porters were inoculated in the center of the filter, and when supporters alone were inoculated along the filter periphery, spirochetal growth occurred only under the center inoculation site.

It was conceivable that the vacuum drawn in the anaerobic technique might disrupt the filters. When anaerobiosis was established by flushing with N_2 and CO_2 without the use of a vacuum, typical hazes were found beneath the filter. Nonirradiated, nonsterile filters could be substituted for the sterile filters without affecting the ability of the spirochetes to pass through them.

Ten-millimicron filters which had permitted the passage of *Treponema microdentium* were returned to the Millipore Filter Corporation for evaluation. They found these filters to be defective (*5*). They reported retesting their own stock supplies of 10-mμ filters and detecting an alteration in their pore size. They stated that the pores in this filter measure 10 mμ ± 20 percent immediately after manufacture, but the pore size enlarges during storage. They found no demonstrable alteration of stock supplies of 100- and 50-mμ filters. They advised us that steps are being taken to assure the manufacture of a stable 10-mμ filter.

We believe this defect was primarily responsible for spirochetal passage through the 10-mμ filter. However, with the 100- and 50-mμ filters, the possibility exists that the absence of a rigid cell wall in the ordinary bacterial sense could permit the spirochetes to penetrate through pores significantly smaller than the organism's normal diameter, or an L-type form might traverse the narrow pores.

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21 May 1962

Jamin and "True" Meniscal Resistances: A Single Meniscus Apparatus

Abstract. Meniscal resistance to movement of aqueous liquids in glass capillary tubes is due either to soiled walls or to dissolved surface-active agents. With the latter there are sharp maxima at concentrations of ¼ to ½ gram per liter. Blood serum and plasma exhibit significant "true" meniscal resistance.

Jamin reported in 1860 that a chain of droplets in a fine tube could withstand a finite force (*1*). Smith and Crane showed that this resistance is absent in clean tubes filled with pure water (*2*). But Calderwood *et al.* found it present under most ordinary circumstances (*3*). The resistance in moving menisci has been attributed to surface tension by Barr (*4*) and others. It appears that all these authors were occupied with resistance due to soiled walls.

The instrument shown in Fig. 1 was devised to observe single menisci. It avoids (i) the combination of advancing and receding menisci and (ii) the effects of varying bubble length that complicate work with bubbles in a capillary. The device consists of a horizontally placed precision bore (0.25 mm) glass capillary tube *A* about 180 mm long, bent and flared to join larger tubes as shown. The vertical reservoir *B* is about 25 mm wide and 150 mm high. Tube *F* and diaphragm stopper *C* allow liquid to be added or removed by hypodermic needle and syringe.

During operation the liquid level in the reservoir *B* is adjusted to put the capillary meniscus in tube *A* at rest in the middle of the capillary. Then the capillary attraction of the meniscus in *A* is precisely balanced by a hydrostatic force and the meniscus is free to move in either direction in response to small forces.

Two or more controlled air pressures are applied alternately to *D* and *E*, and the movements of the meniscus back and forth over a 10-cm course are timed. To assure constant speed over the timed course, a run of 3 cm is always made before the meniscus reaches the starting mark.

When there is little or no meniscal resistance the rate-pressure plots are linear and cross the origin. The advancing and receding menisci move at identical rates at a given pressure.

When meniscal resistance is present the meniscus no longer responds to

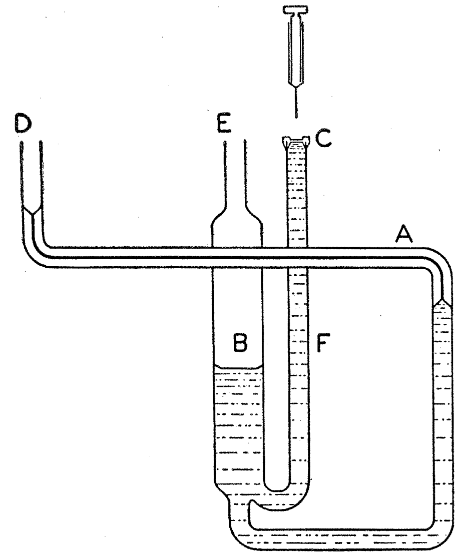

Fig. 1. Apparatus for single menisci.

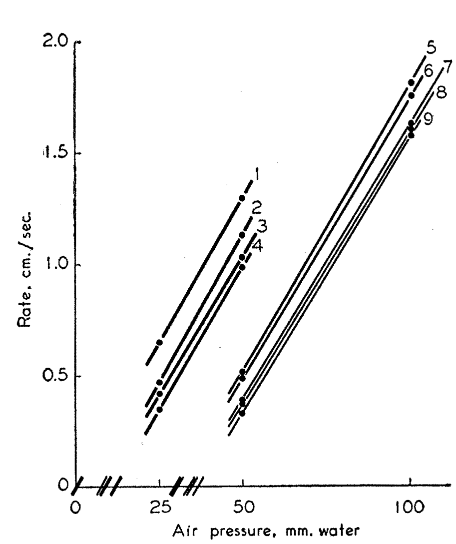

Fig. 2. Flow lines for water and eight aqueous solutions of surface active agents, all at 1 g/l: *1*, water; *2*, hexyl resorcinol; *3*, nonyl phenol 20 EO; *4*, Aerosol OT; *5*, dinonyl phenol 20 EO; *6*, Tween 80; *7*, sodium oleate; *8*, ammonium oleate; *9*, Triton A-20.

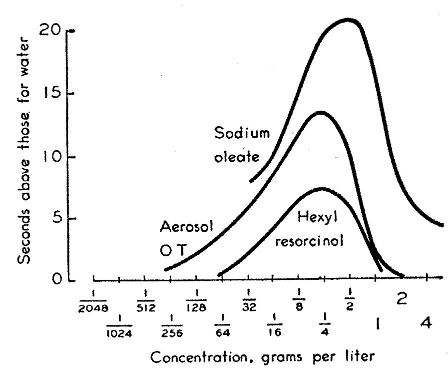

Fig. 3. Maxima in "true" meniscal resistance. Concentrations in grams per liter at which maxima occur. Time in seconds above those required for water alone (7.8 sec). Temperature, 37°C; capillary, 0.25 mm; pressure, 50 mm of water.

small forces and the method has to be modified. The level in the reservoir *B* is adjusted to make advancing and receding rates identical at one pressure. Rates at other pressures are measured at this new "dynamic" hydrostatic height. They are often slightly dissimilar, but they may be averaged to give a single value for plotting.

Figure 2 shows how water compares with eight aqueous solutions of surface-active agents. Water produces a rate-pressure line that crosses the origin, as it should. The others miss the origin to produce intercepts on the pressure axis. Note that all flow lines are parallel to the one for water. This fact suggests that meniscal resistance due to dissolved agents is not affected by variations in velocity. (The solutions named in Fig. 2 have viscosities very nearly that of water.)

The magnitude of "true" meniscal resistance depends on the concentration of the dissolved reagent. Figure 3 shows that sharp maxima occur. For the three substances shown, and for many others of similar molecular weight, the maxima lie near a concentration of about ¼ to ½ g per liter. Note that meniscal resistance falls rapidly with increasing concentration after the maxima. For example, maximum resistance for Aerosol OT is at ¼ g per liter, but it falls to zero at 2 g per liter. Sodium oleate follows a similar pattern but fails to reach zero.

True meniscal resistance is associated with elastic recoil, progressive slowing of flow, and apparent soiling of the wall. Elastic recoil is always greater in the direction of the advancing meniscus.

It appears that a quasi-rigid structure composed of solvent, solute, wall, and air forms within the three-phase contact at the meniscus. Whether this phenomenon will be found generally in nonaqueous systems has not been determined. Calderwood *et al.* found that soiled walls could raise meniscal resistance to 25 dyne/cm of meniscus periphery (*3*). We have found that "true" meniscal resistance in sodium oleate solution (½ g/l) reaches 22 dyne/cm of meniscus periphery. Blood serum shows about 18 dynes and plasma about 20. These values were calculated from intercepts on the pressure axis for a tube 0.25 mm in diameter.

It is apparent that surface tension is not primarily involved because true meniscal resistance rises to a maximum and falls again through a concentration range in which surface tension falls steadily. Pure water, at maximum surface tension, has negligible meniscal resistance, but reagents that lower surface tension are able to cause considerable meniscal resistance.

Doubtless a clear distinction should be made between the meniscal resistance described by Jamin, which is due to soiled walls, and the "true" meniscal resistance described here that is due to dissolved reagents. The latter exhibits "apparent" soiling of the wall with certain active agents at concentrations when meniscal resistance is highest.

Meniscal resistance introduces an adventitious friction into procedures where a meniscus is in motion. If it is "true" meniscal resistance, it will remain in spite of the most painstaking preparation of apparatus and reagents. The peculiar behavior of dilute hexyl resorcinol solutions in a capillary described by Washburn and Dunning (*5*) seems to be an example (*6*).

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Application of a Time Series Statistic to Physiology and Psychology

Abstract. A statistic describing variability for continuously collected time-ordered data with changing mean level is presented. The Mean Square Successive Difference, developed by von Neumann, was employed in the analysis of basal levels of galvanic skin potential recorded for 40-minute periods.

The quantification of time-ordered data has been a persistent problem in physiological and psychological research. The need for statistical treatment of such data has become more apparent with recent advances in behavioral and physiological recording techniques. Many researchers are interested in evaluating change and difference in cumulative response rates (*1*) and in continuously recorded physiological response levels (*2*). In the past the evaluation of change and difference in the curves obtained has depended on visual inspection. Quantitative comparison has rarely been attempted except over short time periods.

Table 1. Consistency of galvanic skin potential basal level in 15 female subjects across five group situations on mean ($\bar{X}$), variance (s^2), and Mean Square Successive Difference (δ^2).

Correlations	p	Number of correlations, Spearman Rank Order		
		$\bar{X}$	s^2	δ^2
> .59	< .01	1	5	10
.45–.59	< .05	1	2	0
< .45	N.S.	8	3	0

In 1941 von Neumann *et al.* (*3*) developed a statistic, the Mean Square Successive Difference, for describing the variability of a time series of observations. This statistic has particular application for continuous response data where the mean level is varying over time. It provides a description of variability between successive points of a continuously changing function. If X_i is a time series of a continuous variable, sampled at times $i = 1, 2, \ldots, n$, where the sampling rate can have any constant value, then δ^2 is defined as

$$\delta^2 = \frac{\sum_{i=1}^{n-1} (X_i - X_{i+1})^2}{n-1}.$$

The conventional statistics, mean,

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n},$$

and variance,

$$s^2 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1},$$

describe the overall central tendency of the series and the variability around it. Where there is a trend in the changing level, $\bar{X}$ and s^2 may not be sufficiently descriptive.

The ratio of δ^2 to s^2, according to von Neumann (*4*), may be used to test for randomness or trend in a time series. It bears a linear relationship to the serial correlation (R) between X_i and X_{i+1}, $i = 1, 2, \ldots, n-1$. It can be shown that δ^2/s^2 when n is large is approximately equal to $2(1-R)$. This ratio is closely related to the autocorrelation function used in neurophysiological research (*5*), where millisecond sampling rates are employed. The application of these statistics and other