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Practical Skills in Forensic Science

THIRD EDITION

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26 Investigating fingerprints

History of fingerprinting – the concept of fingerprinting as a means of identification was introduced in the 1870s by Dr Henry Faulds, who recognised the importance of fingerprints as a means of identification. This was followed by a detailed study by Sir Francis Galton who, in 1892, published a book on 'fingerprints'. Included within this book was a classification for fingerprinting, the essentials of which are still used today. This led in 1901 to its incorporation in criminal investigation by Sir Richard Edward Henry and its first use in court in England and Wales in 1902.

The uniqueness of fingerprints has made them an indispensable means of personal identification. Essentially, the patterns of ridges and troughs that form a vital component of any fingerprint provide a unique identifier. The pattern remains unchanged for life unless, damaged by burning or scarring.

Touching an object or surface with a hand leaves behind a characteristic deposit of the retaining features of the ridges and troughs of a fingerprint. The skill of a crime scene investigator (CSI) is to recover the fingerprint from the object or surface even when it is virtually invisible (latent).

In the UK, fingerprints are not examined in a forensic science laboratory by a forensic scientist. Instead they are examined by a fingerprint examiner, a scientific support unit of the police force. The scientific support unit typically comprises teams of CSIs, photographers, chemical enhancement unit, fingerprint examiners, footwear examiners and technical support staff. Some units also have a specific digital evidence unit.



KEY POINT Essentially, a fingerprint is a deposit of fatty acids and sweat left after sweat has evaporated. The pattern within the deposit provides a mirror image of the ridges and troughs of the finger or part of the body that made it.

Eccrine glands – are present over all the body and secrete sweat (predominantly water with a combination of inorganic and organic constituents)

Sebaceous glands – are present over all the body and secrete sebum, which mixes with the sweat to produce latent marks.

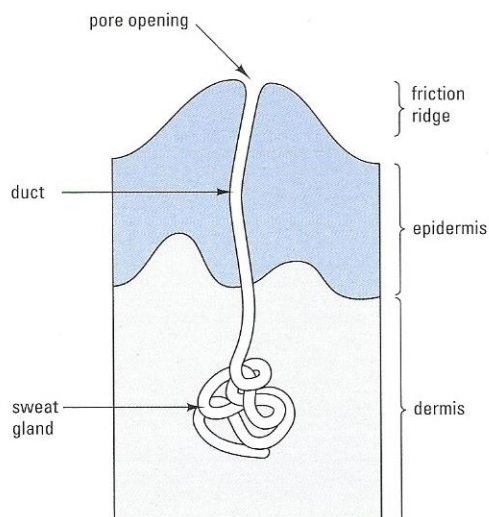


Fig. 26.1 Cross-section of skin through a friction ridge.

The nature of fingerprints

A layer of skin covers the entire body and approximately 95% is relatively smooth. However, in certain areas, for example fingers and palms of the hands and toes and soles of the feet, friction ridges occur (Fig. 26.1). They are called friction ridges because they help us to grasp and hold on to objects. Within the ridges are pore openings, each of which is associated with a sweat gland. The outer layer of skin consists of stratified epithelium called the epidermis, with an underlying layer called the dermis. It is this latter layer, the dermis, that contains the sweat glands. Fingerprint deposits are produced by the eccrine and sebaceous glands. While the majority of sweat is made up of water, typically 98.5% or more, it does contain trace amounts of other chemicals (Table 26.1). It is the deposition of these components that allow the characteristic pattern of the fingerprint to be left on a surface that has been touched. It should be noted that in the ridged epidermis, the eccrine ducts open at the tip of the ridges. Therefore, the position of the secreted deposits marks the tips of the ridges. On close examination, a print will have small voids in the detail where the pores surface (Fig. 26.1).

The main problems in fingerprint recovery arise due to the following:

- the nature of the surface on which the mark is present;
- the method used to recover the mark;
- deposition conditions of the mark (humidity and light can alter the appearance of the mark).

Where to look for fingerprints

This will depend on the circumstances of the crime. For example, in many investigations the point of entry is the obvious place to start the search.

Typical chemical composition of the sweat gland secretions

Water (99.5%)
Electrolytes (0.2-1µg)
Organic acids in order of abundance – lactic acid, alanine, aspartic acid)
Urea
Ammonia
Glucose
Proteins (7-15 µg)
Enzymes
Sebum
Cholesterol
Triglycerides
Unsaturated fatty acids – approximately 38% of which linoleic acid is predominant
Carbohydrates
Hydrocarbons – e.g. squalene – a 30 carbon hydrocarbon – approximately 15%
Alcohol – approximately 4%

Adapted from Cadd et al., 2015

Recording fingerprints – always photograph a fingerprint prior to lifting, and also ensure you record appropriate identification details.

Searching for fingerprints – when searching the surface of an object for fingerprint deposits, ensure that it is well-illuminated.

Types of brush – fibreglass, animal hair, synthetic or natural fibre brushes are used to develop fingerprints. Care needs to be taken to ensure that the bristles of the brush do not make a significant contact with the surface being examined for fingerprints – valuable evidence may be destroyed.

point of entry may have been a door, forced open or not (see Chapter 28) or via a window that has been broken. All of these sites are appropriate places to begin the search for fingerprints. Once this has been done it will be necessary to check for fingerprints in locations within the building that have been disturbed by the burglar. Another important area to check for fingerprints is on or near light switches, light bulbs, door handles, drawer openings and other places where hands may have made contact. However, fingerprints may not be left on some surfaces, for example carpet, or when the perpetrator has worn gloves, washed their hands or their hands were very cold.

How to recover a fingerprint

Various approaches are available for recovering fingerprints from a crime scene or objects recovered from a crime scene, victim or suspect.

Fingerprints are normally distinguishable in three forms:

1. those that are visible (or 'patent') prints;
2. those that are invisible to the naked eye ('latent' prints);
3. those that are formed in or on a substrate ('plastic' prints).

The recovery of visible fingerprints is more straightforward since they do not require any means of development or enhancement for their visualisation. For example, fingerprints may have been left on substances that melt easily or soften when held in the hand, such as chocolate, layers of dust, flour, soap, greasy surfaces, ink, etc. Another obvious approach is to look for fingerprints in blood present at a crime scene. A hand placed in spilled blood will leave fingerprints on everything that is subsequently touched until the blood dries. Once a fingerprint has been found it should be recorded using photography (p. 231).

The most common approaches for visualisation of latent fingerprints are powder dusting, chemical enhancement and illumination methods (Fig. 26.2) – their main features are described below.

Powder dusting

The simplest procedure for latent fingerprint recovery is powder dusting. The process relies on the mechanical adherence of powder particles to the sweat components of the skin ridge deposits. The application of the powder is carried out with a hand-held brush but it is important to choose the correct brush for the appropriate powder.

Similarly, it is important that the brushes are used in the appropriate manner – for example, swirling the brush in contact with the mark versus a brushing stroke. The most common types of powder that are recommended for crime scene use are aluminium powder and carbon black (Table 26.2). Details of the procedure for recovery of fingerprints using powder dusting are given in Box 26.1.

There are a variety of other powders that could potentially be used – for example, magnetic powders that contain fine ferromagnetic particles and are applied with a magnetic applicator, for example a Magna-Brush. The process of application is the same as that in Box 26.1. One benefit is that excess powder can be recovered with the magnetic applicator and reused. More recently, SupraNano™ fingerprint powders have been developed that could perhaps offer an alternative means of visualisation, although to be adopted for routine use, they would have to be validated to meet the accreditation standard ISO17025 that forces in England and Wales are currently undertaking as of 2017. The

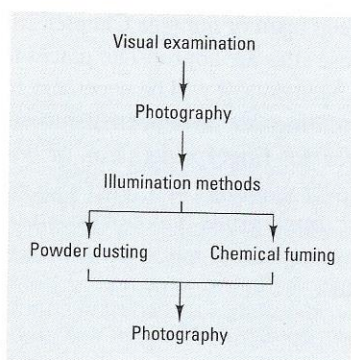


Fig. 26.2 Procedure for developing latent fingerprints.

Table 26.2 Some common dusting powders used for fingerprint recovery

Powder type	Application
Carbon black	Universal powder, ideal for smooth non-porous surfaces e.g. table tops. Especially good for light-coloured surfaces.
Aluminium	Universal powder, especially good for dark-coloured surfaces e.g. door frames.
Magnetic powder	Ideal method to minimise excess powder. Can be used on non-magnetic surfaces, e.g. wood or plastic.

choice of which powder to use depends on the colour and surface type on which the mark has been deposited.



KEY POINT These fine powders can cause respiratory problems; it is always advisable to wear a mask when using powders.

Based on trials (Bandey and Gibson, 2006) conducted by The UK Home Office Scientific Development Branch (HOSDB), the following are recommended:

- **flake powders**, e.g. aluminium powder; these can also be used for dry, smooth and non-porous surfaces and would be applied using a Zephyr brush in a light rotation motion;
- **granular powders**, e.g. black powder; these can be used for semi-smooth, non-porous, textured or weathered surfaces and would be applied using a squirrel brush in a light brushing motion;

Box 26.1 How to locate, enhance and recover a latent fingerprint using dusting powder

1. **Locate the mark** – you need to sequentially examine an item making sure that you have covered all surfaces that could possibly have a latent mark on them. Visually examine the surface, making sure that you have looked for any marks at differing angles, followed by re-examination using a white light source, e.g. Maglite®. In the case of a window, examine the window ledge first, then sequentially the window glass.
2. **Assess which powder you should use** – decide which powder you should use (see p. 257). Remember to use the appropriate application brush, e.g. synthetic brush for flake powders, i.e. Zephyr®, Lightning Powder, USA; animal hair brush for granular powders, i.e. squirrel, Lightning Powder, USA; and a magnetic applicator (Lightning Powder, USA) for magnetic powders.
3. **Carefully apply the dusting powder** – apply a small amount of powder to the surface of the object using the appropriate brush by lightly dusting the latent print in the same direction as the ridge pattern (do not

brush too hard or you will smear the print). Remove excess dusting powder carefully to allow the optimum fingerprint image to be observed. Take care not to overload the mark.

4. **Apply fingerprint-lifting tape to the print** – place the sticky side of a low-tack adhesive sheet over the dusted print and, taking care not to move it sideways, press gently and evenly over the print to transfer the image to the sheet, then remove carefully from the object.
5. **Place the recovered mark on a fingerprint card** – attach the adhesive sheet to the fingerprint card, taking care not to trap any air bubbles between the two. The card should be fully labelled with the crime reference number, details of who recovered the mark, the date on which it was recovered, the specific location where it was found, including directional markers (or gravity arrow) to indicate which side of the tape was at the top, and an exhibit number for continuity purposes.

in how the donor mark will be enhanced – for example, with ninhydrin the reaction of ninhydrin with the amino acids results in the mark being visualised as purple (Ruhemanns purple) friction ridges. However, with some donors, only a slight reaction occurs, leading to a very faint orange/red colouration. The composition can change according to gender, ethnicity, psychological state and diet, as well as environmental conditions that occur following deposition (Cadd *et al.*, 2015). It is also known that some individuals are also known to be poor or good secretors and, in combination, these factors will play a part in the successful effective chemical enhancement of any mark. Consult the *Fingerprint Development Handbook* (2005) or the *Fingerprint Source Book* (2012) for further advice.

Illumination and enhancement methods

These are based on exposing the fingerprint to UV light or laser light. Certain substances present in perspiration (including body oils and/or foreign bodies contained in a latent fingerprint residue) fluoresce when exposed to laser or UV light. In this situation, no pre-treatment of the fingerprint is necessary. If fingerprints are not detected using UV or laser light, then enhancement can be performed. This is usually done after application of a dye – for example, BY40 post-Superglue® fuming. The dye will stain the polycyanolacrylate deposits, which can be photographed (p. 230).

As can be seen from the above, the choice of techniques for visualisation of latent fingerprints is varied. For this reason, a process has been developed to allow the fingerprint examiner to systematically apply the correct procedures with the minimum risk of destroying valuable information. The procedures are subdivided in to those that are applied to porous surfaces and those to non-porous surfaces (Table 26.4). It should be noted that the first procedures, irrespective of surface type, are both visual inspections with either the naked eye or different light sources. Only when this has been completed, and taking into consideration any other non-destructive techniques, should you apply powder dusting or chemical enhancement.

Examination of fingerprint characteristics

Comparison of a recovered mark with a reference fingerprint will need to be performed. To do this, the photograph of the mark is compared against a reference set of fingerprints taken from a suspect or for elimination purposes.

Table 26.4 Typical process to be considered in relation to marks on porous and non-porous surfaces Bowman (ed), (*Fingerprint Development Handbook*, 2005)

Porous surfaces	Non-porous surfaces
1. Visual examination 2. Inherent fluorescence by laser or UV light 3. Other non-destructive considerations, e.g. ESDA (p. 282) 4. DFO (1,8-diazofluoren-9-one) with visualisation at 473–548 nm; viewing goggles/filter 550 nm 5. Re-examine after 10 days 6. Ninhydrin 7. Re-examine after 10 days 8. PD	1. Visual examination 2. Inherent fluorescence by laser or UV light 3. Cyanoacrylate fuming 4. Laser or UV light 5. Fluorescent dye 6. Laser or UV light - with visualisation using for example BY40 at 400–469 nm; emission viewing goggles/filter at 495 nm

Note: Any marks that are observed will be photographed. Not all processes need to be performed; this is left to the discretion of the examiner.



Fig. 26.3 Some of the principal characteristic fingerprint patterns.

Pattern occurrence – in the general population it is accepted that loops are most commonly encountered (approximately 70%), followed by whorls (25%) and arches (5%).



KEY POINT Fingerprint comparisons are always performed from mark to reference print and never the other way round.

Reference fingerprints are obtained at a police station and serve a two-fold function – as a set of elimination fingerprints and also from the suspect arrested for the recordable offence. Ink is applied to a glass plate and firmly rolled on to form a thin film. Each of the fingers is then rolled on to this film, and then rolled on to a standard ten-print form in a designated box for each finger – this should capture the ridge pattern from nail bed to nail bed.



KEY POINT This rolling procedure must be performed in a single motion for each finger and not by forwards and backwards movements.

Likewise, in a single motion the inked fingers are also placed together at the bottom of the form and rolled forward to capture the ridge pattern to the tip of the finger. Palms can also be inked and their prints placed on to the reverse side of the form, providing a full record of the ridge detail of the whole hand. If a person has been arrested for a recordable offence then this ten-print card, including palm print, is uploaded to IDENT1 – the UK's national fingerprint database.

Automated fingerprint identification systems

Automated fingerprint identification systems, or AFISs, are computer-based databases that allow rapid searching of archive fingerprint information against a fingerprint found at a crime scene.

The UK National Fingerprint database is known as IDENT1. Recent developments in fingerprint technology include the use of scanning devices at the police station, e.g. LiveScan, and mobile fingerprint devices that link directly to the IDENT1 database. This allows for rapid and effective screening for verification of the identity of an individual.

Fingerprint patterns can be divided into three main groups. The groups are arches, loops and whorls – the words accurately describe the shapes you would be looking at (Fig. 26.3).

There are also further subdivisions – for example, tented arches (where the ridge pattern extends to a point rather than a smooth curve), left or right loops (where the ridge pattern extends on a particular direction, also known as ulnar or radial loops), twinned loops (where two loop patterns converge at the base with one overlapping the other – typically the ridge pattern here appears as an 'S' shape) and elongated whorls (where the characteristic whorl pattern has been elongated). These groups are easily identified and are designated as the characteristics.

In all patterns other than arches, there are areas close to the core known as 'deltas' (Fig. 26.3) where the ridges appear as a triangular feature. Loops have only one delta, with the exception of the twinned loop where you would find two deltas, the same as you would find for whorls, but you can still easily distinguish this pattern.

To be able to take a comparison further, a series of classifiable characteristics 'points' are required. These ridge characteristics are essentially the minutiae (the Galton characteristics) and are used to identify the individual and are designated as individual characteristics. There are seven basic ridge characteristics (ridge ending, bifurcation, lake, independent ridge, dot or island, gap, crossover) (Fig. 26.4). The comparison will start at the class characteristics

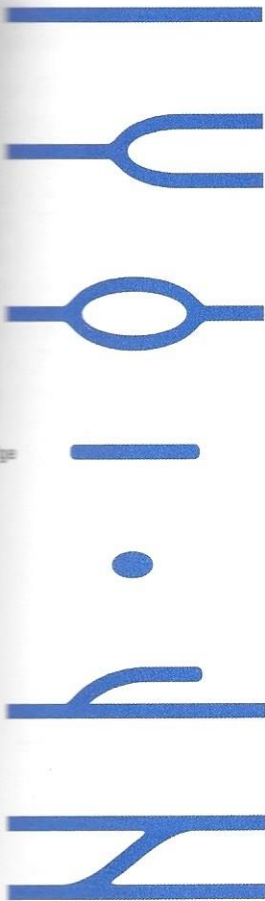


Figure 26.1 Characteristics of fingerprint ridges.

(level 1) that identifies the overall ridge pattern. Level 2 records the individual minutae characteristics, with a further level 3 where the examiner may observe similarities in the distribution of the pores (although this latter is dependent on the quality of the enhanced mark). Examples of fingerprints are shown in Photo 26.1. Careful examination of Photo 26.1 will allow you to identify many of the basic ridge characteristics of fingerprints – a few are highlighted.

The ACE-V process

It is a combination of the class and individual characteristics that allow the fingerprint examiner to offer an opinion on whether or not a positive identification between the recovered fingerprint mark and the reference fingerprint card can be made.

In the UK, the process of comparison of a crime scene mark to a referent print is based on the examiner following the ACE-V process – **A**nalysis, **C**omparison, **E**valuation and **V**erification. In the analysis stage, the mark is assessed for quality and whether any ridge detail that can be observed is sufficient to proceed to comparison. If it is, then the mark will be compared to (i) a suspect or (ii) if unknown, then the mark can be searched against IDENT1 and any possible suspects can then be used for comparison. The comparison stage involves the examiner observing points of similarity (the minutae) on the mark and the corresponding points of similarity on the reference print. This process is now non-numerical and is based on the competence, experience, skill and opinion of the fingerprint examiner.

If sufficient points of similarity are found (the evaluation stage), then the examiner, in their opinion, may conclude that the mark can be identified to the person. Alternatively, in the absence of points of similarity, they may conclude that the mark cannot be identified to the person – i.e. exclusion. Two alternative evaluations may arise – insufficient, where there are simply not sufficient points of similarity to come to a conclusion, or inconclusive, where the quality of the mark is such that no conclusion can be attained.

The final stage in the process, and part of the accreditation process, is the verification stage, where the opinion has to be corroborated by one to two further fingerprint examiners. Ideally, this should be undertaken as a blind verification to ensure an independent conclusion is arrived at, rather than simply 'checking' someone else's work.

It is only at this stage, once the opinion is in agreement, that the results can be reported.

Accreditation – All police forces in the UK currently in 2017 are pursuing accreditation to ISO17025 see also (p. 475), a process that includes organisational and operational parameters such as method validation and competency testing of all fingerprint examiners.

sources for further study

Newton, V. (ed.) (1998) *Manual of Fingerprint Development Techniques*, 2nd edn. Home Office Police Scientific Development Branch, Sandridge.

Turner, I.K. (2005) *Crime Scene Investigation Methods and Procedures*. Open University Press.

Lee, H.C. and Gaensslen, R.E. (eds) (2001) *Advances in Fingerprint Technology*, 2nd edn. CRC Press, Boca Raton.