

Chapter V: Biology and Forensic Science

Introduction

Forensic science is the scientific field used to investigate crimes. It involves examining and analyzing physical evidence to reconstruct events and identify those involved. Biology is key because it helps study biological traces left by humans or animals at crime scenes, such as blood, hair, bodily fluids, tissues, and fibers. Advances in genetics, microscopy, and chemistry enable forensic biologists to provide reliable evidence for the court.

I. Biological Elements Studied in Forensics

I.1. Blood

Blood is a crucial biological trace examined in investigations (Fig. 1). The analysis involves blood typing (ABO and Rh), nuclear or mitochondrial DNA for individual identification, and the detection of chemical or toxic substances. Bloodstain pattern analysis aids in reconstructing events, including the direction, speed, and type of injury.

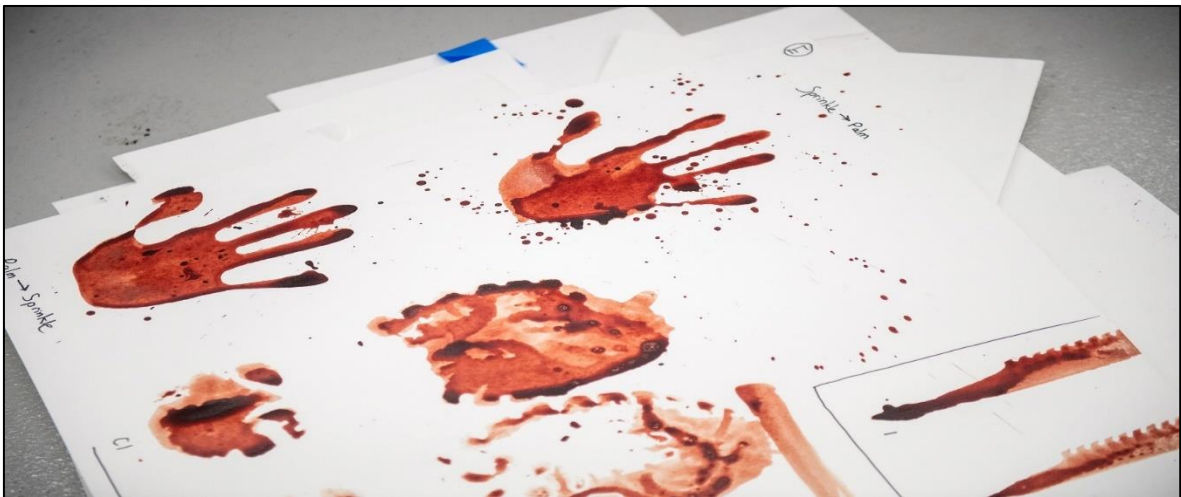


Figure 1: Updating the Science of Bloodstain Analysis and Forensics.

I.2. Hair and Fur

Hair provides nuclear DNA (follicle) and mitochondrial DNA (shaft) and allows individual identification. Chemical and isotopic analyses reveal exposure to drugs or heavy metals. Morphological comparison (color, structure, length, thickness) helps determine human or animal origin.



Figure 2: Hair Evidence Analysis Forensic Investigation Crime Scene.

I.3. Bodily Fluids

Saliva, semen, sweat, and urine contain genetic and chemical information. Analysis confirms the presence of a person, detects diseases, or identifies chemical substances. Other fluids, such as tears or cerebrospinal fluid, can provide additional evidence (Fig. 3).



Figure 3: Direct comparison of body fluid identification technologies (Forensic Science innovations).

I.4. Tissues and Organs

Examination of bodies includes a biological autopsy (Fig. 4) to determine the cause of death and post-mortem interval, histological analysis to identify injuries, infections, and intoxications, and toxicology to detect toxic substances in organs or fluids.

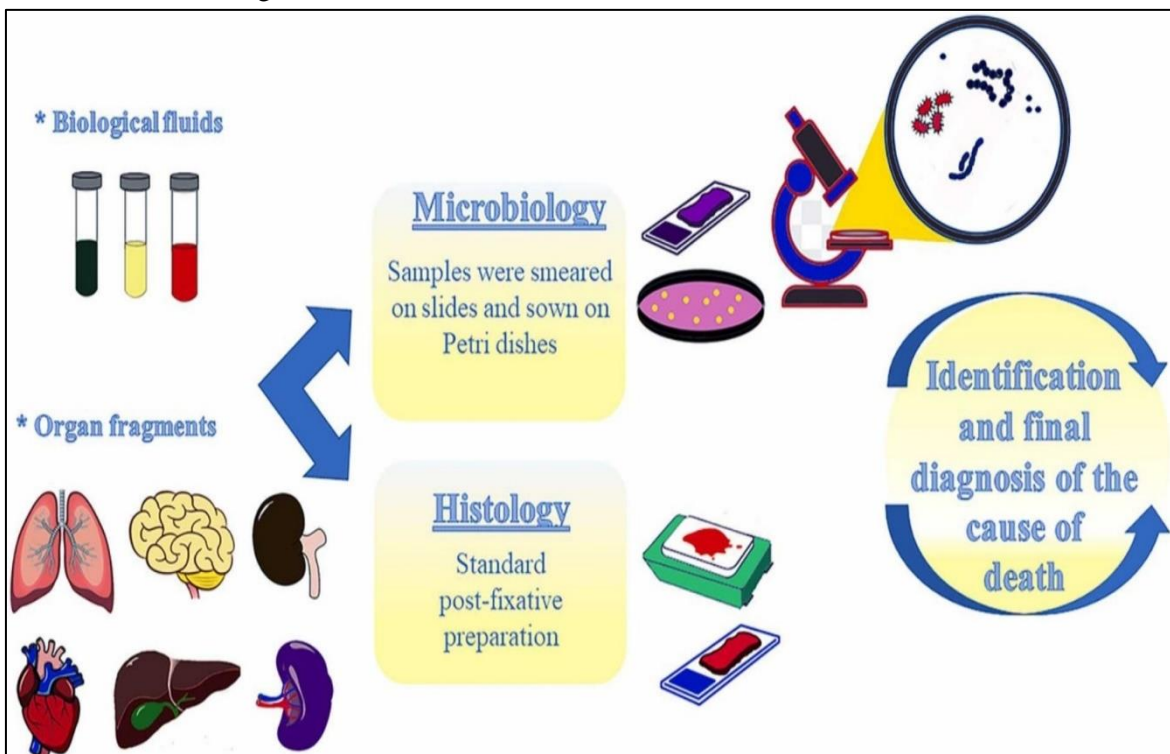


Figure 4: Utility and diagnostic value of postmortem microbiology associated with histology for forensic purposes.

I.4.1. Biological Autopsy

- This is a thorough and detailed examination of the body, both externally and internally, conducted by a forensic pathologist (Fig. 5).

- It aims to identify the cause of death, whether natural, accidental, suicidal, or homicidal.
- It enables estimation of the post-mortem interval (PMI) using signs like rigor mortis, livor mortis, and body decomposition.
- The autopsy also helps identify traumatic lesions (blunt force injuries, sharp force wounds, firearm injuries), pathological signs of disease, and possible medical interventions before death.

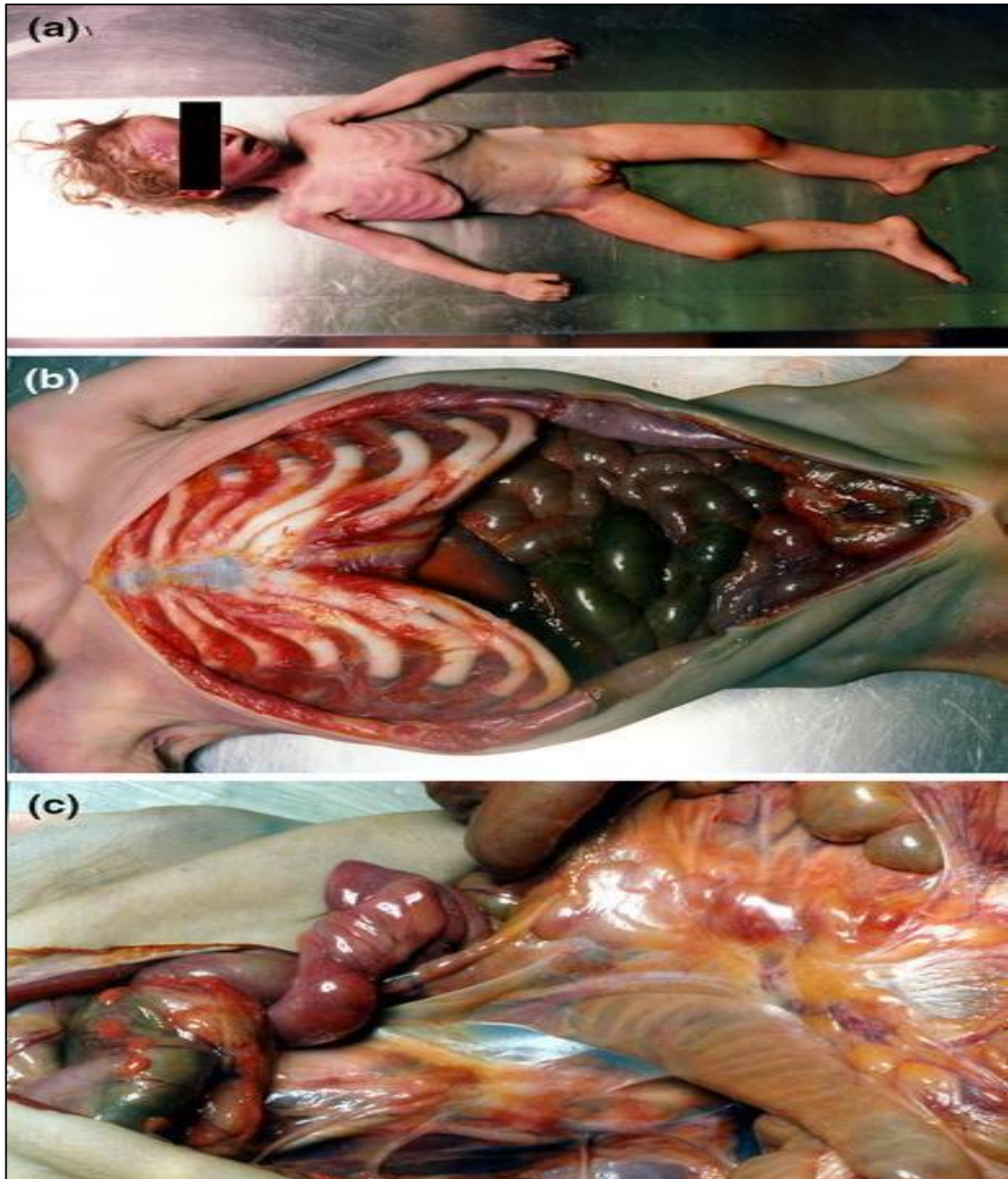


Figure 5: Typical autopsy findings in starvation are (a: emaciation with loss of Bichat's fat pad, sunken eyes, protruding ribs), (b: complete loss of subcutaneous adipose tissue) and (c: loss of adipose tissue of the mesenterium).

I.4.2. Histological Analysis

- Tissue samples are gathered and analyzed using a microscope.
- This method offers insights into cellular and tissue changes, enabling the detection of diseases, infections, inflammations, or degenerative processes that may have led to death.

- Histology is also essential for identifying vital reactions, aiding in distinguishing antemortem injuries (occurred while the victim was alive) from postmortem lesions (Fig. 6).
- It can reveal subtle signs of **intoxication** or poisoning when toxic substances cause structural changes in organs.

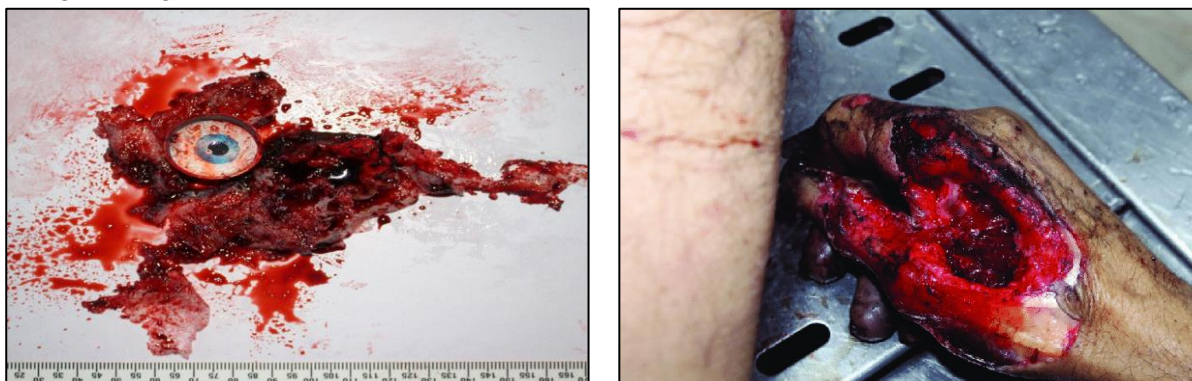


Figure 6: Crime scene body tissue.

I.4.3. Toxicological Examination

- Biological fluids (blood, urine, vitreous humor) and organ samples (liver, kidney, brain) are examined to detect and measure toxic substances (Fig. 7).
- This includes drugs, alcohol, poisons, carbon monoxide, heavy metals, and other chemical substances.
- Toxicology helps determine whether intoxication was accidental, suicidal, or homicidal, and how much it contributed to the cause of death.
- It is also helpful for evaluating the therapeutic or abusive use of medications, especially in overdose cases.



Figure 7: Forensic toxicology.

I.5. Fingerprint

Fingerprint analysis has been a fundamental part of forensic identification for over a century, and it remains one of the most dependable tools in modern law enforcement (Fig. 8). Its key strength is in linking crime scenes, helping investigators determine if the same individual is involved in multiple crimes. Additionally, fingerprint records provide crucial information for legal processes, such as verifying a suspect's identity, tracing previous arrests or convictions, and supporting judicial decisions related to sentencing, probation, parole, or pardons.

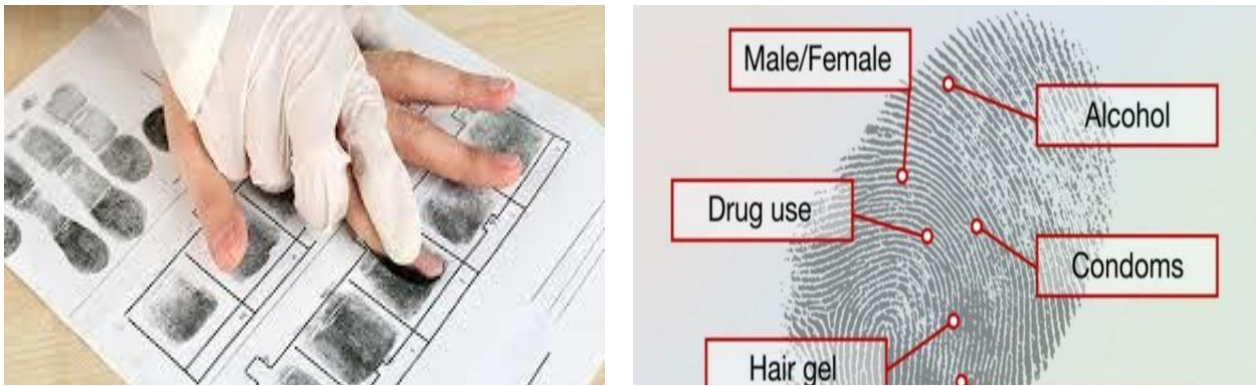


Figure 8: Fingerprint analysis-facts.

From a scientific viewpoint, the dependability of fingerprint analysis depends on three core principles:

I.5.1. Uniqueness

- No two people, even identical twins, have the same fingerprint patterns.
- The ridge features and minutiae points (such as bifurcations and ridge endings) create highly unique patterns.

I.5.2. Permanence (Immutability)

- Fingerprints develop during fetal growth and stay the same throughout a person's life, except for superficial injuries that do not change the underlying ridge pattern.
- This stability makes them a lasting biological marker of identity.

I.5.3. Classifiability

- Fingerprints can be systematically classified into common pattern types like arches, loops, and whorls, which aid in their storage and retrieval in extensive databases.
- Automated Fingerprint Identification Systems (AFIS) improve accuracy and efficiency by utilizing digital scanning and algorithmic comparison.

Together, these principles show why fingerprint analysis remains essential in forensic investigations, blending scientific accuracy with legal relevance in the quest for justice.

II. Biological Methods in Forensics

II.1. DNA Analysis

DNA extraction, PCR amplification, sequencing, and STR analysis of genetic profiles. Mitochondrial DNA is used when nuclear DNA is degraded.

II.2. Blood Typing and Serotyping

Determining ABO and Rh blood groups, along with rare antigens, to reduce the pool of suspects.

II.3. Microscopy

Microscopy: Using optical microscopy to examine fibers, hair, and cells, and using electron microscopy to study tiny structures, and comparing the morphology of biological evidence.

II.4. Chemical and Toxicological Analysis

Mass spectrometry is used to identify drugs, poisons, and heavy metals. Chromatography separates and detects chemical substances-immunoassays identify specific proteins or biological markers.

III. Practical Applications

- Identification of suspects through DNA found on weapons, clothing, or surfaces.
- Victim identification in disasters or with decomposed bodies.
- Reconstructing events by analyzing blood patterns, fibers, and fluids.
- Legal evidence presented in courts.
- Forensic epidemiology: monitoring infectious diseases or toxins involved in crimes.