33		637			323	15	8
Wisconsin	10	367	115		1,308		1	1,375	104	17

[1] In addition, an outbreak of smallpox occurred during January in Cleburne County. Over 100 cases found; no deaths.

RECIPROCAL NOTIFICATION, JANUARY, 1924.

Cases of communicable diseases referred during January, 1924, to other State health departments by departments of health of certain States.

Referred by—	Diphtheria.	Measles.	Poliomyelitis.	Scarlet fever.	Smallpox.	Trachoma.	Tuberculosis.	Typhoid fever.
Connecticut	1	2	....	2	2	....	1	....
Illinois	....	....	....	....	1	2	20	2
Massachusetts	....	....	....	....	....	....	....	1
Minnesota	1	....	....	1	....	....	24	3
New Jersey	....	....	....	1	....	....	....	1
New York	1	....	1	5	2	....	....	4

CITY REPORTS FOR WEEK ENDED FEBRUARY 9, 1924.

Diphtheria.—The cities included in the table showed very little variation in the number of cases of diphtheria reported each week from the first of the year to February 9. The figures are, in general, very close to the estimated expectancy and very slightly higher than the figures for the corresponding period of last year.

Influenza and pneumonia.—An increase in the number of deaths attributed to influenza and to pneumonia is shown in the tables from the first of the year to February 9. The figures are small, however, as compared with those for the corresponding period of last year.

Measles.—Some improvement was shown for the week ended February 9, 1924, in the number of cases of measles as compared with the preceding week. There were more cases reported than for the first two weeks of this year, however, and more than were reported by the same cities during the corresponding week of last year.

Scarlet fever.—The reports from the cities, and also reports from States, indicated that scarlet fever was more prevalent during the first six weeks of this year than it was during the corresponding period of last year. The number of cases reported is considerably higher than the estimated expectancy.

Smallpox.—Continued improvement was noted in the reports of smallpox from the cities in the Pacific Coast States for the week ended February 9, 1924, as compared with the three preceding weeks. Increased prevalence in a few eastern cities made the total for all the cities higher than it was for the two preceding weeks.

City reports for week ended February 9, 1924.

The "estimated expectancy" given for diphtheria, poliomyelitis, scarlet fever, smallpox, and typhoid fever is the result of an attempt to ascertain from previous occurrence how many cases of the disease under consideration may be expected to occur during a certain week in the absence of epidemics. It is based on reports to the Public Health Service during the past nine years. It is in most instances the median number of cases reported in the corresponding week of the preceding years. When the reports include several epidemics, or when for other reasons the median is unsatisfactory, the epidemic periods are excluded and the estimated expectancy is the mean of the number of cases reported for the week during nonepidemic years.

If reports have not been received for the full nine years, data are used for as many years as possible, but no year earlier than 1915 is included. In obtaining the estimated expectancy, the figures are smoothed when necessary to avoid abrupt deviations from the usual trend. For some of the diseases given in the table the available data were not sufficient to make it practicable to compute the estimated expectancy.

Division, State, and city.	Chicken pox, cases reported.	Diphtheria.		Influenza.		Measles, cases reported.	Mumps, cases reported.	Pneumonia, deaths reported.	Scarlet fever.	
		Cases, estimated expectancy.	Cases reported.	Cases reported.	Deaths reported.				Cases, estimated expectancy.	Cases reported.
New England:										
Maine—										
Lewiston	3	2	0	0	0	1	0	0	2	6
Portland	0	2	4	0	0	1	0	3	2	2
New Hampshire—										
Concord	0	1	0	0	0	12	0	0	0	0
Nashua	....	0	0	0	0	0	....	1	2	4
Vermont—										
Barre	4	0	0	0	0	4	0	1	1	1
Burlington	....	1	2	0	0	0	....	2	2	1
Massachusetts—										
Boston	70	65	86	4	1	157	34	21	53	124
Fall River	2	6	7	2	0	3	1	5	2	3
Springfield	6	5	5	0	0	49	5	0	7	12
Worcester	12	5	0	0	0	10	30	4	9	0
Rhode Island—										
Pawtucket	0	1	2	0	0	0	0	2	1	10
Providence	0	16	9	....	1	1	0	16	8	90
Connecticut—										
Bridgeport	0	9	5	1	1	0	0	2	4	13
Hartford	....	8	16	0	0	27	....	0	5	41
New Haven	8	5	2	0	0	1	16	19	5	11
Middle Atlantic:										
New York—										
Buffalo	....	26	18	2	0	14	....	12	18	34
New York	262	273	246	60	21	771	179	233	177	244
Rochester	0	11	7	0	0	0	2	6	11	13
Syracuse	35	10	12	0	0	62	0	8	17	78
New Jersey—										
Camden	....	4	9	0	0	2	....	6	2	4
Newark	73	28	10	19	0	58	65	12	22	21
Trenton	1	8	10	1	0	23	0	4	2	7
Pennsylvania—										
Philadelphia	0	74	140	3	8	56	163	71	55	124
Pittsburgh	73	23	36	1	4	9	57	66	19	43
Reading	....	4	2	0	0	7	....	3	1	4
Scranton	7	5	2	....	1	0	0	6	6	1
East North Central:										
Ohio—										
Cincinnati	33	14	9	1	3	84	10	21	9	15
Cleveland	67	34	41	7	2	17	179	27	39	19
Columbus	....	3	7	....	1	4	....	3	7	14
Toledo	0	8	8	0	0	33	0	8	15	23
Indiana—										
Fort Wayne	10	3	3	0	0	6	0	0	3	10
Indianapolis	27	14	8	....	2	2	116	18	10	1
South Bend	....	2	2	0	0	0	....	0	1	21
Terre Haute	3	2	2	0	0	4	0	4	3	1
Illinois—										
Chicago	127	149	126	25	9	77	73	71	155	144
Cicero	8	2	2	0	0	1	17	3	2	0
Peoria	4	1	0	....	1	1	0	6	6	2
Springfield	2	2	1	0	0	1	1	5	1	1

City reports for week ended February 9, 1924—Continued.

Division, State, and city.	Chicken pox, cases reported.	Diphtheria.		Influenza.		Measles, cases reported.	Mumps, cases reported.	Pneumonia, deaths reported.	Scarlet fever.	
		Cases, estimated expectancy.	Cases reported.	Cases reported.	Deaths reported.				Cases, estimated expectancy.	Cases reported.
East North Central—continued.										
Michigan—										
Detroit	58	76	56	1	1	62	40	35	76	100
Flint	9	9	2	0	0	25	12	3	9	7
Grand Rapids		3	4	1	1	1		5	6	15
Saginaw	6	1	2	0	0	6	2	3	3	20
Wisconsin—										
Madison	12	1	0	0		2			2	13
Milwaukee	38	18	12	1	0	5		16	37	43
Racine	4	1	8	0	0	1		5	4	22
Superior	0	1	1	0	0	0		0	2	0
West North Central:										
Minnesota—										
Duluth	27	3	3	0	0	1	1	2	4	13
Minneapolis	115	20	18		1	13	3	7	23	67
St. Paul		12	25	0	0	52		7	23	64
Iowa—										
Davenport	1	1	11	0		0	0		2	6
Sioux City	0	2	3	0		1	0		2	0
Waterloo	1	1	0	0		2	7		2	5
Missouri—										
Kansas City	2	10	2	4	3	98	9	14	12	7
St. Joseph	2	3	0	0	0	31	1	3	3	2
St. Louis	35	64	32	0	0	24	13		27	70
North Dakota—										
Fargo	0	0	0	0	0	0	0	0	1	0
Grand Forks		1	0	0		2			2	1
South Dakota—										
Sioux Falls		1	2	0	0	22		2	4	4
Nebraska—										
Lincoln		1	3		1	96		2	3	2
Omaha	5	6	5	0	0	69	1	6	10	6
Kansas—										
Topeka	19	2	3		2	95	0	1	1	2
Wichita	8	2	4	0	0	233	148	4	2	7
South Atlantic:										
Delaware—										
Wilmington		2	1	1	0	0		3	3	12
Maryland—										
Baltimore	146	32	25	43	6	44	19	45	34	82
Cumberland		0	1	1	0	0		2	1	0
Frederick	1	1	0	0	0	28	2	0		3
District of Columbia—										
Washington	69	17	10	0	0	7	0	24	20	48
Virginia—										
Lynchburg	5	1	0	0	0	1	1	0	0	0
Norfolk	30	2	2	0	0	37	1	8	1	0
Richmond	5	4	1		2	13	0	5	4	4
Roanoke	3	2	1	0	1	0	1	1	1	1
West Virginia—										
Charleston	1	1	1	0	0	0	1	0	1	2
Huntington	4	2	0	0	0	0	0	0	1	2
Wheeling	2	1	1	0	0	1	2	4	1	10
North Carolina—										
Raleigh	3	1	1	0	0	18	0	0	1	1
Wilmington	0	1	2	0	0	28	0	1	1	0
Winston-Salem	3	1	1	0	0	115	5	2	1	13
South Carolina—										
Charleston	0	1	0	0	1	4	0	6	0	1
Columbia	4	1	0	0	0	48	9	3	0	0
Greenville	0	0	0	0	0	51	6	6	0	0
Georgia—										
Atlanta	1	2	2	3	2	9	0	18	3	5
Brunswick	0	0	0	0	0	38	0	0	0	0
Savannah	4	1	0	3	2	10	0	2	1	0
Florida—										
St. Petersburg			0	0	0	43		1		1
Tampa		2	1	1	0	10		3	1	0

City reports for week ended February 9, 1924—Continued.

Division, State, and city.	Chicken pox, cases reported.	Diphtheria.		Influenza.		Measles, cases reported.	Mumps, cases reported.	Pneumonia, deaths reported.	Scarlet fever.	
		Cases, estimated expectancy.	Cases reported.	Cases reported.	Deaths reported.				Cases, estimated expectancy.	Cases reported.
East South Central:										
Kentucky—										
Covington	2	2	0	0	0	6	0	4	1	1
Lexington	4	0	0	0	0	3	0	2	1	0
Louisville	4	9	3	3	0	2	2	22	5	5
Tennessee—										
Memphis	42	3	4		2	35	5	10	2	2
Nashville	4	1	1		1	0	1	9	3	2
Alabama—										
Birmingham	11	2	5	17	4	46	14	15	2	8
Mobile	2	1	0		3	5	0	1	1	0
Montgomery		1	0		3	4		2	1	0
West South Central:										
Arkansas—										
Fort Smith	4	0	2	0		13	1		0	2
Little Rock	0	1	1	4		11	0		2	2
Louisiana—										
New Orleans	3	12	10	4	6	67	0	19	4	10
Shreveport	1		0	1	1	23	3	3		0
Oklahoma—										
Tulsa	10	3	0	0		5	0		1	1
Texas—										
Dallas	6	5	14	0	0	243	12	9	2	2
Galveston	0	1	1	0	0	10	0	1	0	0
Houston		3	3	0	0	110		8	1	3
San Antonio	1	2	2	0	0	34	0	13	1	0
Mountain:										
Montana—										
Billings	1	0	0	0	0	23	0	0	1	0
Great Falls	7	1	0	0	0	129	0	0	1	9
Helena	0		0	0	0	0	0	0		0
Missoula	1	0	4	0	0	20	0	1	1	1
Idaho—										
Boise	0	0	0	0	0	3	0	0	1	1
Colorado—										
Denver	27	11	10		1	51	3	11	11	13
Pueblo	4	5	1	0	0	232	0	2	2	1
New Mexico—										
Albuquerque	0	0	0	1	0	0	0	1	3	1
Utah—										
Salt Lake City	23	3	6		1	517	5	9	4	1
Nevada—										
Reno	4	0	0	1	0	0	0	1	0	1
Pacific:										
Washington—										
Seattle	13	5	13	0		243	6		9	16
Spokane	17	5	8	0		132	0		4	11
Tacoma	4	1	1	0		191	3		4	1
Oregon—										
Portland	9	8	10	0	0	33	0	9	6	5
California—										
Los Angeles		24	105	12	0	119		21	15	54
Sacramento	13	1	2	0	0	18	0	4	1	3
San Francisco	24	18	52	8	3	95	6	9	16	49

City reports for week ended February 9, 1924—**Continued.**

Division, State, and city.	Population July 1, 1923, estimated.	Smallpox. Cases, estimated expectancy.	Smallpox. Cases reported.	Smallpox. Deaths reported.	Tuberculosis, deaths reported.	Typhoid fever. Cases, estimated expectancy.	Typhoid fever. Cases reported.	Typhoid fever. Deaths reported.	Whooping cough, cases reported.	Deaths, all causes.
New England:										
Maine—										
Lewiston	33,790	0	0	0	1	0	0	0	1	9
Portland	73,129	0	0	0	0	0	0	0	0	17
New Hampshire—										
Concord	22,408	0	0	0	2	0	0	0	2	7
Nashua	29,234	0	0	0	1	0	0	0	......	10
Vermont—										
Barre	[1] 10,008	0	0	0	0	0	0	0	0	3
Burlington	23,613	0	1	0	0	0	0	0	......	8
Massachusetts—										
Boston	770,400	0	0	0	17	2	0	0	2	214
Fall River	120,912	0	0	0	2	1	0	0	9	25
Springfield	144,227	0	0	0	1	0	0	1	1	30
Worcester	191,927	0	0	0	4	0	0	0	14	63
Rhode Island—										
Pawtucket	68,799	0	0	0	1	0	0	0	0	25
Providence	242,378	0	0	0	4	0	0	0	2	80
Connecticut—										
Bridgeport	[1] 143,555	0	0	0	2	0	0	0	0	41
Hartford	[1] 138,036	0	0	0	2	0	0	0	......	35
New Haven	172,967	0	0	0	1	0	0	0	3	66
Middle Atlantic:										
New York—										
Buffalo	536,718	0	0	0	6	1	3	2	......	136
New York	5,927,625	1	0	0	[2] 87	8	16	3	156	1,560
Rochester	317,867	0	0	0	7	0	1	0	9	73
Syracuse	184,511	0	0	0	1	0	1	0	2	46
New Jersey—										
Camden	124,157	0	0	0	1	0	0	0	......	27
Newark	438,699	0	0	0	6	1	0	0	11	95
Trenton	127,390	0	0	0	4	0	0	0	1	39
Pennsylvania—										
Philadelphia	1,922,788	0	0	0	32	5	3	0	37	509
Pittsburgh	613,442	0	0	0	12	1	0	0	56	223
Reading	110,917	0	0	0	3	0	0	1	......	43
Scranton	140,636	0	0	0	0	0	0	0	0	31
East North Central:										
Ohio—										
Cincinnati	406,312	2	1	0	11	1	0	0	16	109
Cleveland	888,519	3	3	0	11	1	0	0	31	191
Columbus	261,082	1	0	0	2	0	0	0	......	70
Toledo	268,338	3	8	0	5	1	0	0	0	78
Indiana—										
Fort Wayne	93,573	1	4	0	0	0	0	0	0	18
Indianapolis	342,718	6	12	0	1	0	2	0	11	99
South Bend	76,709	0	2	0	0	0	0	0	......	11
Terre Haute	68,939	1	0	0	0	0	0	0	5	26
Illinois—										
Chicago	2,886,121	2	4	0	45	3	5	0	25	676
Cicero	55,968	0	0	0	0	0	0	0	0	10
Peoria	79,675	2	0	0	2	0	0	0	0	39
Springfield	61,833	1	0	0	1	0	0	0	5	21
Michigan—										
Detroit	995,668	6	52	0	22	2	1	1	14	252
Flint	117,968	3	3	0	0	0	0	0	3	21
Grand Rapids	145,947	0	1	0	4	1	0	0	......	44
Saginaw	69,754	0	0	0	1	1	4	0	9	16
Wisconsin—										
Madison	42,519	1	0	......	......	0	0	......	1	......
Milwaukee	484,595	4	1	0	6	1	0	0	33	......
Racine	64,393	1	0	0	1	0	0	0	2	13
Superior	[1] 39,671	2	4	0	0	0	0	0	......	2
West North Central:										
Minnesota—										
Duluth	106,289	2	16	0	2	0	0	0	1	18
Minneapolis	409,125	18	4	0	3	1	3	0	3	86
St. Paul	241,891	14	20	0	4	1	1	0	......	68
Iowa—										
Davenport	61,262	2	11	......	......	0	0	......	0	......
Sioux City	79,662	3	0	......	......	0	0	......	1	......
Waterloo	39,667	0	0	......	......	0	0	......	6	......

[1] Population Jan. 1, 1920.

[2] Pulmonary only.

City reports for week ended February 9, 1924—Continued.

Division, State, and city.	Population July 1, 1923, estimated.	Smallpox. Cases, estimated expectancy.	Smallpox. Cases reported.	Smallpox. Deaths reported.	Tuberculosis, deaths reported.	Typhoid fever. Cases, estimated expectancy.	Typhoid fever. Cases reported.	Typhoid fever. Deaths reported.	Whooping cough, cases reported.	Deaths, all causes.
West North Central—Continued.										
Missouri—										
Kansas City	351,819	5	0	0	9	1	0	0	2	102
St. Joseph	78,232	3	0	0	0	1	0	0	1	19
St. Louis	803,853	2	8	0	12	1	2	0	39	244
North Dakota—										
Fargo	24,841	1	0	0	0	0	0	0	0	3
Grand Forks	14,547	1	0	......	......	0	0	......	......	......
South Dakota—										
Sioux Falls	29,206	1	0	0	0	0	0	0	......	5
Nebraska—										
Lincoln	58,761	2	5	0	0	0	0	0	......	22
Omaha	204,382	6	0	0	1	0	1	0	......	42
Kansas—										
Topeka	52,555	0	1	0	0	0	0	0	3	25
Wichita	79,261	3	10	0	0	0	0	0	7	23
South Atlantic:										
Delaware—										
Wilmington	117,728	0	0	0	0	0	0	1	......	24
Maryland—										
Baltimore	773,580	0	0	0	28	2	2	2	22	263
Cumberland	32,361	0	0	0	1	0	0	0	......	14
Frederick	11,301	0	0	0	0	0	0	0	0	1
District of Columbia—										
Washington	[1] 437,571	0	9	0	8	2	0	0	10	133
Virginia—										
Lynchburg	30,277	0	0	0	2	0	0	0	7	7
Norfolk	159,089	0	0	0	1	0	0	0	8	......
Richmond	181,044	0	0	0	5	1	0	0	5	59
Roanoke	55,502	1	0	0	1	0	0	0	0	17
West Virginia—										
Charleston	45,597	1	2	0	0	0	0	0	4	18
Huntington	57,918	0	0	0	0	0	0	0	0	......
Wheeling	[1] 56,208	0	0	0	1	1	10	2	0	22
North Carolina—										
Raleigh	29,171	0	5	0	1	0	0	0	10	9
Wilmington	35,719	0	0	0	0	0	0	0	0	11
Winston-Salem	56,230	1	0	0	1	0	0	0	19	19
South Carolina—										
Charleston	71,245	0	0	0	1	0	1	0	0	23
Columbia	39,688	0	0	0	1	0	0	1	0	23
Greenville	25,789	0	3	0	1	0	0	0	4	13
Georgia—										
Atlanta	222,963	3	99	0	7	0	0	0	2	100
Brunswick	15,937	0	0	0	0	0	0	0	0	2
Savannah	89,448	0	0	0	5	0	1	0	2	35
Florida—										
St. Petersburg	24,403	......	0	0	0	......	0	0	......	15
Tampa	56,050	0	0	0	0	0	1	0	......	23
East South Central:										
Kentucky—										
Covington	57,877	0	0	0	0	0	0	0	2	21
Lexington	43,673	0	0	0	1	1	0	0	4	18
Louisville	257,671	1	0	0	4	1	0	0	1	93
Tennessee—										
Memphis	170,067	4	0	0	9	0	1	0	2	68
Nashville	121,128	1	2	0	2	1	0	0	7	41
Alabama—										
Birmingham	195,901	1	6	0	9	1	1	0	7	84
Mobile	63,858	1	0	0	0	0	0	0	0	23
Montgomery	45,383	0	0	0	0	0	0	0	......	20
West South Central:										
Arkansas—										
Fort Smith	30,635	0	0	......	......	0	0	......	2	......
Little Rock	70,916	0	0	......	......	0	0	......	1	......
Louisiana—										
New Orleans	404,575	3	0	0	17	1	3	0	0	178
Shreveport	54,590	......	6	0	6	......	0	1	0	33
Oklahoma—										
Tulsa	102,018	2	7	......	......	1	0	......	0	......

[1] Population Jan. 1, 1920.

City reports for week ended February 9, 1924—Continued.

Division, State, and city.	Population July 1, 1923, estimated.	Smallpox. Cases, estimated expectancy.	Smallpox. Cases reported.	Smallpox. Deaths reported.	Tuberculosis, deaths reported.	Typhoid fever. Cases, estimated expectancy.	Typhoid fever. Cases reported.	Typhoid fever. Deaths reported.	Whooping cough, cases reported.	Deaths, all causes.
West South Central—Continued.										
Texas—										
Dallas	177,274	3	0	0	2	0	3	0	3	47
Galveston	46,877	0	0	0	0	0	0	0	0	15
Houston	154,970	2	0	0	4	0	3	1	......	55
San Antonio	184,727	1	0	0	17	1	1	0	0	80
Mountain:										
Montana—										
Billings	16,927	0	0	0	0	0	0	0	0	3
Great Falls	27,787	3	0	0	1	0	0	0	4	4
Helena	[1] 12,037	......	0	0	0	......	0	0	0	4
Missoula	[1] 12,668	0	1	0	1	0	0	0	5	8
Idaho—										
Boise	22,806	0	3	0	0	0	0	0	0	6
Colorado—										
Denver	272,031	14	0	0	9	0	0	0	17	65
Pueblo	43,519	0	0	0	1	0	1	0	0	12
New Mexico—										
Albuquerque	16,648	0	0	0	1	0	0	0	1	3
Utah—										
Salt Lake City	126,241	4	0	0	0	1	0	0	1	32
Nevada—										
Reno	12,429	0	0	0	0	0	0	0	0	4
Pacific:										
Washington—										
Seattle	[1] 315,685	6	0	......	......	1	0	......	7	......
Spokane	104,573	15	23	......	......	0	0	......	0	......
Tacoma	101,731	2	4	......	......	0	0	......	0	......
Oregon—										
Portland	273,621	5	12	0	2	0	0	0	0	......
California—										
Los Angeles	666,853	2	118	0	22	2	9	1	......	254
Sacramento	69,950	0	0	0	5	1	0	0	0	24
San Francisco	539,038	2	0	0	4	1	0	0	1	158

Division, State, and city.	Cerebrospinal meningitis. Cases.	Cerebrospinal meningitis. Deaths.	Lethargic encephalitis. Cases.	Lethargic encephalitis. Deaths.	Pellagra. Cases.	Pellagra. Deaths.	Poliomyelitis (infantile paralysis). Cases, est. expectancy.	Poliomyelitis (infantile paralysis). Cases.	Poliomyelitis (infantile paralysis). Deaths.
New England:									
Massachusetts—									
Boston	2	0	0	0	1	0	0	0	0
Rhode Island—									
Pawtucket	1	0	0	0	0	0	0	0	0
Middle Atlantic:									
New York—									
New York	5	0	5	4	0	0	1	0	0
New Jersey—									
Newark	0	0	0	0	0	0	0	1	0
Pennsylvania—									
Philadelphia	1	1	2	0	0	0	0	0	0
East North Central:									
Ohio—									
Cleveland	0	0	1	0	0	0	0	0	0
Indiana—									
Terre Haute	0	0	0	1	0	0	0	0	0
Illinois—									
Peoria	0	1	0	0	0	0	0	0	0
Michigan—									
Detroit	0	1	1	1	0	0	0	0	0
Flint	0	0	0	0	0	0	0	1	0
Wisconsin—									
Milwaukee	0	0	1	0	0	0	1	0	0

[1] Population Jan. 1, 1920.

City reports for week ended February 9, 1924—Continued.

Division, State, and city.	Cerebrospinal meningitis.		Lethargic encephalitis.		Pellagra.		Poliomyelitis (infantile paralysis).		
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases, est. expectancy.	Cases.	Deaths.
West North Central:									
Missouri—									
Kansas City	1	0	0	0	0	0	0	0	0
South Atlantic:									
Maryland—									
Baltimore	1	0	1	0	0	0	0	1	0
District of Columbia—									
Washington	0	0	2	2	0	0	0	0	0
West Virginia—									
Charleston	1	0	0	0	0	0	0	0	0
North Carolina—									
Winston-Salem	0	0	0	1	0	0		0	0
South Carolina—									
Columbia	0	0	0	0	2	1	0	0	0
Georgia—									
Atlanta	1	4	0	0	0	0	0	0	0
West South Central:									
Louisiana—									
Shreveport	1	1	0	0	0	0		0	0
Pacific:									
Oregon—									
Portland	0	0	2	0	0	0	0	0	0
California—									
Los Angeles	0	0	0	0	0	0	0	1	0
San Francisco	0	0	1	0	0	0	0	0	0

The following table gives a summary of the reports from 105 cities for the six-week period ended February 9, 1924. The cities included in this table are those whose reports have been published for all six weeks in the Public Health Reports. Nine of these cities did not report deaths. The aggregate population of the cities reporting cases was estimated at nearly 29,000,000 on July 1, 1923, which is the latest date for which estimates are available. The cities reporting deaths had more than 28,000,000 population on that date. The number of cities included in each group and the aggregate population are shown in a separate table below.

Summary of weekly reports from cities, December 30, 1923, to February 9, 1924.

DIPHTHERIA CASES.

	1924, week ended—					
	Jan. 5.	Jan. 12.	Jan. 19.	Jan. 26.	Feb. 2.	Feb. 9.
Total	1,339	1,385	1,453	1,387	1,288	1,305
New England	172	123	130	141	161	133
Middle Atlantic	401	476	488	479	410	490
East North Central	341	352	333	305	291	284
West North Central	133	102	125	124	125	97
South Atlantic	59	86	112	72	59	50
East South Central	19	20	15	17	19	13
West South Central	46	36	38	41	38	33
Mountain	26	19	19	27	21	21
Pacific	142	171	193	181	164	181

Summary of weekly reports from cities, December 30, 1923, to February 9, 1924—Con.

MEASLES CASES.

	1924, week ended—					
	Jan. 5.	Jan. 12.	Jan. 19.	Jan. 26.	Feb. 2.	Feb. 9.
Total	4,008	4,997	5,479	5,571	5,908	5,794
New England	175	161	176	170	227	265
Middle Atlantic	611	639	699	770	899	1,004
East North Central	283	356	328	296	330	292
West North Central	525	444	383	411	522	643
South Atlantic	553	439	499	507	556	508
East South Central	45	92	98	121	118	98
West South Central	352	375	370	552	564	511
Mountain	300	458	434	723	1,005	975
Pacific	1,164	2,033	2,492	2,021	1,687	1,498

SCARLET FEVER CASES.

Total	1,550	1,731	1,883	1,925	1,858	1,934
New England	281	287	330	327	368	307
Middle Atlantic	386	445	461	530	492	572
East North Central	413	404	487	419	405	426
West North Central	190	265	227	245	227	248
South Atlantic	122	113	128	142	145	183
East South Central	10	27	26	27	12	18
West South Central	22	20	21	15	19	19
Mountain	20	25	36	24	24	27
Pacific	106	145	167	196	166	134

SMALLPOX CASES.

Total	178	341	454	379	368	427
New England	0	2	0	1	0	0
Middle Atlantic	1	1	1	6	3	0
East North Central	28	58	92	64	74	87
West North Central	25	49	45	50	36	59
South Atlantic	37	52	81	55	58	118
East South Central	2	7	4	3	5	8
West South Central	2	10	6	3	12	6
Mountain	2	2	4	2	2	4
Pacific	81	160	221	195	178	145

TYPHOID FEVER CASES.

Total	63	81	77	69	78	76
New England	2	1	11	1	5	0
Middle Atlantic	11	29	30	21	26	24
East North Central	26	27	16	18	14	8
West North Central	3	1	3	2	5	7
South Atlantic	7	9	7	11	18	15
East South Central	6	0	3	8	1	2
West South Central	4	8	6	4	1	10
Mountain	1	2	0	0	1	1
Pacific	3	4	1	4	7	9

INFLUENZA DEATHS.

Total	46	76	68	70	82	100
New England	4	9	2	6	3	3
Middle Atlantic	13	24	32	14	29	33
East North Central	7	17	11	23	18	19
West North Central	0	4	10	4	5	6
South Atlantic	6	5	1	6	5	14
East South Central	3	6	4	3	7	13
West South Central	3	5	2	6	10	7
Mountain	2	1	0	1	0	2
Pacific	8	5	6	7	5	3

Summary of weekly reports from cities, December 30, 1923, to February 9, 1924—Continued.

PNEUMONIA DEATHS.

	1924, week ended—					
	Jan. 5.	Jan. 12.	Jan. 19.	Jan. 26.	Feb. 2.	Feb. 9.
Total	852	1,105	1,054	1,002	1,120	1,064
New England	52	80	78	51	73	73
Middle Atlantic	328	448	422	409	463	421
East North Central	182	203	202	177	222	216
West North Central	59	67	73	70	64	46
South Atlantic	97	143	132	129	123	134
East South Central	35	43	30	50	62	63
West South Central	28	44	47	60	64	53
Mountain	28	32	30	20	21	24
Pacific	43	45	40	36	28	34

Number of cities included in summary of weekly reports and aggregate population of cities in each group, estimated as of July 1, 1923.

Group of cities.	Number of cities reporting—		Aggregate population of cities reporting—	
	Cases.	Deaths.	Cases.	Deaths.
Total	105	96	28,898,320	28,112,698
New England	12	12	2,098,746	2,098,746
Middle Atlantic	10	10	10,304,114	10,304,114
East North Central	17	17	7,032,535	7,032,535
West North Central	14	10	2,515,330	2,353,248
South Atlantic	22	22	2,566,901	2,566,901
East South Central	7	7	911,855	911,855
West South Central	8	6	1,124,564	1,023,013
Mountain	9	9	546,445	546,445
Pacific	6	3	1,797,830	1,275,841

FOREIGN AND INSULAR.

CUBA.

Communicable Diseases—Habana—January 11–February 10, 1924.

Communicable diseases have been notified at Habana, Cuba, as follows:

Disease.	New cases.	Deaths.	Remaining under treatment Jan. 20, 1924.
January 11-20, 1924.			
Cerebrospinal meningitis	1		[1] 1
Chicken pox	16		14
Diphtheria	6		2
Leprosy	1		14
Malaria	16		[2] 27
Measles	4	1	5
Typhoid fever	7	1	[3] 12
January 21-31, 1924.			
Cerebrospinal meningitis			[1] 1
Chicken pox	9		13
Diphtheria	6	1	2
Leprosy	1		[4] 15
Malaria	15		22
Measles	10		10
Scarlet fever	2		2
Typhoid fever	3		[3] 12
February 1-10, 1924.			
Cerebrospinal meningitis	1		[1] 2
Chicken pox	9		11
Diphtheria	5		4
Leprosy			14
Malaria	15		[4] 22
Measles			4
Scarlet fever	1		1
Typhoid fever	6		[3] 15

[1] From the interior, 1.
[2] From the interior, 17.
[3] From the interior, 3.
[4] From the interior, 9.

JAMAICA.

Chicken Pox.

During the period under report, five cases of chicken pox were reported in the Island of Jamaica.

Smallpox (Alastrim).

During the week ended January 26, 1924, eight cases of smallpox (reported as alastrim) were reported in the Island of Jamaica.

Typhoid Fever—Kingston.

During the same period, 26 cases of typhoid fever were reported at Kingston.

MALTA.

Communicable Diseases—January 1-15, 1924.

During the period January 1 to 15, 1924, communicable diseases were reported in the island of Malta as follows: Influenza, 61 cases; malaria, 1 case; pneumonia, 12 cases; trachoma, 7 cases; undulant fever, 23 cases; whooping cough, 186 cases. (Population, 216,702.)

POLAND.

Communicable Diseases—November 4-10, 1923.

Communicable diseases have been notified in Poland as follows:

Disease.	Cases.	Deaths.	Districts showing greatest number of deaths.
Cerebrospinal meningitis	6	2	Lodz.
Diphtheria	90	11	Posen.
Measles	334	23	Kielce.
Scarlet fever	646	50	Lwow.
Smallpox		1	Krakow.
Tuberculosis	82	169	Warsaw.
Typhoid fever	425	50	Lodz.
Typhus fever	63	4	Lwow.
Typhus fever, recurrent	3		Not reported.
Whooping cough	122	21	Lwow.

Dysentery—Malaria.

During the same period, 103 cases of dysentery, with 31 deaths, and 19 cases of malaria were reported in Poland.

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER.

The reports contained in the following tables must not be considered as complete or final as regards either the lists of countries included or the figures for the particular countries for which reports are given.

Reports Received During Week Ended February 29, 1924.[1]

CHOLERA.

Place.	Date.	Cases.	Deaths.	Remarks.
India:				
Calcutta	Dec. 30-Jan. 5	46	33	

PLAGUE.

Place.	Date.	Cases.	Deaths.	Remarks.
Ceylon:				
Colombo	Dec. 16-29	9	6	
India:				
Bombay	Dec. 30-Jan. 5	2	2	
Karachi	Jan. 6-12	2		
Rangoon	Dec. 30-Jan. 5	3	3	
Java:				
East Java—Socrabaya	Dec. 9-15	2	2	

[1] From medical officers of the Public Health Service, American consuls, and other sources.

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received During Week Ended February 29, 1924—Continued.

SMALLPOX.

Place.	Date.	Cases.	Deaths.	Remarks.
Arabia:				
Aden	Jan. 13-19	1		
Canada:				
Ontario—				
London	Feb. 3-9	1		
North Bay	do	1		
India:				
Bombay	Dec. 23-29	9	6	
Do	Dec. 30-Jan. 5	10	5	
Calcutta	do	1	1	
Madras	Jan. 6-12	1	1	
Rangoon	Dec. 30-Jan. 5	1		
Jamaica				Jan. 20-26, 1924: Cases, 8 (alastrim).
Japan:				
Tokyo	Jan. 1-23	46		
Java:				
East Java—				
Soerabaya	Dec. 9-15	107	15	
West Java—				
Batavia	Dec. 22-28	1	1	
Netherlands:				
Rotterdam	Jan. 20-26	3		
Persia:				
Teheran	Oct. 25-Nov. 22		1	
Poland				Nov. 4-10, 1924: 1 death.
Portugal:				
Lisbon	Jan. 20-26	4		
Switzerland:				
Berne	Jan. 13-19	2		
Union of South Africa:				
Northern Rhodesia	Dec. 25-31	20	3	

TYPHUS FEVER.

Place.	Date.	Cases.	Deaths.	Remarks.
Canary Islands:				
Teneriffe	Jan. 14-20		1	
Germany:				
Coblenz	Jan. 27-Feb. 2	1		
Java:				
East Java—				
Soerabaya	Dec. 9-15	4		
Poland				Nov. 4-10, 1923: Cases, 63; deaths, 4. Recurrent typhus, 3 cases.
Syria:				
Damascus	Jan. 27-Feb. 2	1		
Turkey:				
Constantinople	Jan. 13-19	2		
Union of South Africa:				
Johannesburg	Dec. 1-31	1	2	

Reports Received from December 29, 1923, to February 22, 1924.[1]

CHOLERA.

Place.	Date	Cases.	Deaths.	Remarks.
China:				
Hongkong	Nov. 18-24	1		
India				Oct. 14-Dec. 8, 1923: Cases, 9,691; deaths, 6,153.
Calcutta	Nov. 11-Dec. 29	85	69	
Madras	Nov. 25-Dec. 29	15	5	
Do	Dec. 30-Jan. 5	1		
Rangoon	Nov. 11-Dec. 29	8	5	
Siam:				
Bangkok	Nov. 18-Dec. 8	4	2	
Turkey:				
Constantinople	Dec. 2-8		1	

[1] From medical officers of the Public Health Service, American consuls, and other sources.

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

PLAGUE.

Place.	Date.	Cases.	Deaths.	Remarks.
Azores:				
St. Michael Island	Oct. 20-Nov. 10	9	5	At localities 3 to 9 miles from port of Ponta Delgada.
Bolivia:				
La Paz	Oct. 1-31		3	
Brazil:				
Bahia	Nov. 11-Dec. 22	5	3	
British East Africa:				
Kenya—				
Mombasa	Oct. 14-20	1	1	Infected rats, 2. Dec. 9-15, 1923: Cases, 4; deaths, 2; removed from vessel arrived Dec. 11, 1923.
Nairobi	Nov. 1-21	40		In rural districts, several hundred.
Tanganyika				To Nov. 24, 1923: Cases, 39; deaths, 25.
Uganda	Aug. 1-Oct. 31	734	719	
Canary Islands:				
Las Palmas	Oct. 15-Nov. 15	14	14	
San Juan de la Rambla	Dec. 11	1		Locality 52 km. from Teneriffe.
Celebes Island	Nov. 30			Epidemic.
Ceylon:				
Colombo	Nov. 11-Dec. 15	22	15	Plague rodents, 18.
China:				
Nanking	Dec. 16-29			Present.
Do	Dec. 30-Jan. 12			Do.
Ecuador:				
Guayaquil	Nov. 16-Dec. 15	15	6	Rats taken, 35,070; found infected, 91.
Jipijapa	do			Present.
Quito	Nov. 1-30	11	1	
Vino del Milagro	Dec. 1-15	1		
Egypt				Jan. 1-Dec. 27, 1923: Cases, 1,518; deaths, 724.
City—				
Alexandria	Jan. 1-Dec. 27	65	33	Date of last case, Nov. 29, 1923.
Cairo	do	2	2	Date of last case, Dec. 25, 1923.
Port Said	do	51	29	Date of last case, Sept. 10, 1923.
Suez	do	46	24	Date of last case, Dec. 26, 1923.
Hawaii:				
Honokaa				Jan. 8-10, 1924: Three plague-infected rodents.
Paauhau				Dec. 14, 1923: One plague rat.
India				Oct. 14-Dec. 8, 1923: Cases, 25,781; deaths, 17,435.
Bombay	Oct. 28-Dec. 22	5	5	
Calcutta	Dec. 23-29	1	1	
Karachi	Nov. 11-Dec. 29	42	33	
Do	Dec. 30-Jan. 5	1	1	
Madras Presidency	Nov. 4-Dec. 29	1,657	1,021	
Rangoon	do	20	15	
Indo-China:				
Saigon	Oct. 28-Dec. 8	19	6	Including 100 square kilometers in surrounding country.
Iraq:				
Bagdad	Nov. 11-Dec. 8	6	4	
Java				Oct. 1-31, 1923: Deaths, 902. Nov. 1-30, 1923: Deaths, 942.
Province—				
Djokjakarta	Oct. 1-31		56	
Do	Nov. 1-30		37	
Kedoe	Oct. 1-31		252	
Do	Nov. 1-30		444	
Pekalongan	Oct. 1-31		25	
Do	Nov. 1-30		46	
Samarang	Oct. 1-31		218	
Do	Nov. 1-30		118	
Soerabaya	Oct. 1-31		3	Nov. 11-24, 1923: Cases, 2; deaths, 2.
Do	Nov. 1-30		2	
Soerakarta	Oct. 1-31		348	
Do	Nov. 1-30		295	
Madagascar:				
Tananarive Province	Oct. 1-Nov. 30	153	137	Bubonic, pneumonic, septicemic.
Tananarive town	do	54	54	
Paraguay:				
Asuncion	Dec. 18	6	4	

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

PLAGUE—Continued.

Place.	Date.	Cases.	Deaths.	Remarks.
Peru				Nov. 1-Dec. 31, 1923: Cases, 38; deaths, 24.
Locality—				
Canete	Nov. 1-30	1	1	
Chancay	Dec. 1-31	2		
Chepen	Nov. 1-30	1		
Chiclayo	Nov. 1-Dec. 31	2	1	
Lima (city)	do	22	15	
Lima (country)	do	8	7	
Lurin	do	2		
Portugal:				
Lisbon	Dec. 13-21	7		
Do	Dec. 31-Jan. 6		1	
Portuguese West Africa:				
Angola—				
Loanda	Oct.-Nov	59	23	
Siam:				
Bangkok	Nov. 4-Dec. 8	3	2	
Spain:				
Malaga	Dec. 17	2		
Straits Settlements:				
Singapore	Nov. 11-Dec. 22	4	4	
Syria:				
Beirut	Nov. 1-Dec. 10	3		
Turkey:				
Constantinople	Dec. 2-22	6	3	
Union of South Africa:				
Cape Province—				
Uitenhage district	Dec. 9-15			Plague rodent found vicinity Haarhoff's kraal farm.
Orange Free State—				
Kroonstad district	Dec. 16-27	7	3	At Zandfontein farm, Bothaville area: Cases, white, 4; native, 3; deaths, white, 1; native, 2.
Wonderfontein farm	Dec. 2-8	4		Vicinity of Hoopstad. At Hoopstad, Dec. 9-15, 1923, one death of case previously reported.
On vessel:				
Ship ——	Dec. 11	4	2	At Mombasa, British East Africa.

SMALLPOX.

Place.	Date.	Cases.	Deaths.	Remarks.
Algeria:				
Algiers	Nov. 1-30	1		
Arabia:				
Aden	Dec. 16-22	1		Imported.
Belgium:				
Brussels	do	10		
Bolivia:				
La Paz	Oct. 1-Dec. 31	45	15	
Brazil:				
Pernambuco	Nov. 4-Dec. 1	15	3	
Porto Alegre	Dec. 23-29		1	
Porto Rico	Dec. 30-Jan. 5		1	
Rio de Janeiro	Nov. 18-24	3	1	
Do	Jan. 6-12	2	1	
Sao Paulo	Sept. 3-9	1		
British East Africa:				
Tanganyika Territory	Sept. 30-Oct. 27	14	1	
Uganda	Sept. 1-30	6	1	
Zanzibar	Sept. 1-Oct. 31	116	18	Sept. 1-30, 1923: In areas 27 miles from town of Zanzibar. Oct. 1-31, 1923: In vicinity, 1 case, 1 death. In Mkokotoni district, 30 cases, 14 deaths reported.
Canada:				
Alberta—				
Calgary	Jan. 27-Feb. 2	2		
British Columbia—				
Vancouver	Dec. 22-29	10		
Do	Dec. 30-Jan. 26	17		
Manitoba—				
Winnipeg	Nov. 25-Dec. 29	21		
Do	Dec. 30-Feb. 8	47		

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

SMALLPOX—Continued.

Place.	Date.	Cases.	Deaths.	Remarks.
Canada—Continued.				
New Brunswick—				
Madawaska County	Dec. 8-15	1		
Restigouche County	Jan. 20-26	1		
Ontario				Jan. 1-31, 1924: Cases, 50.
Fort William and Port Arthur.	Dec. 16-29	3		Occurring at Fort William.
Quebec—				
Montreal	Nov. 30-Jan. 26	3		
Do	Feb. 3-9	1		
Saskatchewan—				
Regina	Dec. 9-15	1		
Ceylon:				
Colombo	Nov. 11-17	1		Port case.
Chile:				
Antofagasta	Jan. 13-19	3		
Concepcion	Oct. 1-Nov. 30		13	Nov. 12-Dec. 3, 1923: Deaths, 5.
Do	Dec. 25-31		1	
Talcahuano	Nov. 26-Dec. 2	3		Dec. 22, 1923: Five cases present.
Valparaiso	Dec. 9-15		1	
China:				
Amoy	Nov. 18-Dec. 8			Present.
Canton	Dec. 23-Jan. 13			Do.
Chungking	Nov. 4-Dec. 15			Present and endemic.
Do	Dec. 23-29			Present.
Foochow	Nov. 4-Dec. 15			Do.
Do	Dec. 31-Jan. 12			Do.
Hongkong	Oct. 28-Dec. 29	718	630	
Manchuria—				
Harbin	Nov. 12-Dec. 22	36		
Do	Jan. 1-7		5	
Nanking	Dec. 2-15			Present.
Do	Dec. 30-Jan. 12			Do.
Shanghai	Dec. 29			Prevalent.
Do	Jan. 6-12	3	8	Cases, foreign.
Chosen (Korea):				
Seoul	Nov. 1-30	1		
Columbia:				
Buenaventura	Nov. 18-Dec. 15	8		
Ecuador:				
Esmeraldas	Nov. 16-30	4		
Quito	Nov. 1-30	167	26	
Egypt:				
Port Said	Nov. 24-Dec. 2	1		
Esthonia				Nov. 1-30, 1923: Cases, 32.
Greece:				
Saloniki	Oct. 22-Nov. 11		8	
Guadeloupe (West Indies)				Jan. 2-16: Present.
Basse Terre	Dec. 18			Present.
Do	Jan. 12			Do.
Marie Galante	Dec. 18			Off shore island; present.
Moule	Jan. 12			Present.
Point à Pitre	Dec. 18			Present in vicinity.
India				Oct. 14-Dec. 8, 1923: Cases, 6,544; deaths, 1,355.
Bombay	Oct. 28-Dec. 22	46	19	
Calcutta	Dec. 16-29	4	4	
Karachi	Dec. 30-Jan. 5	2		
Madras	Nov. 4-Dec. 29	23	3	
Do	Dec. 30-Jan. 5	5		
Rangoon	Nov. 4-Dec. 29	12	4	
Indo-China:				
City—				
Saigon	Nov. 4-Dec. 8	69	34	Including 100 square kilometers of surrounding country.
Iraq:				
Bagdad	Oct. 24-Dec. 8	25	16	
Jamaica				Nov. 25-Dec. 29, 1923: Cases, 115.
Do				Dec. 30, 1923-Jan. 19, 1924: Cases, 57. (Reported as alastrim.)
Kingston	Nov. 25-Dec. 29	3		
Do	Dec. 30-Jan. 19	4		
Java:				
East Java—				
Surabaya	Oct. 28-Nov. 24	219	28	
West Java—				
Batavia	Oct. 27-Dec. 14	64	12	
Latvia				Oct. 1-31, 1923: Cases, 3; Nov. 1-30, 1923: Cases, 1.

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

SMALLPOX—Continued.

Place.	Date.	Cases.	Deaths.	Remarks.
Manchuria:				
Dairen	Dec. 31-Jan. 6	1		
Mexico:				
Manzanillo	Dec. 4-10	5	1	
Mexico City	Nov. 25-Dec. 29	32		Including municipalities in Federal District.
Do	Dec. 30-Jan. 26	49	23	Do.
Tampico	Jan. 27			Present among military.
Vera Cruz	Nov. 3-Dec. 30		4	
Do	Jan. 6-13	1	1	
Do	Jan. 21-27		1	
Persia:				
Teheran	Sept. 24-Oct. 23		1	
Poland				Sept. 23-Nov. 3, 1923: Cases, 22; deaths, 3.
Portugal:				
Lisbon	Nov. 11-Dec. 29	19	10	
Do	Dec. 30-Jan. 19	10	3	
Oporto	Nov. 25-Dec. 29	39	23	
Do	Dec. 30-Jan. 20	36	20	
Siam:				
Bangkok	Oct. 28-Dec. 8	33	18	Nov. 25-Dec. 1, 1923: Epidemic.
Siberia:				
Dauria Station	Oct. 21			Present. Locality on Chita Railway, Manchurian frontier.
Sierra Leone:				
Sherbro District—				
Tagbail	Nov. 1-15	3		
Spain:				
Barcelona	Nov. 15-Dec. 26		2	
Do	Jan. 3-9		2	
Valencia	Nov. 25-Dec. 29	152	12	
Do	Dec. 30-Jan. 13	64	9	
Do	Jan. 21-26	24	2	
Straits Settlements:				
Singapore	Dec. 16-22	1		
Switzerland:				
Berne	Nov. 18-Dec. 22	12		Corrected.
Do	Jan. 6-12	1		
Lucerne	Nov. 1-30	34		
Do	Dec. 1-31	26		
Syria:				
Aleppo	Nov. 25-Dec. 1	1		In vicinity, at Djisr Choughour.
Damascus	Nov. 16-Dec. 15	7		
Tunis:				
Tunis	Oct. 27-Nov. 2	5	1	
Do	Jan. 8-21	3	1	
Turkey:				
Constantinople	Nov. 11-Dec. 8	3		
Do	Jan. 6-12	1		
Union of South Africa				Oct. 1-31, 1923: Colored, cases, 41; deaths, 2; white, cases, 3.
Cape Province	Oct. 28-Dec. 8			Outbreaks.
Natal	Oct. 28-Nov. 3			Do.
Northern Rhodesia	Dec. 4-10	10		
Do	Dec. 18-24	10	2	
Orange Free State	Oct. 28-Nov. 24			Do.
Transvaal	Nov. 18-Dec. 1			Do.
Johannesburg	Nov. 25-Dec. 15	3		
Uruguay:				
Montevideo	Oct. 1-31	1		
Venezuela:				
Caracas	Jan. 22			Epidemic.
On vessels:				
S. S. Torres	Jan. 14	1		At New Orleans quarantine station from Tampico, Mexico, via ports. Case in seaman signed on at Galveston, Tex., on outward voyage.
S. S. Tupper	Jan. 20-26			At Gonaiges, Haiti.
S. S. Vasari	Dec. 31	1		At Trinidad, West Indies, from Buenos Aires, Argentina. Vessel left Buenos Aires Dec. 15, 1923, for New York, via Santos, Rio de Janeiro, Trinidad, Barbados.

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

TYPHUS FEVER.

Place.	Date.	Cases.	Deaths.	Remarks.
Algeria:				
Algiers	Nov. 1-Dec. 31	7	3	
Do	Jan. 11-20	1	1	
Bolivia:				
La Paz	Oct. 1-Dec. 31	43	5	
Bulgaria:				
Sofia				Nov. 18-Dec. 15, 1923: Paratyphus fever cases, 17.
Chile:				
Antofagasta	Dec. 2-8	4		
Concepcion	Oct. 1-Nov. 30		4	Dec. 11-24, 1923: Deaths, 3.
Talcahuano				Dec. 5, 1923: 3 cases under treatment.
Do	Dec. 31-Jan. 4	1		
Valparaiso	Nov. 25-Dec. 15		29	Dec. 24, 1923: In hospital, 34 cases.
China:				
Antung	Nov. 12-Dec. 30	5		
Chungking	Nov. 18-24			Present.
Do	Dec. 23-29			Endemic.
Ecuador:				
Quito	Nov. 1-30	14	1	
Egypt:				
Alexandria	Nov. 19-Dec. 23	3		
Do	Jan. 8-14	1		
Cairo	Sept. 10-Nov. 11	28	5	
Esthonia				Nov. 1-30, 1923: Paratyphus fever; cases, 8.
Finland				Dec. 1-15, 1923: Paratyphus fever; cases, 15.
Hungary				July 1-Aug. 31, 1923: Cases, 24.
Latvia				Oct. 1-31, 1923: Cases, 12; paratyphus fever, 7; recurrent typhus, 3. Nov. 1-30, 1923: Cases, 1; paratyphus fever, 2 cases.
Mexico:				
Mexico City	Nov. 25-Dec. 29	86		Including municipalities in Federal District.
Do	Dec. 30-Jan. 5	8		Do.
Norway:				
Stavanger	Dec. 25-31	1		
Palestine:				
Jaffa	Jan. 1-7	1		
Persia:				
Teheran	Sept. 24-Oct. 23		1	
Poland				Sept. 23-Nov. 3, 1923: Cases, 207; deaths, 24; recurrent typhus, cases, 22.
Rumania:				
Kishineff District	Nov. 1-30	10		
Spain:				
Barcelona	Nov. 29-Dec. 12		2	
Do	Jan. 3-9		2	
Madrid	Dec. 1-31		7	
Turkey:				
Constantinople	Nov. 11-Dec. 29	15	1	
Do	Dec. 30-Jan. 12	3		
Union of South Africa				Oct. 1-31, 1923: Colored, 287 cases, 58 deaths; white, 2 cases; total, 289 cases, 58 deaths.
Cape Province				Oct. 1-31, 1923: Colored, cases, 245; deaths, 47.
Do	Oct. 28-Dec. 8			Outbreaks.
Natal				Oct. 1-31, 1923: Colored, cases, 4; deaths, 3.
Do	Oct. 28-Nov. 3			Outbreaks.
Durban	Nov. 24-Dec. 1	73		Cases occurring among native stevedores in the harbor area of the port and confined to one barracks.
Orange Free State				Oct. 1-31, 1923: Colored, cases, 25; deaths, 8.
Do	Dec. 15			Outbreaks.
Transvaal				Oct. 1-31, 1923: Colored, cases, 13.
Do	Oct. 28-Dec. 1			Outbreaks.
Johannesburg	Oct. 1-Dec. 15	2	2	

CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER—Continued.

Reports Received from December 29, 1923, to February 22, 1924—Continued.

TYPHUS FEVER—Continued.

Place.	Date.	Cases.	Deaths.	Remarks.
Venezuela:				
Maracaibo	Dec. 16-22		1	
Yugoslavia:				
Croatia—				
Zagreb	Dec. 2-15	3		
Serbia—				
Belgrade	Nov. 25-Dec. 1	1		

YELLOW FEVER.

Place.	Date.	Cases.	Deaths.	Remarks.
Brazil:				
Pernambuco City	Nov. 16	3	2	

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