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PHILOSOPHICAL TRANSACTIONS

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[PLATES 1, 2.]

THE PATTERNS IN THUMB AND FINGER MARKS.

ON THEIR ARRANGEMENT INTO NATURALLY DISTINCT CLASSES, THE PERMANENCE OF THE PAPILLARY RIDGES THAT MAKE THEM, AND THE RESEMBLANCE OF THEIR CLASSES TO ORDINARY GENERA.

BY

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I. *The Patterns in Thumb and Finger Marks.—On their arrangement into naturally distinct classes, the permanence of the papillary ridges that make them, and the resemblance of their classes to ordinary genera.*

By FRANCIS GALTON, *F.R.S.*

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[PLATES 1, 2.]

I PROPOSE to describe some results of a recent inquiry into the patterns formed by the papillary ridges upon the bulbs of the thumbs and fingers of different persons. The points upon which I shall chiefly dwell are, the classification of the patterns, their permanence throughout life, and the apt confirmation they afford of certain views concerning the more important conditions by which the genera of plants and animals are determined.

My attention was drawn to the subject nearly three years ago, when preparing a lecture for the Royal Institution on "Personal Identification." (See either the 'Journal of the Royal Institution,' for Friday, May 25th, 1888, or 'Nature,' June 28th, 1888, in which the portion of the lecture with which we are now concerned is printed.)

I would refer to that lecture, as it contains numerous references to the existing literature on the subject, and because it formed the starting point from which the present inquiry proceeded. Two conclusions were strongly impressed on my mind at the time when I gave it :—

(1.) That although much had been asserted as to the permanence of these markings, and though I was then able, through the kindness of Sir W. J. HERSCHEL, to submit two instances in proof, the truth of the assertion had never been adequately investigated.

(2.) That the method of classifying the markings, which was originated by PURKINJE, in his 'Commentatio,' dated 1823 (a copy of this rare pamphlet is now

in the library of the College of Surgeons), and subsequently adopted by other writers, with more or less variation, was not based on a sufficiently good foundation.

Since then I have steadily pursued the inquiry and found its interests to widen considerably as I proceeded. They led in many directions, and among others to the topic that will be the last discussed.

Data.

The data on which this memoir is based are:—

(1.) The impressions of the two thumbs of about 2500 persons made for me, at my Anthropometric Laboratory, together with several impressions of the fingers.

(2.) A small and unique collection of impressions put at my disposal by Sir W. J. HERSCHEL, of which one half were taken many years ago, and the other half were taken quite recently from the same persons. I will speak of these more at length when the time comes for using them.

As regards the first set:—

I chose the two thumbs rather than two adjacent fingers on the same hand, in order to obtain data respecting symmetry, on which however very little will be said here, and I chose a thumb of each hand, rather than a finger of each hand, because the thumb being greater than that of the finger the width of it affords a proportionately larger field for variety of pattern. However, all that will be said about thumb marks, applies with but little reservation to finger marks, but with much more reservation to those of the toe.

I have myself not studied the latter, but PURKINJE states that the patterns of the toes are always of that particular sort which I shall define later on, and call a loop.

Origin of the Ridges.

I do not attempt to discuss the origin of the papillary ridges, because my knowledge is entirely second hand, and it would be presumptuous in me to do so. It will be sufficient to say that KOLLMANN'S (A. KOLLMANN, 'Der Tastapparat der Hand.' Hamburg and Leipzig, LEOPOLD VOSS, 1883) dissections seem to prove (see his figs. 19, 20):—

(1.) That each of the papillæ (which lie below the cuticle) has two heads, which I will symbolise by the fork in the printed capital letter Y.

(2.) That the duct of the sudorific glands in passing outwards between the papillæ, is bound up, as in a bundle, with the adjacent head of each of two neighbouring papillæ. So that if the sudorific duct is symbolised by the printed letter I, a section across the ridges might be symbolised by a row of the letters Y and I printed alternately, thus—YIYIYIY. Then the union of the I with the adjacent prongs of two Y's forms the foundation of a ridge, and the clefts between the heads of the Y's correspond to the furrows.

There is, I believe, no adequate explanation of the fact that the prominences through which the ducts issue, on the bulbs of the finger, and in some other parts, are strongly disposed to arrange themselves into continuous ridges, and not to form isolated craters. There is, however, abundant analogy in the animal kingdom of external ridges of various sorts running in a variety of spirals and whorls.

Obtaining Impressions.

The impressions in my collection were made by thinly inking a copper plate with printer's ink, by means of a printer's roller. The plate was about eight inches by twelve, and fixed to a solid block of wood. The thumb was rather lightly rolled on the inked plate, not simply pressed upon it, and then rolled on paper. Thus the impression it left was a cylindrical projection of the whole bulb of the thumb, extending nearly from one side round to the other (fig. 8), and including all the principal characteristics of the pattern, which a simple impression (see those in Plate 2) often does not. The thumbs were easily cleaned by dipping them into a dish of turpentine and wiping with a cloth. It is an essential condition for making clear impressions that the ink should not lie low down the sides of the ridges. The furrows should remain quite uninked. I had much difficulty at first in contriving a rough and ready method of obtaining good impressions, and do not say that the plan just described is the best. But it has acted well for a long time, and, therefore, it is hardly necessary for me to speak here of later experiments to improve it.

Reversal of Patterns.

Patterns of similar kinds lie on the two thumbs in opposite directions. They should never be read from right to left, but from outwards, inwards. Consequently, in order to make the pattern on the one thumb comparable with that on the other, it must be reversed. It is convenient to take a duplicate of the impressions upon tracing cloth, which shows the reversed pattern when it is viewed face downwards.

Origin of the Patterns.

The reason why the patterns appear on the bulbs of the thumb and finger is apparently to be found in the presence of the thumb nail, which disarranges the otherwise parallel course of the ridges in the way that is diagrammatically shown in fig. 1.

Here we see that the upper ridges near the tip of the thumb are thrown into bold arches, while the ridges that lie below the level of the nail run horizontally. There is, in consequence, a tendency to leave an interspace, which has somehow to be filled up with a scroll work of ridges, and this scroll work constitutes the patterns with which we are concerned.

In about one case in thirty, the interspace is avoided by an arrangement like that in *a*, figs. 7 and 9, but this is an unstable form, or it often shows signs of having

been on the point of breaking into a different pattern, as will soon be explained more fully. I call these patterns "Primaries," because they are the fundamental arrangement from which all the vast varieties of other patterns are lineally descended, and in all of which the interspace of which we have spoken exists.

Fig. 1.

Fig. 2.

Fig. 3.

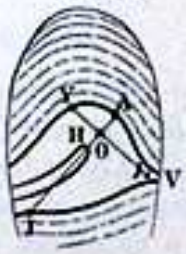


Fig. 4.

Points of Reference.

Wherever an interspace occurs, two ridges must have diverged in order to make room for it. There may be a divergence of the ridges on both sides of the interspace, as in fig. 2, or on one side only, as in figs. 3 and 4. Moreover, just in front of the place in the furrow, beyond which the parallel ridges begin to diverge, there are always one or more little cross lines, diagrammatically shown in all these figures, which cut off a small triangle.

The centres of these triangles form excellent spots or points of reference, though doubt may exist as to the exact position in which they should be placed. It is easy enough to determine their position approximately, and that is all we want.

Hereafter I shall always call these two points V and W. V being to the outside of the thumb, and W to the inside, that is to say, nearest to the rest of the hand. They are cardinal points in my classification, and are very useful in constituting the two ends of a base line (fig. 2) from which measurements may be made and bearings taken.

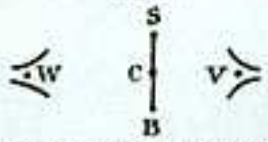
Reversals.

After the proper letters have been affixed to the points, it does not matter whether the pattern we are studying is direct or reversed. There is a curious variety in the way in which patterns are apt to be presented. Those on the right thumb are reversed forms of those met with on the left. The impression is the reversed form of the pattern itself. If made on a lithographic stone, it is re-reversed in the print. If made on transfer paper and thence put on the stone, it is re-re-reversed in the print. This is enough to show the confusion that will arise if the points V and W are not lettered, but it by no means exhausts the list of ordinary contingencies. As the letters V and W are unchanged in shape when they are reversed, they are convenient for the purpose to which they are here applied.

Basis of the Classification.

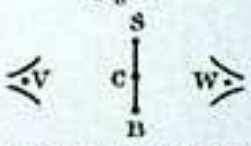
In one respect the divergent lines that bound the pattern admit, in the earlier part of their courses, of nine, and only nine, possible variations. Draw a line (figs. 5, 6) through what appears to be the most central part of the pattern (which we may call C), that shall be roughly parallel to the median line of the thumb, and shall cut

Fig. 5.



Print of left thumb, or appearance of face of right thumb.

Fig. 6.

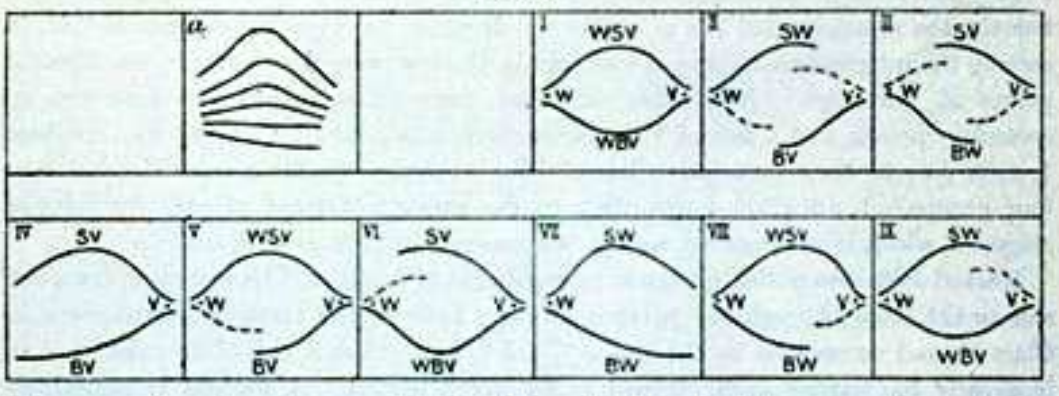


Print of right thumb, or appearance of face of left thumb.

the upper boundary of the pattern at S and the lower boundary at B. Consequently, S and B, whose positions are very roughly determined, may be taken to represent the summit and the base of the pattern. Now the ridge in which S is situated must, by construction, have come either from V or from W, or from both. There are these three, and only these three, alternatives, SV, SW, WSV. Similarly, as regards the ridge on which B is situated, there are the three alternatives, BV, BW, WBV. As any one of the former events may be combined with any one of the latter, there are 3 × 3, or nine possible combinations. In the primaries neither V nor W exist, so they form a class by themselves, making a total of ten classes. The nine of which we have been speaking are as follows:—

I. WSV—WBV	IV. SV—BV	VII. SW—BW
II. SW—BV	V. WSV—BV	VIII. WSV—BW
III. SV—BW	VI. SV—WBV	IX. SW—WBV

Fig. 7.



These, as well as the primary, which is distinguished by the letter *a*, are drawn in the diagram, fig. 7.

Outlines of the Patterns.

A pattern is quickly analysed by following with a pencil the course of the two pair of divergent ridges from V and W respectively (fig. 8), or if one of these points

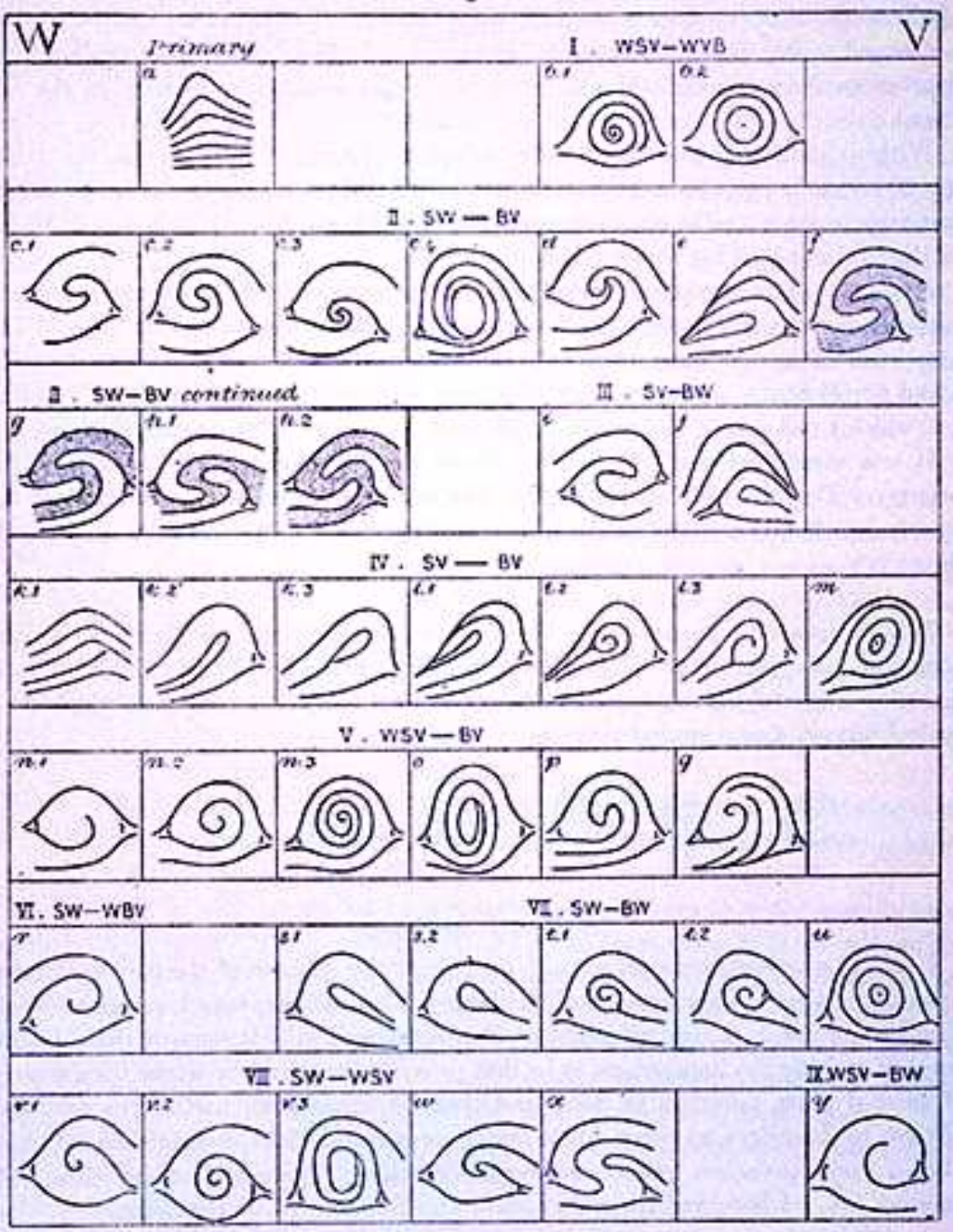
Fig. 8.

is absent, then following those that diverge from the other (see also figs. 2, 3, 4). As ridges are apt to bifurcate, to join with others, and also to end abruptly, it is necessary to follow a consistent course in such cases. In bifurcations the innermost branch should be followed. Whenever a ridge ends, the pencil should stop also, and recommence on a new ridge, selecting that which appears to continue the direction of the former one in the truest way. In case of doubt, the pencil should, as before, follow the innermost of the two lines between which the doubt lies. If opposite rules to these were imposed, the outline would be much less speedily analysed, and be by no means so simple when completed. The sudden transformation of a maze of ridges into an orderly pattern by this easy process is truly remarkable.

I outlined, where necessary, or otherwise examined, more than 1000 photographically enlarged impressions with much care, and found, on sorting them, that nearly all their patterns fell satisfactorily into one or other of the divisions in fig. 9, where twenty-five main divisions are arranged, according to the ten classes already described, namely, the primaries and the nine others. It must, however, be understood that, in sorting the impressions, no regard was paid in the first instance to other than essential points of difference. After this was done, some little regard was bestowed on secondary points, and a few of the species were subdivided by adding the numbers 1, 2, 3, &c., to their descriptive letter. For example, species *c* is subdivided into four groups, *c* 1, *c* 2, *c* 3, *c* 4, according to the amount of twist of the two belts of ridges of which it is composed, and to the presence or absence of a nucleus.

Marked instances of the occasional interpolation of a belt of ridges running from one side to the other through the pattern, and in a more or less tortuous course, occur in Class II. and correspond to the forms *f*, *g*, *h* 1, *h* 2. Such a belt often exists, but it is usually too narrow or ill defined to be worth regard. A pattern is sometimes composed altogether of such a tortuous belt, in which case it would rank along with the Primaries in Class *a*. As there are twenty-six letters of the alphabet, and only

Fig. 9.



twenty-five of them are used in fig. 9, the last letter, *z*, will serve to show that any pattern to which it is attached is *not* one of those in fig. 9.

All the patterns in fig. 9, are drawn on the supposition that W lies to the left and