Comments and Communications

Cult or Science?

THERE may be a "growing tendency toward statism, with its enslavement of body and mind to the whims of the relatively few men whose aim is to force conformity . . . ," as Metcalf says (SCIENCE, 113, 696 [1951]), but the New York state law referred to by Goldstein and Pollet (*ibid.,* 249) is no protection against this tendency. Does Metcalf think that the bacterial theory of the origin of many diseases is a state philosophy, one of the "whims of the relatively few men," as his letter implies?

I know of no scientist who will deny that "there is today no avenue of scientific investigation in which the intellectually honest scientist will assert that the theories on which current investigations are conducted have been 'established beyond doubt'." The qualifying phrase "with enormously high probabilities" Metcalf omitted from his quotation. If any person, scientist or not, has any evidence or serious argument to present against any of the accepted scientific theories currently being taught, any science teacher worthy of the name will gladly give him a hearing. However, the Christian Science Church does not challenge currently accepted scientific theory as a scientist would who had reason to believe a current theory is in need of revision. Their objection to certain instruction is the fact that it "conflicts with the religion" of the parents of the students, not that they have evidence controverting the theories taught.

Science teachers are not trying to "abrogate the right of the individual citizen to refuse acceptance of a scientific theory." On the contrary, the law that Metcalf defends abrogates a student's right to choose between alternative theories by denying him a chance to hear the alternatives to the dogmas of his parents' church. Teachers, generally, are willing to have a student or individual citizen refuse to accept a scientific theory if he has reason for so doing, or even if he has no reason, only a contrary religious belief; but they are not willing to have religious groups prevent students from having a chance to judge whether the theory is acceptable.

Science teachers have confidence that most of their students, when presented with the known facts and suggested theories for their explanation, will accept the theory most in accord with the facts. Apparently the Christian Science Church does not have a similar confidence in students, or does not want them to accept the theory with most evidence in its favor.

What "ample reason" is there to believe that any specific one of the currently accepted scientific theories that are objected to by the Christian Science Church, or other group, will be outmoded tomorrow? If Mr. Metcalf has such reason, it is his duty to bring this reason to the attention of fellow-scientists in the usual way by publication and discussion at scientific meetings, so that his point of view may get a hearing. Then, if his reason is sound, his view will prevail, and all students will get the benefit of the improved theory.

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(Potentiometric) Measurements in (Some) Colloidal Systems

THE article by Jenny *et al.* (*1*) evoked two replies (*2, 3*) which clarified several issues involved but at the same time obscured an important consideration—namely, the explanation of the so-called suspension effect which may render meaningless potentiometric measurements such as pH determinations in many colloidal systems.

Jenny *et al.* (*1*) studied suspensions of an ion exchange resin in KCl solutions and tried apparently, to prove three points: (*a*) that Donnan equilibrium does not exist; (*b*) that potentials of concentration cells whose junction occurs in a resin suspension can be calculated if transference numbers in the suspension are known; and (*c*) that a saturated KCl salt bridge cannot be used in these systems to eliminate junction potentials.

Point (*a*) has been duly criticized by Marshall (*2*), and little needs to be added. Point (*b*) is evident from thermodynamic considerations (*4*), and the necessary transference numbers can either be measured in the same system, as has been done by Jenney *et al.,* or they can be calculated under idealized conditions, if the properties of the membrane are known from Donnan equilibria according to the Meyer-Sievers-Teorell theory (*5, 6*), as pointed out by Marshall (*2*) and by Erikson (*3*).

Point (*c*), the effect of the salt bridge, has, however, been dismissed by Marshall as not likely to amount to more than a trivial correction, and by Erikson as only "comparatively small (insignificant according to the Meyer-Sievers-Teorell theory)." It is this point that I should like to try to clarify.

Both Marshall and Erikson seem to treat the dispersion of resin in KCl solution as a single phase, whereas in reality it is composed of small but discrete regions of resin and solution. (The thickness of the ion atmosphere or ion swarm is of the order of 50 A in the most dilute solutions and hence negligible in comparison.) Furthermore, the resin is a hard, nondeformable solid.

The Donnan condition of restriction of an ion to given spatial area can apply only to the resin region (and not to the solution region). It is also apparent that it is not easy to determine directly either the concentrations or the potentials within the resin.

Under some circumstances it may, nevertheless, be permissible to discuss the properties of the suspension as a whole; for example, its electric resistance over large enough regions will be a well-defined quantity.

Similarly, the transference number in the suspension may be a well-defined (but not simple) average of transference numbers in the solutions and in the resin. In dilute solutions, where the resin may be a much better conductor, the transference number in the suspension may approach that of the resin alone.

On the other hand, when a salt bridge containing concentrated KCl is inserted into such a suspension, conditions may vary greatly, depending on the construction of the bridge and other experimental details. The two possible extremes occur when the concentration gradient between concentrated KCl and the dilute salt solution either contains no resin or is formed entirely within the resin. When the concentration gradient is established through a layer of the suspension, intermediate effects may be expected.

Where the concentration gradient is entirely formed in solution so that the resin plays no part, the transference numbers of the K^+ and Cl^- are substantially equal and, as usual in simple electrolyte solutions, the junction potential is negligible.

Where the resin plays a role, conditions are quite different from the classical case of a salt bridge immersed in a solution containing a mobile colloidal ion and separated from another solution by a semipermeable membrane. Here the colloidal ion shows its peculiar behavior only at the membrane, whereas at the salt bridge its effect is swamped out by the high concentration and equal mobility of the K^+ and Cl^- ions. In other words, the situation of the salt bridge is essentially the same as in the presence of any simple electrolyte solution. This is presumably the case Marshall had in mind when he assumed that the junction potential of the salt bridge is negligible. The resin, on the other hand, contains immobile ions. It needs no membrane to show the Donnan effects, and it shows these effects at any boundary of solutions. When a concentration gradient from dilute to concentrated KCl is formed between two sides of a resin (or within a resin suspension), the Donnan effects, particularly near the dilute region, cause an inequality of concentrations of the K^+ and Cl^- ions and hence an alteration of their transference numbers, thereby giving rise to junction potentials that need not be negligible. These potentials can be calculated, either as shown by Jenny, from measured transference numbers in the same system, or under idealized conditions from the Meyer-Sievers-Teorell theory or its extensions.

Contrary to Erikson's statement, the Meyer-Sievers theory does not predict a negligible potential for this case. If their Equation 6 is applied to a membrane separating a very low and a very high concentration of an electrolyte whose anion and cation have equal transference numbers, it simplifies to

$$E = \frac{RT}{F} \cdot \frac{1}{2} \ln \frac{A}{A-A},$$

where A is the concentration of immobile ions of the membrane and the remaining symbols have their usual meaning. In other words, the membrane potential tends toward infinity under these conditions, if A (the exchange capacity of the resin) is not negligible.

Apparently, it is *because* of the existence of Donnan effects in suspensions of ion exchange resins that, as suggested by Jenney *et al.*, the use of salt bridges in these and related systems can lead to high junction potentials, which necessitate considerable caution in the interpretation of potentiometric measurements, even of simple pH determinations.

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Book Reviews

Propagation of Short Radio Waves. M.I.T. Radiation Laboratory Series, Vol. 13. Donald E. Kerr, Ed. New York-London: McGraw-Hill, 1951. 728 pp. $10.00.

This book is another excellent volume of the reference series that resulted from the work of the MIT Radiation Laboratory during World War II. In contrast to most of the series, this book does not restrict itself to the radar problem but treats propagation of short radio waves (microwaves) through space without specific regard to their application.

The phrase "propagation of radio waves" usually implies the phenomenon of propagation of radio waves through space as it is affected by the presence of ground and atmospheric disturbances. This book uses a more general definition of propagation, defining the later as transmission of signals from a transmitting to a receiving antenna. In the case of a radar system, this implies that reflection properties of the target must be considered, as well as the characteristics of the background illuminated by the transmitting beam. This book, in fact, devotes considerable space to the study of echoes from various kinds of radar targets, starting from idealized subjects such as scattering from a sphere, and proceeding to the more complex ones such as reflection from aircraft, the