Innovations in Forensic Fingerprint Analysis Over the Last Half-Decade

By Dina Cirigliano

Plaza College, Forest Hills, New York

The study of fingerprints has come a long way from its meager beginnings in 1892, when Galton introduced the world's first fingerprint analysis publication. So much had happened in the field since then that by the year 1980, the database known as the Automated Fingerprint Identification System (AFIS) was not only founded, but up and running, so that print sharing between law enforcement agencies could occur seamlessly. Today, forty-three years after the establishment of AFIS, fingerprint research is still at the forefront of forensic scientists' focus. The purpose of this piece is to highlight advances in fingerprint science in the last five years, particularly 1) how and when fingerprints develop on the bulbs of human fingers, 2) the role of INTERPOL in fighting international crime, 3) the recognition of irregularly rare fingerprints, and 4) the ability to estimate the sex of an offender or victim based on the ridge density of the fingerprints left behind at the crime scene.

"How the unique arrays of swirls, arches, and loops on the tips of our fingers form is a longstanding scientific enigma. As of recent, a paper published February 9 in *Cell* has solved the mystery, revealing not only the process by which fingerprints are formed, but also the genes responsible" (Gaines, 2023). For the past three years, developmental biologists, Dr. Denis Headon and Dr. James Glover from Scotland's University of Edinburgh, along with their team of colleagues, have been establishing that distinguishing fingerprints branch from the very same phenomenon "that gives zebras their stripes and leopards their spots" (Gaines, 2023). During their research, Headon and Glover explored the development and maturation of skin while making fingerprints the point of emphasis. They deemed that fingerprints appear prior to birth, as they are wholly "developed in intra-uterine life and remain unaltered until the death of the individual" (Sharma, et al, 2021), and likely hold the purpose of bettering humans' capability to

grasp onto or sense the texture of items at hand. The team deemed that in-utero, “patterns seemed to originally start in three areas in humans: up near the nail, towards the center of the fingertip, and down near the crease from the first knuckle” (Gaines, 2023). It was at this point that Drs. Headon and Glover recalled the work of Dr. Alan Turing, an English mathematician, of 1952. That was the year that Turing proposed that naturally-occurring patterns like stripes or spots come to be on account of two opposing molecules. He stated that the first must be a sluggish activator, and the second must be a rapid inhibitor. “The activator would do three things: 1) tell cells to do something, such as make colored pigment; 2) tell cells to make more activator; and 3) tell cells to start making its inhibitor. Meanwhile, the inhibitor tells the cell to slow down activator production (and thus, ultimately, to make less of itself)” (Gaines, 2023). Unsurprisingly these patterns came to be known as Turing patterns. As Headon, Glover, and their team continued, they found that as the Turing pattern matures, or as the fetus ages, “the fingerprint ridges then spread out as a series of waves from these initiation sites, eventually meeting in the middle and forming the unique fingerprint pattern each of us is born with” (Gaines, 2023), just as a design of activation and inhibition produces a succession of stripes or spots contingent upon how the result waves outwardly from the point at which it began. Going a step further, Headon and Glover, proved that WNT and EDAR are the proteins that serve as the slow-moving activators that generate ridges in the forming skin. They also showed that BPM proteins, which are fashioned in retort to WNT, act as rapidly-moving inhibitors to create the unique print on the bulbs of human fingers (Gaines, 2023). Long ago, the question, “When and how do fingerprints come into existence?” was posed. Finally, Headon and Glover were able to provide an answer.

Headon and Glover were not the only ones to make a breakthrough in the field of fingerprint science in the past half-decade. INTERPOL, "a global organization that enables police to work directly with their counterparts, even between countries which do not have diplomatic relations" (INTERPOL, 2022), has as well. In our modern world, travel can be achieved very inexpensively without a travel agent. All a person needs are a computer with internet access to book the flight or cruise, a few thousand dollars to pay for it, and a passport. Because of this, crimes of today are becoming progressively more international. Now more than ever before, it is critical that there is synchronization between the various individuals whose jobs are to preserve safety and security on the global level. INTERPOL, only four years ago in the year 2019, fostered over one thousand six hundred identifications as an effect of improved distribution and assessment of fingerprint data by countries that are members. By way of Automated Fingerprint Identification System (AFIS), users obtain the outcomes of their fingerprint checks extremely speedily. With regard to persons unidentified within the AFIS database, the process will be a mere couple of minutes in an automatic search. With regard to persons identified within the AFIS database, the process will be approximately one hour in a semi-automatic search. With regard to unidentified, latent prints from the scene of a crime, the process will also be about one hour in a manual search. The current "automated process means the database can make more than 3,000 comparisons per day. The system is also capable of searching and filing palm prints" (INTERPOL, 2023). INTERPOL has released that in the near future, innovative Automated Biometric Identification System (ABIS) know-how will be applied to empower quicker more precise searches. ABIS will streamline a biometric center to permit a modernized search transversely through each INTERPOL forensic database. This means that fingerprint scanning, palmprint scanning, DNA profile scanning, facial recognition scanning,

voice recognition scanning, iris scanning, and signature recognition scanning will all be possible simultaneously in a short period of duration. “This will save valuable time and reveal connections that could otherwise go unnoticed, as records will be saved and exchanged in the format set by the National Institute of Standards and Technology (NIST)” (INTERPOL, 2023). INTERPOL currently circulates a technical text with operation procedures for the sharing of biometric data. “The latest version (v. 6.0), published in 2020, introduces the use of XML and will, in future, replace the previous version (v 5.03). To facilitate the transfer of fingerprint data, INTERPOL has made a tool available to member countries which converts JPEG files into NIST files (Image2NIST)” (INTERPOL, 2023). This will aid in finding the identity of not only victims of homicide, but of the unclaimed homeless who perished on the streets, and those who succumbed to manmade and natural disasters.

While INTERPOL has made recent strides as it perfects its technologically-based fast-speed database scanning ability, researchers Baryah, Krishan, and Kanchan published the results of their study which revealed uncommon, naturally occurring fingerprints. Their 2023 study’s “purpose was to explore unusual pattern types on the finger balls and compare these with commonly occurring and classifiable pattern types. Furthermore, we discuss the occurrence of unusual fingerprints in both the sexes with reference to the finger digits” (Baryah, et al, 2023). The researchers’ study was led on five hundred twelve partakers between the ages of eighteen and thirty-five from two North Indian ethnic groups. The trio acquired five thousand twelve fingerprints from every digit of the five hundred twelve partakers in the study. The scientists analyzed each print according to Henry's classification of patterns from whorls to arches. “Patterns that did not fall in the prescribed category as per the definition of the published finger

pattern types were identified as unusual fingerprints. We found an incidence of unusual prints of 0.21% and describe these based on a comparison with the general pattern types according to Henry's classification" (Baryah, et al, 2023). The trio then defined a total of eleven rare fingerprint patterns and created groupings that will assist in the process of individualizing. Finally, these three scientists propose new terminology regarding the unusual fingerprints so that forensic scientists and fingerprint examiners can label with ease when working on cases (Baryah, et al, 2023). This was not the only recent development in fingerprint research involving scientists, Krishan and Kanchan.

Two years prior to their 2023 research study with Baryah, in the year 2021, Krishan and Kanchan came together with avid forensic research leaders, Sharma and Shrestha to present an analysis that evaluates the work of Dr. Acree. Acree established that "the number of ridges present in a unit area on a fingerprint, known as the Fingerprint Ridge Density (FPRD), can be utilized to determine the sex of whom the fingerprint belongs" (Sharma, et al, 2021). It was confirmed that the density of the epidermal ridge can be deemed by investigating two sectors: the width of ridges and the length of space betwixt ridges. The team focused on the sexual dimorphism and concluded that "the thickness of the epidermal ridges varies between individuals and between the sexes" (Sharma, et al, 2021). They confirmed the validity and reliability of Acree's methodology of approximation of sex on both Caucasians and African-Americans, reiterating that females "have a fine detailing of ridges and consequently more ridges are covered in a unit space in the fingerprints of females as compared to males" (Sharma, et al, 2021).

In the past five years, fingerprint science has flourished. How and when fingerprints develop on the bulbs of human fingers has been established, and the role of INTERPOL in fighting international crime has broadened with technology's increase. In addition, irregularly, rare fingerprints have been studied, and the sex of individuals is able to be determined based on the ridge density of the person's fingerprints. Fingerprint science will likely develop even more so as time passes; the interest of forensic scientists in this specialization continues to broaden.

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