VARIATION IN THE FUNCTIONAL POWER OF HUMAN SWEAT GLANDS

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PLATE 12

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Suppose the sweat from an area of skin were produced by a population of big and little glands, which secreted at different rates and perhaps formed droplets of different compositions. How much could one learn about the cellular processes of these glands by analysis of their combined output? Certainly the average output per gland would depend upon the relative contributions of the different glands, and might not correspond to the output of any real gland in the field. The time curve of output from the area would be determined by changes in the relative activity of glands, some responding more slowly than others, or fatiguing at unequal rates. Obviously, one must know something about the relative activities of glands in the field if he is to bridge the gap between the function of an organ and the cellular physiology of its individual units.

The present work will deal with differences in the output of water from adjacent glands. It will be shown that there are persistent differences, commonly as much as 25-fold and at extremes as much as 500-fold.

Method

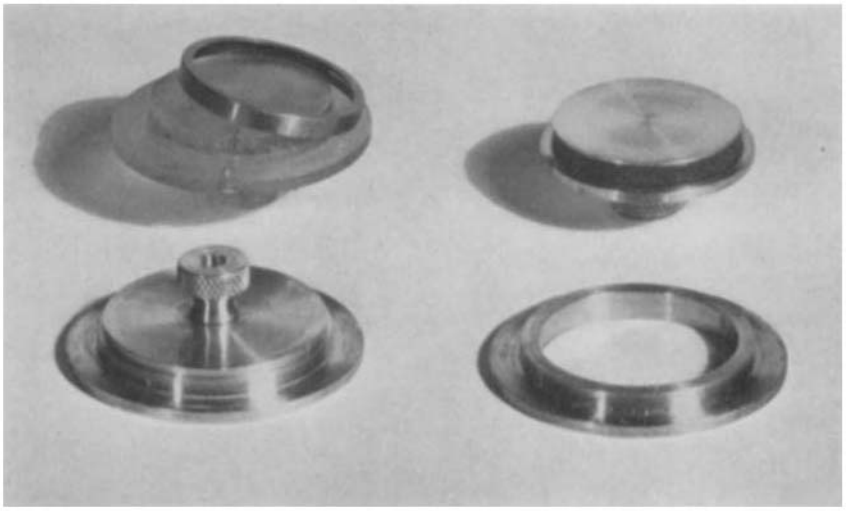
Previous workers have used the starch-iodine reaction to detect the water emerging from sweat glands. Minor (1) painted a tincture of iodine on the skin, allowed it to dry and then dusted it with starch. General areas of sweating were shown by the appearance of an intense blue stain on the skin. Randall (2, 3) improved the method by the introduction of paper as the vehicle for starch, but continued to paint iodine on the skin. He pointed out that some papers are impregnated with starch in manufacture, and so will make a print of the individual glands.

There are two disadvantages to painting the skin with tincture of iodine: it irritates the tissue being studied and it washes away irregularly as sweating proceeds. In the present work, iodine has been introduced into the paper by sublimation, thus making the treated paper a complete reagent for the sweat. Some effort has been given to a trial of various kinds of paper and to a study of the conditions that determine reproducibility. As a result of a few modifications, the method provides the quantitative data that are needed for a statistical analysis of the glandular activity.

A proper choice of paper is of first importance. The paper must absorb iodine uniformly, since any mottling of color makes it impossible to identify the smaller dots. It must be of such uniform texture that the dots will be sharply defined and almost round, even when as

small as 20 μ in diameter. It must limit penetration of water to a small, uniform depth in order to make the ratio of area of dot to volume of water both high and constant. Of all the papers tested, the best was one designated "80 lb. substance, white richfold coated."[1]

Iodine is distributed into the paper by sublimation. Some crystals of iodine are placed in the bottom of a Petri dish; the paper is laid over the top and held in place with the cover; the unit is placed in an oven at about 60°C. for a few minutes. When taken out of the unit the paper should be light to medium brown in color. Fortunately, the sensitivity of the method is not affected by large variations in the deposit of iodine. The paper loses iodine by evaporation and should, therefore, be prepared on the day of use and be kept in closed dishes at tem-



TEXT-FIG. 1. The lucite cover, used to hold print paper, is shown at upper left; the paper is held against the cover by the thin ring. The other cover (upper right) is used to seal the chamber when sweat is collected onto filter paper discs (lower left). At lower right is shown the aluminum ring which is glued to the skin, and can receive either cover.

peratures no higher than 20°C. The blue dots, formed by the reaction with water, are more permanent and can be studied at leisure over the next week or two.

The printing paper is cut into circles of 24 mm. diameter by means of a special punch; these discs are held by a ring onto a lucite cover. Text-fig. 1 shows the cover, and in addition the collecting unit which has been described previously (4, 5). Since the cover is interchangeable with the cover of the sweat-collecting unit, prints and collections can be made in alternation from the same site. The counts are multiplied by 1.29 if they are to be related to the quantities of sweat collected, since the ring that holds the printing paper to the lucite cover has an internal diameter of 22 mm., while the internal diameter of the chamber is 25 mm. ($25^2/22^2 = 1.29$). Because the print registers a sample, rather than all the glands in the field, it is important that the sample be made constant by a close fit of the lucite cover to the fixed ring of the collecting chamber.

All experiments in the present study were made with normal adult male subjects. For the

[1] The paper used in these experiments was purchased from the Rex Stationery Co., New York City.

most part the volar surface of the forearm was used, this being the area employed in previous studies (4, 5); additional data have been obtained from the back, abdomen, and legs. As before, the aluminum ring of the sweat collecting unit was glued to the skin with duco household cement and sweating was induced either by a local injection of mecholyl or by environmental heat (105°F.). The former is much more convenient, and was adequate for most experiments: 2 mg. of mecholyl (β-acetylmethylcholine·HCl) in 0.5 cc. saline was injected through a long, thin needle (1½ inches, 26 gauge), entering the skin outside the fixed ring and travelling to an intradermal position in the center.

Timing of the exposure of the print is critical, since the quantity of water delivered by each sweat gland is proportional to it. The skin inside the ring was blotted by filter paper discs stapled to the end of a cork. Immediately after the last twist of the cork, the printing paper was applied and held for the desired exposure. It was found that the interval from the end of blotting to the beginning of print was not of critical importance, since it could be varied from a fraction of a second to a few seconds without effect on the final result. This result showed that sweat begins to accumulate the instant that blotting ceases and is not appreciably evaporated during the brief interval before the paper comes in contact with the skin. The true exposure, therefore, is the interval from end of blot to end of print.

The prints were counted with a binocular microscope, working at a magnification of 40. The print was divided into squares by a ruling of fine pencil lines, spaced about 4 mm. apart. A scale in one eyepiece was used for measurement of the dots, the smallest units of the scale corresponding to 0.02 mm. The average print from the forearm contained 400 to 600 dots, all of which were classified by diameter into equal intervals of 2 scale divisions. The total count on a single print can be repeated with a coefficient of variation of less than 2 per cent. Likewise, the sum of frequencies in all the classes should agree with the total to within 2 per cent. It is desirable that the completeness of inventory be checked in this way whenever statistical analysis is made of the dot sizes on a print.

VALIDATION OF THE METHOD

The Size of a Dot Is an Accurate Measure of the Amount of Water Absorbed by the Paper.—The volume of water absorbed can be calculated from the area of a dot if the ratio of these values, *i.e.* the depth of penetration, is a known constant. It is not easy to prove that the penetration is constant, however, because the volumes of water involved are too small to deliver accurately from a micropipette. As it works out, the dots on a print of the sweat glands correspond to volumes of from 5×10^{-9} to 4×10^{-6} cm.^{3}. Two kinds of indirect calibration were made; the same depth of penetration, 14 μ, was found in the two cases.

In the first, the total volume of water absorbed on a print was estimated from measurements of the sweating rate and the exposure of the paper. The total area of color on the print was calculated from the number and sizes of dots.

Experiment 1.—A ring was glued onto the forearm and sweating was induced by an intradermal injection of mecholyl. 10 minutes later, when the flow was brisk and uniform over the field, prints were made with exposures of 1 and 3 seconds. A preweighed filter disc was inserted into the ring and covered in the usual way; 900 seconds later it was returned to the weighing bottle. Prints were made again, this time with exposures of 5 and 10 seconds because the general flow had decreased. Second and third collections were made, each followed by prints of 5

and 10 seconds. The weights of filter discs showed that the average flux of sweat was 0.205 $mm.^3$ per 5 seconds; the average total area of color on the 5 second prints was 15.2 $mm.^2$. The ratio of these two values is 0.0135 mm., or 14 μ.

In the second procedure the volume of water absorbed on the paper was measured by delivery of one droplet from a micropipette. The area of color was estimated by cutting out the large blot and weighing it. The ratio of area to volume in this experiment was the same as in the first.

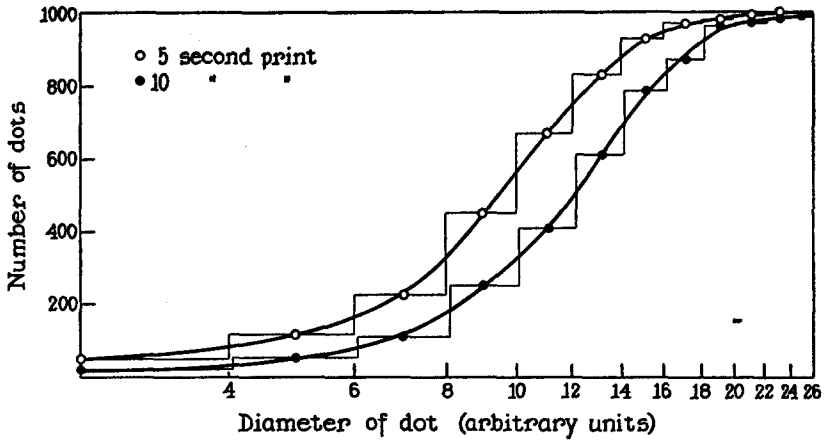
Experiment 2.—A constriction micropipette, with a precision of about 1 per cent (6), was used to deliver 7.3 $mm.^3$ of water onto the surface of a glass plate that had been made water-repellent with silicone. The print paper was laid upon the drop without delay, and pressed firmly from above with a second glass plate. The blot was cut out and its area determined by weight, with allowance for the weight of water absorbed. Four such experiments checked closely, giving an average area of 578 $mm.^2$. The ratio of volume to area was 0.0126 mm., or 13 μ. The check between this value and the preceding one of 14 μ is even closer than would be expected from the many approximations of the two methods.

Three Distinct Aspects of the Sweat Glands Are Registered in a Print: The Number per Unit Area, Mean Flux, and Relative Activity.—First, the number of glands per unit area of skin is given directly by a count of the dots in a known area, if all glands have appeared on the print. Second, the mean output of water per gland during a known exposure of the print (*i.e.* the mean flux) can be calculated from the total area of all the dots and the number of glands. Third, the variation in activity from gland to gland, which is evident on inspection of the print, can be analyzed quantitatively by measurement of the sizes of dots. Further calculation is needed to present the relative activity in a form suitable for comparison, since the distribution of dot size is affected by the total amount of water delivered to the print—in other words by the length of contact with the skin. What is wanted is some way to quantitate those features of the population that are due to differences in the relative activity of glands and are independent of a technical detail such as exposure of the print.

An increase in the exposure of a print increases proportionately the water delivered from each gland, and therefore, with constant penetration, the area of each dot. If the logarithms of the areas are used, rather than the areas themselves, a proportionate increase of water in each dot will add the same constant factor to each logarithm. Graphically, this means that the distribution of log area is shifted without change in shape, while the distribution of area is both shifted and deformed. But it is not necessary to compute areas, since the distribution of log diameter is the same as that of log area apart from a constant scale factor of no importance. Therefore the distribution of log diameter is the one of choice.

This distribution can be studied in either of two forms, integral or differential. The integral form is a plot of the number of dots with a value of log diam-

eter equal to or less than a given value. Measurements of diameter in increments of 0.04 mm. place the dots in about 15 classes of equal size. A simple consecutive sum of these classes, when plotted against log diameter, gives the integral distribution of log diameter. The differential, or frequency distribution, gives the relative frequency of dots in each class; this differs from the frequency of diameters since the class intervals have become unequal upon change to the logarithm. The number of dots in each of the original classes must be divided by the length of the class interval on the scale of log diameter in order to show the relative frequency of dots with any given value of log diameter. Each of



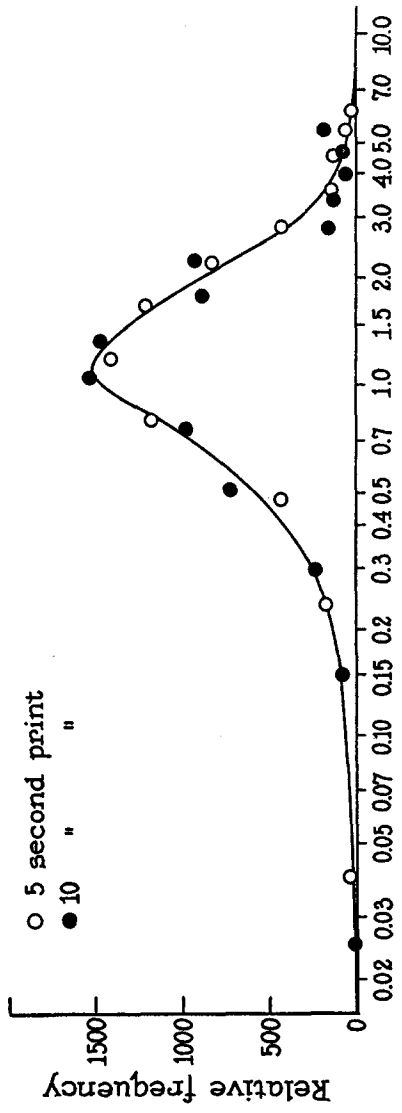
TEXT-FIG. 2. The integral distributions of log diameters, obtained from two prints of the same area. One print had been exposed for 5 seconds and the other, for 10 seconds. The distribution is shifted but unchanged in form (Experiment 3).

these distributions has an advantage: the first is obtained directly from the data; the second is a more familiar way to show the heterogeneity of a population. Both will be used in the next section.

A Change in the Exposure of a Print Does Not Affect the Determination of Relative Activity.—

Experiment 3.—A ring was attached to the forearm; sweating was induced by local mecholyl. After a wait of 15 minutes to insure a brisk, uniform flow, two prints were made with exposures of 5 and 10 seconds. The dots were counted, measured, and assigned to classes which represented intervals of 2 scale divisions on the eyepiece of the microscope (0.04 mm.).

The total count agreed closely with the sum of numbers in the classes for each print, and the totals for the different prints agreed closely with each other. The values for total and sum of classes were, respectively, 414 and 417 in the 5 second print; 409 and 408 in the 10 second print.



TEXT-FIG. 3. The frequency distributions of log diameter, obtained from the same data as Text-fig. 4 (Experiment 3). The distributions have been shifted to a common mean flux; note the detailed correspondence of their shapes.

Text-fig. 2 shows the integral distributions of log diameter. It can be seen that the increase in exposure merely shifted the distribution along the logarithmic scale without change in form. The magnitude of the shift was 0.20 log units, a little less than the expected shift of 0.30 log units, but within experimental error; the difference corresponds to only 1 second exposure.

The constant form of the distribution can be seen somewhat better in the frequency distributions of Text-fig. 3. These distributions have been shifted to a common mean[2] to correct for the difference of exposure; their match is a sensitive test of the correspondence between the two distributions. The fact that the same distribution is obtained with a doubled exposure is additional evidence that the relation between area of dot and volume of water is a constant one over a wide range of dot sizes.

The Span of the Method Is Large in Relation to the Span of the Distribution; Therefore, the Great Majority of Glands Can Be Registered.—With the prints, as with any other method, there is an upper and a lower limit to the measurements that can be made. The upper limit of dot size is reached when adjacent dots touch each other; this occurs when the larger dots are about 0.7 mm. in diameter. The lower limit may be put at 0.02 mm., although with higher magnification this limit probably could be made even lower. The span of the method, defined as the length of this interval on the scale of log diameter, is the difference between the logarithms of these numbers, or 1.5 log units.

The span of any distribution can be defined as the interval that contains some arbitrary percentage of the total count, say 90 per cent. The distributions of Text-figs. 3 and 5 are typical; their spans are about 0.7 log units.

The importance of making a comparison between the span of the method and the span of a distribution arises from the fact that the distribution can be shifted without change in form simply by a difference in the exposure. Since the span of the method is more than twice that of the distribution, one can be sure that almost all of the distribution will be registered, if a suitable exposure is chosen. The choice of an exposure, moreover, is not critical.

On the other hand the procedure of painting iodine on the skin (2, 3) gives a less sensitive print; the lower limit of detection appears to be about 10^{-7}cm.[3] of sweat. The upper limit, which is determined by the spacing of glands, is about the same; from these figures the span of the method appears to be about 0.6 log units. Under these conditions it would be impossible to register the

[2] Grouping the data affects the calculation of a mean value for log diameter. Both the skewness of the distribution and the inequality of the grouping intervals cause the apparent value to be less than the true mean of the distribution. These factors are independent of magnitude of the mean, however, and can be neglected in a calculation of the difference between means of two distributions. If the true mean is wanted for other purposes, it can be obtained by graphical integration of a curve fitted to the data, and will be found to exceed the apparent mean by about 0.1 log units.

whole distribution on a single print, and if the exposure were not well chosen, a majority of the glands would fail to appear.

EXPERIMENTAL RESULTS

Differences in Size of Dots Reflect Persistent Differences in the Output of Individual Glands.—This can be seen in comparisons of successive prints taken from the same area (Figs. 1 to 3). To obtain these pictures each print was photographed and reprinted with enlargement onto transparent film. The left member of each pair in Figs. 1 to 3 shows a photograph of a single transparent reprint; on the right, two transparencies of prints taken 1 hour apart have been superimposed for comparison. The later print in each case was reprinted darker in order to distinguish the two prints by the color of the dots. The two transparencies were brought into conjunction, and then shifted slightly to put the later dot just to the right of the earlier dot from the same gland. The reader can observe that the large dots of the earlier print continued to be large and the small dots remained small. This persistence of the relative sizes of dots held despite the reduction of size of all dots in the later prints, due to a general waning of output from the area. Similar results were obtained from the forearm under stimulation with local mecholyl (Figs. 1 and 1 *a*), from the forearm of another subject sweating in a hot room (Figs. 2 and 2 *a*), and from the back of a subject in the hot room (Figs. 3 and 3 *a*). Presumably these constant differences in output are due to differences in size of the glands. Anatomical work of more than a hundred years ago (7) showed that glands do, in fact, vary in size, but quantitative studies of the anatomy are lacking.

Experiment 4.—The ring of the collecting chamber was glued onto the volar surface of the forearm. Sweating was induced by the intradermal injection of mecholyl. Prints, each of 5 seconds duration, were made at 15 minute intervals over a period of 2 hours. Transparent photographs were made of all prints and compared. It was found that the dots maintained their relative sizes throughout the experiment. Fig. 1 shows the field at the onset and Fig. 1 *a* shows a comparison of this field and the same area 1 hour later.

Experiment 5.—In another test, rings were glued onto the forearms and backs of two subjects, and general sweating was induced in a hot room (105°F.). Again it was found that the dots in the early print maintained their relative sizes when compared with the dots in the second print from the same area 1 hour later (Figs. 2 and 3).

The Glands Appeared to Discharge in a Steady Manner, without Intermittency.—Two kinds of intermittency should be distinguished: the individual glands might discharge periodically but without relation to each other, or the field as a whole might wax and wane. The first type of intermittency would cause the dots in consecutive prints to vary at random, not, as is shown in Figs. 1 to 3, to keep their relative sizes. In this respect the glands of the forearm and back appear to differ from the palmar glands, since the latter do discharge intermit-

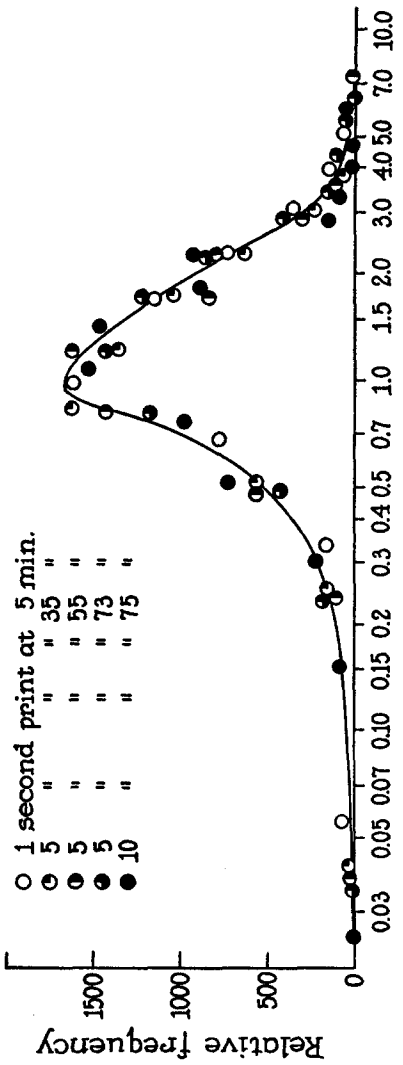
tently, as can be proven by careful observation of one's own finger tips (8–11). But the palmar glands are notable for their thick walls and muscular fibers, whereas most glands of the body (except axillary and genital) do not contain large amounts of muscle (7). It is possible that the intermittent discharge of palmar glands is a special adaptation to the need for a slight but constant amount of moisture on tactile surfaces; their behavior does not seem to be typical of the glands that respond in thermal sweating.

The second type of intermittency, a fluctuation in mean activity of the field, might be mistaken for the first. We had used a less sensitive printing method for several months, and even made elaborate graphs of apparent changes in number of active glands, before realizing that only a fraction of the population was being registered. After the present method was developed, making it possible to register essentially all the glands, fluctuations in count were no longer seen. Possibly the variations in count with the earlier method were due to fluctuations in the mean activity of glands, with a considerable number working near the threshold of the method being seen in one print and missed in the next. We could not be sure of this, however, since slight differences in the exposure or sensitivity of the print would have had the same effect.

Of course, abrupt changes in activity of the glands can occur as a result of nervous reflexes (12), or of large changes in skin temperature (13). This sort of variation is not a true intermittency but rather is a fluctuation of stimulus to the glands. The experiments in the present work were planned to avoid reflex or temperature changes.

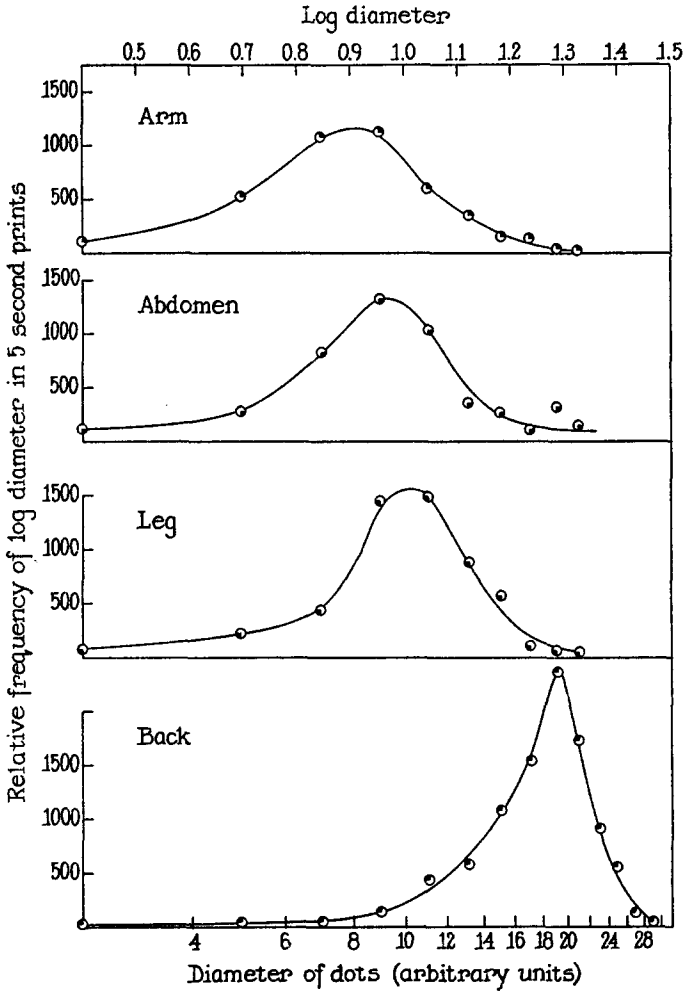
The Relative Activity of Glands in a Given Area Remained Constant Despite Change in Flux.—The rate of sweat flow per unit area (*i.e.* the flux) rises to a maximum within minutes after the injection of mecholyl, and then declines to nothing during the next 2 or 3 hours. From the fact that the count of glands in a given area remains constant despite changes in flow from the area, it is evident that there are large differences in the rate of flow from individual glands at different times. The question, and an important one for any theory of gland function, is whether the set of glands varies together as a unit, the individuals differing from each other at any instant but always making the same relative contribution to the total output, or whether the distribution itself is changed with time. The following experiment showed that the frequency distribution of log diameter remained constant despite a fivefold change in the flux over a period of 75 minutes (Text-fig. 4). This means that the set of glands varied effectively as a unit.

Experiment 6.—A ring was glued to the inner surface of the forearm and sweating was induced by the injection of mecholyl in the usual way. Prints were made at 5, 35, 55, and 75 minutes, several different exposures being made at each time to make sure that a good print would be obtained.



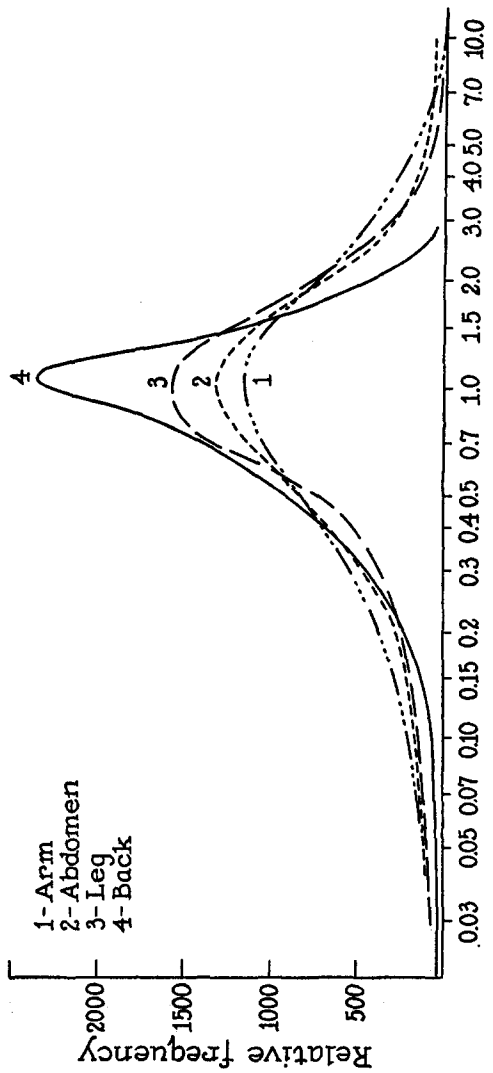
TEXT-FIG. 4. The frequency distributions of log diameter, given by five prints from the same area (Experiment 6). The distributions have been shifted to a common mean. Note the constant form of the distribution.

The most suitable prints had exposure times of 1 second at 5 minutes, 5 seconds at 35 and 55 minutes, and 10 seconds at 75 minutes. Calculation of the flux from the whole field, based on measurements of the sizes of dots and



TEXT-FIG. 5. The frequency distributions of log diameter, given by four prints from different areas of the body (Experiment 7). They differ greatly in average size, as shown by different positions on the scale of log diameter, but the shapes of the distributions are similar.

exposure of the prints, gave the following values: 7.5 mg./cm.^{2} min. at 5 minutes, 1.8 at 35 minutes, 1.8 at 55 minutes, and 1.5 at 75 minutes. The density of glands remained constant at 115 glands/cm.^{2}; the mean flux per gland,



TEXT-FIG. 6. The distributions of Text-fig. 5, brought to a common mean for comparison.

therefore, was 0.39 γ/gland sec. at 5 minutes, 0.10 at 35 minutes, 0.10 at 55 minutes, and 0.08 at 75 minutes. Throughout the whole experiment the frequency distribution of log diameter remained constant. This is shown in Text-fig. 4, in which each distribution is shifted to a mean flux of unity and the remaining variation is identical for all prints.

The Number of Glands per Unit Area, and Their Functional Powers Are Quite Different in Various Parts of the Body; the Dispersion of Relative Activity about the Means Are Similar.—

Experiment 7.—Mecholyl was injected intradermally in four sites: inner side of forearm, inner side of lower leg, midabdomen near anterior axillary line, and back under tip of scapula. About 15 minutes after the injections three prints were made at each site; the best of each was chosen for analysis.

Measurements were made of the density of glands and the outflow of sweat from the four sites: forearm, 130 glands/cm.^{2}; abdomen, 72; leg, 87; back, 85. Despite the greater density in the forearm, the flow of sweat per unit area was much greater from the back: forearm, 3.7 mg./cm.^{2} min.; abdomen, 2.6; leg, 3.7; back, 10.7. The distributions of log diameter are shown in Text-fig. 5. They are differently placed on the scale of log diameter, corresponding to the great differences in mean values, but the forms of the distributions are similar (Text-fig. 6). This illustrates the fact that the distribution of log diameter is independent of the density of glands and the mean flux per gland.

These results show that neither the rate of sweat flow per unit area of skin nor the mean flow per gland is a sufficient basis for comparison of two different areas of skin. Either of these values can be the same for two areas and yet the glands be in different functional states if, for instance, glands of greater power in a low state of activity are compared with weaker glands under maximal stimulation. Useful comparisons can be made only between the consecutive states of a single area, or between the functional states of two areas that are comparable in mean glandular power. It remains for future work to establish a basis for comparison of regions when the glands differ greatly in power.

SUMMARY

A method has been worked out for the measurement of the volume of sweat produced by individual glands. A special paper, impregnated with iodine, absorbs water in a uniform way and shows the area of wetting by a sharply defined blue dot. Indirect calibrations showed that 1 cm.^{3} of water would form a spot of 700 cm.^{2} area, and that this relation of volume to area was a constant one over a wide range. The actual volumes encountered in prints of the sweat glands were from 5×10^{-9} to 4×10^{-6} cm.^{3}.

The relative activity of glands at any instant of time can be expressed by the statistical distribution of log diameter of the dots on the print. This distribution, which might at first sight seem rather artificial, has the advantage of being unaffected by a proportionate change in the output of water from each gland. Thus it is independent of the duration of contact between print paper and skin, and of changes in the average flow from the field as a whole. It is sensitive only to changes in the activity of glands relative to each other.

The methods of printing and statistical analysis were used to study the relative activity of glands in a field of 22 mm. diameter. Glands of the forearm and back were studied both under direct stimulation with mecholyl and under the reflex stimulation of environmental heat, similar results being obtained with the two kinds of stimuli. Glands of the abdomen and leg, stimulated with mecholyl, were studied in one experiment.

Detailed comparison of the dots in consecutive prints showed that the large dots remained large and the small dots continued to be small. These persistent differences in the outflow of water from adjacent glands were interpreted as being due to differences in the functional power of the glands.

Repeated prints of the glands during a period of 75 minutes, in which the sweat flow was declining, showed that the relative activity of the glands remained constant. This meant that the set of glands, although differing greatly in power, varied together as a functional unit.

Different regions of the body show not only the variation of glandular power within each small area, but also marked differences in the average power of glands belonging to the different regions. Glands of the back, for instance, show a much greater outflow than glands of the forearm when stimulated equally with a local injection of mecholyl. Equal rates of outflow, therefore, do not mean equal states of functional activity, unless the regions being compared are of equal functional power.

BIBLIOGRAPHY

1. Minor, V., *Deutsch. Z. Nervenheilk*, 1927, **101**, 302.
2. Randall, W. C., *J. Clin. Inv.*, 1946, **25**, 761.
3. Randall, W. C., *Am. J. Physiol.*, 1946, **147**, 391.
4. Dole, V. P., Stall, B. G., and Schwartz, I. L., *Proc. Soc. Exp. Biol. and Med.*, 1951, **77**, 412.
5. Schwartz, I. L., Thaysen, J. H., and Dole, V. P., *J. Exp. Med.*, 1953, **97**, 429.
6. Brüel, D., Holter, H., Linderstrom-Lang, K., and Rozits, K., *Compt.-rend. trav. Lab. Carlsberg*, 1944–47, **25**, 289.
7. von Kölliker, R. A., A Manual of Human Microscopic Anatomy, London, John W. Parker and Son, 1860, 124.
8. Kuno, Y., The Physiology of Human Perspiration, London, J. and A. Churchill, Ltd.. 1934. 215.

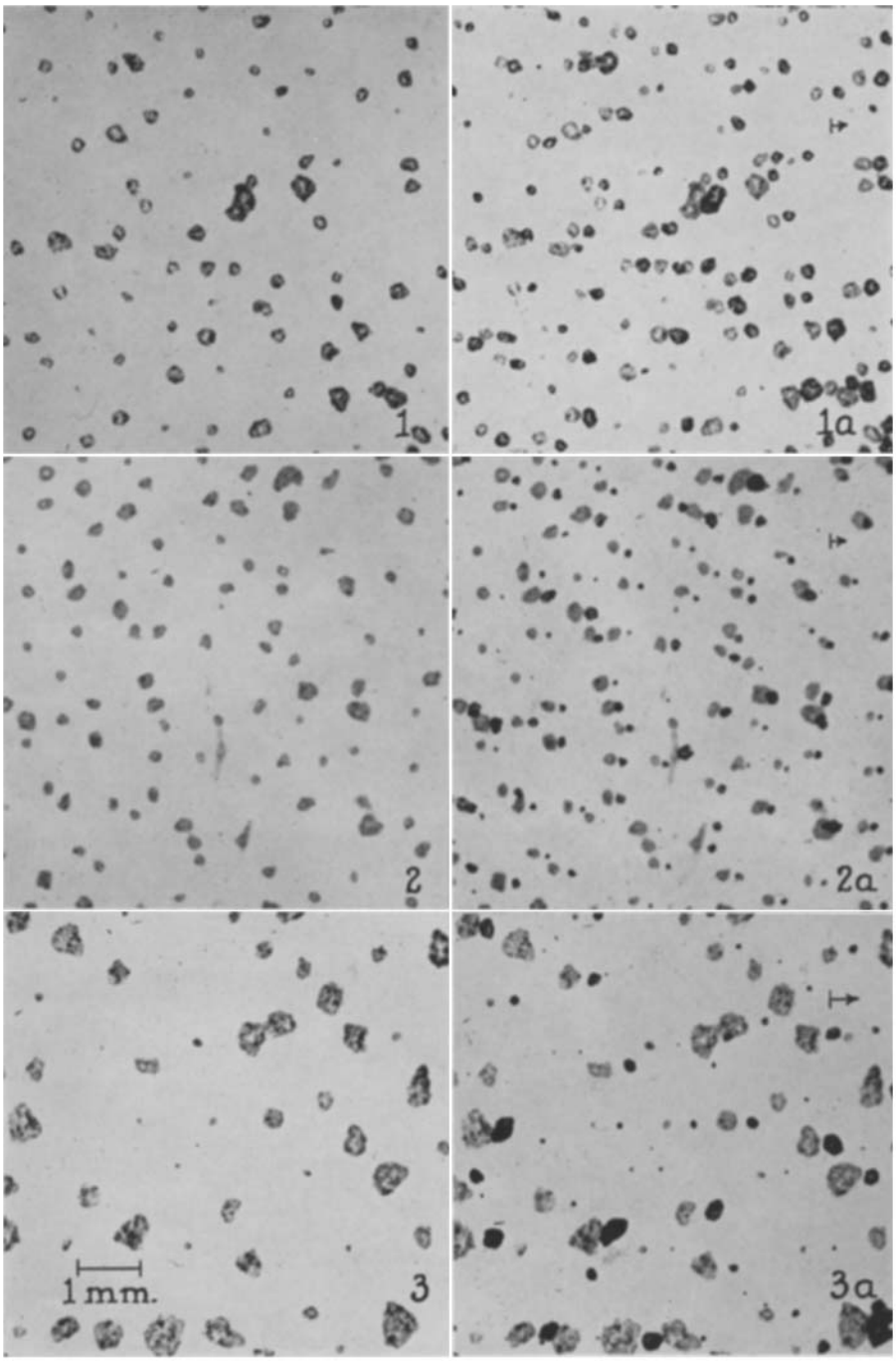
9. Kuno, Y., *Lancet*, 1938, **1**, 299.
10. Buley, H. M., *Arch. Dermatol. u Syphilol.*, 1938, **38**, 340.
11. Lobitz, W. C., Jr., and Osterberg, A. E., *J. Inv. Dermatol.*, 1945, **6**, 63.
12. Burch, G. E., Cohn, A. E., and Neumann, C., *Am. Heart J.*, 1942, **23**, 1.
13. Kuno, Y., The Physiology of Human Perspiration, London, J. and A. Churchill, Ltd., 1934, 124.

EXPLANATION OF PLATE 12

The photographs were taken Mr. Richard F. Carter.

FIGS. 1 to 3. Photographs of prints from arm and back. On the left in each case is an unretouched photograph; on the right a print of the same area, taken 1 hour later, is superimposed for comparison. The later print has been made darker for identification and shifted to the right as shown by the small arrow in the upper right hand corners. The scale mark at the bottom of Fig. 3 applies to all figures in the group.

Figs. 1 and 1 *a*: forearm, sweating induced by mecholyl (Experiment 4). Figs. 2 and 2 *a*: forearm, another subject, sweating induced by general heat (105°F.). Figs. 3 and 3 *a*: back, sweating induced by general heat (Experiment 5). The reader will observe that the dots generally maintain their relative sizes. This holds even in Fig. 3 *a* in which the late dots are smaller because of a decline in activity of the whole field.



(Dole and Thaysen: Functional power of human sweat glands)