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Challenges and Emerging Trends in Crime Scene Investigation and Forensic Science in India: A Critical Legal Analysis

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ABSTRACT

Crime scene investigation and forensic science play a vital role in the effective functioning of the criminal justice system by assisting investigating agencies in the scientific detection, collection, preservation, and analysis of evidence. With the advancement of technology and the increasing complexity of crimes, forensic science has emerged as an indispensable tool for ensuring accurate investigation and fair administration of justice. This article critically examines the challenges, legal framework, procedural principles, and recent advancements relating to crime scene investigation and forensic science in India. The study analyses the practical difficulties faced by the Indian forensic system, including backlog in forensic laboratories, shortage of trained experts, inadequate infrastructure, lack of technological resources, and issues concerning contamination and preservation of evidence. It further explores the principles governing crime scene management, documentation, evidence collection, emergency response procedures, and contamination control. Special emphasis is placed on the evidentiary value of forensic and medical evidence in criminal trials, particularly with reference to postmortem reports, medico-legal certificates, and judicial interpretation of expert evidence. The article also discusses modern forensic technologies such as DNA profiling, Restriction Fragment Length Polymorphism (RFLP), Polymerase Chain Reaction (PCR), Automated Fingerprint Identification Systems (AFIS), facial reconstruction, 3D scanning, digital surveillance, and laser-based analytical techniques. In addition, scientific interrogation methods including narco-analysis, polygraph tests, and brain mapping are critically examined in light of constitutional safeguards, evidentiary admissibility, and human rights concerns under Indian law. Through doctrinal and analytical research, the article highlights the growing significance of forensic science in strengthening criminal investigations while also identifying the legal and ethical challenges associated with emerging technologies. The study concludes that modernization of forensic infrastructure, specialized training, incorporation of forensic education in legal studies, and strict adherence to procedural safeguards are essential for improving the reliability

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and effectiveness of crime scene investigation in India. A balanced integration of science, law, and constitutional protections is necessary to ensure justice, transparency, and public confidence in the criminal justice system.

Keywords: *Crime Scene Investigation, Forensic Science, DNA Profiling, Scientific Evidence, Criminal Justice System, Forensic Technology.*

I. INTRODUCTION

Forensic science has several obstacles as it develops in India, but it also offers chances for substantial advancement. In addition to outlining ways for bolstering India's forensic science infrastructure, this chapter looks at present difficulties affecting forensic practices and makes policy recommendations.

Issues with Forensic Practices Today Despite playing a vital role in the criminal justice system, the Indian forensic science system faces a number of serious obstacles that limit its efficacy and efficiency. To guarantee the provision of high-quality forensic services, these problems need to be addressed right away and in a methodical manner.

Backlog in Forensic Laboratories

The large backlog of cases in forensic labs throughout India is one of the most urgent issues facing the country's forensic science system. There are several reasons for this backlog, such as a growing number of cases that call for forensic analysis, a shortage of laboratory space, and resource limitations. In many jurisdictions, the situation has gotten so bad that some laboratories are reporting waiting times for standard analyses ranging from months to years. The entire criminal justice system is impacted by this backlog, not just the labs. Longer trials, more court cases, and possibly compromised evidence quality owing to prolonged storage times are all consequences of forensic analysis delays. Courts have occasionally been compelled to continue without forensic evidence, which may have an impact on the standard of justice administered. The issue is especially severe in specialist fields like toxicology, digital forensics, and DNA analysis, where extra bottlenecks are caused by the intricacy of the investigation and the scarcity of equipment. The increasing sophistication of crimes, which frequently call for several forms of forensic analysis and increase the workload of already overburdened laboratories, further complicates the problem.

Limited Availability of Trained Experts

Another major issue is the lack of skilled forensic specialists. There is a significant shortage of qualified forensic scientists in India. All facets of forensic practice are impacted by this scarcity,

including laboratory analysis, expert testimony in court, and crime scene investigation. Recruitment, retention, and ongoing professional development are some of the many facets of the challenge. Due to issues including poor pay, little prospects for professional progression, and difficult working circumstances, many forensic laboratories find it difficult to draw in and keep talented employees. In specialist sectors needing significant technological expertise, the situation is especially dire. Additionally, the quick development of forensic technologies necessitates ongoing skill and knowledge updates.¹ However, there are frequently little possibilities for specialized training and ongoing professional development, which makes it difficult for forensic professionals to stay up to date with developing forensic techniques and technological advancements.

Policy Recommendations Comprehensive policy interventions at all levels are necessary to address the issues confronting India's forensic science system. The goal of these suggestions is to build a more reliable and effective forensic science infrastructure that can handle the increasing demands of the criminal justice system.

Modernization of forensic infrastructure:

Forensic infrastructure modernization is a top goal for enhancing forensic services in India. To properly satisfy present and future expectations, this modernization must include both technology capabilities and physical infrastructure. Investing in cutting-edge facilities and equipment is crucial for lowering case backlogs and raising the standard of forensic analysis. This entails equipping current labs with cutting-edge analytical tools,² putting in place cutting-edge information management systems and building new, specialized facilities for newly developing forensic specialties. The modernization endeavor should also concentrate on creating regional centers of excellence that can manage complicated cases and operate as forensic practitioners' training institutes. These facilities should have state-of-the-art equipment and be manned by highly skilled professionals capable of conducting complex forensic investigations and analysis.

Introduction of forensic education in legal studies:

A critical first step in enhancing the comprehension and use of forensic evidence in the judicial system is the integration of forensic science education into legal studies curricula. From fundamental forensic awareness courses for law students to specialized training programs for

¹ D. Mittal, a Two-Year Prospective Study from Punjab Region of India. 19(1) *Medico Legal Update* 20-25 (2019).

² M.M. Rohith, W.R. Belcher, et.al., —Tattoo in forensic science: An Indian perspective 74 *Journal of Forensic and Legal Medicine* 102022 (2020).

judges and practicing attorneys, this integration should take place on several levels.

Emerging technologies, forensic evidence interpretation, and basic forensic science concepts should all be included in the curriculum.³ Understanding statistical analysis, the scientific method, and the limitations of different forensic techniques should be given special attention. Legal practitioners would be better equipped to assess forensic evidence and interact with expert witnesses if they had this information.

II. CRIME SCENE INVESTIGATION PRINCIPLES & PROCEDURES

A. Initial Response/Receipt of Information Principle

Preserving the crime scene with the least amount of contamination and disturbance of tangible evidence is one of the most crucial parts of crime scene security. An event must be responded to quickly and methodically. When the police or officers arrive, they will evaluate the location and handle it like a crime scene.

Policy: The first responding officer or officers must approach and enter crime scenes quickly but carefully, keeping an eye out for any people, cars, events, possible evidence, and surrounding circumstances.

Process: The first responding officer or officers ought to: a. Take note of or record dispatch details (e.g., address/location, time, date, kind of call, persons involved). b. Keep an eye out for any people or cars leaving the scene of the incident. c. Take caution when approaching the location, look around to fully evaluate it, and make a note of any potential secondary crime scenes. Keep an eye out for any nearby people and cars that might be connected to the crime. d. Before moving forward, make preliminary observations (look, listen, smell) to evaluate the situation and guarantee officer safety. e. Continue to be vigilant and focused. Until it is proven differently, assume the crime is still going on. f. Until the site is evaluated and found to be different, treat it as a crime scene.

In summary, it is critical that the first responding officer or officer's approach, enter, and leave a crime scene with caution.

The principle of safety procedures

The main responsibility of the first responding officer or officers is the safety and physical well-being of officers and other people in and around the crime scene.

Policy: Any hazardous conditions or individuals must be identified and controlled by the first

³ R. Gupta, —Hookah/Sheesha Water Pipes Smoking: Why it should be Completely Prohibited? | 9EC Pulmonology and Respiratory Medicine 112-114 (2020).

responding officer or officers that arrive at the area.

Procedure: The first responding officer or officers should: a. Verify that no other responders are in imminent danger by scanning the area for sights, sounds, and odors that could endanger staff (e.g., hazardous materials such as gasoline, natural gas). In the event that a covert drug laboratory is involved, biological weapons⁴, regarding chemical or radioactive hazards, the relevant staff or agency should be notified before arriving on the site. b. Approach the incident in a way that maximizes the safety of victims, witnesses, and other nearby parties while lowering the possibility of injury to the officer or officers. b. Examine the area for potentially hazardous individuals and maintain control. d. Call for support or backup and notify supervisory staff.

In summary, officers' and other people's safety will be guaranteed by the management of physical threats.

B. Emergency Care Principle

The first responding officer or officers' next duty is to make sure that injured people receive medical assistance while minimizing contamination of the scene after handling any risky circumstances or individuals.

Policy: The first responding officer or officers are responsible for ensuring that medical care is administered with the least amount of scene contamination. Process: The first responding officer or officers ought to:

- a. Assess the victim(s) for signs of life and medical needs and provide immediate medical attention.
- b. Call for medical personnel.
- c. Guide medical personnel to the victim to minimize contamination/alteration of the crime scene.
- d. Point out potential physical evidence to medical personnel, instruct them to minimize contact with such evidence (e.g., ensure that medical personnel preserve all clothing and personal effects without cutting through bullet holes, knife tears), and document movement of persons or items by medical personnel.
- e. Instruct medical personnel not to “clean up” the scene and to avoid removal or alteration of items originating from the scene.

⁴ V. Venkatraman and D. Rajendran, —Why Woman Want Vote?: Writings of Sri Dharma on Woman's Suffrage in Madras Presidency, 1922–1936| SSRN Electronic Journal (2021).

- f. If medical personnel arrived first, obtain the name, unit, and telephone number of attending personnel, and the name and location of the medical facility where the victim is to be taken.
- g. If there is a chance the victim may die, attempt to obtain “dying declaration.”
- h. Document any statements/comments made by victims, suspects, or witnesses at the scene.
- i. If the victim or suspect is transported to a medical facility, send a law enforcement official with the victim or suspect to document any comments made and preserve evidence. (If no officers are available to accompany the victim/suspect, stay at the scene and request medical personnel to preserve evidence and document any comments made by the victim or suspect.)

Summary: Assisting, guiding, and instructing medical personnel during the care and removal of injured persons will diminish the risk of contamination and loss of evidence.

C. Secure and Control Persons at the Scene Principle

One of the primary responsibilities of the first responding officer or officers is to control, identify, and remove people from the crime scene, as well as to restrict the amount of people who enter the site and their movement. Policy: The first responding officer or officers are responsible for identifying individuals at the crime scene and managing their movements.

Process: The first responding officer or officers ought to:

- a. Control all individuals at the scene—prevent individuals from altering/destroying physical evidence by restricting movement, location, and activity while ensuring and maintaining safety at the scene.
- b. Identify all individuals at the scene, such as:
 - Suspects: Secure and separate.
 - Witnesses: Secure and separate.
 - Bystanders: Determine whether witness, if so treat as above, if not, remove from the scene.
 - Victims/family/friends: Control while showing compassion.
 - Medical and other assisting personnel.
- c. Exclude unauthorized and nonessential personnel from the scene (e.g., law enforcement officials not working the case, politicians, and media).

In summary, preserving scene integrity, protecting evidence, and reducing contamination all

depend on restricting the amount of people who enter the crime scene and managing their mobility.

D. Boundaries: Identify, Establish, Protect, and Secure

Principle: One way to secure and safeguard the crime scene or scenes is to define and manage boundaries. The number of crime scenes and their boundaries depend on the type of crime and the location or locations. Boundaries must be set beyond the original extent of the crime scene or scenes, with the idea that they can be made smaller if needed, but they are more difficult to enlarge.

Policy: The initial responding officer(s) at the scene shall conduct an initial assessment to establish and control the crime scene(s) and its boundaries.

Procedure: The initial responding officer(s) should:

- a. Establish boundaries of the scene(s), starting at the focal point and extending outward to include:
 - Where the crime occurred.
 - Potential points and paths of exit and entry of suspects and witnesses.
 - Places where the victim/evidence may have been moved (be aware of trace and impression evidence while assessing the scene).
- b. Set up physical barriers (e.g., ropes, cones, crime scene barrier tape, available vehicles, personnel, other equipment)⁵ or use existing boundaries (e.g., doors, walls, gates).
- c. Document the entry/exit of all people entering and leaving the scene, once boundaries have been established.
- d. Control the flow of personnel and animals entering and leaving the scene to maintain integrity of the scene.
- e. Effect measures to preserve/protect evidence that may be lost or compromised (e.g., protect from the elements (rain, snow, wind) and from footsteps, tire tracks, sprinklers).
- f. Document the original location of the victim or objects that you observe being moved.
- g. Consider search and seizure issues to determine the necessity of obtaining consent to search and/or obtaining a search warrant.

Note: Individuals should refrain from smoking, chewing tobacco, using the restroom or phone,

⁵ M. Hopkins, L. Neville, et.al., —Preventing Acid Attacks and Corrosive Substance Crimel, in *Acid Crime* pp. 137-170 (Palgrave Macmillan, Cham, 2021).

eating or drinking, moving any objects, including weapons (unless absolutely necessary for the safety and well-being of those present), adjusting the thermostat or opening windows or doors (maintaining scene as found), touching anything needlessly (noting and documenting any moved items), repositioning moved items, littering, or spitting within the scene's defined boundaries.

In summary, defining limits is essential to maintaining the integrity of evidence.

Section II: Composites and Mug Books 6. Transfer Scene Control and Brief the Investigator or Investigators in Charge: Controlling the crime scene and establishing additional investigation responsibilities are made easier by briefing the investigator or investigators in charge.

Policy: The investigator or investigators in charge of the scene must get a thorough crime scene briefing from the first responding officer or officers on the scene.

Process: The first responding officer or officers ought to:

- a. Give the lead investigator or investigators a briefing.
- b. Help maintain scene control.
- c. Transfer accountability for entry/exit documents.
- d. Stay on the scene until you are released of your duties.

In summary, the next in command's only chance to learn preliminary details about the crime scene before doing further investigation is during the scene briefing.

E. Document actions and observations principle

To preserve information, all actions taken and observations made at the crime scene must be recorded as quickly as feasible.

- a. Policy: All documentation needs to be kept on file forever. Process: The first responding officer or officers should record:
- b. Observations of the crime scene, such as where people and objects are located, as well as how the place looks and feels when you get there.⁶
- c. Conditions upon arrival (e.g., lights on/off; shades up/down, open/closed; doors, windows, open/closed; smells; ice, liquids; movable furniture; weather; temperature; and personal items.)

⁶ M. Khanna and S. Garg, —Narcotic Drugs and Psychotropic Substances Act (Ndps 1985): A Critical Analysis|3 (1) Nimitmai Review Journal 28-32(2020).

- d. Personal information from witnesses, victims, suspects, and any statements or comments made.

Own actions and actions of others.

In summary, the first responding officer or officers at the crime scene are required to capture their observations and actions in a clear, succinct manner. In order to provide information to support investigative considerations, this documentation is essential.

Preliminary Documentation and Evaluation of the Scene

Conduct Scene Assessment Principle:

In summary, the first responding officer or officers at the crime scene are required to capture their observations and actions in a clear, succinct manner. In order to provide information to support investigative considerations, this documentation is essential.

Procedure:

The investigator(s) in charge should:

- a. Converse with the first responder(s) regarding observations/ activities.
- b. Evaluate safety issues that may affect all personnel entering the scene(s) (e.g., blood borne pathogens, hazards).⁷
- c. Evaluate search and seizure issues to determine the necessity of obtaining consent to search and/or obtaining a search warrant.
- d. Evaluate and establish a path of entry/exit to the scene to be utilized by authorized personnel.
- e. Evaluate initial scene boundaries.
- f. Determine the number/size of scene(s) and prioritize.
- g. Establish a secure area within close proximity to the scene(s) for the purpose of consultation and equipment staging.
- h. If multiple scenes exist, establish and maintain communication with personnel at those locations.
- i. Establish a secure area for temporary evidence storage in accordance with rules of evidence/chain of custody.

⁷ S. Sharma, K.Kumar, et.al., —An Overview on Narcotic Drugs and Psychotropic Substances Act, 1985|4 (3) Journal of Forensic Sciences & Criminal Investigation555644 (2017).

- j. Determine and request additional investigative resources as required (e.g., personnel/specialized units, legal consultation/ prosecutors, equipment).
- k. Ensure continued scene integrity (e.g., document entry/exit of authorized personnel, prevent unauthorized access to the scene).
- l. Ensure that witnesses to the incident are identified and separated (e.g., obtain valid ID).
- m. Ensure the surrounding area is canvassed and the results are documented.
- n. Ensure preliminary documentation /photography of the scene, injured persons, and vehicles.

Summary:

The creation of a plan for the coordinated identification, gathering, and preservation of tangible evidence as well as the identification of witnesses is made possible by scene assessment. It also makes it possible for law enforcement officials to share information and create investigative plans.

F. Scene "Walk-Through" and First Documentation Principle:

The scene "walk-through" guarantees the preservation of tangible evidence, gives a comprehensive overview of the entire scene, and detects any threats to scene integrity. Documentation, both written and visual, creates a permanent record.

Policy:

The responsible investigator or investigators will walk through the scene. The people in charge of processing the scene will participate in the walk-through.

Procedure:

During the scene walk-through, the investigator(s) in charge should:

- a. Avoid contaminating the scene by use the designated entrance route.
- b. Create an initial record of the scene as it was witnessed.
- c. Recognize and safeguard perishable or fragile evidence (e.g., take into account crowds, hostile environments, and weather conditions).

Make sure that any potentially corrupted evidence is promptly recorded, captured on camera, and gathered.

An overview of the entire scene is given to the responsible investigator or investigators by

conducting a scene walk-through. The walk-through offers the first chance to find important and/or delicate evidence and decide on preliminary investigative steps, allowing for a methodical inspection and recording of the scene.

Documentation, both written and photographic, creates a permanent record of the scene's state as it was initially witnessed.

G. Processing the scene

Determine Team Composition Principle:

The investigator or investigators in charge will decide the team composition based on the nature of the incident and the intricacy of the scene. Scene processing will be carried out by trained staff.

Policy: The responsible investigator or investigators will evaluate the scene to decide whether specialized resources are needed.

Procedure: After the walkthrough, the responsible investigator or investigators should:

- a. Assess the need for additional personnel. Be aware of the need for additional personnel in cases of multiple scenes, multiple victims, numerous witnesses, or other circumstances.
- b. Assess forensic needs and call forensic specialists to the scene for expertise and/or equipment.
- c. Ensure that scene security and the entry/exit documentation are continued.
- d. Select qualified person(s) to perform specialized tasks (e.g., photography, sketch, latent prints, and evidence collection).
- e. Document team members and assignments.

Summary: The scene(s) assessment determines the number of personnel and how responsibilities will be assigned.

H. Contamination control principle

Maintaining staff safety and the integrity of evidence requires contamination management and avoiding cross-contamination at one or more scenes.

Policy: To guarantee scene safety and evidence integrity, the investigator or investigators in charge must mandate that all staff adhere to protocols. Procedure: Other responders and/or team members should:

- a. Limit scene access to people directly involved in scene processing.

- b. Follow established entry/exit routes at the scene.
- c. Identify first responders and consider collection of elimination samples.
- d. Designate secure area for trash and equipment.
- e. Use personal protective equipment (PPE) to prevent contamination of personnel and to minimize scene contamination.
- f. Clean/sanitize or dispose of tools/equipment and personal protective equipment between evidence collections and/or scenes.
- g. Utilize single-use equipment when performing direct collection of biological samples.⁸

Summary: Minimize contamination by being safe, clean, and careful to ensure the welfare of personnel and the integrity of the evidence.

I. Documentation

Principle:

The type of documentation that is required is determined by an evaluation of the scenario (e.g., photographs, video, sketches, measurements, notes). 25 Policy: The responsible investigator or investigators are responsible for making sure the scene is documented.

Method: The team member or members ought to:

- a. Review assessment of the scene to determine the type of documentation needed.
- b. Coordinate photographs, video, sketches, measurements, and notes.
- c. Photograph:
 - Scene utilizing overall, medium, and close-up coverage.
 - Evidence to be collected with and without measurement scale and/or evidence identifiers.
 - Victims, suspects, witnesses, crowd, and vehicles.
 - Additional perspectives (e.g., aerial photographs, witness' view, area under body once body is removed).
- d. Videotape as optional supplement to photos.
- e. Prepare preliminary sketch (es) and measure:
 - Immediate area of the scene, noting case identifiers and indicating north on the sketch.

⁸ A. A. Kumar, (2018). The Narcotics Drugs and Psychotropic Substances Act, 1985.

- Relative location of items of evidence and correlate evidence items with evidence records.
 - Evidence prior to movement.
 - Rooms, furniture, or other objects.
 - Distance to adjacent buildings or other landmarks.
- f. Generate notes at the scene:⁹
- Documenting location of the scene, time of arrival, and time of departure.
 - Describing the scene as it appears.
 - Recording transient evidence (e.g., smells, sounds, sights) and conditions (e.g., temperature, weather).
 - Documenting circumstances that require departures from usual procedures.

In summary, a thoroughly recorded scene guarantees the integrity of the inquiry and offers a permanent record for assessment at a later time.

J. Prioritize collection of evidence principle:

Make gathering evidence a top priority in order to avoid contamination, loss, or destruction.

Policy: The order in which evidence is gathered will be decided by the team members and the lead investigator or investigators.

Procedure:

The team member or members ought to:

- a. Carefully and methodically assess all potential physical evidence (such as biological fluids, latent prints, and trace evidence).
- b. Before moving on to out-of-sight areas, concentrate on the conveniently accessible parts in open view.
- c. Depending on the size and location of the scene or scenes, choose a methodical search methodology for gathering evidence.
- d. Choose a series of processing and collection procedures so that the methods used at the beginning do not affect the methods used at the end.

⁹ D. B. Thorat, —A Review on Role of Pharmacist in Current Healthcare Scenario||11 (4) Asian Journal of Pharmaceutical Analysis 281-284 (2021).

- Start with the most ephemeral types of tangible evidence and work your way down to the least ephemeral ones.
 - Switch from the least intrusive to the most intrusive methods of collection and processing.
- e. Continue to evaluate environmental and other variables that could impact the evidence.
 - f. Be aware of multiple scenes (e.g., victims, suspects, vehicles, locations).
 - g. Identify alternative techniques that can be used to find, technically record, and gather evidence (e.g., alternate light source, enhancement, blood pattern recording, and projectile trajectory analysis).

In summary, prioritization ensures that evidence is collected and preserved in a timely and systematic manner.

K. Collect, preserve, inventory, package, transport, and submit evidence principle:

One of the most crucial aspects of the inquiry is how physical evidence is handled.

Policy: The team member or members are responsible for ensuring that evidence is collected, preserved, packaged, and transported in an efficient manner. Method: The team member or members ought to:

- a. Until the scene is released, keep it secure during processing.
- b. Keep track of the evidence's location at the scene, the date it was collected, and the person who took it.
- c. Gather every item that has been designated as proof.
- d. Create a chain of custody.
- e. Collect reference or standard samples from the scene.
- f. Acquire samples for control.
- g. Take into account acquiring elimination samples.
- h. Quickly remove electronically recorded evidence from the area, such as answering machine tapes, surveillance camera videotapes, and computers.
- i. Locate and protect evidence in containers at the crime site (e.g., label, date, initial container). Different containers are needed for different kinds of evidence (e.g., porous, nonporous, crushproof).
- j. Pack goods to prevent cross-infection and contamination.

- k. Before making firearms and weapons suitable for submission and transportation, record their condition.
- l. After gathering evidence, do not handle it excessively.
- m. Preserve evidence at the scene in a way that minimizes loss or deterioration.
- n. Move and turn in evidence items for safekeeping.

Summary: When documenting, gathering, preserving, or packing evidence at crime scenes, care should be taken to maintain the integrity of the scene and prevent contamination or harmful alteration. Evidence should be properly packaged, tagged, and kept in a safe, temporary location until it is finally packaged and sent to a crime lab or a guarded evidence storage facility.

L. Completing and recording the crime scene investigation:

Establish the principle of the crime scene debriefing team:

Before releasing the site, law enforcement officers and other responders can exchange information about specific scene discoveries through the crime scene debriefing. It offers a chance to provide feedback on unique requests for help, post-scene obligations, and follow-up investigations.

Policy:

To make sure the crime scene investigation is finished and to confirm post-scene obligations, law enforcement officers and other responders must take part in or start a crime scene debriefing¹⁰.

Procedure:

A crime scene debriefing team should be formed by the investigator or investigators in charge of the crime scene. Law enforcement officers and other responders who take part in a scene debriefing should:

- a. Form a crime scene debriefing team that consists of the investigator or investigators in charge of the crime scene, additional investigators, and personnel who collect evidence (e.g., photographers, evidence technicians, latent print personnel, specialized personnel, and initial responding officer or officers, if still present).
- b. Identify the evidence that was gathered.
- c. Talk to team members on the initial scene findings.

¹⁰ L. Voora, S. K. Sah, et.al., —Doctor of pharmacy: boon for the healthcare system||14 (1) Drug invention today 153-158 (2020).

- d. Talk about possible technical forensic testing and the order in which it should be carried out.
- e. Start the action or actions mentioned in the conversation that are necessary to finish the crime scene investigation.
- f. Inform the person or people in charge when the designated crime scene tasks are finished.
- g. Assign law enforcement officers and other responder's post-scene duties.

The best chance for law enforcement officers and other responders to make sure the crime scene investigation is finished is during the crime scene debriefing.

M. Perform final survey of the crime scene principle:

A last examination of the crime scene guarantees that the scene has been processed and evidence has been gathered before it is released. A thorough examination of the scene also guarantees that any hazardous items or circumstances have been reported and dealt with, and that no evidence, tools, or materials produced by the investigation are accidentally left behind.

Policy¹¹: At the end of the scene investigation, the lead investigator or investigators will do a walkthrough to make sure the investigation is finished. Procedure: The lead investigator or investigators should make sure that:

- a. Every place designated as a crime scene is examined visually.
- b. Every piece of evidence gathered at the spot has been recorded.
- c. All tools and supplies used in the investigation are taken out.
- d. Any hazardous circumstances or items are notified and dealt with.
- e. In compliance with jurisdictional regulations, the crime scene is released.

In summary, doing a scene walk-through guarantee that all evidence has been gathered, that no materials have been unintentionally left behind, and that any hazardous materials or circumstances have been notified and dealt with.

N. Documentation of the crime scene principle:

The investigator or investigators in charge of the crime scene must assemble reports and other documents related to the inquiry into a "case file." The activities performed and the evidence gathered at the scene will be documented in this file. The job completed will be able to be independently reviewed thanks to this documentation.

¹¹ Subhash C. Mandal (ed.), *Drug Information Bulletin* (Indian Pharmaceutical Association, 2018).

Policy: The responsible investigator or investigators are responsible for compiling reports and other documents related to the crime scene investigation.¹²

Procedure: For the crime scene case file, the responsible investigator or investigators should acquire the following:

- a. Documentation from the first responding officer or officers.
- b. Documents for emergency medical professionals.
- c. Documentation for entry and departure.
- d. Pictures and videos.
- e. Diagrams and sketches of crime scenes.
- f. Documentation of evidence.
- g. Documentation from other responders.
- h. The consent form or search warrant record.
- h. When reports, including technical and forensic reports, become available, they should be put to this file.

Note: Only crime scene documentation is included in the above list. This is by no means an exhaustive list of all the documents that are part of an investigative case file.

In summary, this will guarantee that the investigator or investigators in charge of the crime scene collect reports and other documentation related to the inquiry into a case file, allowing for an impartial evaluation of the job done.

III. CRIME SCENE EQUIPMENT:

Initial Responding Officer(s)

Consent/search forms are essential. Barricade tape at crime scenes. First aid package. Flashes. A flashlight and additional batteries. Paper sacks. PPE, or personal protective equipment these supplies have to be in police cars or easily accessible to the first responding officer or officers.

Audiotape recorder optional. Camera with extra film and a flash. Paint. A compass or direction marker. Cleaning agent. A map. Plastic purses. A pocket blade. Vest with reflection. Measuring tape. Tarps to shield evidence from inclement weather. Cones of traffic. Waterless hand wash (germicide-treated towel). Wireless telephone.

¹² C. J. Landmark and U. Brandl, —Pharmacology and drug interactions of cannabinoids‖ 22 *Epileptic Disorders* S16-S22 (2020).

Crime Scene Investigator/Evidence Technician

* Bindle paper is essential. Sacks for biohazards. Collecting set for bodily fluids. 35 mm camera with film, flash, and tripod. Materials for casting.

Identifiers of evidence. Evidence tape or sealing. First aid supplies. Additional batteries and a flashlight. Bright lights. Latent print kit. Magnifying glass. Measuring tools. Marks that are permanent. Crucial:

Bindle paper. Sacks for biohazards. Collecting set for bodily fluids. 35 mm camera with film, flash, and tripod. Materials for casting.

Consent/search forms are essential. Barricade tape for crime scenes. First aid supplies. Flashlight, flares, and additional batteries. Paper bags.

PPE, or personal protective equipment, should be kept in police cars or easily accessible to the first responding officer or officers. Audiotape recorder is optional. Camera with additional film and a flash. Chalk. Directional compass or marker.¹³ Disinfectant. Maps. Plastic containers. Knife in the pocket. Reflective jacket. Use a tape measure. Tarps to shield evidence from the elements. Cones for traffic. Waterless hand wash (germicide-infused towel). Phone that is wireless. Search and consent forms. Barricade tape for crime scenes. Knives, box cutters, scalpels, and scissors are examples of cutting tools. Directional compass or marker. Disinfectant. Receptacles for gathering evidence. PPE stands for personal protection equipment. Scale for photography (ruler). Presumptive materials for blood tests. Sketch paper. Toolbox.

Forceps and tweezers should be kept in police cars or easily accessible to the first responding officer or officers.

IV. ADVISORIES

- **Forensic Medicine and Autopsy Reports:**

As scientific links between medical discoveries and legal proceedings, forensic medicine and autopsy reports are essential components of the criminal justice system. The legislative framework governing forensic medicine, the importance of autopsy reports in criminal investigations, and significant cases that have influenced how medical evidence is interpreted and applied in Indian courts are all covered in this chapter.

¹³ E. Perucca, —Antiepileptic drugs: evolution of our knowledge and changes in drug trials|21 (4) Epileptic Disorders 319-329(2019).

- **Legal Provisions**

As scientific links between medical discoveries and legal proceedings, forensic medicine and autopsy reports are essential components of the criminal justice system. The legislative framework governing forensic medicine, the importance of autopsy reports in criminal investigations, and significant cases that have influenced how medical evidence is interpreted and applied in Indian courts are all covered in this chapter.

- **Inquest Procedures under Section 174 CrPC**

The basic foundation for holding inquests into situations of suspicious or unnatural deaths is established in Section 174 of the Code of Criminal Procedure. This clause requires particular protocols for performing post-mortem examinations and gives police officials the authority to look into such deaths. The condition of the deceased, the apparent cause of death, and any marks or injuries seen on the corpse must all be thoroughly documented in this section. Additionally, the clause highlights how crucial it is to preserve any evidence that could indicate the actual cause of death, making it crucial for both legal and investigative purposes.¹⁴

The section also outlines the situations in which an inquiry is required, such as fatalities that occur while a person is in jail, deaths that result from suicide, deaths that occur under suspicious circumstances, and deaths that may be the consequence of criminal activity. These protocols guarantee the methodical recording and examination of fatalities that can have legal ramifications, serving as the foundation for ensuing criminal investigations.

- **Authority to Summon Medical Professionals:**

In order to supplement the inquest proceedings, Section 175 CrPC gives investigative officials the power to call in medical experts. This clause gives authorities the authority to guarantee a thorough medical examination of the deceased and acknowledges the crucial role that medical knowledge plays in death investigations. In order to ensure that certified experts perform the required examinations and offer professional opinions, the section lays out the legal foundation for collaboration between law enforcement and medical professionals.

- **Medical Evidence in Courts**

Both scientific correctness and legal criteria must be carefully considered when presenting and interpreting medical evidence in court. The many facets of medical evidence and their importance in court cases are examined in this section.

¹⁴ K. Wailoo, —The FDA ‘s proposed ban on menthol cigarettes|380 The New England Journal of Medicine 995-997(2019).

- **Use of Postmortem Reports in Homicide Cases**

In homicide investigations and the trials that follow, postmortem reports are the main source of scientific evidence. In order to determine the circumstances surrounding a death, these reports offer thorough documentation of injuries, the cause of death, and other pertinent medical findings. In order to comprehend the type of injuries, the events leading up to death, and the potential weapons or techniques employed, courts mostly rely on these reports.

Postmortem reports are important for many reasons than only determining the cause of death. These records frequently include important chronological details, support or contradict witness accounts, and aid in piecing together the circumstances surrounding a death. Courts take into account a number of factors in these reports, such as the type and severity of injuries, the timing of death, and any indications of resistance or fight.

Importance of Medico-Legal Certificates

Another essential piece of medical evidence in court is medico-legal certificates. Regarding injuries, assault cases, and other situations requiring medical scrutiny, these publications offer expert medical opinions. The certificates must uphold medical objectivity and accuracy while adhering to certain regulatory standards. These certificates are used in court for a number of reasons, such as proving the extent of injuries, recording the type of assault, and offering professional medical views on causality.¹⁵ These certificates are used by courts to evaluate the seriousness of crimes and choose the proper course of action. It is impossible to overestimate the significance of accurate documentation and following established procedures while creating these certifications.

V. RELEVANT CASES

The interpretation and use of medical evidence in Indian courts have been greatly impacted by landmark court rulings. In terms of the weight assigned to medical evidence and the requirements for its adoption in court, these cases set significant precedents.

- **Rathinam v. State of Tamil Nadu (1997)**

Regarding the significance of expert medical opinion in interpreting autopsy findings, the Rathinam case is a noteworthy precedent. The Supreme Court underlined the importance of expert medical testimony in providing the court with an explanation of complex medical findings. The case highlighted that although expert medical judgments should be given the

¹⁵ P. Das, M. D. Delost, et.al., —A survey of the structures of US FDA-approved combination drugs|62 (9) Journal of medicinal chemistry4265-4311(2018).

proper weight, courts must also take other facts into account. The ruling emphasized a number of crucial ideas about medical evidence, such as the need of accurate recording, the necessity of precise and reliable medical views, and the court's function in assessing expert testimony. The case also discussed how important it is to keep medical evidence in the right chain of custody and how autopsies must adhere to established processes.

➤ **K. Chinnaswamy Reddy v. State of Andhra Pradesh (1962)**

In addition to addressing the validity of medical evidence, this seminal case set crucial guidelines for evaluating it in court. The Supreme Court stressed that the scientific value of medical data and the reliability of the expert offering the opinion should be taken into consideration. The case demonstrated that, although while medical evidence is important, it must, whenever possible, be supported by further evidence. The ruling also addressed the significance of timing while doing medical exams and writing reports, stressing that delays may compromise the validity of results.

The court set rules for assessing medical evidence, such as the necessity of taking into account the credentials and expertise of medical professionals, the thoroughness of their examination, and the scientific foundation for their judgments. As medical research and forensic procedures grow, so does the role of autopsy reports and forensic medicine in the Indian legal system. The legislative framework, which is backed by court rulings, guarantees that medical evidence upholds scientific integrity while fulfilling its primary function of promoting justice.

Both scientific correctness and legal criteria must be carefully considered when medical professionals interface with the legal system. Medical experts, attorneys, and law enforcement officers involved in medico-legal matters must comprehend certain legislative provisions, procedural requirements, and landmark cases. Following established standards and procedures is essential since the success of criminal investigations and prosecutions frequently rests on the appropriate gathering, recording, and presentation of medical evidence.

The legal system must change to accommodate new methods and approaches while upholding the core values of justice and a fair trial as forensic medicine develops. Medical evidence will always be a trustworthy instrument in the fight for justice because of the careful balancing act between scientific progress and legal needs.¹⁶

¹⁶K. Chinnaswamy Reddy v. State of Andhra Pradesh (1962), as forensic medicine continues to advance, the legal framework must adapt to incorporate new techniques and methodologies while maintaining the fundamental principles of justice and fair trial.

VI. RECENT ADVANCEMENT AND THEIR TECHNIQUES

DNA Typing Techniques:

Tests for DNA typing are used to identify variations in DNA samples taken from different individuals, including blood, saliva, and other bodily fluids. The procedure begins with a sample of a person's DNA (usually referred to as a "reference sample"). If a buccal swab is necessary, additional techniques for collecting a sample of blood, saliva, reproductive cells, or other pertinent fluid or tissue from intimate objects like toothbrushes, razors, and so forth may be needed¹⁷ is not available, such as if a court order is required and not available.

DNA typing is one of the most important developments in the field of forensic sciences in recent years. DNA typing is a technique used by forensic scientists to help identify individuals based on their DNA profiles. The same process is referred to as DNA testing, genetic fingerprinting, and DNA profiling.¹⁸ This technology was first developed by Dr. Alec Jeffrey of the University of Leicester in the United Kingdom. He used it to solve two murders in Leicestershire. In 1987, Imperial Chemical Industries established a blood-testing laboratory in the UK, making his technology chemically accessible.¹⁹ A technique for analyzing DNA extracted from a biological sample taken from a single individual is called DNA typing. A DNA profile is created by processing each person's DNA to produce a distinct pattern. Every individual has a distinct profile, with the exception of identical twins.

Alternatively, preserved resources like biopsy tissue or sperm may be utilized. A person's profile can be inferred from profiled human remains and samples taken from blood relatives. After that, a reference sample is assessed using a number of techniques to create a person's DNA profile. The many methods include the following:

- Restriction Fragment Length Polymorphism (RFLP): This is the most conventional technique that uses examiner comparison and radioactive fragmentation.
- Polymerase Chain Reaction (PCR): Rather than cloning tiny or fragmented amounts of DNA, PCR measures match probability using a computer or operator.
- Small Tandem Repeats (STR) – A method for detecting short, repeating parts of micro variant allele²⁰ patterns as short as 3-7 base pairs using computer expert systems and

¹⁷ Buccal swab is a way to collect DNA from the cells on the inside of the person's cheek.

¹⁸ William C. Thompson, DNA in a Courtroom, (2003), <http://www.bioforensics.com/articles/Chapter11.pdf>

¹⁹ *ibid*

²⁰ A recognisable physical position on a chromosome (for example, a restriction cutting site or a gene) that can be tracked in terms of inheritance.

- markers, but optical detection is also possible.²¹
- Mitochondrial DNA Analysis This is a type of PCR used on samples exposed to harsh environmental conditions, and because mitochondrial DNA is only passed down through the mother, it's been employed in maternity cases.
- Rapid DNA ID Microchip-Based Genetic Detectors – These are portable laptop analysis devices that may be used at crime scenes to show profiles and upload data to the CODIS²² database. ²³The method uses the same microchips that are used to diagnose genetic illnesses, but they have been modified to transport, concentrate, and hybridize DNA,²⁴ as well as to distinguish between specific genetic disorders.²⁵

Polymerase Chain Reaction techniques are a more sophisticated technology, but restriction is the most used method for performing fragment length polymorphism analysis, a type of DNA profiling that has been the focus of the most litigation to date.

RESTRICTION FRAGMENT LENGTH POLYMORPHISM TECHNIQUE:

The following steps are part of the time-consuming DNA profiling method:

1. DNA extraction and purification from biological materials such as urine, saliva, and blood.
2. Restriction enzymes are used to break apart pure DNA. Think about the GCGC pattern that appears multiple times in DNA. The frequency of occurrence varies from person to person. Every time the GCGC pattern appears, the restriction enzyme splits the DNA in half. In this instance, Person 2 does the procedure twice, whereas Person 1 repeats it three times. Between the first G and the first C, the restriction enzyme will make a cut. Consequently, person 2 has a single large fragment and person 1 has two small fragments, CGCATGTT and CGCAAGAG.

²¹ It is an alternative form of a gene for a character producing different effect

²² CODIS is for Combined DNA Index System, and it refers to the FBI's programme of support for criminal justice DNA databases or the software that runs them. CODIS is for Combined DNA Index System, and it refers to the FBI's programme of support for criminal justice DNA databases or the software that runs them.

²³ Alleles of genes, or DNA polymorphisms, are used as experimental probes to track individuals, tissues, cells, nuclei, chromosomes, and genes. In other words, any character that serves as a marker or signal in a population member for the presence or location of a gene or hereditary characteristic. Markers are changes in four chromosomes that are passed down from generation to generation.

²⁴ A disorder which may or may not be apparent at birth, which is a consequence of a mutation present in one or more patient's gene.

²⁵ *ibid*

3. An Agarose gel is used to separate the limited pieces based on size. Proteins are separated using the electrophoresis process. The particles are divided into lanes and exposed to an electric current on an electrophoresis gel surface.
4. The DNA samples are then separated into distinct bands by the fragments' subsequent migration toward the positive electrode, with smaller fragments moving more quickly than larger fragments (southern blotting transfer of separated fragments to nylon membrane).²⁶. This method keeps the DNA fragments on the membrane and secures them.
5. The hybridization procedure involves introducing a radioactively tagged probe, a kind of DNA molecule that sticks to the base sequence that corresponds to the membrane.

The radioactivity of the probe²⁷ related fragments can then be recorded using an X-ray plate. Autoradiography is the term for this procedure. Dark bars that mimic bar codes will show up on the X-ray plate.²⁷

TECHNIQUE FOR POLYMERASE CHAIN REACTION:

A more modern method of DNA profiling has been developed and is strongly advised when DNA is inadequate for analysis or has deteriorated. The sample is heated in a chemical solution to extract the DNA, which is then combined with additional reagents and short segments of known DNA known as primer to start replication using the polymerase chain reaction.

The steps involved are as follows:

- A. Test tube containing DNA is filled with a little amount of a balanced solution that includes DNA polymerase, oligonucleotide primers, four deoxynucleotide DNA building blocks, and the cofactor MgCl₂.
- B. Several replication cycles are applied to the mixture, including the following:
 1. At 94–96 degrees Celsius, denatured DNA transforms 91 strands into single strands in one to several minutes.²⁸
 2. Primers create hydrogen bonds with their complementary sequences on either side of the target sequence after one to several minutes at 50 to 65 degrees Celsius.

²⁶ A technique named after Professor Ed Southern in which, after electrophoresis in agarose gels; DNA is transferred to membrane where it can be analysed by hybridization with a probe

²⁷ A short segment of synthetic tagged DNA used to detect a specific DNA fragment or sequence

²⁸ In Forensic DNA, separating double-stranded DNA into two complementary single strands by heat or chemical methods is a crucial task.

3. At 72 degrees Celsius, polymerase binds and stretches a complementary DNA strand from each primer for one to several minutes.
4. With each round of amplification,²⁹ the DNA sequence between the primers doubles.³⁰
5. After 30 cycles, the potential amplification factor is close to one billion.

SCIENTIFIC SUSPECT INTERROGATION MODELS RECENTLY DEVELOPED:

The police use interrogation to get information from a suspect, witness, or victim following a crime. Torture, the use of mind-altering drugs like Narco-analysis, and the use of expert techniques like brain mapping and polygraphs to probe the subconscious are all examples of interrogation.

Narco-Analysis

Narco-analysis is a medical examination and psychotherapy technique that uses psychotropic medicines, usually barbiturates, to induce a state of unconsciousness when the therapist can take advantage of the emergence of mental components with strong accompanying emotions. Horseley coined the term "narco-analysis."³¹ In 1922, a Texas obstetrician named Robert House gave scopolamine to two prisoners for the first time, popularizing this method. Since then, the majority of democratic governments—including those in the US and the UK—have essentially given up on drug testing. Hypnosis and truth serums are not really novel ideas.³² It describes the practice of lowering a person's inhibitions so they may perform tasks that would otherwise be challenging by using painkillers or other pharmacological substances, most frequently pentothal sodium (thiopentone sodium).

In order to generate a hypnotic state and lessen inhibition, a hypnotic medication is injected into the patient's veins during this test. The drug-induced hypnotic phase is advantageous to investigators since it motivates the subject to divulge information. The medication utilized in this test is sodium pentothal, which is frequently used to induce general anesthesia during

²⁹ Making several identical copies (replicates) of a DNA sequence is referred to as amplification. This can be done in a variety of ways, including cell cloning, in which host cells (which have been altered with a vector to include a DNA insert of interest) are allowed to divide and the insert is duplicated as well.

³⁰ A primer is a nucleic acid strand that acts as a starting point for the production of DNA. Because the enzymes that catalyze DNA replication, DNA polymerases, can only add new nucleotides to an existing strand of DNA, it is required. At the 3' end of the primer, the polymerase begins replication and replicates the opposing strand. The primer for DNA synthesis and replication in most situations of natural DNA replication is a short strand of RNA (which can be made de novo). DNA primers are required for several biochemistry and molecular biology laboratory techniques that use DNA polymerase, such as DNA sequencing and the polymerase chain reaction (PCR). Short, chemically produced oligonucleotides with a length of roughly twenty bases are used as primers

³¹ Selvi v. State of Karnataka AIR 2010 SC 1974.

³² *ibid*

surgical procedures. This medication is also utilized in psychiatry because the disclosures can help diagnose mental health issues.

Technique:

- In a controlled laboratory environment, the suspect or witness is administered barbiturates such sodium amytal (amylobarbitone) or pentothal sodium.
- The individual's age, gender, health, and physical state all affect the dosage.
- A person under hypnosis cannot speak on his own, but he can respond to basic questions if certain suggestions are made.

An Examination of Polygraph:

Blood pressure, pulse, respiration, breathing patterns, body temperature, and skin conductivity are among the physiological reactions that the polygraph records and monitors as the subject is asked and responds to a series of questions.³³ During questioning, the polygraph detects physiological changes caused by the sympathetic nervous system.

Lombroso, a criminologist, experimented with a gadget that took pulse and blood pressure readings to gauge the sincerity of those accused of crimes. This device was called a hydrosphygmograph. William Marston, a psychologist, employed a similar method in espionage cases during World War I, which before its application in the CJS. In 1939, Leonard Keeler added an amplifier and electro dermal to the polygraph machine's settings, which John Larson had added in 1921. The idea behind polygraph testing is that when someone lies in response to a question, their body reacts differently than it would naturally.

False denials and physiological reactions were observed during the polygraph. These answers are contrasted with those generated by the appropriate questions. In theory, a real subject should react physiologically more strongly to the control questions that they voluntarily and fraudulently responded than to the important questions that they can quickly and properly respond to. A range of tools for tracking and recording physiological reactions are given to the test subject. The examiner next reviews the findings, evaluates them, and determines the veracity of the subject's answers. Instruments including cardiographs, pneumographs, cardio-cuffs, and sensitive electrodes are used in polygraph exams. Among other things, they monitor breathing, blood pressure, blood flow, pulse, and galvanic skin resistance. The topic's sincerity or dishonesty is established.

³³ A recognisable physical position on a chromosome (for example, a restriction cutting site or a gene) that can be tracked in terms of inheritance.

Working Procedure

There are two kinds of instrumentation: digital and analog. Many nations encourage the use of digital equipment. The three most common polygraph examination techniques are the relevant-irrelevant (R-I) method, the control question (CQ) technique, and the Directed Lie-Control (DLC) strategy.

Every single one of these approaches includes a pre-test interview in which the subject is informed about the test process and the inspector gathers data to identify the questions that need to be answered. Reducing the likelihood that the subject will be taken aback by an unexpected question is one of the activity's main goals. The most popular method is the control-question (CQ) approach, which is described in CBI's literature along with the scoring system. Both relevant and control questions are included in the test. The purpose of the CQ is to elicit answers; it has nothing to do with the facts being investigated.

A dishonest person would exhibit greater physiological reactions while providing false answers to important questions than when providing incorrect answers to control questions. In other words, lying about significant facts is more crucial to a guilty person than lying about unimportant facts. An innocent person would struggle to answer the control questions poorly, but it would have minimal difficulty answering the important questions properly. The tests are scored based on the positive or negative numerical value assigned to each respondent's response. The total degree of deceit is determined by comparing the result to a standard numerical value once all the numbers have been taken into account. The overall conclusion may reveal dishonesty or the truth.

The Relevant or Irrelevant Test, Control Question Test, and Directed Lie Test are the three most popular polygraph lie detection techniques. They are predicated on the idea that liars will be more agitated when responding to "relevant" questions than "control" questions because they are afraid of being caught lying. This assumption is false because truth-tellers may be more motivated to respond to pertinent questions, particularly those that elicit strong emotions (for example, when an innocent man accused of killing his loving wife is asked questions about her during a polygraph test, the memory of his late wife may reawaken his strong sentiments about her); and when the pertinent questions are provoking ones (for example, when an unarmed victim accused of killing his devoted wife is questioned about his wife). The Guilty Knowledge Test is another common test that is predicated on the idea that examinees who are guilty will be more concerned about particular knowledge because of distinct orienting reactions, i.e., they will have enhanced orienting responses when identifying specific facts.

Brain Mapping

Brain mapping is also known as the 70 Brain Electrical Activation Profile (BEAP) test or the P300 wave test. It is a way to assess someone's character and level of subject-matter expertise. This information was obtained by tracking brain activity triggered by exposure to particular stimuli. Examining and analyzing event-related potentials (ERPs), which are electrical waveforms produced after the brain has processed external input, is the aim of this test. When a patient is exposed to a stimulus in the form of a picture or a concept presented in phrases, an ERP examination is used to uncover certain patterns of electrical brain activity that are indicative of specific mental processing processes. By monitoring cognitive brain activity, the examiner can determine whether the person recognized the stimulus they were exposed to. The P300 wave test enabled further neuroscientific methods, like "Brain Fingerprinting" by Dr. Lawrence Farwell. The latter strategy has already been contested in court and is mostly recognized in the criminal justice system. The Brain Fingerprinting method employed by Indian Forensic Science Laboratories differs greatly from the P300 waves test. According to Dr. Lawrence Farwell, the P300 wave component is a part of a broader reaction that lasts longer than the initial P300 stimulus rather than a single sensory brain side effect. This prolonged response is associated with cognitive processing, which takes place after the P300 wave and between 300 and 800 milliseconds after the stimulus is presented. The extended brain wave 74 component of the memory-and-encoding-related multifaceted electroencephalographic response is known as the MERMER effect (Memory-and-Encoding-Related-Multifaceted EEG Response).³⁴ The electroencephalograph (EEG), which is still frequently used in the medical field today, was developed as a means of monitoring the electrical impulses that the brain was producing during the late 19th century. Extremely simple brain wave patterns that may indicate a range of unrelated brain activity are shown by EEG scans. Only with the development of computers was it feasible to separate individual wave components on an EEG and ascertain the link between the waves and certain stimuli. One of these elements is the P300 wave, which Dr. Samuel Sutton discovered in 1965. The brain generates an event-related brain potential (ERP) when it determines that information about a particular event is significant.

Working Process

The P300 waves test is performed by applying electrodes to the subject's scalp and monitoring the wave components' emission. The test must be conducted in an enclosed, well-ventilated

³⁴ Laboratory Procedure Manual - Polygraph Examination (Directorate of Forensic Science, Ministry of Home Affairs, Government of India, New Delhi - 2005)

space to prevent weather-related anomalies. Similar to narcoanalysis and polygraph examinations, this test requires a close relationship between the investigators and the examiner, particularly when it comes to creating the stimuli, or tests. Determining the probes' familiarity with the subject might help identify dishonesty or obtain relevant information. The test taker is exposed to both irrelevant words and visuals and auditory and visual stimuli (words, sounds, images, and videos) that are connected to the facts being investigated. This category includes two kinds of stimuli: neutral probes and material probes. The basic idea is that when guilty suspects are subjected to material probes, they will generate P300 wave elements, which the apparatus would precisely capture. By examining the records of these wave components, the examiner can make conclusions about the person's awareness of the information pertinent to the crime.³⁵

Because of this, the witness is often asked a range of questions, such as neutral phrases that are directly related to the case, probe words that attempt to uncover information that the accused may have hidden, and target words that include case-related discoveries that the suspect is not aware of. The exam does not need an oral response; the accused is merely required to listen to the words. If the words and the stimuli were correlated, the suspect's brain would release P-300 waves, which would be picked up by sensors. The test results are assessed by an expert, which makes it possible to determine the subjects that the suspect is knowledgeable about. He might then be asked detailed questions on the particular subjects for which he is expected to provide information. Either conventional questioning or a scientific test, such a polygraph or narcoanalysis, may be employed. Therefore, the test findings can be utilized to determine

³⁵ Sections 24 to 30 of the Indian Evidence Act deal with the admissibility of an accused's confession given during the course of a criminal investigation in specific circumstances. Section 24 enacts the universal rule of inadmissibility of involuntary confessions, which is provided by Article 20(3) of the Indian Constitution. In a criminal action, a confession given under circumstances that make it appear to the Court that the confession was prompted by any incentive, threat, or promise from a person in power is irrelevant. The Code of Criminal Procedure forbids police officers from offering such an enticement, threat, or promise. Sections 25 and 26 go beyond the constitutional protections to bar and debar confessions made to a police officer by an accused individual. Sections 25 and 26 go beyond the constitutional safeguard and prohibit confessions made by an accused individual to a police officer or while in police custody to anyone other than a Magistrate from being used as evidence. Then, under Section 27 of the Evidence Act, a confession or any other statement that is deposed to have led to the discovery of some facts is admissible in evidence to the extent that the law allows, to the extent that the actual part of the statement distinctly leading to the discovery is admissible in evidence. Sections 25 and 26 are both qualified by this exception, although Section 24 is not. Sections 28 and 29 provide more or less clarification. A confession made after the removal is admissible under Section 28. A confession given after the erasure of an impression generated by incentive, threat, or promise as described in Section 24 is admissible under Section 28. The mere fact that a confession was made under the promise of secrecy or by deception for the purpose of obtaining it, or when the person making the confession was drunk, or in response to queries to which he was not obligated to respond, does not render it irrelevant under section 24. 98Circulatory depression, respiratory depression with apnoea, and allergy are all side effects of sodium pentothal, the active substance used in most narco analytic examinations. Head soreness, retrograde amnesia, emerging delirium, protracted somnolence, and recovery may be caused by its effects on the Central Nervous System; P. Chandra Sekharan, Untruth Serum, COMBAT LAW, Vol.6 Issue 4, 2007.

whether the accused has or is hiding any important information.

Recent Techniques and Their Impact on the Subject

The terms "witness," "accused," and "suspects" are all used in this context. Interrogation is crucial to any criminal investigation in order to get the truth from the accused and suspect. Since the dawn of time, investigators have employed a range of techniques, most of which relied on torture, to obtain information from suspects and accused. As a result of scientific and technological advancements, sophisticated instruments like the "lie-detection test" have been developed, eliminating the need of "third-degree torture" by law enforcement. The three main scientific interrogation techniques that have lately been identified for obtaining confessions are the Lie Detector or Polygraph test, the P300 or Brain Mapping test, and the Narco Analysis or Truth Serum test.³⁶ These psychoanalytic tests are also utilized to support the investigating officer's findings and look into questionable or criminal behavior.

During a polygraph or Brain-Mapping test, the subject exerts mental capacity, which is followed by physiological reaction. Based on the measures of these responses, the investigators receive the information. A current investigation may benefit from this information, or it may reveal fresh evidence that could be utilized against the test respondent. In any event, the mandatory administration of the challenged exams compromises the subject's right to decide whether or not to take them.

When taken improperly, sodium pentothal's harmful side effects can cause unconsciousness and even death. Any negative consequences of sodium pentothal that could be fatal include anaphylaxis, apnea (breathing difficulties while sleeping), and blood circulation and breathing disorders (an immune system reaction that is quickly growing and potentially deadly). One study claims that it can result in delirium, retrograde amnesia, and a number of other detrimental effects on the central nervous system. Consent requires knowledge of what you're doing. When someone gives their "permission," it's likely that they are totally unaware of the risks.³⁷ It has long been believed that the right to health is an essential component of the right to life. The Kerala High Court ruled in *Rojo George v. Deputy Superintendent of Police* that barbiturates used during narco-analysis had detrimental side effects. The High Court declared it unfeasible since X-rays and CT scans are used to diagnose illnesses even though it is known that they may have unfavorable effects, and patients are given chemicals that are similar to medications despite the fact that they have adverse effects. The Court also cited a report that stated

³⁶ 2006 (2) KLT 197.

³⁷ <https://www.atascientific.com.au/technologies-forensic-sciences/>

pharmaceuticals used in medical therapy were administered in larger doses than those used in scientific research.

During a polygraph test, the patient is urged by feelings such as worry, dread, bewilderment, or concern. Additionally, recorded responses may be impacted by the physical conditions of the polygraph testing chamber. The exam should be given in a comfortable environment with no potential distractions and complete secrecy regarding the specific subject. The subject's mental state is particularly important since a person in a condition of despair or hyperactivity is more likely to have markedly different physiological reactions, which could lead to the examiner being misled. In certain cases, the person may have experienced memory loss between the relevant behavior and the administration of the test. There won't be any awareness of truth or falsehood in oneself if the person doesn't remember the facts. Therefore, documenting bodily consequences will be useless. Errors can also result from memory-hardening, which is the process by which a person creates and solidifies incorrect recollections regarding a particular incident. This is typical when traumatic memories are involved, and the person may not be aware that they are lying.

Investigative examination methods are therefore disregarded since they are not exact. It has been discovered that some persons have made utterly bogus statements. It was also discovered that someone had provided false information after the medication was ordered. When malingerers or unreliable individuals are present, these techniques aren't very helpful, and it can be challenging to suggest the appropriate pill amounts for a particular individual, like in the case of Narco Analysis. The dimensions of the pill will vary according to the subject's physical characteristics, mental disposition, and level of self-control. For these investigative strategies to be effective, a skilled and knowledgeable questioner who is prepared to make late and productive queries is necessary.

Every aspect of our lives is being rapidly impacted by technology, including the investigation of crimes. Rapid technology improvements have given criminal solving a futuristic feel, almost like something from a science fiction novel. To process samples and evidence and solve crimes, forensic equipment is needed in the forensic science process. Evidence analysis, DNA or fingerprint identification, drug or chemical analysis, and handling bodily fluids are all examples of measurements. Importantly, the interaction of science and technology allows forensic scientists to perform much of their work. To process evidence, a range of technologies are integrated with biology, chemistry, and mathematics. The majority of individuals are unaware

of the various technologies utilized in FS.³⁸

VII. RECENT ADVANCES IN FORENSIC SCIENCE AND THEIR TECHNIQUES

1. Phenom Desktop SEM:

The Phenom SEM is the greatest tool for forensic scientists since it offers a quick, high-quality, and user-friendly imaging tool together with the ability to determine elemental composition. This makes it possible for scientists to analyze evidence more quickly and accurately, which can aid in the conclusion of criminal cases. Criminal labs may utilize the Phenom GSR Desktop SEM specifically to search for gunshot evidence particles. It is completely automated, has integrated hardware and software, and is incredibly easy to use. The Phenom GSR Desktop SEM is a system that combines the Phenom XL desktop SEM with element recognition and automated GSR analysis and categorization software. Many software features can be altered to satisfy particular needs. For example, you may alter it to make it faster or more responsive.

2. Alternative Light Photography:

One of the easiest methods to determine whether a body has been injured before it appears on the surface is alternative light photography. Forensic nurses use alternative light photography, which can literally mean the difference between life and death. In order to detect bruises beneath the skin's surface, the camera uses blue and orange filters in addition to ultraviolet light to highlight bruises, bite marks, and the hunt for trace evidence. Infrared photography highlights blood on dark and patterned clothing and tattoos that are hard to see due to degradation, lividity, and scorching.

3. Digital Surveillance for Gaming Equipment

In an attempt to evade discovery as a potential target for evidence, criminals have been known to conceal illicit content on Xboxes. After mounting the Xbox file system, an analyst can use an XFT Device to explore the directory tree, list its contents, access and analyze files, and extend subdirectories and folders. The XFT Device, which may record visiting sessions for use as evidence in court, will allow authorities to access concealed data on 82 Xbox hard disks.

4. Facial Reconstruction

When unidentifiable remains are found at a crime scene, forensics employ facial reconstruction. Using a blend of imagination, anthropology, osteology, and anatomy, the method reconstructs a person's face from their skeletal remains. The three basic methods of facial reconstruction are

³⁸ Laboratory Procedure Manual - Polygraph Examination (Directorate of Forensic Science, Ministry of Home Affairs, Government of India, New Delhi - 2005)

two-dimensional (photographic prints or drawings), three-dimensional (sculpture or high-resolution 3D computer image), and superimposition. Even though face reconstruction isn't always the most reliable method, many forensic labs use it to determine the appearance of people whose bodies are too damaged or whose remains are deteriorating to make a visual observation. The system receives input from the user and uses it to anticipate an individual's physical attributes.

5. DNA Sequencing

DNA can be used to identify both victims and perpetrators through trace evidence like skin or hair. DNA sequencing determines the arrangement of the four chemical units (referred to as "bases") that comprise the DNA molecule. DNA profiling has established the gold standard in FS since the first case more than 30 years ago, even though DNA evidence alone is no longer sufficient for a conviction. Forensic investigators may use DNA sequencing to sequence STR (short tandem repeat) markers, perhaps enhancing their capacity to distinguish between individuals in intricate DNA combinations. In casework labs, alternative marker types, such as SNPs (single nucleotide polymorphisms), can be more easily incorporated, enabling further capabilities like ancestry and phenotypic estimations in unresolved cases.

6. Automated Fingerprint Identification

Using fingerprint identification, forensic investigators can compare recovered fingerprints to an extensive digital database. Since its introduction in the 1980s, automated fingerprint identification systems (AFIS) have grown to be an essential component of the work of police and other law enforcement agencies worldwide. These methods have changed how authorities look into a variety of criminal offenses by significantly raising the possibility of a successful suspect identification. The rapid uptake of AFIS has probably led to increased financing for its development. In addition to using multi-modal biometrics, integrating with digital mug pictures and live scan devices, and connecting the AFIS to other criminal justice information systems, palm prints will be incorporated. To get an accurate image without destroying the fingerprint, investigators can also use more recent technologies like magnetic fingerprinting dust.

7. Link Analysis Software

In network theory, link analysis is a data analysis method used to examine connections or ties between network nodes. A connection or relationship can be formed by any kind of element or thing, including individuals, organizations, or transactions. There is always a mountain of paperwork to do when it comes to money. To find any anomalous financial behavior found in the trail of evidence, expert accountants use link analysis technology. After looking at bank

transactions and customer profiles, the goods and manufacturing department uses statistics to predict likely criminal activity. Financial organizations, including banks and insurance companies, as well as cyber security firms, frequently use it to identify criminal networks. Link analysis is used by government organizations to detect fraud, enhance screening procedures, look into illegal activity, and expose terrorist networks. To put it briefly, link analysis software helps investigators or examiners visualize communication between individuals involved in a criminal investigation.

8. Drug Testing

Forensic teams frequently need to identify unknown compounds in powder, liquid, or pill form. While confirmatory tests, like gas chromatography or mass spectrometry, ascertain the molecule's composition, presumptive tests, like color testing, demonstrate the existence of a chemical. Several tests were conducted, including gas chromatography (which separates the medication from any mixing components), UV spectrophotometry (which requires examining how a chemical reacts to ultraviolet and infrared light), and microcrystalline testing (which uses the crystal patterns formed to determine what drug is present).

9. LA-ICP-MS

(Laser ablation inductively coupled plasma mass spectrometry) is a highly sensitive statistical technique for elemental and isotopic analysis of solid materials. By concentrating a laser beam on the sample surface, laser ablation is utilized in LA-ICP-MS to produce microscopic particles. The secondary excitation source of the ICP-MS system receives the ablated particles and uses them to digest and ionize the sampled mass. A mass spectrometer receives the excited ions from the plasma torch for elemental and isotopic analysis.

Because it can do ultra-sensitive chemical analysis down to parts per billion (ppb) without even requiring sample pre-treatment, LA-ICP-MS is one of the most intriguing analytical technologies available today. By reassembling even the smallest pieces of glass, LA-ICPMS can assist forensic experts in determining bullet direction, force of impact, and even the type of weapon used during a crime. By comparing it to other types of glass in a database, it also enables forensic investigators to determine the type of glass they have found. Because the findings are available in seconds, LA-ICP-MS is the fastest analytical technique currently in use, with a detection time of less than a minute.

10. Fire Technology

Burning, or combustion, is an exothermic reaction that produces fire, which produces heat and light. An oxidant (O₂), a fuel source, and a significant quantity of heat energy are required for

a fire to start. When arsonists set a building on fire, they almost never leave much evidence. On the other side, accelerants are often used by arsonists to speed up the spread of a fire. Determining where the fire originated, what caused it, and whether it was the result of an accident, a natural disaster, or a deliberate act are the primary objectives of a fire investigation. Combustion, often known as burning, is an exothermic event that results in fire, which generates heat and light. A fire needs a fuel supply, an oxidant (O₂), and a substantial amount of thermal energy to ignite. Almost no evidence is left behind when arsonists set a structure on fire. Conversely, arsonists frequently utilize accelerants to hasten the spread of a fire. The main goals of a fire investigation are to ascertain where the fire started, what caused it, and whether it was the consequence of an accident, a natural disaster, or an intentional act.

11. 3D Scanner

A 3D scanner was formerly among the most expensive tools accessible to crime scene investigators, but it is now among the most practical. Put the scanner in the center of the room to turn it on. Following that, the scanner will make a full 360-degree circle while gathering all of the things in the surrounding area. Additionally, it will compute the separation between the scanner and the objects in the room and between the scanner and the walls. It took a lot of time and effort to draw a place before the 3D scanning. It also required a great level of artistic ability. Items were often omitted in order to avoid "packing" a drawing, which led to an inaccurate depiction of the inside. A 3D scanner can provide accuracy in 10 to 30 minutes compared to an artist.

12. High-Powered Microscopes

Almost all trace evidence is examined in the forensic sciences using polarized light microscopy, scanning electron microscopy, x-ray spectroscopy, and infrared microscopy. Size and form are important forensic identifiers because most evidence gathered at crime scenes is hard to identify or evaluate with the unaided eye. High-powered microscopes make it easier to see and identify small pieces of evidence. The Malvern Morphologi 4-ID, in particular, has a revolutionary capacity to identify fake drugs. It uses Raman spectroscopy to enable chemical identification while analyzing the shape and size of hundreds of particles.

13. High-Speed Ballistics Photography

You would most likely only get the background if you attempted to take a picture of a bullet flying by. Because bullets move swiftly, high-speed ballistics photography is required. Ballistics photography is the process of photographing projectiles being fired from a gun or bullets piercing their targets. Ballistic photography uses the same methods as any other fast-

moving subject, such as a balloon exploding or liquid splattering. Ballistics photography requires specialized equipment, much as any other specialized area of photography. To synchronize the high-speed flash with the event, a photographer might also require a trigger and a cable release. The catalyst, which may be the most crucial component, tells the camera to take a picture based on the information provided.

VIII. CONCLUSION

Crime scene investigation and forensic science have become indispensable components of the modern criminal justice system. Scientific methods such as DNA profiling, fingerprint analysis, forensic pathology, digital surveillance, and advanced investigative technologies have significantly improved the accuracy, reliability, and efficiency of criminal investigations. The integration of forensic science into criminal administration not only assists in identifying offenders but also protects innocent individuals from wrongful conviction. In India, the growing acceptance of forensic evidence by courts reflects the increasing importance of scientific investigation in ensuring fair and effective justice delivery.

Despite these advancements, the Indian forensic system continues to face several practical and legal challenges, including inadequate forensic infrastructure, shortage of trained experts, delays in forensic reports, lack of modern equipment, and insufficient awareness among legal professionals regarding scientific evidence. Issues relating to admissibility, reliability, and constitutional validity of techniques such as narco-analysis, polygraph tests, and brain mapping also raise significant concerns regarding privacy, consent, and protection against self-incrimination under Article 20(3) of the Constitution of India. Furthermore, improper crime scene management and contamination of evidence continue to weaken the evidentiary value of forensic findings in many criminal cases.

The study demonstrates that effective crime scene investigation depends upon coordinated efforts between police officers, forensic experts, medical professionals, and judicial authorities. Proper documentation, preservation, collection, packaging, and analysis of evidence are essential for maintaining the integrity of investigations and ensuring successful prosecution. Judicial precedents have also emphasized the need for scientific accuracy, procedural fairness, and proper chain of custody while dealing with forensic evidence.

Recent technological developments such as 3D scanning, automated fingerprint identification systems, DNA sequencing, alternative light photography, and advanced analytical tools have revolutionized forensic science and opened new possibilities for criminal investigation. However, the benefits of these technologies can be fully realized only through adequate

investment, specialized training, modernization of forensic laboratories, and incorporation of forensic education into legal and police training institutions.

In conclusion, forensic science has the potential to transform the Indian criminal justice system by promoting objectivity, transparency, and scientific accuracy in investigations. Strengthening forensic infrastructure, ensuring timely forensic analysis, improving legal awareness, and establishing uniform procedural standards are essential for enhancing the credibility and effectiveness of crime scene investigation in India. A balanced approach that combines technological advancement with constitutional safeguards and human rights protections will ultimately ensure that forensic science serves as a reliable instrument for the administration of justice.
