

# Role of Forensics in Crime Investigation - A Review Article

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## ABSTRACT:

Forensic science plays a pivotal role in modern crime investigation, serving as a bridge between law enforcement and the judicial system. This interdisciplinary field encompasses various scientific techniques and methodologies that are employed to collect, preserve, and analyse physical evidence from crime scenes. Moreover, forensic science contributes to crime prevention by helping to establish patterns and profiles of criminal behaviour.

**Keywords:** Crime investigation; Judicial system and DNA analysis

## 1. INTRODUCTION

Forensic science is widely used in the investigation of crimes, and is recognised as a valuable tool in administering justice <sup>[1]</sup>. Recorded human history goes back for 6000 years. Sumeria, Babylon and Egypt all contributed to the development of forensic medicine. Imhotep was probably the first real medico-legal expert. Hippocrates, the Greek physician, and Galen, the Roman, made considerable contributions. Little advance was made during the millenium of the Dark Ages. But Renaissance medicine gave this branch of medicine an impetus in

the seventeenth, eighteenth and nineteenth centuries, and in the twentieth, interest in forensic medicine is worldwide <sup>[2]</sup>. The main objectives of forensic medicine are not only to establish the cause and manner of death but also to record samples, to analyze the crime scene, and to identify the cadaver through an autopsy <sup>[3]</sup>. This comprises a crime scene investigation, which is a scene where the case investigator and crime scene personnel work together to define and secure areas that may contain evidence; examine and document the scene; collect physical evidence; preserve, pack, and submit the evidence to the laboratory for analysis. Traditional methods of documentation of a death scene include photography, sketches, and notes, electrostatic lifting, or casting, as well as field forms and video footage. Additionally, the investigative techniques in forensic science have been thoroughly lined up, such as DNA analysis, finger printing, voice recognition, handwriting analysis, ballistics, autopsy, etc. Further, forensic psychology and crime investigation elucidates the use of clinical specialties to walk through criminal acts and behaviours by applying psychological research, data, and theory to differentiate between the suspects and the main culprits <sup>[4]</sup>. The application of forensic

science enhances the accuracy and reliability of investigations, enabling law enforcement agencies to solve crimes with greater efficiency and precision. Key components of forensic science include DNA analysis, fingerprinting, ballistics, toxicology, and digital forensics, among others. DNA profiling, for example, has revolutionized the identification process, allowing for the accurate matching of suspects to biological evidence left at crime scenes. Fingerprinting remains a cornerstone of forensic investigation due to its uniqueness to each individual. Ballistics analysis assists in tracing firearms used in criminal activities, while toxicology helps in detecting drugs, poisons, and other substances that may have contributed to a crime. Digital forensics has gained prominence with the rise of cybercrime, involving the recovery and examination of data from electronic devices. The integration of forensic science in crime investigation aids in the reconstruction of events, identification of suspects, and exoneration of the innocent. It provides critical evidence that can withstand judicial scrutiny, thus strengthening the legal process. Forensic science can be involved not only in investigation and prosecution of crimes such as rape, murder, and drug trafficking but also in matters in which a crime has not been committed but in which someone is charged with a civil wrong, such as willful pollution of air or water or causing industrial injuries.

The main areas of forensic science include: Forensic anthropology, Criminalistics, Forensic engineering, Jurisprudence, Forensic pathology, Forensic odontology, Forensic entomology, Psychiatry and behavioral science, Questioned-document analysis, Toxicology [5].

**1.1. Forensic anthropology:** It represents the application of knowledge and methodology of anthropology, especially biological anthropology and archaeology, to medico-legal issues. Traditionally, the practice of forensic anthropology has focused on the

recovery and analysis of human remains. This work includes not only search and recovery, but also determination if recovered evidence is bone or tooth, species representation, estimation of time since death, sex, ancestry, age at death, living stature, taphonomic history and recognition of any other features that may assist identification and detection of foul play. The technique is used in an attempt to reach out to the public in search of investigative leads. The scope of forensic anthropology has been expanded to include issues of the living related to identification and age determination [6].

**1.2. Forensic engineering:** It is the application of engineering principles or techniques to the investigation of materials, products, structures or components that fail or do not perform as intended. In particular, forensic engineering can involve providing solutions to forensic problems by the application of engineering science. A criminal aspect may be involved in the investigation but often the problems are related to negligence, breach of contract, or providing information needed in the redesign of a product to eliminate future failures. Forensic engineering may include the investigation of the physical causes of accidents or other sources of claims and litigation (for example, patent disputes). It involves the preparation of technical engineering reports, and may require giving testimony and providing advice to assist in the resolution of disputes affecting life or property [7].

**1.3. Forensic pathology:** It has been characterized by a necessary conjunction between tradition and innovation, which primary achievement is finding the truth and scientific objectivity. During the past centuries several studies have enriched scientific forensic panorama, until the most recent introductions in radiological fields (3D post-mortem CT and MRI) and in the molecular

biological one, with disclosure of miRNA. MiRNAs are small, endogenous, single stranded, non-coding RNA molecules identified in plants, animals and DNA virus transcriptome. Various and growing are the fields of application: to establish time of death, to evaluate vitality of skin lesions, in cases of head trauma, and cases of acute myocardial infarction. The introduction of new molecular biology techniques will certainly be useful in the coming years to find the “truth” in challenging judicial cases [8].

**1.4. Forensic odontology:** It is a dental branch, involves handling, examining, and presenting dental findings for justice. Accurate identification in disasters or assaults is crucial, often relying on dental factors like restorations, missing teeth, and prosthetic devices when other records are unavailable. Prosthodontics, especially denture identification systems, which play a vital role in identifying edentulous individuals’ postmortem. From printed labels to advanced technological methods, including implant-retained dentures and radiographs contributing significantly to human identification [9].

**1.5. Forensic entomology:** This branch includes application of the study of insects and other arthropods to legal issues, especially in a court of law. Lord and Stevenson identified three categories of forensic entomology: urban, stored-product, and medico-legal. Urban forensic entomology includes such things as litigations and civil law actions involving arthropods in dwellings or as house and garden pests. Law suits dealing with the misuse of pesticides are included here. Stored-product forensic entomology generally deals with arthropod infestation or contamination of a wide range of commercial products (e.g. beetles or their parts in candy bars, flies in ketchup, or spiders in bathroom tissue).

Like its urban counterpart, this category usually involves litigation. The third category, medico-legal forensic entomology, is the focus of this review and is the most popularized aspect of the science. It deals with arthropod involvement in events surrounding felonies, usually violent crimes such as murder, suicide, and rape, but also includes other violations such as physical abuse and contraband trafficking [10].

**1.6. Psychiatry and behavioural science:** It encompasses science of behaviour and Mental processes of the criminal. Here the focus is “individual's criminal behaviour - how it is acquired, evoked, maintained or modified”. It considers both the social and personality factors and how these are mediated by mental processes. Recently there is a shift in its focus to the cognitive aspects of offending. Exploring consistent, stable personality disposition or traits was the serious study in the past. In search of personality traits little attention was paid to the environment or situation. It was thought that once personality variables were identified it would be possible to determine and predict which individual was most likely to engage in criminal behaviour [11].

**1.7. Questioned-document analysis:** This includes the use of new technologies to analyse inks and papers and the use of chemo-metrics to evaluate the analytical data. Forensic handwriting examination involves the comparison of writing samples by forensic document examiners (FDEs) to determine whether or not they were written by the same person. Ideally, a handwriting comparison involves questioned writing that is original, is freely and naturally prepared, and contains a sufficient quantity and quality of writing. Questioned writing that is limited in one or more of these attributes may provide insufficient evidence to make a source determination. A handwriting

comparison should also, ideally, include known writing that is original and freely and naturally prepared; is comparable to the questioned writing in format, style, characters, and character combinations; and is provided in sufficient quantity and quality to be representative of the individual's range of writing. Limitations in the questioned or known writing may result in inconclusive or qualified conclusions [12].

**1.8.Toxicology:** It represents a number of related disciplines aimed to assist in the detection and interpretation of drugs and poisons for medico-legal purposes. It is an important science that supports a range of medico-legal applications. The selection of the appropriate range of samples will depend on the application but will always require proper documentation, transport and storage to guarantee the integrity of the items for analysis. Knowledge of drug effects and pharmacokinetics, together with an appreciation of possible limitations in the interpretation of results, ensures credible evidence that has not been overstated [13].

## **2. CRIME ANALYSIS AND FORENSICS**

In order to create a desirable synergy between forensic science, crime analysis, investigation and other fields related to the study of crime, a fully integrated forensic case data should be collected. This program starts via a "bottom-up" approach that consists of collecting and classifying existing systems (DNA, AFIS, etc.) through the kind of intelligence they provide into an analytical framework that is abstract from the computer. The resulting structure is presented as an organised set of elementary logical steps whose relevance is evaluated in relation with the criminal context, the existing pragmatic constraints and other parameters imposed by the criminal justice system. Finally, the primitive inference structures identified are integrated into the specific process of serial crime analysis.

This shows how forensic science can become part of an approach that facilitates the resolution of problems by sharing the knowledge of investigators, crime analysts and forensic scientists [14]. Forensic science encompasses a wide range of sub-disciplines, each playing a unique role in the investigation process:

**2.1.DNA Analysis:** One of the most significant advancements in forensic science is DNA profiling. DNA analysis allows for the identification of individuals based on their unique genetic makeup. This technique is instrumental in linking suspects to crime scenes, identifying victims, and exonerating the innocent. The development of the Combined DNA Index System (CODIS) in the United States has further enhanced the ability of law enforcement to match DNA samples from different cases [15].

**2.2.Fingerprinting:** Fingerprint analysis remains a cornerstone of forensic science due to the uniqueness of fingerprints to each individual. Integrated automated fingerprint identification systems (IAFIS) have streamlined the process of comparing fingerprints found at crime scenes with those in a database, significantly speeding up investigations [16].

**2.3.Ballistics:** Forensic ballistics involves the examination of firearms, ammunition, and the effects they produce. This sub-discipline is crucial in cases involving gun violence, as it can help determine the type of firearm used, trace the weapon to its owner, and establish the trajectory of bullets.

**2.4.Toxicology:** Forensic toxicology focuses on detecting and identifying drugs, alcohol, poisons, and other chemicals in biological samples. This analysis can reveal whether substances played a role in a crime, such as poisoning, overdose, or impairment during an incident.

**2.5.Digital Forensics:** With the rise of cybercrime, digital forensics has become increasingly important. This field

involves the recovery and examination of data from electronic devices, such as computers, smart phones, and storage media. Digital forensics can uncover crucial evidence, including communications, financial transactions, and deleted files.

### 3. THE IMPACT ON CRIME INVESTIGATION

Forensic science significantly enhances the investigative process in several ways:

**3.1.Reconstruction of Events:** Forensic evidence helps reconstruct the sequence of events leading up to, during, and after a crime. For example, bloodstain pattern analysis can provide insights into the actions that occurred during a violent crime, while forensic anthropology can help determine the cause and manner of death from skeletal remains.

**3.2.Identification of Suspects:** Scientific techniques such as DNA profiling and fingerprint analysis are vital in identifying suspects. This objective evidence can corroborate or refute witness statements and alibis, thereby narrowing down the list of potential perpetrators.

**3.3.Exoneration of the Innocent:** Forensic science not only helps in convicting the guilty but also plays a crucial role in exonerating the innocent. Post-conviction DNA testing has led to the release of wrongfully convicted individuals, highlighting the importance of accurate forensic analysis- Innocence Project [17].

**3.4.Judicial Scrutiny:** Forensic evidence must withstand rigorous judicial scrutiny to be admissible in court. This requires that forensic scientists adhere to stringent protocols and maintain high standards of accuracy and reliability in their analyses. The standard, established by the U.S. Supreme Court, sets criteria for the admissibility of expert testimony, ensuring that forensic evidence is scientifically valid and relevant.

### 4. CHALLENGES

Challenges in forensic science include the need for continuous advancements in technology, rigorous training of personnel, and adherence to stringent ethical standards. The reliability of forensic evidence depends on the meticulous collection and handling of samples, as well as the expertise of forensic scientists.

### 5. CONCLUSION

In conclusion, forensic science is indispensable in the realm of crime investigation. Its scientific rigor and methodical approach not only aid in solving crimes but also uphold the principles of justice by ensuring that evidence presented in court is credible and scientifically valid. As technology advances, the role of forensic science will continue to expand, offering new tools and techniques to combat crime and support the judicial system. It is that piece without which the puzzle of a criminal investigation is incomplete. Without the application of forensic science, criminals can never be convicted unless an eyewitness is present. While detectives and law enforcement agencies are involved in the collection of evidence, be it physical or digital, it is forensic science that deals with the analysis of those evidence in order to establish facts admissible in the court of law<sup>[4]</sup>.

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