Finger Prints*

A Chapter in the History of Their Use for Personal Identification

By Henry Faulds

THE famous Tichborne case gave a great impulse to the study of identification as a question in jurisprudence. I was leaving this country for Japan in 1873 and the vast crowd around the old Court at Westminster impressed me greatly with the importance of the subject. Craniology seemed to many to have had its day, and the complexities of constantly varying methods had induced almost complete skepticism. If a race could not be distinguished on anatomical grounds, how could we ever hope to identify a single member of the human family on the basis of anatomy with confidence and precision? It had been decreed, *nemine contradicente*, except Virchow—an important exception—that all the soft tissues, hair, skin, and the like, were now useless for such a purpose. I had studied photographs most carefully, but found them to be traitorous, the same people being made to look quite different in a changed light, by another mode of developing, with the varying psychological moods of the sitter. They were useful but not precise. After certain illnesses, too, the living face was found to change, as in typhoid fever, and more temporarily in ague. The tragic effects of small-pox are well known to novel readers. Our police in England used not long ago to keep an indexed record of tattoo-marked persons who had once been convicted. I doubt if they ever had a case like that of a Japanese once employed by me in their collection. This man's case was unique, I think, his whole skin surface being one finely-wrought pattern, not only intricate but really beautiful. Now such a case might be copied, at great trouble and expense, to win a fine estate. But no one can produce to order the simplest finger-print pattern in living tissue. It may be destroyed, whereas, on the other hand, a complex tattoo pattern can be created but can hardly be destroyed. Sir Edward Henry says of finger-patterns that they are out of all proportion more numerous than such measurable features as tattoo marks, but I think he cannot have contemplated such cases as that just described.

Along the great populous beach of the Bay of Yedo, where the hospital was which I had charge of, were many shell-heaps or kitchen middens. Some of them were ancient, while others had an almost unbroken history coming down to our own day. Amid the oldest heaps I often found fragments of sun-baked pottery, on which finger-marks had been impressed when the clay was soft. These seemed to have been made by children, perhaps young girls, whose ancient fingers had dinted the edges of the soft ware as pie-crusts are still molded by the thumb of baker or pastry-cook. Similar articles were then (1878) made and sold as toys, and I purchased many of them in the bazaars of Tokyo. Ancient ware, baked in the sun but never fired, and marked with finger furrows, is in high repute for the ceremonial tea-drinking of Japan, but it is quite incorrect to say, as has been said and written, that no other is ever used in those depressing festivities. Sometimes the furrows or ridges of those ancient finger-marks came out sharp and clear, but much oftener they were blurred or smudged by movement during the act of impressing. In the modern toys, however, the imprints were better impressed and were obviously intended for ornament. Endowed, or afflicted, with myopic eyes, I was led very early to notice how, in the modern ware, one peculiar pattern of lineations would reappear with great persistency, as if the same artist had again left her sign-mark on her work.

I examined directly many thousands of living fingers, then passed on to consider impresses on putty, bees-wax, sealing-wax, clay, and other substances, taken from my

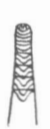

Fig. 2. — *Rugae* or ridges on the under surface of the prehensile tail of *Ateles ater* (Spider Monkey).

Fig. 4.—Smudge from a finger. A typical example of the general appearance, in natural size.

own fingers, those of students under my care, and medical men, native and foreign, and out-patients who might visit the hospital. These were at first very roughly classified and analyzed. I am quite sure that at this point the conception of a wide and general method of identification flashed upon me with suddenness. Almost immediately followed a most depressing sense of moral responsibility and danger. What if someone were wrongly identified and made even to suffer innocently through a defective method? It seemed to me that a great deal had to be done before publicly proposing the adoption of such a scheme. Till then we had used wax and other plastic substances (and on the whole, paraffin was found to be best) but now I remembered lessons on botany I received in Anderson's College, Glasgow, as a lad attending business. We used to print the leaves collected in Saturday afternoon excursions with an oily mixture of burnt cork. Using good printing ink in Japan, then, we got large numbers of clear and excellent finger impressions. Their variety was wonderful, and we could study details with much greater ease and delicacy than in *relievo* impressions. From that stage

Fig. 1.—Enlarged Finger-Print Showing Sweat Pores.

onward I made steady observations, seeking specially to determine whether the patterns characteristic of one individual ever varied from time to time, either in general arrangement or in linear detail. At this time I had noticed that the pigment in human freckles and in the skin affection called *leucoderma* (supposed by some to be the "white leprosy" of the Hebrews) migrated, as my teacher, Lord Lister, had shown to be the fact with the pigment on a frog's foot. The mode I took to test whether the ridges ever shifted their situation or changed their form was by shaving away their elevations or rubbing them down with various powders to smoothness, having first taken careful imprints of the patterns. After the skin grew up again fresh imprints were taken and compared with the old ones. These were scrutinized very carefully for changes, but in many hundreds of cases, tested thus three or four times, not one solitary example of a variation in pattern was detected.

The patterns always came up with perfect fidelity to the old standard. Arrangements were made for a still more extensive test extending also over a greater period, but exhausting illness from climate and overwork caused my return to England, and broke for a time the thread of my investigations. I returned to Japan after a rest, but had again to come back to England in 1886. The firm conviction, however, was established in my mind, which nothing has occurred to change, that skin furrows for the purposes of identification are invariable throughout adult life. Observations of select cases from that period—thirty-two years ago—till now have been made from time to time only to confirm my early results. Fig. 1 is one of my earliest prints. In fourteen years it had not changed in the living person. From time to time I have watched cases of fever, and have drawn medical attention to the subject, thinking the great activity of the skin shown by peeling or desquamation might be accompanied with some changes of pattern, but no case has yet been observed by myself or recorded by others so far as known to me. The subject of classification now presented itself. Those who talk glibly about comparing a single "thumb print"—the favorite digit—with, say, four millions of single finger prints, do not seem, as a rule, to perceive the difficulty. It seemed that a good system should be able to face such numbers. Five years of my early life had been spent in learning a trade—that of Paisley shawl manufacture—which almost vanished before the end of my time. It seemed to have been an utterly wasted time, leading to nothing and helping no one; but it had drummed into my dull head how to deal with patterns. What I intend to convey by a pattern in finger prints may best be understood by looking at a few enlarged diagrams of the central or most characteristic portion of the *rugae*, or skin-ridges, with their complementary furrows or *sulci*, which are found running over the sole of the foot (*planta*), the palm of the hand (*vola*), and front or palmar surface of the fingers. Indeed, they are even found in the prehensile tail of the spider-monkey, as in the diagram. (See Fig. 2—spider-monkey's tail.) Near the middle of the last joint of each finger there are usually lineations in the skin of much complexity, which form the basis of identification by finger prints. (See Fig. 3).

Without going into details, which would require a wealth of illustrative figures and would probably interest but a few, it may be explained that my system proceeds on the conception that an elementary pattern is like a character in a foreign fount of type. So the classification is that of a syllabic dictionary, each syllable standing for a single finger-pattern as a Chinese character is printed in many dictionaries, and as Japanese is now printed. Each vowel may be a syllable in this sense, but no consonant stands alone, and the vowels associated with consonants always preserve their original pattern significance. The consonants go in related pairs, as t, d; p, b; f, v; s, z; l, r; m, n; k, g. The elements that compose patterns of any complexity are similarly related in pairs, and thus the association of sound and sense soon becomes complete in the mind of the dactylographer. But the syllable, after all, only denotes a class which may contain several—usually not a great many—individuals, all differing in minute details. With my system the whole strain of the original translation into the finger-print vocabulary, which is never great, lies upon the shoulders of one or perhaps two experts, but all the rest of the work can be done by any schoolboy who can turn up a word in a dictionary. To give an example offered to the War Office Committee by me when being examined as a witness; the expert, reading off a new set of say five finger-prints in one hand which has come in, calls for all old records filed past containing *Abracadabra* (a fanciful word of five syllables). That word in syllabic form might read

A–bra–ca–da–bra, or
Ab–rac–ad–ab–ra, or
Ab–ra–cad–a–bra, and so on.

Under any of these forms there might be several people indicated. But it would be found that only one, if any, would correspond exactly with the person to be identified. At all events, that is the belief, not easily to be shaken, of some hundreds of experts working for now about a decade, in different countries. This means quite an extraordinary security, beyond anything hitherto conceived, in regard to personal identification, but its efficiency does not depend on any one method of classification.

On February 15th, 1880, I wrote to Charles Darwin, sending specimens of prints and an outline of my first results, and requesting him to aid me in obtaining access to imprints from lemurs, monkeys and anthropoids, as I had found them to show lineation patterns which I hoped might be serviceable for the elucidation of man's lineage. I had failed to find any trace of previous notices of the subject in anatomical or recent biological works. The great naturalist's reply, two years before his death, was as follows:

Via BRINDISI,
April 7th, 1880.

DOWN,
BECKENHAM, KENT,
RAILWAY STATION,
ORPINGTON, S.E.R.

DEAR SIR: The subject to which you refer in your letter of February 15th, seems to me a curious one which may turn out interesting; but I am sorry to say that I am most unfortunately situated for offering you any assistance. I live in the country and from weak

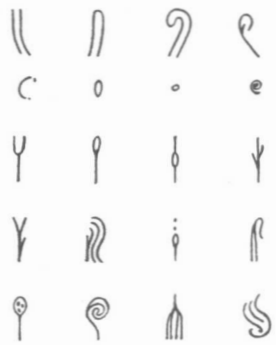

Fig. 3.—Skin Lineations (diagrammatic).

health seldom see anyone. I will, however, forward your letter to Mr. F. Galton, who is the most likely man that I can think of to take up the subject to make further enquiries.

Wishing you success,
I remain, dear Sir,
Yours faithfully,
(Signed) CHARLES DARWIN.

* Reprinted from *Knowledge*.

The original of the above holograph letter, with envelope addressed by Mr. Darwin and duly postmarked, along with the proof sheet of the first copperplate form to receive finger-prints, made for me in Japan, is now in the Library of the Royal Faculty of Physicians and Surgeons, Glasgow. On October 28th, in *Nature*, appeared a contribution by me, "On the Skin-furrows of the Hand," which was printed in the *Index Medicus* of the United States as the first recorded contribution on that subject. At the International Medical Congress, about ten months afterward, Dr. Billings, then editor of the *Index*, said, in a speech: "Just as each individual is in some respects peculiar and unique, so that even the minute ridges and furrows at the end of his forefingers differ from those of all other forefingers, and are sufficient to identify," and so on. (Report in *The Times*, August 5th, 1881.) My proposal was certainly the first public suggestion to establish a scientific method of identification on the basis of finger-prints. Sir William Herschel wrote soon afterward to *Nature*, admitting my priority of publication, but stating that he had used a method of finger-prints in India before this. There is no dispute between Sir William Herschel and myself, as each had reached his own conclusions quite independently. This little personal matter was discussed in *Nature* (October, 1894) and in *Gegenbauer's Jahrbuch* for 1905, in which the date of my first contribution is considered the starting-point of recent study of the subject. In 1881, Monsieur Bertillon, of Paris, brought out his delicate anthropometric system, to which the independent finger-print method from England was superadded. The finger-print method alone was used in a United States expedition in 1882, and it was tried in San Francisco, as afterward in South Africa, to identify the fluctuating population of Chinamen. In the year after my final return to England greatly renewed interest was aroused in the subject. Herbert Spencer tried to explain the origin of the ridges in an article in *The Nineteenth Century*, May, 1886. Sir Francis Galton, to whom Charles Darwin wrote to me in 1880 that he would refer the matter, began the study, as he states on page 2 of "Finger Prints," in 1888. In that same year, Inspector Tunbridge from Scotland Yard was officially appointed to investigate my proposals. No report has ever been made public, but Mr. Tunbridge told me that he feared the method was too fine to work, and said that nothing could be done, at least without fresh legislation. Some years afterward he was appointed to New Zealand, where he was the means of inducing the prison authorities and police to apply the method, which has been now in successful operation all over Australasia for some years; so Mr. Tunbridge wrote to me in 1907.

In 1894, a committee appointed by Mr. Asquith met and finally, after some rambling conclusions, adopted Bertillonage with finger-prints as some help, the former being used as the basis of classification. The proposal was absurd, and it was soon found, as might have been foreseen, that finger-print patterns yield a far firmer and more searching basis of classification in themselves than the other method, and need no auxiliary crutches.

In 1897, the two associated methods began to be applied in British India; while in civil cases there, as in attestations, pension claims, and so on, the finger-print method was used by itself.

In 1901, the ten-finger method in serial order, exactly as originally advocated by me in 1880, was finally adopted in England, after other trials, and has met with an immediate and triumphant success in giving rapid and easy identifications of recidivists or old professional criminals, often living under aliases. Monsieur Bertillon, who at first did not use finger-prints at all, wrote to me officially that since 1894 the two methods had been jointly used in Paris, and that greater security was now felt in identifying. In 1902, finger-prints took the place of bodily measurements in Austria-Hungary, being easier of application, and less likely to give varying results. Two years afterward Spain followed suit. The method had been worked before that period in Buenos Aires with success. A private service for identification by the finger-print method was, I believe, instituted in Belgium by Dr. de Laveleye, but I have heard no report of results.

It is a curious fact, but true beyond question, that the effectiveness of the method has proved to be the chief obstacle to its more extensive application. In short, its miraculous effect in tearing the mask from old criminals who try to veil their identity by an *alias*, has created a horror of it among the class from which many recruits used to be drawn for army and navy.

In conclusion, I should like to point out that there are five distinct ways in which Dactylography, as the scientific study of finger furrows is called, may be serviceable:

(1) In relation to the problem of human lineage. Much tentative work has been now done in this field by many workers, and a scientific pathway begins to open up before us.

(2) In elucidating the relations of front and hind limbs; Prof. Bowditch, of Harvard, wrote to me that he had early begun an inquiry into this subject. It promises to yield results of interest, but more workers are required.

(3) In identifying for life insurance, pensions, passports, affidavits, cheques, signing deeds, and so on. Again, in identifying the dead by former records, after battle, flood, fire or earthquake.

(4) In identifying old convicted criminals who have assumed other names.

(5) In testing evidence of bodily presence at a scene of crime by bloody finger-marks, sweaty or greasy smears on glass windows, wine glasses, lamps, or cash boxes and the like, or indented impressions on putty, wax, paraffin and so on. Faint impressa can be revived; invisible ones quite clearly brought out by chemical means; imprints *in relievo* may be photographed and made clearly intelligible to a jury. (See Fig. 4—a smudge from a finger.)

The last, and I think by far the least, of these once potential, now actual, utilities has taken the deepest hold of the popular imagination, and has seemed, to me at least, to threaten some danger to the innocent by its often ignorant and unscientific application. The method is not "mathematical," as certain officials are never tired of repeating, but demands common sense and the use of their own eyesight and mother wit by the plain men in the jury box. It is essentially English, and every accused person in the dock is as able as a judge, or counsel, or official witness, to test its validity.

The Genesis of the Rare Earths*

Their Relation to the Earth's Past History

By Dr. R. Böhm

In spite of the large monazite sand deposits in Brazil, the total quantity of all the rare earths probably does not exceed all told 1/1,000,000 per cent of the entire crust of the earth. When the latter was still in a heated state, composed of a mixture of all the elements, the atoms probably united to form the principal components of the earth's crust. In that condition the rocks formed gradually and slowly, taking their origin from those materials which were most widely and largely scattered throughout the mass, and in this way the granites, quartzes, the gneisses, the feldspars and the micas came into existence. These crystalline formations grew denser and denser, drifted into each other and were raised high up into mountain ranges of gneiss, granite and other primary rocks. The other component parts of the magma of the earth could not keep pace with the growth of the more common and larger kinds of rocks. They had to search too long for their chemical affinities. Auer von Welsbach in his experiments with the salts of thorium, was able to prove an enrichment or concentration of the traces of cerium, which had been present in the thorium in the mother lye, and thus the less or least largely represented ingredients of the fluid magma, which here represented the mother lye of the crystalline formation, were concentrated. Then began a process of selective crystallization, during which the rarer ores and minerals, for whose recovery we are now digging and searching through the primitive rocks, were formed. Thus the shining particles of gold passed into quartz, and the modest little dark crystals of monazites, thorites, gadolinites, euxenites, and other derivatives of the rare earths were saturating the granite. However small their dissemination in the magma may have been, in the end like aggregated with like, and the rare earths were safely imprisoned in the grasp of the powerful giant granite. But at this time another younger and still more powerful giant appeared upon the scene and began to fight an obstinate war with granite, which lasted millions of years. This young giant was the water. Without rest or interruption, swift and mobile, yet fighting with untiring perseverance, he renewed his attacks on the old granite again and again, and though his advances were but slow, he always remained victorious, and every year his armies, the rivers and rivulets, carried all the loose material which the granite held imprisoned, down into the valleys. Among those that were freed by the water were also the minerals of the rare earths, and every once in a while some of them would bid farewell to their old prison and migrate in company with the quartzes and feldspars, whose numbers were so great that the stranger quite disappeared among them. But when we bear in mind the long ages during which these forces have been working, it becomes plain that gradually quantities of rare earths, which for us seem immense, must have been washed into the sedimentary rocks. But though large in themselves, these quantities, compared with the thousands of millions of tons of solid matter which finely ground covered the crust of the earth, seem very small. The rare earths were in fact as finely disseminated as before, and any possibility of finding them and proving their occurrence seemed to be out of question.

And yet it was possible to find again what seemed to be lost forever. The organic power of nature found it possible to enrich the infinitely small traces of rare earths in the surface soil, so that it has been found within our means to prove their occurrence. Just as sea weed attracts and accumulates the infinitesimal particles of iodine in the sea water, so the plants' hunger for mineral substances has concentrated the salts of the rare earths and absorbed them as parts of the organic structure of the plants, using the decomposing faculty of the roots as an agent. Cossa, the Italian physiologist, has been able to prove that the rare earths, especially the cerite earths, are present in very small quantities in the ashes of plants and bones. This is the end of nature's organic reduction process and in this way the very rare minerals cerite, thorite, and monazite have been found in the sand strata of very great thickness in Brazil, Australia, North America, and the Ural Mountains, where nature has eliminated and deposited the heavy monazite sands from the corrosion and decomposition products of the rocks. The monazite sand is also associated with gold, an occurrence which finds an easy explanation in what has been said above. The gold districts of Carolina contained wash drifts of the mountain rivers, showing a sand which consists mainly of brown or yellowish brown crystals. This so-called monazite sand had already attracted the attention of the miners, at a time when gold washing was in full swing, by its heavy weight, but it had been thrown aside as worthless until the genius of Auer von Welsbach recognized its real value.

The commercially important monazite sand deposits lie in the alluvial detritus of the rivers and their sub-soils, as well as in the sand deposits along the sea coast. Such deposits could only have been formed in countries which remained immune from the erosive action of prehistoric glaciers. The latter at one time covered a large portion of the earth's surface, especially in the northern hemisphere. In the countries lying outside of the limits of these prehistoric glaciers, the soft surface layer of the decomposed rocks remained in their original position, excepting, of course, the changes caused by the action of the running water. These surface layers of detritus (also called saprolith, i. e., rock decomposed but not washed away) often reach a thickness of 50 to 200 feet. Owing to water erosion these saproliths have been further broken up, and were carried down into the river beds and their sub-soils. There the material is subjected to a further natural eliminating and concentrating process, the heavy matter being deposited first. Wherever the saproliths carried monazite, this mineral has, owing to its great specific weight, accumulated together with other minerals such as titanium-oxide, granite, feldspar, and quartzite. The process by which sandbanks are deposited in the sea is similar in nature. Sea waves, when breaking against monazite-bearing, crystalline sands, loosen the latter, and, washing away the less heavy earths and minerals, leave along the coast concentrated deposits of monazite sands, mixed with greater or less quantities of other minerals.

To-day the designation "rare earths" hardly has the same meaning it had a little while ago, especially, at the time when the incandescent gas light, in whose production some of the rare earths play an important part, was first invented. At present we are acquainted with about one hundred minerals containing rare earths. But, of course, when we compare them in quantity with other kinds of earths, we can still give them the designation "rare earths," even though their quantity and number is considerable.

* Abridged from the *Zeitschrift für angewandte Chemie*.

AT the beginning of 1910 the United States, where there is no State telephone monopoly, had 7,000,000 telephones for a population of 80,000,000, or 87 telephones for 1,000 inhabitants.—*The Engineer*.