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TABLE OF CONTENTS

1. Learning Outcomes
2. Introduction
3. Functions of Finger Ridges
4. Fundamental Principles of Fingerprinting
5. Fingerprint Patterns
6. Summary

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1. Learning Outcomes

After studying this module, you shall be able to know –

- The correlation between fingerprints and ridges on the fingertips.
- The functions of finger ridges.
- Fundamental principles on which the science of fingerprinting is based.
- The broad patterns of fingerprints.
- How fingerprints may be used for individualization.

2. Introduction

Fingerprints are the distinctive ridges appearing as corrugated lines on the tips of fingers and thumbs. The corrugation results due to rising of a portion of the upper layer of fingertip skin slightly above the normal level. Since the upper layer of skin is called *epidermis*, the finger ridges are also referred to as *epidermal ridges*. The depression between two ridges is called a *furrow* or a *valley*. The ridges and valleys form a complex, curved pattern on the fingertips. One such pattern is shown in Fig. 1.

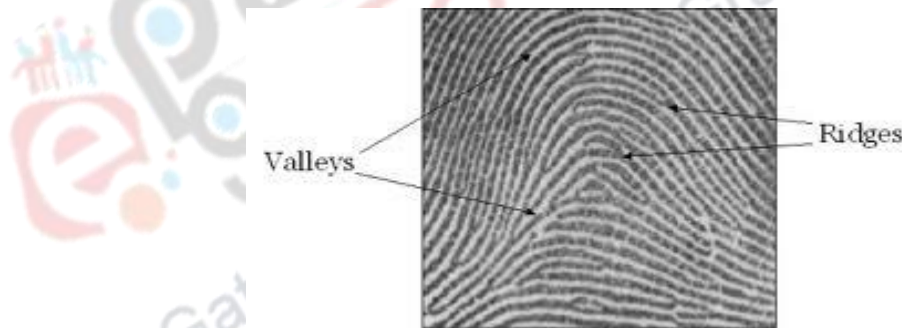


Fig. 1 The pattern formed by ridges and valleys on fingertips

The pattern on each finger of a person is so unique that it is not repeated on another finger of the same person or on the fingers of any other person. This makes fingerprints the most infallible means of identification.

3. Functions of Finger Ridges

Finger ridges have an average width of 0.48 millimeters in males and 0.43 millimeters in females. These perform the following two functions.

1. *They increase security of contact with objects.* The ridges are studded with small holes, called sweat pores through which perspiration is exuded. The sweat pores are shown in Fig. 2.

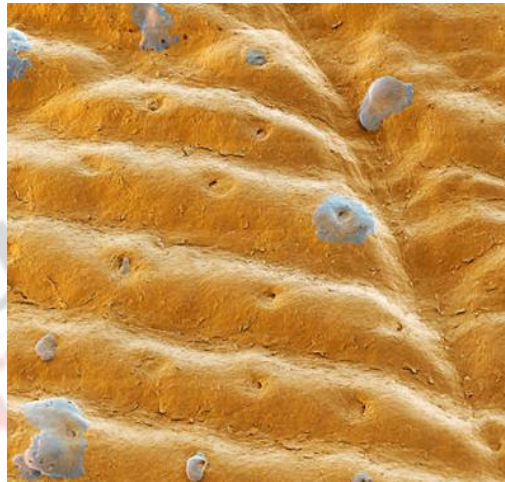


Fig. 2 Sweat pores along the finger ridges

The perspiration acts as a lubricant and ensures firmness of grip (Fig. 3).



Fig. 3 Ridges increase security of contact

2. *They enhance the sense of touch.* When a finger comes into contact with an uneven surface, the epidermal ridges amplify the vibrations caused due to friction and transmit the signal to sensory nerves involved in texture perception, increasing the sense of touch (Fig. 4).



Fig. 4 Ridges increase the sense of touch

For this reason, epidermal ridges are also called *friction ridges*.

4. Fundamental Principles of Fingerprinting

The science of identification by screening and comparing fingerprints is called *dactyloscopy*. This science is based on the following three principles.

1. *No two persons and no two fingers of the same person have identical ridge design on the fingertips.* Fingerprints are absolutely unique – more unique than the DNA, the genetic material in the human cells. Although identical twins have same DNA sequencing, they do not have identical fingerprints (Fig. 5).



Fig. 5 Each fingerprint is unique

2. *The fingerprints remain unchanged throughout life.* The ridge pattern begins to take shape during fetal stage and does not alter during a person's lifespan. It is only after death that decomposition sets in and the finger ridges are destroyed. Fig. 6 (A) and (B) are the fingerprints of a child, recorded at the age of 2 and 15 years respectively. The prints do not show any variation.



Fig. 6 Fingerprints of a child recorded with a time lag of about 13 years show no variations

[Source: *Indian Civilization and the Science of Fingerprinting*, G.S. Sodhi and J. Kaur, Publication Division, New Delhi (2013)]

In the growing age, the fingerprint pattern expands; as a result of aging, it may shrink. However, the basic design remains the same.

3. *Fingerprints can be classified for record keeping.* When a person commits a crime and is arrested, he is fingerprinted by the police. The fingerprint record is then passed on to the nearest fingerprint bureau. There are about twenty five state-level fingerprint bureaus in India. Their functioning is coordinated by *Central Fingerprint Bureau, Ministry of Home Affairs*. Each bureau maintains a catalogue of fingerprints (Fig.7).



Fig. 7 Cataloguing fingerprint record

The mathematical formula for classifying fingerprints was worked out in the Bengal Bureau, the world's first fingerprint bureau, established at Calcutta (now Kolkata) in 1897.

5. Fingerprint Patterns

There are three broad patterns of fingerprints: Arches, loops and whorl. These are shown in Fig. 8.

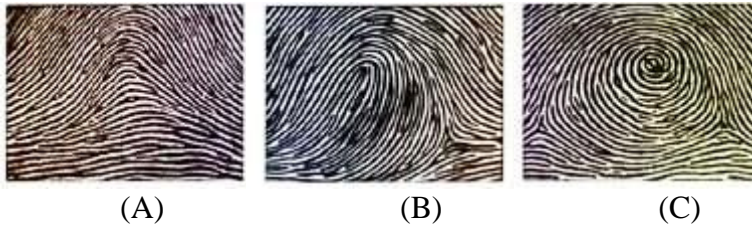


Fig. 8 Three patterns of fingerprints. (A) arches; (B) loops; and (C) whorls

In the arch pattern, an epidermal ridge starts from left (or right), rises like a tent and flows back to the right (or left). In a loop, the ridge initiates from left (or right), re-curves and comes back to the left (or right). The whorl pattern, as its name implies, is similar to a whirlpool, having a design of concentric circular lines. As has already been stated, arches, loops and whorls represent only a broad classification of fingerprint patterns. There are several sub-categories under each of these classifications. These are being dealt elsewhere (FSC_P3_M3).

A cursory glance at Fig. 8 induces a pre-supposition that the ridges flow parallel to each other. However, a closer scrutiny reveals that the parallel trend is interrupted by irregularities, known as *fingerprint characters* or *minutiae*. The seven common types of fingerprint characters are depicted in Fig. 9.

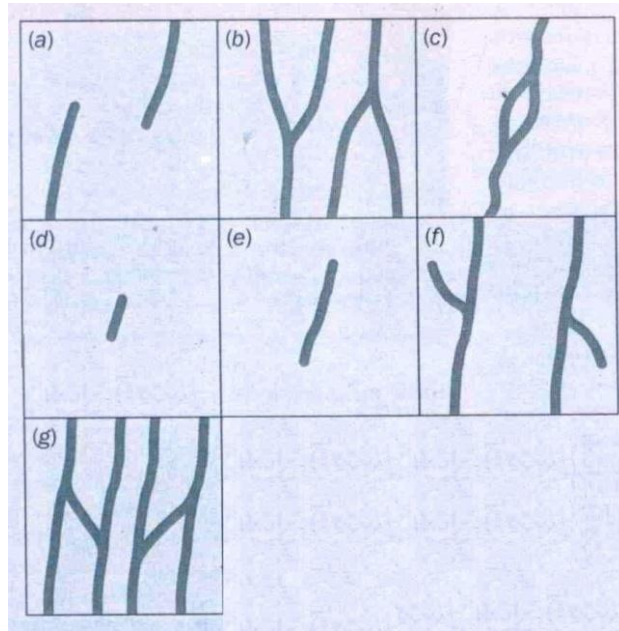


Fig. 9 The fingerprint characters

- (a) *Ridge termination* or *ridge ending* – when the ridge flow abruptly ends.
- (b) *Bifurcation* – when the ridge splits into two, making a ‘Y’.
- (c) *Lake* – when there is an enclosed area in between the ridge.
- (d) *Island* or *ridge dot*– when there is a small dot or circle within the overall pattern.
- (e) *Short independent ridge* – when there is a relatively small ridge within the overall pattern.
- (f) *Hook* or *spur* – when a small curved ridge is attached to a regular ridge.
- (g) *Crossover* – when two parallel ridges are joined by a small ridge.

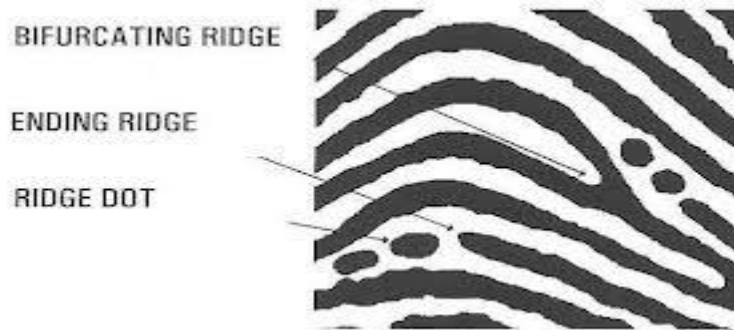


Fig. 10 Fingerprint characters within the pattern

For example, three minutiae are identified in Fig. 10. These are: Bifurcation, ridge ending or termination and island or ridge dot.

A set of the minutiae within the overall pattern makes each fingerprint unique. In no two fingers identical minutiae would occupy exactly similar positions, even if the overall ridge pattern (arch, loop or whorl) is the same. In case of identical twins, the overall ridge pattern on similar fingers of the siblings is identical. For example, if one sibling has an arch pattern on left thumb, the other sibling too will have the arch pattern on the left thumb (Fig. 11).



Fig. 11 The outer pattern on similar fingers of identical twins is same

Nevertheless, the location of minutiae in the two fingers will vary. Thus even identical twins can be individualized by fingerprints.

If a finger is superficially injured to a depth of one millimeter or less, a part of the ridge pattern and/or some of the ridge characters get temporarily damaged (Fig. 12). Upon healing, the pattern and characters reappear in their original form.



Fig. 12 A superficial injury causes only a temporary damage to ridge pattern and characters

However, as shown in Fig. 13, a deeper injury causes permanent damage to a portion of ridge pattern and ridge characters.



Fig. 13 A deeper injury causes a permanent damage to ridge pattern and characters

In such cases a scar remains even after the finger is healed (Fig. 14). Yet it does not render the fingerprint useless as far as identification is concerned.



Fig. 14 Scars in the fingerprint pattern

On an average, there are about 80 ridge characters in a fingerprint. According to the Indian law, the location of eight characteristics is enough to individualize a person. This means that if the placement of eight characteristics in a fingerprint lifted from a crime scene, matches with the inked fingerprint of a person, then the latter is the accused. Thus, even if one-tenth of total characters on a fingertip can be visualized, the identity of the person can still be established.

6. Summary

The science of fingerprinting is based on the premise that no two persons and no two fingers of the same person have identical design on their fingertips. Moreover, fingerprints remain unchanged from birth till death. These may be classified for criminal recordkeeping. There are three broad patterns of fingerprints: Arches, loops and whorls. Within these patterns are embedded irregularities called fingerprint characters or minutiae. On an average, 80 minutiae are present on a fingertip. The position of only eight of these is required to individualize a person. Thus even a partial fingerprint, found at a scene of crime, is enough to establish the identity of the accused.