**HISTORY AND DEVELOPMENT OF FORENSIC SCIENCE IN INDIA**

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# **ABSTRACT**

This review paper gives the idea of Forensic science in India has a long history dating back to ancient times and new developments, where it was used for solving criminal cases and disputes. However, the formal development of forensic science in India began during British colonial rule, with the establishment of the first medico-legal department in Calcutta. Despite the significant progress made in the field of forensic science in India, there are still several challenges that need to be addressed. One of the biggest challenges is the need for more trained forensic scientists. India has a large population, and there are still many areas that lack trained forensic experts. The establishment of better forensic facilities in rural areas is another area that needs attention. Moreover, the need to improve the quality of forensic evidence presented in court is also a pressing issue. Forensic science continued to evolve with the development of new techniques and technologies, including DNA analysis, ballistics analysis, and digital forensics. There have been efforts to improve forensic science practices, including the establishment of national standards and the use of more rigorous scientific methods. There has been a renewed focus on improving the quality and reliability of forensic science in India. The government has introduced several initiatives, including the establishment of the Bureau of Police Research and Development which provides technical assistance to law enforcement agencies. history and development of forensic science in India is a fascinating tale that spans centuries. The modern development of forensic science in India began during the British colonial era in the 19th century. Over the years, forensic science has played a crucial role in several high-profile cases in India, and it has led to the establishment of several academic programs in the field. However, there are still several challenges that need to be addressed to improve the quality of forensic science in India. Nonetheless, the history and development of forensic science in India is a testament to the importance of science in the legal system, and its potential to.

**INTRODUCTION**

Forensic science in India has a long and fascinating history that dates back to ancient times. In the early days, forensic science was used in India primarily for identifying the authenticity of documents, such as wills, deeds, and contracts. However, over time, the field expanded to include other areas such as investigating crimes, identifying suspects, and analyzing physical evidence. One of the earliest references to forensic science in India is found in the ancient Indian epic, the Mahabharata, which describes the use of fingerprints to identify the author of a threatening letter. During the British colonial period, forensic science in India was influenced by developments.The British government established the Government Chemical Examiner’s Department, which later became the Forensic Science Laboratory (FSL). The FSL played a crucial role in the development of forensic science in India. The FSL also developed new methods for analysing evidence, such as the use of spectroscopy to identify substances. After that, the Central Forensic Science Laboratory (CFSL)was established and it became the premier forensic science laboratory in India. The CFSL was responsible for providing scientific support to law enforcement agencies across the country and for conducting research in forensic science. In recent years, forensic science in India has continued to evolve and expand. In 2000, the government established the National Institute of Criminology and Forensic Science (NICFS) in New Delhi, which offers postgraduate programs in forensic science and criminology. Overall, forensic science in India has come a long way since its early days. Today, forensic science plays a crucial role in the investigation of crimes and the administration of justice in India.

# **History and development of forensic science**

Forensic science has a long history in India, and its development can be traced back to the late 19th century. The first forensic department in India was established in Calcutta in 1878, which marked the beginning of forensic science in the country.[1]

 During the British Raj, forensic science was primarily used for criminal investigations, and several forensic laboratories were set up across the country. In 1913, the first forensic laboratory in India was established in Calcutta. Over the years, more forensic laboratories were established in different states.[9]

 Over the years, forensic science has evolved in India, and its scope has expanded to include various scientific disciplines, including biology, chemistry, physics, and digital forensics. The development of forensic science in India can be divided into several phases:

* Establishment of Forensic Science in India (1878-1947): During this phase, the focus was on establishing forensic science as a separate discipline in India. The first forensic laboratory in India was established in 1913 in Calcutta. In 1925, the Indian Criminal Law Amendment Act was passed, which made provisions for using forensic science evidence in courts. [1]
* Expansion of Forensic Science (1947-1990): After India gained independence in 1947, forensic science continued to expand. The Central Forensic Science Laboratory (CFSL) was established in 1957 in Delhi, followed by other forensic science laboratories in different states. During this phase, DNA fingerprinting was introduced in India in the late 1980s.
* Modernization of Forensic Science (1990): In this phase, forensic science in India has undergone significant modernization and technological advancements. The use of digital forensics in criminal investigations has become widespread, and several universities now offer forensic science courses. In 2017, the Indian government established the National Forensic Sciences University in Gujarat to promote research and development in forensic science.
* In 1957, the Central Forensic Science Laboratory (CFSL) was set up in Delhi, which marked a significant step in the development of forensic science in India. The CFSL is the premier forensic laboratory in India and is responsible for analyzing evidence in high-profile criminal cases.
* In the 1970s and 1980s, the use of forensic science in criminal investigations became more widespread. The introduction of DNA fingerprinting in the late 1980s marked a significant milestone in forensic science in India. In 1989, the first DNA fingerprinting laboratory was established in Hyderabad.
* In the 1990s and 2000s, forensic science in India underwent significant modernization and technological advancements. Digital forensics became more prevalent, and several universities began offering forensic science courses. [6]
* In 2017, the Indian government established the National Forensic Sciences University in Gujarat to promote research and development in forensic science. The university offers courses in various forensic science disciplines, including forensic biology, forensic chemistry, forensic physics, and digital forensics.

Despite the significant developments in forensic science in India, the field still faces several challenges, such as outdated equipment, inadequate funding, and a shortage of trained personnel. However, the Indian government has taken steps to address these issues, such as increasing funding and improving training programs.

 Forensic science has come a long way in India since its inception in the late 19th century. Today, it is an essential tool in the country's justice system and plays a crucial role in solving crimes and bringing perpetrators to justice.

# **DEVELOPMENT OF FORENSIC SCIENCE IN INDIA TODAY**

Forensic science in India has undergone significant development in recent years. The government has established several institutions and agencies to promote research, development, and training in the field of forensic science.[2]

 The Central Forensic Science Laboratory (CFSL) is the apex scientific body in India that provides forensic support to law enforcement agencies. It has several branches across the country and is responsible for conducting forensic analysis and providing expert opinions in criminal cases. In addition to CFSL, several other institutions and universities in India offer courses in forensic science, including postgraduate programs and diploma courses. These institutions also conduct research in various areas of forensic science, such as DNA analysis, toxicology, and ballistics.[6]

 The use of forensic science in criminal investigations has also increased in India in recent years. Law enforcement agencies are increasingly relying on forensic evidence to solve crimes, and courts are placing more emphasis on forensic evidence in criminal trials.[4]

 However, there are still several challenges that need to be addressed in the development of forensic science in India. These include the need for more trained forensic experts, better infrastructure and facilities for forensic analysis, and the need for better coordination between law enforcement agencies and forensic laboratories.

 Overall, the development of forensic science in India is an ongoing process, and it is essential for the government and other stakeholders to continue to invest in research, development, and training in this field. This will not only help solve more crimes but also ensure that justice is served more fairly and accurately.

# **HUNDRED YEARS OF FORENSIC SCIENCE IN INDIA**

This provides an in-depth account of the development of forensic science in India during the colonial period. The history of forensic science in India goes back to 1849 when the British East India Company established the first medico-legal department in Calcutta (now Kolkata). The department was tasked with conducting post-mortem examinations and providing medical evidence in criminal cases. [5]

Over the next century, forensic science gradually evolved in India, establishing new departments and introducing new forensic techniques. Some of the key milestones highlighted in the book include:

* The establishment of the Indian Medical Service in 1870, provided a formal training program for medical practitioners and helped to standardize medical practices across India.
* The establishment of the Anthropological Survey of India in 1910, helped to advance the field of forensic anthropology in India.
* The introduction of fingerprint analysis in 1897, quickly became an essential tool in criminal investigations.
* The establishment of the Indian Forensic Science Laboratory in 1930, helped to centralize forensic services and improve the quality of forensic analysis in India.
* The development of new forensic techniques, such as ballistics and toxicology, which were used to solve a range of criminal cases.[8]

Throughout this the challenges faced by forensic scientists in India during the colonial period, including inadequate funding, limited resources, and a lack of recognition for their work. Forensic science continued to evolve and expand, providing valuable evidence to help solve crimes and administer justice. Hundred years of forensic science in India provide a comprehensive overview of the development of forensic science in India during the colonial period and shed light on the contributions of early forensic science.[5]

# **THE DEVELOPMENT, STATUS, AND FUTURE OF FORENSIC SCIENCE IN INDIA**

Forensic science is a branch of science that deals with the application of scientific principles and techniques to investigate crimes and establish facts in legal cases. In India, the development of forensic science can be traced back to the late 19th century, when the first fingerprint bureau was established in Calcutta (now Kolkata) in 1897. Since then, forensic science has come a long way in India, with the establishment of various forensic laboratories and Institutions across the country.[2]

 Today, forensic science has a critical role in the investigation and prosecution of crimes in India. Some of the key areas of forensic science in India include forensic pathology, forensic toxicology, forensic serology, forensic odontology, and forensic psychology. [11]

 In India, the development of forensic science has been slow, then a shortage of and inadequate infrastructure in many parts of the country. However, there have been significant efforts in recent years to strengthen forensic science in India. For example, the government has established several new forensic Laboratories and Institutions including the national forensic science University in Gujarat.[1]

 There has also been a push to improve the training and education of forensic Sciences in India with the establishment of new courses and training programs at various University is and institutions. Additionally, the use of technology in forensic investigations has increased in recent years with the introduction of DNA profiling, ballistics analysis, and digital forensics.[1]

 Looking to the future, there is a need to further strengthen forensic science in India with a focus on increasing the number of trained personnel, improving infrastructure and equipment, and promoting research and development in the field. The government and private sector must work together to address these challenges and ensure that forensic science continues to play a critical road in the investigation and prosecution of crimes in India.

# **NEW DEVELOPMENT OF FORENSIC SCIENCE IN INDIA**

Forensic science is an ever-evolving field, and there have been several new developments in India in recent years. Here are some examples:

1. DNA Profiling: In 2019, the Ministry of Home Affairs approved the use of Rapid DNA profiling technology for investigating sexual assault cases. This technology can generate a DNA profile within 90 minutes, which can help speed up investigations.[10]
2. Digital Forensics: With the increasing use of technology, digital forensics has become a crucial area of forensic science. There have been several new developments in this area in India, including the establishment of the Cyber Forensics Laboratory in Mumbai in 2020.[13]
3. Forensic Psychology: Forensic psychology is a relatively new area of forensic science in India, but it has been gaining importance in recent years. It involves the application of psychological principles and techniques to legal issues. In 2021, the National Institute of Criminology and Forensic Science (NICFS) launched a new M.Sc. program in forensic psychology.[11]
4. Toxicology: The detection and analysis of drugs and toxins have always been an important aspect of forensic science. In 2020, the All India Institute of Medical Sciences (AIIMS) established a new toxicology lab in Delhi, which is expected to improve the quality and efficiency of toxicology analyses in the country.[15]
5. Forensic Accounting: Forensic accounting is another emerging area of forensic science in India. It involves the investigation of financial transactions and accounting records for evidence of fraud, embezzlement, and other financial crimes. Several new firms specializing in forensic accounting have emerged in recent years in India.[12]
6. Forensic genetics: Forensic genetics is a branch of forensic science that involves the use of DNA analysis and other genetic techniques to investigate crimes, identify human remains, and establish paternity or other familial relationships.[35]
7. Forensic linguistics: Forensic linguistics is a field of study that uses linguistic analysis in legal contexts, such as criminal investigations, trials, and other forms of legal disputes. Forensic linguists analyze language data, such as written texts, audio recordings, and spoken statements, to provide evidence in legal cases. They may also provide expert testimony in court regarding language-related matters.[42]
8. Forensic archaeology: Forensic archaeology is the application of archaeological techniques and principles to the investigation of crimes, human rights abuses, and other legal issues. Forensic archaeologists work alongside forensic scientists and law enforcement officials to locate, excavate, and analyze physical evidence related to a crime or other legal matter. Forensic archaeologists may be called upon to assist in a wide range of cases, including homicide investigations, missing person cases, and mass grave sites related to war crimes or genocide. They use their knowledge of archaeological methods and techniques to carefully document and recover evidence, such as bones, teeth, and other physical remains, as well as items like clothing, jewelry, and personal belongings.[43]
9. Forensic geoscience: Forensic geoscience is an interdisciplinary field that applies geological and earth science principles to forensic investigations. This field is concerned with the analysis of geological materials as evidence, including soils, rocks, sediments, minerals, and water.

The new developments in forensic science in India, As the field continues to evolve, we can expect to see further advancements in technology, methodology, and training, which will help improve the quality of forensic science services in the country.

# **NEW ESTABLISHMENT OF FORENSIC SCIENCE IN INDIA**

Forensic science is a rapidly growing field in India, and there have been several new establishments in recent years to support its development [1]. Here are some examples:

1. National Forensic Sciences University (NFSU): The NFSU was established in 2020 in Gujarat as the first and only university in India dedicated to forensic sciences. The university offers undergraduate, postgraduate, and doctoral programs in various areas of forensic science.
2. Central Forensic Science Laboratory (CFSL): The CFSL is the premier forensic laboratory of India, under the Ministry of Home Affairs, and has several regional laboratories across the country. It provides forensic analysis services to law enforcement agencies and the judiciary.
3. Directorate of Forensic Science Services (DFSS): The DFSS is a national-level organization under the Ministry of Home Affairs responsible for providing forensic science services to investigating agencies and the judiciary. It has several regional forensic science laboratories across the country.
4. State Forensic Science Laboratories (SFSLs): Most Indian states have their own SFSLs, which are responsible for providing forensic science services to law enforcement agencies and the judiciary within their respective states.
5. Forensic Science Colleges: Several colleges across India offer courses in forensic science, including B.Sc. and M.Sc. programs. Some of the top institutions offering these courses include Amity University, Lovely Professional University, Gujarat Forensic Sciences University, and Punjab University.[5][6]

# **NEW TECHNIQUES THAT COME INTO FORENSIC SCIENCE IN INDIA**

* Biometric Analysis: Biometric analysis is a crucial component of forensic science that involves the identification of individuals based on unique physical or behavioral characteristics. The use of biometric analysis in forensic investigations has increased significantly in recent years due to advances in technology and the growing need for more reliable and accurate methods of identification. Ex: Fingerprint analysis, DNA analysis, Voice analysis, and Handwriting analysis.[22]
* Virtual autopsy: Virtual autopsy, also known as virtual autopsy imaging, is a non-invasive method of conducting an autopsy using medical imaging technology. This technique is becoming increasingly popular in forensic science as it provides an alternative to traditional autopsies, which are invasive and require the removal of organs. Virtual autopsy uses medical imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) to create a detailed 3D image of the body. These images can be used to identify injuries, fractures, and other anomalies that may be relevant to a forensic investigation. In addition, a virtual autopsy can be used to identify internal bleeding, organ damage, and other injuries that may not be visible during a traditional external examination.[18][19]
* Laser ablation inductively coupled mass spectrometry: Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is an analytical technique used for the elemental analysis of solid materials. The technique involves the use of a laser to vaporize and ionize a small portion of the sample, which is then carried into an inductively coupled plasma (ICP) for ionization and subsequent analysis by mass spectrometry.[21]
* Stable isotope analysis: It can provide important information about the geographical origin and movement of various materials, which can be used to support or refute witness statements or other types of evidence. One of the main applications of stable isotope analysis in forensic science is in the analysis of drugs, particularly illegal drugs such as cocaine and heroin. The stable isotopes in these drugs can be used to determine their origin, which can help law enforcement agencies to identify the source of the drugs and track down those responsible for their production and distribution. Stable isotope analysis can also be used in the analysis of explosives, which can provide important information about their origin and the identity of the person or group responsible for their use. By analyzing the stable isotopes in explosive residue, investigators can determine where the explosive was made, which can provide important clues about the individuals or groups responsible.[24][25]
* Virtual reality exposure therapy: Virtual reality exposure therapy (VRET) has potential applications in forensic science, particularly in the field of eyewitness identification. Eyewitness identification plays a critical role in criminal investigations and trials, but it is well-established that eyewitness testimony can be unreliable due to factors such as stress, memory decay, and cross-racial identification bias. VRET can be used to help improve the accuracy of eyewitness identification by simulating the crime scene and allowing witnesses to view and interact with the scene from different angles and perspectives. This type of training can help witnesses remember important details and reduce the effects of stress and anxiety that can distort memory.[26]
* Isotope ratio mass spectroscopy: Isotope ratio mass spectrometry (IRMS) is a powerful analytical technique that is widely used in forensic science to determine the origin, authenticity, and history of samples. In IRMS, the ratios of isotopes of elements are measured in a sample. Isotopes are atoms of the same element that have different numbers of neutrons in their nucleus. For example, carbon has two stable isotopes: carbon-12 and carbon-13.In forensic science, IRMS can be used to determine the origin of a sample by comparing its isotopic signature to that of known samples from different locations. This is particularly useful for determining the origin of drugs, explosives, and other illegal substances. IRMS can also be used to determine the authenticity of a sample, such as a vintage wine or a natural fiber, by measuring the isotopic ratios of certain elements. Additionally, IRMS can be used to determine the age of a sample by measuring the ratio of isotopes of certain elements that decay over time, such as carbon-14.[27]
* Vibrational spectroscopy: Vibrational spectroscopy is a powerful tool used in forensic science for the analysis and identification of various substances. This technique involves the study of the vibrational behavior of molecules using infrared (IR) and Raman spectroscopy. Infrared spectroscopy is used to study the absorption of infrared radiation by a sample, while Raman spectroscopy involves the scattering of light by the sample[47]. Both techniques provide information about the vibrational modes of a molecule, which can be used to identify and characterize different compounds. Forensic scientists can use vibrational spectroscopy to analyze various types of evidence, including drugs, explosives, fibers, paints, and fingerprints. For example, IR spectroscopy can be used to identify the functional groups present in a drug, which can be used to determine its identity. Similarly, Raman spectroscopy can be used to analyze explosive residues found at a crime scene, allowing forensic scientists to determine the type of explosive used.[28]
* Terahertz spectroscopy and imaging: Terahertz spectroscopy and imaging have shown great potential in the field of forensic science, particularly in the analysis of evidence such as drugs, explosives, and counterfeit materials. Terahertz radiation is a type of electromagnetic radiation that lies between the microwave and infrared regions of the electromagnetic spectrum, with frequencies ranging from 0.1 to 10 THz.One of the main advantages of terahertz spectroscopy and imaging in forensic science is its ability to penetrate through many non-conducting materials, including clothing, paper, and plastics, without causing any damage. This makes it particularly useful for analyzing hidden objects or concealed items. In drug analysis, terahertz spectroscopy has been used to identify the chemical composition of drugs and to distinguish between different types of drugs. This information can be used to determine the origin of the drugs and to identify any adulterants or contaminants.[29][45]
* Proton nuclear magnetic resonance spectroscopy: Proton Nuclear Magnetic Resonance (NMR) spectroscopy is a powerful analytical tool used in forensic science. It is a non-destructive method that uses the magnetic properties of nuclei to study the chemical and physical properties of molecules. In forensic science, NMR spectroscopy can be used to analyze and identify unknown compounds found at a crime scene[46]. It can also be used to determine the purity of a substance, identify drug metabolites in biological samples, and detect adulterants in illicit drugs. One of the major advantages of proton NMR spectroscopy is its high sensitivity and specificity. It can detect very small quantities of a substance and can distinguish between compounds with similar chemical structures. It is also a relatively quick and straightforward technique that does not require extensive sample preparation.[30][31]
* X-ray Fluorescence analysis: X-ray fluorescence analysis (XRF) is a technique used in forensic science to analyze the elemental composition of materials[56]. XRF can be used to identify the presence and relative concentrations of various elements in a sample[57]. This technique is useful in forensic science because it can provide important information about the source and history of evidence.XRF is used in a wide range of forensic applications, including the analysis of trace evidence such as gunshot residue, paints, and fibers. It is also used in the analysis of soil and mineral samples in cases involving soil transfer, such as hit-and-run accidents or cases involving soil on shoes or clothing.[58]

In forensics there are more new techniques are established in different fields like cardiofacial superimposition, geolocation, eye movement desensitization and reprocessing, cloud forensic, and blockchain forensics.

# **CONCLUSION**

In conclusion, the history and development of forensic science in India have been a long and arduous journey. Starting with rudimentary methods of identification and examination, it has come a long way to become a crucial part of the country's justice system. With the establishment of the Central Forensic Science Laboratory and other state laboratories, forensic science in India has gained recognition as a reliable and efficient method of investigation. However, there is still a lot of work that needs to be done to improve the quality and standard of forensic science in India. The shortage of trained professionals, inadequate funding, and outdated technology are some of the challenges that need to be addressed. There is also a need for increased collaboration between forensic experts and the judiciary to ensure that the results of forensic analysis are presented in court in a manner that is easily understood by judges and juries. The future of forensic science in India looks promising. With advancements in technology, such as DNA analysis and digital forensics, there is a growing demand for forensic experts. The increasing awareness of the importance of forensic science in the investigation of crimes and the administration of justice is also a positive sign. Overall, the history and development of forensic science in India are a testament to the perseverance and dedication of the professionals who have worked tirelessly to establish it as a vital component of the country's justice system. While there are still challenges to be overcome, the future looks bright for this important field.

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