the hydrometer method rather remarkably correct in only fifteen minutes by making only two readings, one at the end of one minute and the other at the end of fifteen minutes. In making these studies about thirty different soils were obtained from the United States Bureau of Soils whose complete mechanical analysis was known. It was found that the percentage of material that settles out at the end of one minute in the regular hydrometer method is almost exactly the same as the percentage of all the combined sands obtained by the mechanical analysis method. If the percentage of material that settles out at the end of fifteen minutes minus the sand which settles out at the end of one minute is considered to be silt, and if the material that still stays in suspension at the end of fifteen minutes is considered to be clay or colloids, it was found that the mechanical analysis and hydrometer methods agreed quite closely in the soils whose silt content was composed mostly of the coarser size—in the neighborhood of .05 mm and disagreed rather widely in the soils whose silt content was composed of the finest size —in the neighborhood of .005 mm. This is as should be expected because recent studies go to show that the finer silt has practically the same characteristics as the clay and should be classed, therefore, with the clay, while the coarser silt does not possess the same characteristics. The hydrometer method, therefore, includes in its clay or colloidal determination the finer silt but not the coarser silt, consequently the hydrometer method would agree with the mechanical-analysis method in soils with the coarse silt content but not with the finer silt content. In other words, the hydrometer and mechanical-analysis methods agree almost perfectly in the determination of the combined sands, coarser silt and clay. Where they do disagree is in the finer silt. The mechanical analysis classes this fine silt with the coarse silt, where the hydrometer method classes this fine silt with the clay, because it has more of the characteristics of clay. Hence there is no serious and radical disagreement between the two methods.

If it is desired to determine only the total sand and the total silt and clay, these determinations can be made by the hydrometer method in only one minute and will be very correct.

With the aid of Stokes's law, the hydrometer method can also be used to make a very detailed mechanical analysis of soils.

Although the method may appear too ideal to be true, yet all facts point such to be the case. Indeed, the method appears to be a rather remarkable and unique means of studying soils quickly, simply and accurately. For all general and practical purposes this method gives nearly all the information that is necessary and essential regarding the physical composition of soils. And in many cases such information seems to be more true than that of the mechanical-analysis method.

Finally, it must be stated that the criticisms which Joseph and Keen have made in *Soil Science* regarding the hydrometer method are not justified and do not apply to the method as is shown elsewhere.

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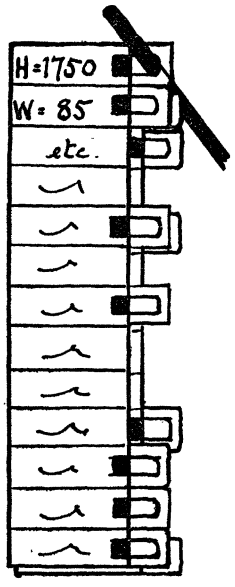
A SIMPLE METHOD OF PICKING UP CORRELATIONS[1]

IN dealing with a long series of systematic observations on individuals, as in the routine work of the Constitution Clinic in the Presbyterian Hospital—besides the opportunity of working out the type characteristics of any group under investigation—there is the possibility of finding a large number of correlations. If there are n observations on each subject or patient, there are n $(n-1)/2$ correlations of the first order. A fair estimate of the significant correlations can be obtained by means of the home-made sorting machine to be described.

The observations on one individual are recorded on a long card about 5 cm. high in vertically ruled spaces



1 cm. wide. Each observation is then compared with some given criterion and classified as plus or minus, yes or no. If the observation is plus, a clip is attached in the appropriate position along the top of the

[1] From the department of medicine of the College of Physicians and Surgeons of Columbia University and the Presbyterian Hospital, New York.

card. When all the cards are filed together, the spaces in which a certain observation has been recorded lie one behind the other; and the clips protrude above the level of the file in their respective rows. Each clip has a hole in it so that a rod may be passed through all the clips in any particular row.

Supposing that there are forty-eight cards in the group, and that for each character the median value has been selected as the criterion. If then it is desired to find the association between one character (*e.g.*, height) and any other character (*e.g.*, weight), the cards for the twenty-four tallest individuals are raised by passing a rod through the clips in the height row. If there were no association between height and weight, there would be, on the average, twelve out of the twenty-four heavy individuals among the twenty-four tall ones—less than twelve if the association is negative, more than twelve if the association is positive. The actual number can easily be determined by counting the clips (or the empty spaces) in the weight row which appear among the cards which have been lifted. In fact, the single operation of raising the cards belonging to the tall subjects reveals at a glance any significant association between height and any other character observed. A second rod enables one to examine "second-order" associations, *i.e.*, to raise the cards belonging to the individuals who are both tall *and* heavy.

For the mathematical treatment of data obtainable by the above procedures, for calculating correlation coefficients, and for some of the pitfalls of interpretation, reference may be made to Yule's book[2] especially chapters V and XI.

Arrangements are being made for the manufacture of the sorting-clips. It is thought that these clips will also be useful in the analysis of questionnaires and in the investigation of sociological problems.

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SPECIAL ARTICLES

A BIOELECTRIC POTENTIAL

BY means of a pair of non-polarizable micro-electrodes that can be inserted into a single living cell,[1] a difference of electrical potential between two points in the protoplasmic stream of the plant cell *Nitella* was detected and measured. The electrodes are operated by means of a Taylor micro-manipulator, and the electromotive force measured by means of a galvanometer (sensitivity 29,200 megohms), and a potentiometer. The two electrodes are both in the protoplasmic stream, usually about 125 μ to 150 μ apart. The difference of the electrical potential ranges from .002 to .004 volts. The E. M. F. drops to zero when the streaming is caused to stop, but will approach the initial magnitude if streaming is resumed. The direction of the current generated with respect to the direction of the protoplasmic streaming is always the same.

Ettisch and Péterfi,[2] using a binant electrometer and micro-electrodes, were unable to detect any potential difference between two points in the interior of the small *Amoeba terricola*. They consequently concluded that no ionic equilibrium that can be measured existed in the protoplasm of this form. In *Nitella* the conditions are somewhat different because of the continual and rapid streaming of the protoplasm. The observed potential difference not only is directly associated with the streaming of the protoplasm, but the two phenomena seem to be dependent upon each other. This is indicated by the fact that the E. M. F. drops to zero when the streaming is caused to stop by a slight mechanical stimulus with one of the electrodes.

In the electrical theories of protoplasmic streaming[3] the view is held that electrical currents are in part concerned in the production of these streaming movements. There is, however, the difficulty in explaining the origin of the E. M. F. The cessation of streaming upon stimulation makes it equally difficult to explain the disappearance of the E. M. F.

The observed potential difference might on the other hand be considered as being produced by the streaming of the protoplasm. We would have, then, in this case, an electrokinetic phenomenon, an E. M. F. that is set up by the impressed motion. This type of an electrokinetic phenomenon is the *streaming potential* and is the reverse of *electrosmosis*.[4] The stationary wall and ectoplasm of *Nitella* are analogous to the solid walls of the capillary tube, and the streaming protoplasm is the moving liquid layer. In *Nitella* the system is a closed one, and the diameter of the cells used ranged from .2 to .4 mm. The conditions for the production of a Helmholtz electric double layer, which is the basis of the explanation of

[1] Gelfan, S., Univ. Cal. Publ. Zool., 29, no. 17, 453, 1927.

[2] G. U. Yule, "An Introduction to the Theory of Statistics," London, 1924.

[2] Ettisch, G., and Péterfi, T., *Plüg. Arch. Phys.*, 208, 3./4. Heft, 1925.

[3] For a discussion of the theories of protoplasmic streaming see Ewart, A. S., "Protoplasmic Streaming in Plants," 1903.

[4] Freundlich, H., "Kapillarchemie," 3rd ed., p. 335.