



Al-Mustaqbal University
College of Science
Department of Forensic Evidence
Second Stage



جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

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Lecture (3)

Examples in forensic science

Second stage

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Introduction:

Forensic science involves the application of scientific principles, methods, and technologies to the investigation of criminal activities, the analysis of physical evidence, and the support of the judicial process in delivering fair and accurate verdicts. It serves as a vital link between science and law by converting minute traces—such as DNA, fingerprints, and bloodstains—into reliable and legally admissible evidence. Key examples include:

DNA profiling enables the identification of suspects or victims through biological materials such as hair, blood, or skin cells recovered from a crime scene.

Fingerprint analysis involves comparing unique latent fingerprints found on weapons or surfaces with known prints to establish individual identity.

Forensic toxicology focuses on detecting drugs, alcohol, or toxic substances in biological samples to determine causes of impairment or death.

Ballistics analysis examines bullets, cartridge cases, and firearm markings to associate a specific weapon with a criminal act.

Digital forensics entails the recovery of deleted data and the analysis of digital footprints from computers, mobile phones, and other electronic devices.

Trace evidence analysis investigates materials such as fibers, glass fragments, or soil particles to establish physical contact between a suspect, a victim, or a crime scene.

Collectively, these forensic techniques play a critical role in reconstructing criminal events, identifying offenders, and ensuring the exoneration of innocent individuals.

This chapter explores a range of forensic science disciplines and highlights their practical application as tools that support law enforcement in criminal investigations. It does not aim to provide an exhaustive review of all available forensic sciences; rather, it offers an overview



that illustrates the diversity and scope of forensic techniques currently in use. investigators are not required to possess expert-level knowledge in every forensic discipline. However, a fundamental understanding of forensic tools is essential to enable investigators to identify appropriate methods and consult qualified specialists when necessary. The forensic analysis topics addressed in this chapter include:

1. Physical Matching
2. Fingerprint Matching
3. Hair and fibre analysis
4. Ballistic Analysis
5. Blood Spatter Analysis
6. DNA Analysis
7. Chemical Analysis
8. Forensic Archaeology
9. Forensic Document Analysis
10. Crime Detection Laboratories

1-Physical matching is a forensic technique that involves comparing physical evidence to establish a connection between a suspect, a victim, and a crime scene. At a basic level, investigators can conduct on-site examinations by visually comparing evidence; however, advanced physical matching requires trained experts whose opinions are accepted by courts. This technique is commonly applied to fingerprints, shoe prints, tire tracks, tool marks, broken glass, and torn materials. Physical matching involves two levels of examination: class characteristics and accidental characteristics. Class characteristics categorize items by general features such as size, type, brand, and pattern, helping narrow suspect pools. Accidental



characteristics are unique marks caused by wear and damage and can lead to positive identification. In cases involving glass or plastic fragments, microscopic analysis and fracture examination are used to reconstruct events and determine impact direction or sequence.

2-Fingerprint matching is a well-established forensic technique widely accepted by courts as reliable evidence of personal identification. Each individual possesses unique and permanent fingerprint ridge patterns, which rarely change except due to injury or deliberate alteration. Fingerprints are often deposited on surfaces through natural skin oils, forming latent prints that can be revealed using powders or chemical fuming methods. Visible prints may also occur when fingers are contaminated with substances such as blood or ink, or when impressions are made on soft materials. Modern identification relies on the Automated Fingerprint Identification System (AFIS) to compare unknown prints with stored databases. When no prior record exists, direct comparison with a suspect's known prints is required, typically using at least ten matching points. The presence of a suspect's fingerprint at a crime scene provides strong circumstantial evidence linking them to the offense.

3-Hair and fibre analysis supports Locard's Theory of Evidence Transfer, which states that individuals both leave and take materials when they enter and exit a crime scene. Humans continuously shed hair, fingerprints, and clothing fibres, while also collecting materials from their surroundings. Hair and fibre evidence is considered corroborative rather than conclusive, as it provides limited certainty. Hair samples can be compared between a crime scene and a suspect to determine similarities. When hair contains root tissue, DNA analysis may allow more definitive identification. Fibre evidence is often more informative than hair, as microscopic analysis can compare colour, size, and material type. These comparisons help strengthen the connection between suspects, victims, and crime scenes.

4-Ballistic analysis plays a vital role in investigating firearm-related crimes by examining bullets, cartridge casings, and firearms. Ballistics focuses on how projectiles are fired, travel,



and impact targets. Through ballistic fingerprinting, investigators compare unique marks left on bullets and casings to determine whether they originated from a specific weapon. Firearms and ammunition are first classified by calibre and firing mechanisms to eliminate incompatible weapons. More conclusive identification relies on microscopic comparisons of striations, chamber marks, firing-pin impressions, and ejector markings. These distinctive features are produced by wear and manufacturing characteristics unique to each firearm. Trajectory analysis further assists investigations by reconstructing the bullet's path to estimate the shooter's position and movement. Proper collection and preservation of ballistic evidence are essential to ensure accurate and reliable forensic conclusions.

5-Blood spatter analysis is a forensic technique used to reconstruct violent events by examining bloodstain patterns at a crime scene. It focuses on how blood is distributed, its direction of travel, and the forces that caused its movement. Scientific studies show that bloodshed during an assault produces predictable spatter patterns. For example, a blow from an object such as a baseball bat creates directional droplets that indicate the angle and direction of the strike. Blood adhering to a weapon may also produce secondary patterns during repeated movements. Analysis of these patterns can reveal the number of blows, positions of the victim and attacker, and sequence of events. Directional stains on walls or ceilings further assist in reconstruction. Blood spatter analysis therefore plays an important role in understanding how a crime unfolded.

6-DNA analysis examines deoxyribonucleic acid, the molecule that carries the genetic blueprint of all living organisms. With the exception of identical twins, each individual has a unique DNA profile. In rare cases, such as chimerism or bone marrow transplants, a person may possess two different DNA profiles. In forensic science, DNA can be extracted from biological materials including blood, saliva, semen, skin cells, and hair roots. Even aged or dried samples can often produce reliable DNA profiles. DNA comparisons allow investigators to link biological evidence to individuals with a high degree of statistical certainty. This



technique has also enabled the re-examination of old cases and the exoneration of wrongly convicted persons. DNA databases further enhance investigations by matching crime scene evidence to known offenders.

7-Chemical analysis plays a vital role in forensic investigations, as many crimes involve the use or presence of chemical substances. It includes the identification and examination of accelerants in arson cases. It also covers explosive analysis related to criminal acts and terrorism. Toxic chemicals and biological agents are analyzed in cases of poisoning, murder, or industrial negligence. Drug analysis is essential in investigations involving drug trafficking and overdose deaths. Gunshot residue analysis helps determine firearm use. Additionally, chemical comparison of paint transfers is used in hit-and-run vehicle investigations. Together, these techniques help link suspects, actions, and crime scenes through chemical evidence.

8-Forensic Archaeology Relatively new in the forensic world, forensic archaeology is the use of archaeological methods by experts to exhume crime scenes, including bodies. These forensic experts are trained to methodically excavate and record their dig. They document the recovery of artifacts (evidence), such as human remains, weapons, and other buried items, that may be relevant to the criminal event. Forensic archaeologists will often work in concert with other forensic experts in DNA, physical matching, forensic entomology, and forensic odontology in the examination of evidence.

9-Crime Detection Laboratories such as the RCMP labs across Canada, provide a range of specialties, including;

- **Biology** — Comparison of the suspect's and victim's body fluids and hair; most often DNA analysis
- **Chemistry** — Identifying non-biological substances found at a crime scene, such as paint, glass, liquids, fuels, and explosive substances



- **Toxicology** — The examination of body fluids to determine the level of alcohol present in the body, and providing expert opinions in relation to the extent of intoxication
- **Documents Examination** — The analysis of documents to determine authenticity for fraud allegations. Can also provide handwriting comparison
- **Firearms Ballistics** — Matching shells, casing, and fired bullets to a weapon and making a determination of bullet trajectory
- **Tool mark examination** — Matching tool impressions to an originating suspect tool

10- **Forensic document analysis** is conducted by certified forensic document examiners, who may work as independent contractors or within government-funded crime laboratories. These specialists primarily handle fraud investigations, examining items such as wills, contracts, deeds, seals, stamps, bank checks, IDs, and documents from photocopiers, fax machines, and printers. Their role is to verify the authenticity of documents and determine whether they have been altered, particularly when fraud or misrepresentation is suspected. They also compare questioned signatures with genuine samples to confirm authenticity. Additionally, forensic document examiners analyze threatening letters, ransom notes, or robbery notes to link them to potential suspects.

This chapter discussed the wide range of forensic tools and services available to criminal investigators. Understanding these tools allows investigators to identify and utilize evidence opportunities that might otherwise be overlooked. Physical evidence at a crime scene initially appears as mere objects connected to the event. However, analyzing these objects with forensic tools can reveal significant information, establish links between individuals and the event, and provide new insights. Effective forensic analysis can be the key factor in solving a crime, preventing it from becoming a cold case.