such as zinc chloride, copper sulphate, sodium fluoride and arsenicals, and the logs from these trees were set in the ground with untreated checks. Ordinarily in wood-impregnation processes only the sapwood is treated, to the depth of one inch or so. This method brings about the same results by use of forces within the living tree.

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SPECIAL ARTICLES

A GENERAL THEORY FOR CALCULATING SURFACE TENSION FROM THE SHAPES OF STABLE LIQUID SURFACES OF REVOLUTION

THE general significance of Laplace's theory of liquid surfaces in the interpretation of all those methods for the determination of surface tension involving stable surfaces of revolution has not been commonly appreciated. The usual application of this theory has been through the integration of its differential equation by the use of particular assumptions. But these assumptions limit the generality of the underlying theory. In a few special cases, it is true, the theory has been applied without limiting assumptions, but even in these cases no hint has been given that the particular applications had general significance. Some methods are associated with this theory only empirically. It is the purpose of this note to state that all surface tension methods involving the use of stable liquid surfaces of revolution may be based upon the Laplace theory alone and that all of them thus are absolute methods in the sense that the value of the surface tension may be obtained from them without the use of limiting assumptions or the necessity for empirical comparison with another method.

The essence of this general method for calculating the value of the surface tension of a liquid is as follows. Draw, from the Laplace equation, the family of curves giving the shape of the surface assumed by the liquid in any of the experimental methods of this group; perform on this family of curves an operation analogous to the experimental procedure of any one of these methods, which gives a pair of corresponding quantities; construct from a number of such operations a curve one of whose coordinates is a dimensionless function of these quantities, while the other is a function the equivalent of which, for any particular liquid, involves its surface tension; and finally use this curve in connection with a measurement on the liquid whose surface tension is sought.

The shapes, though not the sizes, of liquid surfaces of revolution may be found by numerical integration of the equation expressing the Laplace theory:

$$\frac{du}{dx} + \frac{u}{x} = 2(h \pm y)$$

where the terms on the left may be considered as dimensionless ratios obtained by dividing the square root of the capillary constant of the liquid by the radii of curvature of the surface at any point, while that on the right is a ratio obtained by dividing by the square root of the capillary constant the height of a column of the liquid that would exert the pressure which exists at that point. To make this equation apply to any liquid, x, y, and h must each be multiplied by the square root of the capillary constant of that liquid, a. Numerical integration of this equation gives the various families of curves representing these surfaces, which fall into three groups which we have designated by the names meniscus, disk and drop profiles. From these families of profiles it is possible to derive a general theory for all the methods for the determination of surface tension which involve such surfaces.

An outline of our procedure by which relationships between the dimensionless quantities of the equation are used to calculate the value of the surface tension of a particular liquid will be given and illustrated by application to the capillary rise method. The first step is the preparation, from the equation, of a family of meniscus profiles, since this is the shape of the surface in a capillary tube. For the details of this step, which is rather involved especially when the data in the literature are not adequate, reference should be made to the papers mentioned below. In the second step the family of profiles is made to give the values of two dimensionless quantities, the analogues of which are measured in the experiment. In the capillary rise method these quantities are the radius of the tube and the height of the liquid in the tube between the undisturbed level of the liquid and the bottom of the meniscus. The analogous procedure is the selection of a particular value of x, which is equivalent to choosing a definite capillary and a definite liquid; the finding of that member of the meniscus family of curves which is tangent to the constant x line selected, the reading off of the value of the ordinate, y_0, of the point where this meniscus curve crosses the y-axis; and of the repetition of this procedure for other selected values of x. In the third step, from these pairs of corresponding values of x and y_0, a curve is constructed having for one coordinate a function of these quantities, whose identical function in the case of the analogous experimentally measured quantities is dimensionless, and for the other coordinate a function of x and y_0 whose equivalent function in the case of the analogous real quantities must involve the capillary constant. In the capillary rise method the abscissa might conveniently be y_0/x which is dimensionless, and the ordinate y_0x whose analogue involves the capillary constant a^2 and so the surface tension. This curve is independent of any determination of surface tension and is applicable to all liquids. By means of these three steps the Laplace equation is now expressed in a form suitable for application to the measurement of the surface tension of an unknown liquid. In the capillary height method this fourth step is the determination of one pair of corresponding values of the radius, r, of a capillary tube and the height, h, of the liquid in it. From these the ratio h/r may be calculated which is the analogue of and equal to y_0/x. From this value of h/r and from the curve, the corresponding value of y_0x is read off. This must now be expressed in terms of similar quantities which are not dimensionless and which involve the characteristics of the particular liquid we are working with; that is, we must put back the capillary constant in the Laplace equation. This is the equivalent of saying that the y_0x read from the curve is equal, in the case of a particular liquid, to hr/a^2. Thus, knowing the value of y_0x from the curve and the values of h and of r from the experiment, the value of a^2 can be calculated.

For a detailed description of this procedure reference may be made to our application of it to the ring method for the determination of surface tension.[1] The scheme may be applied rigorously to all methods involving only stable liquid surfaces of revolution. We have indicated its application to the capillary height, bubble pressure and sessile drop methods, which involve meniscus profiles; to the pull on a disk and a sphere, which involve disk profiles; to the ring method, which involves both meniscus and disk profiles, and to various drop shape methods which involve drop profiles. The convenient and precise drop weight method, involving as it does a dynamic condition, does not come under this scheme.[2] Thus a single theory for all those methods of determining surface tension using stable liquid surfaces of revolution has been developed. Wherever the calculations based on the theory have been compared with the results of experiment, agreement has been observed within the limits of precision of the particular experiment. All these methods, we think, may therefore be considered absolute ones.

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[1] SCIENCE, 71: 345, 1930; *Jour. Am. Chem. Soc.*, 52: 1772, 1930.
[2] *Jour. Phys. Chem.*, 33: 1217, 1929.

"RIGHT-HANDEDNESS" IN WHITE RATS[1]

THIS report[2] is concerned with the problem of left- and right-handedness. The problem is one of biological, pathological and psychological interest. Biologically, we are interested in the origin, evolution and heredity of bilateral asymmetry which is expressed functionally in hand preference. Pathologically, the problem is often related to speech defect, facial paralysis, epilepsy and feeble-mindedness. Psychologically, we are interested in the acquisition, retention and modification of hand preference.

Statistical studies show that in human beings there are about 95 per cent. who are right-handed, whereas only 5 per cent. prefer to use the left hand. The question immediately arises as to why it is that the great majority of people are right-handed. Up to the present time there have been about five hundred articles published by various scientists to answer the question, but the solution of the problem still remains a mystery. We know very little as to why some people are left-handed while others are right-handed —as little as we know why some of the stars in the sky rotate on their axes from left to right while others rotate in the opposite direction.

However, various theories have been advanced to account for the phenomenon of hand preference. One theory says it is entirely a matter of habit. Now if it were entirely a matter of habit, we should expect that chances are fifty-fifty. We know that habit is formed through repetition. Repetition of what? Repetition of the initial accidental chance fixation. Now we have two hands. And if handedness were entirely a matter of habit, without any organic, environmental or social influence, then it is statistically logical that chances are fifty-fifty. To illustrate, Tsai has studied the ways people clasp their hands. Each person has his habitual way of clasping the hands. Some people clasp their hands with the left thumb uppermost, while others clasp with the right thumb on top. He found that this has nothing to do with handedness, but that the results turned out to be fifty-fifty. This can be very well explained by the theory of habit, which does not seem to account for the fact that 95 per cent. of people are right-handed.

The next theory says it is a matter of social tradition. When we are young, we are ambidextrous—and experiments show that it is true up to the age of about six months. Then society steps in and says, "Thou shalt use thy right-hand!" So we were trained by our parents to be right-handed in handling the fork or the chop-sticks, as the case may be, in shaking hands and in doing a thousand other things. But why

[1] Read before the Midwestern Psychological Association, May 23, 1930.
[2] From the Otho S. A. Sprague Memorial Institute and the departments of pathology and psychology of the University of Chicago.