LCR 907 (FORENSIC SCIENCE) STUDY MATERIAL

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UNIT 1

FORENSIC SCIENCE

1. PRINCIPLES AND LAWS OF FORENSIC SCIENCE

Forensic Science is an applied science in which all the principles of basic Science are utilized for the purpose of law. As other sciences are based on some fundamental principles, Forensic Science is also based on some principles. The main principles of Forensic Science are Law of Exchange (Every contact leave traces), Principle of Individuality (Everything in unique), Law of Comparison (only similar things can be compared with similar), Principle of Linkage (crime scene, evidences, victim and accused somewhere linked with each other), Law of Probability (Probability is a mathematical concept which determines chance of occurrence of event or phenomenon), Law of Progressive change (Everything changes with passage of time) and Law of Analysis (The analysis can be no better than the sample analyzed). These all principles are very useful for solving the crime and in identification of accused. These principles are useful in linking of suspect with crime scene, as well as with victim. These principles are very useful in analysis of physical evidences.

Different principles of forensic science are as following

Law of Individuality

It is the most basic one, and as per this, no two objects, whether naturally occurring or man-made, are similar or have duplicate characteristics.

All objects present in this universe are distinct, and even if they appear alike, there are features that, if examined minutely, will reveal the differences between them.

For example, firearms created in the same factory with the same machine, at the same time, by the same workers, and using the same material are different from each other in their class and individual characteristics.

The same goes for coins. Coins of the same mint and denomination might look exactly alike to the naked eye but acquire individuality during manufacturing that is not easy to observe but can be spotted if seen with high concentration.

Several other pieces of evidence, like toolmarks, fingerprints, footprints, lip prints, etc.,

found at the scene of a crime are examined based on this principle.

Law of Progressive Change

As per this principle, with time, everything undergoes progressive change. Whatever is present today will not remain the same in the coming time, and its appearance will change.

The speed with which the change occurs may vary depending on the object or sample.

That is why it is advised to secure the crime scene immediately to protect evidence from natural calamities (like rain, heat, and storms), human or animal intervention, etc.

The longer the delay, the greater the changes that affect the identification process during investigation as the main identifying features of the sample wear out.

So, if the evidence is not identified, preserved, and sent to the forensic lab at the right time, it will deteriorate and not give the desired results upon investigation.

Similarly, a bullet might get rusted, tissue samples might get degraded if not preserved immediately, and criminals might become unrecognizable if not apprehended in time, except for a few features like fingerprints that remain unchanged.

Principle of Exchange

This was given by a French scientist, Edmond Locard. As per this principle, whenever two objects come into contact with each other, a mutual exchange of material takes place between them.

Whenever a criminal or his weapon of crime comes into contact with the victim or the objects at the crime scene, they leave behind some traces and also pick up traces from the victim or the surroundings, either knowingly or unknowingly.

These traces, or physical evidence, later help investigators identify suspects. A forensic expert analyzes these traces and helps in linking them to the original source, thereby developing a link between the criminal, the victim, and the crime scene.

For example, an investigating officer might receive footprints, fingerprints, bullet residues, blood samples, soil, tools, hair samples, skin, bodily fluids, cloth pieces, etc. to examine.

The officer is required to establish exactly the places and objects with which the perpetrator or tool came into contact during the crime and the points of contact.

Principle of Comparison

From a lab analysis and examination point of view, this principle holds immense importance. As a result, only similar things can be compared to each other, and different things cannot be used for comparison.

You need to have like samples and specimens to examine the questioned sample found at the crime scene for authenticity.

For example, if a forensic lab expert receives a hair and a fiber sample for comparison, he cannot proceed as both differ from each other in appearance, chemical composition, color, shape, size, biological characteristics, texture, etc.

Also, if human blood is discovered at the crime scene, then sending animal blood for comparison is useless.

If a firearm is used, then there is no requirement to send a knife to the lab for comparison.

Principle of Analysis

Investigating officers usually found various physical pieces of evidence from the crime scene that needed to be sent to the forensic lab for analysis and a final opinion by the expert about the evidence.

However, to get the best results out of the examination, it is necessary to gather the correct sample, properly preserve it, pack it using appropriate techniques, and transport it carefully to the lab.

This methodology of collecting samples will help in avoiding damage caused by tampering, contamination, and sample degradation.

For example, a hard disk collected in a paper bag can get damaged due to a strong electromagnetic field if it falls within its range.

Law of Probability

Probability refers to the likelihood of a specific event happening in a specific manner out of a number of ways in which the event has an opportunity to occur or not occur compared to all possible outcomes.

For example, if a forensic scientist receives a biological fluid as physical evidence, the chances of it belonging to a particular person will vary.

Also, if a bank is robbed by a gang, investigators need to calculate the probability that the gang could be held responsible.

Principle of Linkage

As per this principle, facts don't lie, but people can. The human statement might or might not be accurate, but physical evidence recovered from the crime scene can easily help forensic experts link a suspect to a victim. Also, the evidence found can sometimes link directly to the suspect and sometimes indirectly.

Example of direct linking

Fingerprints found at a crime scene are the most valuable piece of physical evidence to directly link a suspect to a crime scene.

Toxicological evidence like animal and plant poison, chemical poison, viscera, etc. can be used to directly link a person to the crime scene.

Example of indirect linking

Physical evidence like tool marks, tire marks, footwear impressions, etc. indirectly points toward the suspect.

Some important questions

1. What is forensic science?
Ans: The application of scientific methods and techniques to matters under investigation
by a Court of Law.
2. Define law of analysis.
Ans. "the analysis can be no better than the sample analyzed".
3. How will you define probability?
Ans: it determines the chances of occurrence of a particular event in a particular way out
of a number of ways in which the event can take place or fail to take place with the equal
facility".
4. Define principle of Individuality.
Ans: Every object, natural or man-made, has an individuality, which is not duplicated in any other object. It is unique. Neither the nature has duplicated itself, nor can man.
5. What do you mean by principle of exchange?
Ans: when two objects come into contact with each other a cross-transfer of material occur.
6. What do you mean by crime scene?
Ans: Scene of crime is a place where crime has been occurred.

7. What is the principle of comparison?

Ans: Only similar things can be compared with similar".

1. Who did give principle of exchange and write about it?

Ans- Edmond Locard gave principle of exchange. He told, "every contact leaves trace" Or in simple words he said "when two objects come into contact with each other a cross-transfer of material occur."

2. What is the principle of uniqueness?

Ans- Principle of uniqueness told that everything in this world is unique even nature does not duplicate the live things. All human beings are different even **monozygotic twins** they look exactly alike but somewhere they are different from each other. Leaves of same branch at plant also are having different. So, this is the individuality of the nature.

3. Give definition of Forensic Science?

Ans- Forensic Science is an applied science. In this science all the principles of basic science (Physics, Chemistry, Biology, mathematics etc) are utilized for the purpose of law and administration.

4. What is the principle of Analysis?

Ans- This principle emphasizes the necessity of correct sampling and packing of the physical evidences. This principle states, "The analysis can be no better than the sample analyzed". On the basis of this principle different physical evidences are analyzed in the Forensic Science Laboratory.

5. What is the law of comparison?

Ans- Likes can be compared with likes. According to this principle "only the same exhibits must be compared with the same." Things which are different from each other in every point such as appearance, morphology, texture, shape, size, color, chemical components and biological characters, but if they are having some similarities they can be compared. So, this is the principle of comparison that emphasizes the necessity of providing like exhibits for comparison with the suspected one.

6. What is law of probability?

Ans- This law determines the chances of occurrence of a particular event in a particular way out of a number of ways in which the event can take place or fail to take place with the equal facility. Forensic scientist always apply the law of probability with the physical evidence like if forensic scientist receives the blood and other biological fluid as physical evidence then what will be the probability of the blood that is belong to so and so person.

7. What is law of progressive change?

Ans- This law states, "Everything changes with passage of time". Or in other word we can say that nothing is permanent, until or unless one day it will change from one form to another.

8. Explain principle of linkage.

Ans- According to this principle if investigating officer gets the physical evidence at the crime scene, one can easily link a suspect to a victim. On the basis of physical evidence, there can be two type of linkage- direct linkage or indirect linkage. Apart from suspect or victim linking it also link suspect to the crime scene, suspect with physical evidence.

2. SIGNIFICANCE OF FORENSIC SCIENCE

Using forensic techniques, the cause of a crime victim's death is determined. This is accomplished by looking at the wounds, bite marks, burn markings, etc. on the victim's body. The medical examiners also look at the changes made to the dead body after the post-mortem procedure. Forensic science also identifies the time and location of a crime, as well as the means of its commission. Specialists inspect the crime scene in order to gather fingerprints and other evidence that will help identify the criminal. Cyber crimes are also found using forensic techniques. Computer forensics is the term for this. This entails deciphering the data, tracking IP addresses or email addresses, etc. To help the police solve a case, forensic scientists collaborate closely with them. In India, there are numerous institutions that provide forensic science courses. The police are using modern criminal detection techniques to solve crimes that were unsolvable just a few decades ago. The legal system and government institutions are heavily reliant on forensic sciences to help them solve instances involving victims whose disfigured remains have nearly completely deteriorated.

3. HISTORY & DEVELOPMENT OF FORENSIC SCIENCE

The application of science and technology to the detection and investigation of crime and administration of justice is not new to India. Although our ancestors did not know forensic science in its present form, scientific methods in one way or the other seem to have been followed in the investigation of crime. Its detailed reference is found in Kautilya's **Arthashastra**, which was written about 2300 years ago. Indians studied various patterns of the papillary lines, thousands of years ago. It is presumed that they knew about the persistency and individuality of fingerprints, which they used as signatures. Even Mr. KM Kata, a frequent contributor to **Nature**, stated that the Chinese records proved the use of fingerprints in an ancient kingdom of southern India. The Indians knew for long that the handprints, known as the Tarija, were inimitable (unique). The use of fingerprints as signatures by illiterate people in India, introduced centuries ago, was considered by some people as ceremonial only, till it was scientifically proved that identification from fingerprints was infallible (Flawless, Perfect).

Chemical Examiner's Laboratories

During the nineteenth century, when the cases of death due to poisoning posed a problem to the law enforcement agencies, a need was felt for isolating, detecting and estimating various poisons absorbed in the human system. The first Chemical Examiner's Laboratory was, therefore, set up for this purpose at the then Madras Presidency, under the Department of Health, during 1849.

Later, similar laboratories were set up at Calcutta (1853), followed by one each at Agra (1864) and Bombay (1870). These laboratories were equipped to handle toxicological analysis of internal organs, biological analysis of stains of blood, semen, etc. and chemical analysis of food, drugs, and various excisable materials to provide scientific support to the criminal justice delivery system within their limited means. These laboratories also provided analytical facilities to the neighbouring States and Union Territories.

Anthropometric Bureau

While some progress was made in the identification of poisons, the identification of people, specifically criminals, was still being done in a rather haphazard manner. Policemen would try to memorize convict's face so that they could recognize him if he got involved in another crime later. With the introduction of Photography, the Criminal Investigation Department (CID) maintained records of every known criminal including a detailed description of his appearance.

With the invention of Bertillon's anthropometric system in 1878, India, along with the other countries of the world, adapted Bertillon's system of personnel identification and

thus an Anthropometric Bureau, for maintaining anthropornetric records of criminals, was established in 1892 at Calcutta.

Finger Print Bureau

William Herschel, the Collector of the District of Hooghly (Bengal) found that markings on the fingertips of a person never changed during his lifetime. Herschel applied his knowledge and skill in devising a system of registration of finger or thumb impressions of native contractors to safeguard the interests of the Government against the refutation of contracts by them. Thereafter, he extended his registration procedure to prison regulations for identifying convicted criminals.

In 1877, Herschel sought the consent of his superior officers in putting his ideas into practice, but did not succeed. In 1891, Edward Richard Henry's appointment, the Inspector General of Police in Bengal, introduced the thumb impressions in the record slips, containing anthropometric data, to avoid wrong identification. Long before 1897, he introduced maintenance of duplicate criminal records with impressions of 10 fingers separately.

Department of explosives

When the use of explosives for subversive activities became common, it was found necessary to detect the causes of explosion, either accidental or intentional. The foundation of the Department of Explosives was laid when the first chief inspector of explosives was appointed in the year 1898, with his headquarters at Nagpur. Later, five regional offices at Calcutta, Bombay, Agra, Madras and Gwalior, and three sub-offices were opened.

They developed competence to provide scientific clues in respect of explosives as well as the possible causes of explosions. Their expertise came handy in police investigations in the crimes related to explosions and for evolving various provisions under the Explosives & Petroleum Act.

Government examiner of questioned document, Shimla

The British Government of Bengal felt the necessity of identifying the handwritings on the secret documents connected with the Indian independence movement and, therefore, created the post of Government Handwriting Expert of Bengal. Mr. CR Hardless, was appointed to this post in 1904.
This set-up was shifted to Shimla in the year 1906 and was placed under the control of the Director, CID. A post of Handwriting Expert for the Government of India was created and Mr. CR Hardless was appointed to this post. He was replaced by Mr. F Brewester, a police officer from the West Bengal CID, and was designated as the Government

Examiner of Questioned Documents (GEQD).

At first, the work of this office was mainly confined to the identification of writings on secret documents. Later, as the application of this branch of science was felt in many other cases, the services of this office were thrown open to criminal as well as civil court cases. During the World War II, this organization took up the additional work of secret censorship, including the detection of invisible writings and training of military personnel in this field of science.

Footprint section of criminal investigation department

During the year 1915, a Footprint Section was established under the CID, Government of Bengal, which helped the police authorities to identify criminals through the examination of footprints collected from the scene of crime.

Ballistics Laboratory

In 1930, an Arms Expert was appointed and a small ballistic laboratory was set up under the Calcutta Police to deal with the examination of firearms. As the threat of firearms grew, other State CIDs also established small ballistics laboratories to help them in the criminal investigation.

State Forensic Science laboratory, Calcutta

The first state forensic science laboratory in India was established in the year 1952 at Calcutta. This laboratory became fully operational in the year 1953. The Medico-legal Section of the Chemical Examiner's Laboratory was also transferred to this laboratory. During the year 1955, a small unit of Physics was established in the West Bengal State Forensic Science Laboratory to deal with various physical examinations of exhibits encountered in crime investigation. During the year 1957, the Physics unit developed into a full-fledged Physics Section.

Central finger print Bureau

On the recommendations of the Royal Police Commission of 1902-03, the first Central Finger Print Bureau (CFPB) in India was established in 1905 at Shimla. The CFPB started functioning from 1955 in Delhi under the administrative control of Intelligence Bureau (IB). The major role envisaged for CFPB was to coordinate the activities of State in tracing/locating inter-state criminals.

Indian Academy of Forensic Science

The Indian Academy of Forensic Sciences (IAFS) was established in the year 1960. This academy started a biennial scientific journal, which served as a forum for the exchange of ideas in forensic science with the other international bodies. The role of the Academy was also to hold annual scientific meetings/seminars or assist in holding seminars in forensic science. In fact, it was at the instance of this Academy that the Government of India established the Neutron Activation Analysis Unit to cater for the forensic needs in the country.

Institute of Criminology & Forensic Science at New Delhi

After a series of debates at the Government level, it was decided that initially the Institute of Criminology and Forensic Science should be established only for training the in-service personnel and for conducting research in the field of forensic science. It was felt that unless the State governments and the consumer organizations agreed to participate in the scheme, it would not be wise to start courses for granting postgraduate degrees.

However, the ultimate objective of the Institute was to develop into a full-fledged academic institution affiliated to a university. With the above aim in view, the Institute of Criminology and Forensic Science (ICFS) was established in Delhi during 1971 with the limited objectives of imparting training to the in-service personnel and conducting research in Criminology and Forensic Science.

It was also envisaged that the Institute should have two distinct faculties viz. the Faculty of Criminology and the Faculty of Forensic Science and both should have a number of eminent teachers and researchers with adequate background and field experience.

4. ORGANIZATIONAL STRUCTURE OF FORENSIC SCIENCE LABS IN CENTRAL & STATE.

India's main body in responsibility for monitoring FSL operations is the Central Forensic Sciences Laboratory (CFSL). It is under the administrative control of the Union Ministry of Home Affairs and is responsible for maintaining standards and quality control across all FSLs in the country. The Department of Justice, Ministry of Home Affairs oversees the Central Forensic Science Laboratory (CFSL), which is the premier forensic laboratory in India. Established in 1905, the CFSL is responsible for setting up standards, protocols, and guidelines for functioning FSLs across the country. It also offers training and technical support to other forensic labs and investigative organizations. Under the CFSL, 21 regional forensic laboratories, known as Forensic Science Laboratories (FSLs), are located in different states and union territories. These FSLs are responsible for

providing forensic services to their respective regions. Additionally, specialized forensic laboratories, such as the National Forensic Laboratory for Narcotics and Psychotropic Substances and the National Institute of Criminology & Forensic Science, cater to specific areas of forensic science. At present, there are 33 FSLs in India, which are categorized into three types:

- Central Forensic Science Laboratories (CFSLs): There are 13 CFSLs in major cities across India, including Delhi, Mumbai, Kolkata, Chennai, and Hyderabad. These laboratories handle cases of national importance and provide technical assistance to state police forces.
- State Forensic Science Laboratories (SFSLs): Are 19 SFSLs located in various states and union territories. These laboratories are responsible for providing forensic services to state police forces and assisting in local investigations.
- Judicial Forensic Science Laboratories (JFSLs): There are 5 JFSLs in different high courts across India. These laboratories provide forensic assistance to the judiciary during trial proceedings.

Functions of FSLs

- Collection and Preservation of Evidence: To guarantee that evidence from crime scenes is admissible in court, FSLs are in charge of gathering and maintaining that evidence. This includes properly handling, packaging, and transporting exhibits to the laboratory.
- Examination and Analysis: The primary function of FSLs is to examine and analyze the collected evidence using various forensic techniques. These techniques include fingerprint identification, questioned document examination, drug analysis, DNA profiling, ballistics, and digital forensics.
- Reporting: After completing the examination and analysis, FSLs prepare detailed reports outlining their findings. These reports are submitted to the investigating agencies and courts to aid in investigating and trial cases.
- Training and Capacity Building: FSLs are responsible for imparting training to forensic scientists, police personnel, and other stakeholders in the field of forensic science. This ensures that the quality of forensic services remains consistent and improves over time.
- Technical Assistance: FSLs provide technical assistance to investigating agencies and courts through expert opinions, consultations, and guidance on forensic matters.
- Research and Development: With the goal to stay aware of the most recent

developments in forensic science and integrate them into their operations, FSLs are also engaged in research and development projects.

UNIT 2

CRIME SCENE EVIDENCES

Crime scene evidence in forensic science includes a wide range of physical and digital evidence, such as:

- Blood and body fluids: Bloodstain patterns can help determine the number of perpetrators, the type of weapon used, and the sequence of events.
- Fingerprints, footprints, and tire tracks: These can be collected at the scene.
- Hairs and fibers: These can be collected as trace evidence.
- Glass fragments: These can be collected as trace evidence.
- Digital evidence: This includes cell phone records, email messages, and internet logs.
- Tool and tool mark evidence: This can be collected at the scene.
- Drug evidence: This can be collected at the scene.
- Firearm evidence: This can be collected at the scene.

Crime scene investigators also collect control samples, which are known substances that can help establish a link between people and things at the scene. For example, investigators might collect glass fragments from a broken cabinet door and compare them to glass fragments found on a suspect's clothing.

Crime scene investigators also maintain the proper chain of custody for all evidence collected.

a. VISCERA & TOXICOLOGICAL EXAMINATION OF VISCERA

A viscera report is compiled in order to establish the reason for death in cases where traditional autopsies are inconclusive. These examinations involve a thorough investigation of the viscera i.e., internal organs, particularly those located in the chest, abdomen, or pelvis. In instances where autopsies fail to provide a definitive answer, viscera are conserved and examined in order to determine the reason for death, typically

in situations involving suspected instances of poisoning, cold blooded murder or dowry-related deaths. They may also be performed in cases lacking crucial clues, as well as criminal cases where there is no evidence or the perpetrator has successfully concealed it, such as murders or poisoning. The viscera can be found in the central cavities of the chest, abdomen, and pelvis. These include the main pulmonary, gastrointestinal, genitourinary, and cardiovascular organs. The term 'viscera' comes from the Latin word 'viscus,' meaning an organ of the body.

The viscera sample collected from the autopsy surgeon should be sent by the investigating police officer to the forensic science laboratory for chemical analysis within 15 days of the postmortem.
Upon death, the human body, being a complex system, undergoes a series of changes that can offer valuable insights into the cause and manner of death. Viscera, which comprises internal organs such as the heart, lungs, liver, and brain, plays a critical role in forensic investigations due to these changes. Through the examination of their condition, appearance, and any abnormalities, forensic pathologists can often determine the cause of death with a high level of certainty.

The most common cause of death that can be identified through the examination of viscera is trauma, which can result from various events such as blunt force injuries, penetrating wounds, and thermal injuries. Upon inspection of the organs, signs of trauma may manifest in the form of lacerations, contusions, or fractures. For instance, a ruptured liver or spleen may indicate blunt force trauma to the abdomen, while a punctured lung may suggest a penetrating injury, such as a stab or gunshot wound.

In addition to trauma, disease is another crucial cause of death that can be determined through the examination of viscera. Various diseases and medical conditions can affect the function and structure of viscera, ultimately leading to death. For example, cardiovascular diseases such as myocardial infarction (heart attack) can cause considerable damage to the heart muscle, which can be observed during an autopsy. Similarly, conditions like pneumonia or pulmonary embolism can affect the lungs, resulting in respiratory failure and death.

Aside from physical trauma and illnesses, toxicological testing on viscera can uncover the presence of drugs, alcohol, poisons or other substances that may have played a role in an individual's death. This type of examination involves analysing samples of blood, urine, and tissues to detect the presence and levels of toxic substances.

For instance, the discovery of alcohol in the blood or liver can suggest alcohol intoxication as a contributing factor in the person's demise. Similarly, the identification of drugs such as opioids, benzodiazepines, or stimulants can provide crucial insights into the circumstances of a death.

Moreover, an evaluation of the brain and central nervous system is crucial in determining the cause of death in cases involving head injuries, neurological disorders, or drug overdose. A macroscopic analysis of the brain can reveal signs of injury such as haemorrhaged or contusions, while a microscopic examination can pinpoint specific pathological changes associated with conditions like stroke, epilepsy, or neurodegenerative diseases. It is worth noting that the interpretation of findings from the examination of viscera requires careful consideration of the individual's medical history, the circumstances surrounding their death, and other pertinent factors. In some instances, multiple factors may contribute to a person's passing, necessitating a careful evaluation of each finding and the overall context.

In summary, the examination of viscera is a crucial aspect of forensic pathology and can provide valuable information about the cause and manner of death. By analysing the condition, appearance, and any abnormalities present in viscera, forensic pathologists can identify traumatic injuries, underlying diseases, toxicological factors, and other contributing factors that may have led to an individual's death. This information is vital in determining the circumstances surrounding a death, aiding in criminal investigations, and bringing closure to families and loved ones.

The perplexing issue of determining the cause of death in cases involving poisoning, where the viscera report yields negative results, creates a dilemma for the forensic pathologist, the legal system, and the general public.

This dilemma is a common occurrence in India, due to various reasons such as delay by investigating police officers in collecting the viscera from the hospital where the autopsy was done and then sending the same to the forensic science laboratory, delays in examining the viscera due to poor infrastructure and shortage of manpower of the forensic science laboratories and sometimes due to negligence, lack of training of the investigating police officers in handling the viscera pre and post-examination, improper preservation methods, use of incorrect analytical techniques, early decomposition of poisons, complete metabolism of poisons in the body, minimal amounts of poison present in the viscera, and lack of suitable chemical tests for certain poisons.

Further, there is lack of adequate facilities at the police stations for preserving the viscera safely, absence of proper tracking system of the viscera at the police stations and negligence by investigating police officers in collecting the viscera report from the forensic laboratories and tagging the same with case diaries.

You may find packets of viscera hanging from the trees at some police stations due to absence of proper construction and management of malkhana. Further, hundreds of viscera reports are pending with the forensic science laboratories as they are unable to conduct examination due to poor infrastructure and understaffed position of the

forensic science laboratories.

Furthermore, the scope of residual analysis for poisons is limited to only 10-15 commonly available ones, leaving out other potent killers like insulin, KCI, and Adrenaline, which cannot be detected in the viscera.

In a ruling on January 21, 2014, the Supreme Court of India mandated that investigating agencies must conduct a viscera test in cases of suspicious deaths, such as those involving possible poisoning or cold-blooded killings. According to a study by the All-India Institute of Medical Sciences (AIIMS), this examination should be completed within six months in order to expedite the investigation process.

Punjab's only chemical examiner laboratory at Kharar has brought attention to the issue of incorrect viscera analysis. The laboratory has discovered that in certain instances, samples are not being sent in accordance with guidelines and without the necessary accompanying documents, leading to objections being raised, due to carelessness on the part of investigating police officers and autopsy surgeons.

According to several unnamed police and judicial officials, there may have been instances where justice was not served due to the failure to send viscera for chemical testing in time and improper and careless handling of the viscera by the investigating police officers and autopsy surgeons.

In many post-mortem reports it is written by the autopsy surgeon that the final opinion regarding the cause of death will be submitted after receipt of viscera report, but by the time the viscera report is received the autopsy surgeon or the investigating police officer gets transferred and a lack of co-ordination in the compilation and processing of post mortem and viscera report is noticed in such cases.

Due to the failure of the police to submit the viscera for examination, there could be numerous pending medico-legal cases in the district courts, potentially allowing murderers to escape punishment.

The police have the authority to gather the viscera and autopsy reports, send the viscera to the forensic science laboratories, collect the viscera report from the forensic science laboratories and send the viscera report to the courts in proper form, but they neglect to do so.

There is no viscera tracking management system working at most of the police stations; hence some viscera reports remain lying at the police stations sometimes due to negligence of the investigating police officers and sometimes due to apathy of the officer-in-charge of the police stations particularly after transfer of the investigating police officer to a different police unit. The destruction of viscera after examination is

completed cannot be done without the court's approval, and it is the responsibility of the judiciary to intervene.

The Orissa High Court in December 2023 has restated that it is the responsibility of investigating agencies to ensure that a 'viscera sample' is sent for chemical testing in any suspected murder cases involving 'poisoning', and to present the resulting report to the trial court after receiving it from the Forensic Laboratory.

The Supreme Court has upheld the verdict of conviction against the accused in a dowry death case despite no chemical poisoning found in the viscera report in the case of Buddhadeb Saha v. State of West Bengal.

b. BLOOD AND BODILY FLOODS

When evaluating forensic tests on suspected blood, semen, or saliva evidence (also known as serology evidence), it is important for defenders to understand first the difference between presumptive and confirmatory tests and why that distinction is so important:

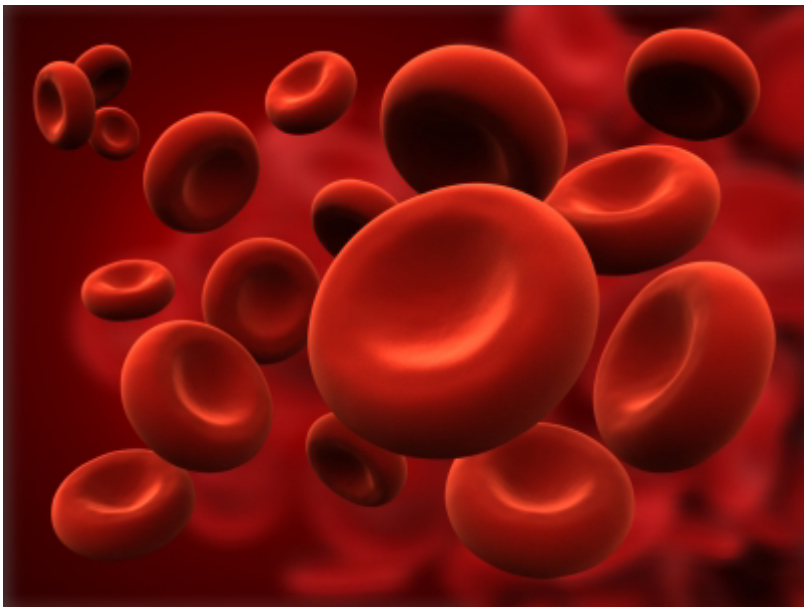
Presumptive Tests

- Also known as preliminary tests, screening tests or field tests
- Establish the *possibility* that a specific bodily fluid is present
- Do not conclusively prove the presence of a specific substance
- Pros: Narrows possibilities, can be used on larger areas, can locate possible evidence not visible to naked eye, relatively inexpensive and quick to perform
- Cons: Risk of false positives and may be overly sensitive
- Uses: Provide initial information to determine what test to perform next, used in combination with confirmatory tests

Confirmatory Tests

- Conclusively identify the identity of a biological material
- May be one or a combination of procedures
- Pros: Conclusively identifies a substance, smaller risk of false positives
- Cons: May be more expensive, require additional equipment, and take longer

Blood



Presumptive Tests

- Phenolphthalein Test
    - Also known as the Kastle Meyer Test
    - How it works: A Phenolphthalein solution is used to show the possible presence of blood based upon a peroxidase reaction of hemoglobin which produces a pink color.
    - Precautions: This test is presumptive because it has produced false positives from other substances, such as saliva, pus, malt extract, vegetable extracts, and the salts of certain heavy metals.
- Luminol Test
    - How it works: A chemical compound, known as Luminol, is used in solution or sprayed onto suspected surfaces. This compound gives a strong blue fluorescence when viewed with a UV light. The Luminol reacts with hematin, a substanced formed as bloodstains age, and produces a luminescence which is best observed in the dark. The luminescence lasts for several minutes and can be photographed. Aged bloodstains tend to give more intense and longer-lasting luminescence than fresh blood, and can be re-sprayed with Luminol to be viewed again.
- Alternative Light Sources

    - How it works: Alternative Light Sources such as the CrimeScope use ultraviolet,

visible or infrared light to cause certain substances to fluoresce (glow) or absorb light (darken). Blood stains will darken rather than glow when certain light wavelengths are used.

Confirmatory Tests

- **Takayama Test**

  - How it works: Through the application of a specific solution developed by Takayama, hemochromogen crystals form by treating a small amount of blood or a stain fragment. The crystals are observable under a microscope and look like salmon-pink rhomboid crystals. This test does not require heating, and can be used on older samples.

- **RSID Test for Human Blood**

  - How it works: This test uses two specialized antibodies to detect the presence of human Glycophorin A which is found in red blood cell membranes. The antibodies are applied to the suspected sample by using a strip test assay. At the end of the test, certain markings will indicate whether human blood was detected or if the test failed.

  - Precautions: This test should be evaluated exactly 10 minutes after the addition of the sample. An appropriate sample size and dilution of the sample must be used. Kits should be stored at room temperature and buffers should be stored at 4 C.

- **ABAcard HemaTrace test strips**

  - How it works: HemaTrace test strips are used to detect blood by indentifying the presence of human hemoglobin. The test strip contains an antihuman hemoglobin antibody. A blood sample is applied to the bottom of the test strip. If human hemoglobin is present, then a mobile antibody-antigen complex will be formed. This complex will then migrate through the test strip to a test window. This window will indicate if there is a positive result for human hemoglobin with a pink dye band.

SEMEN

Presumptive Tests

- **Acid Phosphatase Test**

  - Also known as the Walker Test or Brentamine spot test

- How it works: The male prostate gland produces and secrets into semen a high amount of the enzyme acid phosphatase (AP). In the presence of Alpha-Naphthyl acid phosphate and Brentamine Fast Blue, AP will produce a dark purple color in less than a minute.
- Precautions: The shade of purple color will depend on the activity of the enzyme, which can be negatively impacted by the age of the stain and the storage conditions. This test is highly presumptive because vaginal secretions and other bodily fluids contain detectable levels of this enzyme as well.

- Alternative Light Sources
  - How it works: Under specialized lights, semen will fluoresce due to the presence of molecules such as Flavin and Choline-conjugated proteins. This color will vary from blue to yellow depending on the light equipment used.
  - Precautions: This detection technique is highly presumptive because many molecules (natural and artificial) will fluoresce in a similar way as semen. Also, not all semen stains will fluoresce. Exposure to different environments, different types of fabrics, and different fabric treatments can affect this fluorescent activity.

- Prostate Specific Antigen
  - How it works: Test detects prostate specific antigen (PSA). PSA is produced in high amounts by male prostate gland.
  - Precautions: This antigen can also be found in very small amounts of fecal material and sweat. Studies also indicate that PSA can exist in female urine and breast milk. Caution is urged when interpreting positive PSA results which are not confirmed by actual presence of sperm.

Confirmatory Tests

- Christmas Tree Stain
  - How it works: Positive visual identification of sperm cells using a stain. Two main reagents are used consecutively to produce this distinctive stain: Picroindigocarmine stains the neck and tail portions of the sperm in green and blue, while the Nuclear Fast Red (AKA Kernechtrot) gives the sperm heads a read color and the tip of the heads a pink color.

- Precautions: Sperm cells deteriorate quickly after ejaculation. Sperm survival will depend on the surrounding environment and type of surface. The sperm tails are the most susceptible to damage and will break down first. Therefore, the analyst must be trained to make visual distinctions between sperm heads and other types of cells in the mix. Other cells will also stain red.

- **RSID Test for Semen**
  - How it works: Identifies the presence of the seminal vesicle-specific antigen, or semonogelin. This antigen is unique to human semen; therefore, there is no cross reactivity with other bodily fluids in males and females or with semen from other mammals. This test can also identify semen even if the stain was stored in less favorable conditions.

SALIVA

Presumptive Tests

- **Phadebas Test**
  - How it works: A chemical reagent called Phadebas is used to detect the enzymatic activity of the alpha-amylase enzyme, which is found in saliva.
  - Precautions: This enzyme is found in other organisms as well. Alpha-amylases from bacteria, fungi, or chimps are very similar in structure and function to that of the human alpha-amylase. Also, in humans, there are four variants of alpha-amylase, two of which are found in saliva, and the other two are secreted by the pancreas. This test is presumptive because it will give a positive result if the alpha-amylase enzyme from any organism is present.

Confirmatory Tests

- **Phadebas Test and RSID Test for Human Saliva**
  - How it works: The RSID Test for Human Saliva detects the alpha-amylase molecule itself, and specifically, the alpha-amylase from human saliva (in comparison to the testing for enzymatic activity as seen in the Phadebas test). Performing both of these tests is considered a confirmatory test.
  - Precautions: The RSID test has produced positive reactions in samples containing alpha-amylases from mammals such as gorillas and rats. Positive reactions were also noted in other bodily fluids, such as semen, blood, vaginal discharge, sweat, and breast milk. High reactivity of this test is observed in samples containing human feces. Reactivity was also

noticed in urine samples. Improper swabbing and other factors relating to personal hygiene, personal behavior, and indirect saliva transfer from mouth to surface can result in “false” positives.

c. IMPRESSION AND PATTERN EVIDENCE

One of the most common forms of evidence investigators may detect and collect at a crime scene is impression and pattern evidence.

Impression evidence is created when two objects come in contact with enough force to cause an "impression." Typically impression evidence is either two-dimensional — such as a fingerprint — or three-dimensional — such as the marks on a bullet caused by the barrel of a firearm.

Pattern evidence may be additional identifiable information found within an impression. For example, an examiner will compare shoeprint evidence with several shoe-sole patterns to identify a particular brand, model or size. If a shoe is recovered from a suspect that matches this initial pattern, the forensic examiner can look for unique characteristics that are common between the shoe and the shoeprint, such as tread wear, cuts or nicks.

Footwear & Tire Track Examination

Footwear and tire tracks can be deposited on almost any surface, from paper to the human body. Prints are divided into three types: visible, plastic and latent.

A **visible** print is a transfer of material from the shoe or tire to the surface. This type can be seen by the naked eye without additional aids. For example, bloody shoe prints left on flooring or tracks left by muddy tires on a driveway.

Bloody shoeprints are visible on tile flooring. (Courtesy of John Black, Ron Smith & Associates)

A **plastic** print is a three-dimensional impression left on a soft surface. This includes shoe or tire tracks left in sand, mud or snow.

Plastic shoeprint left in sand. (Courtesy of Aubrey Askins, Tacoma Police Department)

A **latent** print is one that is not readily visible to the naked eye. This type is created through static charges between the sole or tread and the surface. Examiners or investigators use powders, chemicals or alternate light sources to find these prints. Examples include shoeprints detected on a tile or hardwood floor, window sill, or metal counter, or tire tracks detected on road surfaces, driveways or sidewalks.

Dust impression left on a masonite surface, illuminated with oblique lighting. (Courtesy of Scott Campbell, Ron Smith & Associates)

How Samples are Collected

Examiners use several methods for collecting footwear and tire track evidence depending on the type of impression found. For impressions in soil, snow or other soft surfaces, casting is the most commonly used collection method. For imprints, examiners generally try to collect the entire object containing the imprint, such as a whole sheet of paper or cardboard with a shoe print. When that is not possible, for instance, if the print is on a bank counter, the examiner would use a lifting technique to transfer the imprint to a medium that can be sent to the laboratory.

Casts are created of footwear impressions to preserve them and allow for comparison and analysis. (Courtesy of NFSTC)

As with any evidence found at a crime scene, shoeprints and tire tracks must be properly documented, collected and preserved in order to maintain the integrity of the evidence. Impression evidence is easily damaged, so steps must be taken to avoid damage to the evidence. This includes securing and documenting the scene prior to collecting any evidence.

In the case of impression evidence, general photographs of the evidence location in relation to the rest of the scene are taken, along with high-resolution images of the individual imprints or impressions. Examiners may use alternate light sources or chemical enhancers to capture as much detail as possible, especially with latent imprints.

Properly photographing impressions is crucial. Since there is only a slight difference between different shoe sizes, if the photographs are not taken at a 90° angle to the impression, then the true size cannot be produced in order to compare to the actual shoe.

Whenever possible, impression evidence is collected as is and submitted to the laboratory for examination. For shoeprints and tire tracks that cannot be picked up, various lifting techniques are used to recover the evidence. These include:

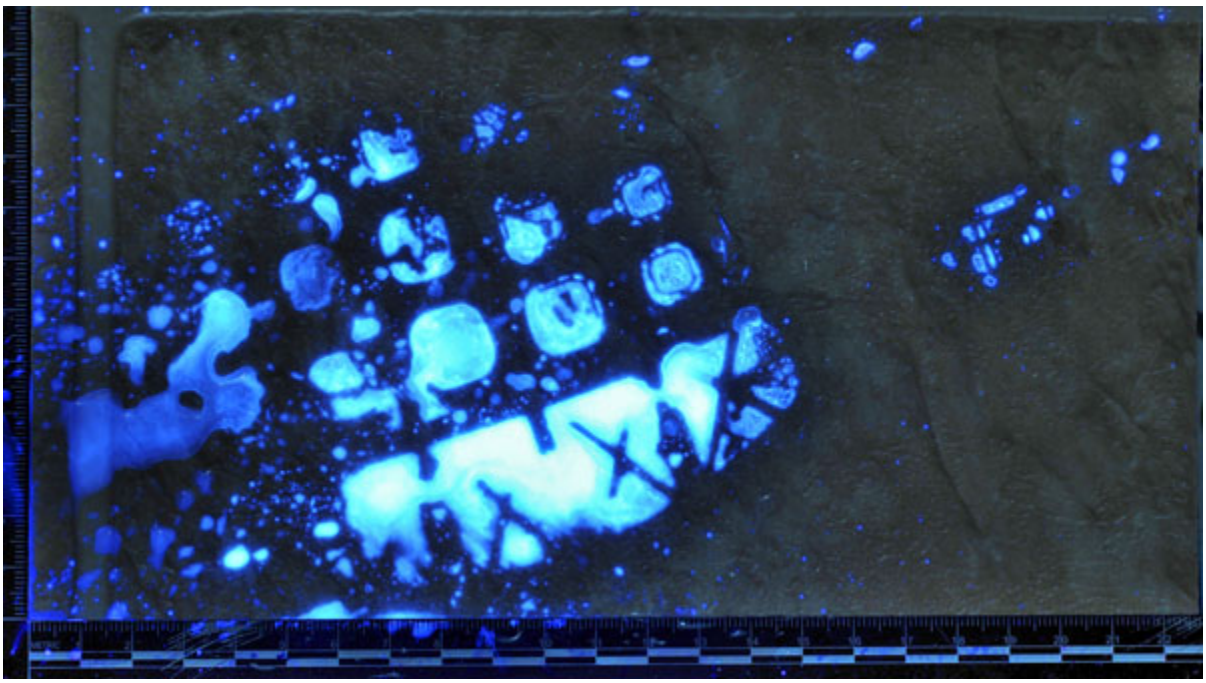
• **Adhesive lifter** - a heavy coating of adhesive lifts the imprint from smooth, non-delicate surfaces such as tile or hardwood floors, metal counters, etc. It is usually used in conjunction with fingerprint powders.

• **Gelatin lifter** - a sheet of rubber with a low-adhesive gelatin layer on one side that can lift prints from almost any surface, including porous, rough, curved and textured surfaces. It is less tacky and more flexible than an adhesive lifter, allowing it to pick up a dusty shoeprint on a cardboard box, for example, but not tear the surface of the box.

• **Electrostatic dust-print lifting device** - a tool that electrostatically charges particles within dust or light soil, which are then attracted and bonded to a lifting film. This method is best for collecting dry or dusty residue impressions on almost any surface, even the skin of a cadaver.

Any plastic, or three-dimensional, footwear or tire impressions can be collected by casting. Casting uses a powdered stone material, such as dental stone, that can be mixed with water and poured into the impression. When it dries, this method creates a three-dimensional model of the impression.

Imprints and impressions may be further processed to enhance or bring out additional minute details. For example, a digital enhancement program such as Adobe Photoshop® can be used to improve the quality of a photographed tire track. Fingerprint powders and chemical stains or dyes can enhance image color or increase the contrast against the background. This enables lifted or casted evidence to be photographed or scanned.



A faint bloody shoe print on linoleum is enhanced by treatment with a chemical, BLUESTAR®, to allow a more detailed photograph to be taken of the evidence. (Courtesy of Erik Savicke, Boston PD)

Comparison samples are usually taken from suspects or suspect vehicles. Shoe

samples should be packaged to avoid cross-contamination and tire samples should remain on the vehicle.

A reference print from a tire is captured by inking the tire and driving over paper. (Courtesy of John Black, Ron Smith & Associates)

TOOL MARK EVIDENCE

Tool marks are the impressions left by a tool on coming in contact with a surface. These tool marks show different types of characteristics depending on the type of impression, its shape and how the mark was created. Depending upon the force with which the marks have been put, the tool marks are divided into different categories. The examination of tool marks is an important factor in the field of criminalistics as it can directly establish the link between a tool mark and the tool that created it. These impressions also help to reconstruct the crime scene.

A tool is a hard object which when forcefully comes into contact with another object, leaves a mark on the softer one like a screw driver, plier or an arcjoint plier , hammer and wire cutters etc. A tool mark is defined as an impression left by a tool when it comes into contact with a surface. If the tool contacts the surface with a large force, it leaves behind an indentation and the pattern of the tool is permanently reproduced on the surface. These marks play a very vital role in forensic science as the criminals have a tendency to use tools for committing burglaries or other heinous crimes such as cold blooded murders. For example, if a burglar tries to enter a house by breaking the lock with the help of a screw driver, the marks left by the tool are a direct evidence of the presence of that tool at the crime scene. But, if the tool is found with a suspect or even near the suspect, it provides a direct link between the suspect and the crime scene. In the field of forensic science, the tool marks can either take the form of negative impressions or an abrasion or both.

Characteristics of tool marks

Tool marks have two different kinds of characteristics:

Class and Individual

Class characteristics:

These types of characteristics of a tool mark include the type of impression, its general shape and dimensions. These characteristics are typically the broad characteristics from which the crime investigator can determine what type of tool created the impression and how was it created. But, this does not serve the purpose of the identification of the exact tool that actually created the mark. Thus, if only the class characteristics would have been available, then it would not have been possible to distinguish which tool among a pack of similar tools made an impression. For this, individual characteristics are taken into consideration.

Individual characteristics:

Individual characteristics are microscopic characteristics, which refer to the small, peculiar features exhibited by the tool that are individual to one particular tool. These characteristics include small, microscopic ridges and irregularities present on the tool itself. For example, the tip of a screw driver is never exactly flat but has irregularities near its edge. These characteristics are created by the use and misuse of the tool, its cleaning and maintenance. These characteristics actually permit a formal identification. If such characteristics are available on a tool mark, then it is possible to identify the tool that was used in committing the crime, even among a series of identical tools.

Types of tool marks

Depending on the force with which a tool comes in contact with a softer surface, Tool marks are divided into two different categories. ·

Impressed tool marks:

These marks occur when the surface onto which the tool comes in contact with, is softer in comparison. When the tool comes in contact with the object (softer than the tool) with a huge force in a motion perpendicular to the plane of the surface leaving an impression on the surface, such tool marks are called impressed tool marks. There is no lateral motion. At the crime scene, the unique imperfections of the tools are transferred to the surface that make possible a positive identification of the tool involved in the crime. As an example, when a tool like a screw driver is used by the criminal to forcefully intend a metal surface without penetrating, then the impressions it leave will be helpful in identifying the tool.

Examination and matching of tool marks:

Examination and comparison of the tool marks from a crime scene with the tool marks

of the actual suspect tool can act as an important ad invaluable evidence in linking the suspect to a particular crime and thus the case can be concluded.

The major precautions that are to be taken while examining the tool marks: ·

- Door and windows and other openings with handles or locks at the crime scene should not be touched if they are broken or the locks are cut, lest the tool marks or the finger prints are destroyed. ·
- A tool should not be fitted forcibly into the impression which may affect the laboratory analysis.
- The tool marks should be documented completely including sketches and photographs before removing.
- If any trace evidence is found on the tool marks, the examination of the trace evidence should be done prior to tool marks examination.
- Tool marks evidence should be packaged so that it is not damaged as it may change the microscopic characteristics.
- If the tools are stained with blood or some other biological material, then that has to be cleaned using a soft bristle brush and disinfectants like Terg-A-Zyme, ethanol etc.
- The tools are always cleaned with a cotton tipped swabs saturated with ethanol or acetone.

The tool mark examination and matching consists of different phases:

- The first step is to observe some physical features of the tool :
  - Manufacturer
  - Type of tool
  - Composition and color
  - Condition of tool's finish
  - Dimensions of the tool (overall length, width etc)
  - Any irregularity at the ends of the tool

- The next step is to observe the physical features of the tool marks:

- ➤ The type of the tool mark
- ➤ Width or diameter of the tool mark
- ➤ Type of cutting motion by the tool
- ➤ Direction of motion of the tool that created the tool mark
- ➤ Position of the tool mark on the tool

- A photograph of the impression made by the tool is taken which provides a permanent record of some of the characteristics of the tool mark.
- If the carrier or the object where the tool mark is located, cannot be collected as an evidence then a cast of the tool mark is made with a dental paste.
- After discovering the tool, if its class characteristics match with those exhibited by the tool mark under consideration, then the comparison process is started.
- The tool is observed and a photograph is taken and then the comparison tool marks are made of a softer surface.
- The comparison is then done between the comparison tool marks and the tool marks under investigation using a comparison microscope which consists of two microscopes connected with each other with which two objects can be viewed simultaneously with the same degree of magnification or a stereomicroscope.
- If a match exists then the common origin between the two tool marks is established which then leads to a conclusive report of the case.

BITE MARKS

Bite mark is defined as a mark caused by the teeth either alone or in combination with other parts of the mouth. It might be viewed as an identical representation of the arrangement and characteristics of dentition. Bite marks are either left on the victim, on the culprit or an inanimate object found at the crime location.
The pattern in a bite mark is unique, like fingerprints, radiographs, and DNA. Teeth are often used as a weapon in mortal combat circumstances such as life and death struggles between attackers and victim. The teeth may be the only defensive method available for a victim to inflict serious harm on an attacker. The pattern of bite-mark can be present, depending on the circumstances, in foodstuffs, other objects, or on an attack or homicide victim itself. It is also well known that sexual assailants, including sexual assassination, rape, and child sex abuse, often bite their victims to express domination, fury, and animalized conduct. The teeth are an essential part of our natural arsenal. When violent abuse involves the use of teeth as a weapon, the morphological and anatomical features of bite marks may be useful to identify the victim.

Comparisons of bite-marks include dental arch size and shape, tooth positions and individual dental characteristics. The sizes, shapes, and patterns in the upper and lower dental arches and the biting edges of the anterior teeth are considered unique to that individual. The main reason for this is the sequence of anterior and posterior teeth eruptions. The resulting dental configuration creates a pattern that is identifiable compared to similar patterns in bitten objects, which determines the likelihood of a particular person leaving their "calling card." These include human skin, clothing, envelopes, gum, telephone receivers, and food. Human bite-marks are most common in the victim's skin and may be present nearly every part of the human body. In sexual attacks, women are bitten in their breasts and legs, whereas bites on their arms and shoulders are most common in males. Arms and hands often receive bites when the arms are held up to prevent an assaulter from attacking as a defensive mechanism.
Teeth injuries can range from bruises to scrapes and cuts or lacerations. It is certainly possible to produce enough force to allow the biting edges of the teeth to penetrate the deep skin layers. When a lot of time from injury to discovery elapses, the diffuse nature of the contusions and changes associated with injuries may further reduce the evidence; this is especially true in the case of living bite victims but also for the deceased.
Non-human bite injuries can sometimes present on victims. The differences in aligning and the specific morphology of the teeth commonly distinguish animal bites from human bite lesions. Animal bites often lead to skin laceration, shear injuries and open wounds, instead of impact injuries. Dog bites characteristically demonstrate a narrow anterior dental arch and consist of deep tooth wounds over a small area, and perhaps it is the most common nonhuman bite. During violent biting, a dog (or other carnivorous mammals) is more likely than a human to cause human tissue avulsion. Cat bites are small and round with sharp cuspid-tooth impressions resulting from the teeth's conical shape.

Bite mark analysis is a forensic technique used to identify and analyze bite marks found on various surfaces, typically on human skin. This field of forensic odontology plays a crucial role in criminal investigations and legal proceedings by attempting to link a bite mark to a specific individual. However, it's important to note that the reliability and accuracy of bite mark analysis have been a subject of controversy and debate in recent years. This article will discuss the methods and techniques commonly used in bite mark analysis for forensic purposes.

Documentation and Photography: The first step in bite mark analysis is the careful documentation of the bite mark. Forensic experts use specialized photography techniques to capture high-quality images of the bite mark, which may include close-ups and wide-angle shots. These images help preserve the initial state of the bite mark and can be used for comparison and analysis later.
Impression Materials: In some cases, when bite marks are on softer surfaces like skin, forensic experts may use impression materials to create a physical mold or cast of the bite mark. Common impression materials include dental stone, silicone, or alginate. These molds provide a three-dimensional representation of the bite mark, making it easier to study and compare with dental records.
Dental Records: Dental records are an essential component of bite mark analysis. They

include dental X-rays, photographs, and dental charts that detail an individual's dental anatomy, such as the arrangement of teeth, dental work (fillings, crowns, etc.), and any unique features. These records serve as a reference point for comparing the bite mark with the potential suspect's dental characteristics.

Comparison and Analysis: Forensic odontologists, who are specially trained dentists, examine the bite mark and the dental records to identify similarities or discrepancies. They look for patterns and characteristics such as the shape and arrangement of teeth, the size and spacing of teeth, and any unique dental features like chipped or missing teeth. This comparison is a critical aspect of bite mark analysis.

Bite Mark Collection: In cases where bite mark evidence is found on items other than human skin, such as clothing or objects, forensic experts may collect and preserve these items as evidence. These objects can undergo various forensic examinations, including DNA analysis, to identify the potential suspect.

Computerized Bite Mark Analysis: In recent years, technology has played an increasingly important role in bite mark analysis. Computer software can assist forensic experts in creating digital overlays of bite marks and dental records for more precise comparisons. This technology aims to enhance the objectivity and accuracy of bite mark analysis.

Bite Mark Databases: Some forensic agencies maintain databases of bite marks and dental records, allowing for comparisons across a broader range of cases. These databases can help identify potential suspects or link bite marks to previous crimes. However, the reliability of such databases can vary depending on the quality and quantity of the data.

Expert Testimony: Forensic odontologists are often called upon to provide expert testimony in court. They present their findings, explain the methodology used, and offer their opinions on whether a bite mark can be linked to a specific individual. Expert testimony can significantly impact the outcome of legal proceedings.

In conclusion, bite mark analysis is a forensic technique used to identify and analyze bite marks for investigative and legal purposes. It involves documentation, photography, comparison with dental records, and expert testimony. While it has been a valuable tool in some criminal investigations, its reliability has come under scrutiny in recent years, prompting calls for more research and the incorporation of other forensic methods, such as DNA analysis, to ensure accuracy and fairness in the criminal justice system.

Documentation of Bite Mark Evidence

As the physical and biological evidence from the bite mark soon deteriorates, photographs provide the most reliable information, preservation, and require careful documentation. Photographs may be in black and white or color, with dimensions included in the pictures/photos. Other methods of documentation include the collection of saliva washings and suitable impressions.

More than 80% of the global population secrete certain specific ABO antigens in their saliva. The cellular contents of saliva have proven to be an appropriate source of genomic DNA, which can be an excellent aid to identify suspected abusers. The double swab technology is used as a protocol for the collection of saliva samples. First, the

surface contacts of the tongue and lips are washed using light pressures and circular movements by a cotton swab moistened with distilled water. Then, the remaining moisture left on the skin by the first swab is collected with a second dry swab. At room temperature, both swabs are thoroughly air-dried for at least 45 minutes before release for testing by legal authorities.
An additional technique for capturing bite mark evidence is the exact impression of the bitten surface to record any teething irregularities, such as cuts, abrasions, etc. Polyether impression material, vinyl polysiloxane, is commonly used to record impressions. The impression material can be rigidly supported with dental acrylic or plaster; this permits accurate recording of the skin's curvature.
Forensic odontologists also use advanced techniques to improve photographic evidence. These advanced techniques include electron microscopy scanning (SEM), videotape analysis, and enhancement of computerized images.

Collection of Bite Mark Evidences

1. *Collection of Bite Marks from Victims*

It is assumed that the evidence gathered from the bite mark victims will be done with authorization from the appropriate authorities. It should first be determined whether the bite mark has been affected by washing, contamination, lividity, decomposition, change of position etc. all the observation should be recorded carefully.

– Photography

- Orientation and close-up photographs of the area should be taken o Photographic resolution should be of high quality o Accuracy of color balance should be assured in case using color films.

- Photographs of marks should be taken with and without a scale in place o When a scale is used, it should be on the same plane and adjacent to the bite mark

- In case of living victim, it may be useful to obtain serial photographs of the bite marks

- Salivary swabbing

- Whenever possible, salivary trace evidence should be collected according to the recommendations of the testing laboratory.

- Impressions

- Impressions should be taken of the surface of the bite mark whenever it appears that this may provide useful information

- The impression ingredients used should meet American Dental Association Specifications and should be mentioned by name in the report.

2. Collections of Bite Marks from Suspects

Before collecting evidence from the suspect, the odontologists should ascertain that the necessary search warrant, court order or legal consent has been obtained and should make a copy of this document a part of his records.

- History

- History of any dental treatment subsequent to or in proximity to, the date of the bite mark is obtained.

- Photography

- To the extent possible, good quality extra oral photographs both full face and profile should be taken. Intraoral photographs preferably would include frontal view, two lateral views, occlusal (Π) view of each arch and any additional photograph that may provide useful information. In case, inanimate materials, such as foodstuffs are used for test bites the results should be preserved photographically.

- Impressions

- Whenever feasible, at least two impressions should be taken of each arch, using materials that meet appropriate American Dental Association specifications and are prepared according to the manufacturer's recommendations, using accepted dental impression techniques.

FIBER

Fibers are threadlike elements from fabric or other materials such as carpet. Most are easily identifiable under a microscope. Fibers fall into three classifications: natural (animal or plant fibers like wool, cotton or silk), synthetic (completely manmade products including polyester and nylon) and manufactured (containing natural materials that are reorganized to create fibers such as rayon).
Fibers are useful in crime scene investigation because their origins can be identified. A carpet fiber on a person's shoe can indicate the individual's presence at a crime scene. However, fibers are very mobile and can become airborne, get brushed off or fall from clothing. This mobility makes timely collection crucial to prevent loss of material or cross-contamination.
Collection: Fibers cling to other fibers and hair, but may be easily brushed off. When approaching a scene, investigators will attempt to pinpoint the most probable locations for deposited fibers. For example, the carpeting under and surrounding a victim's body, clothing from the victim or a suspected weapon are likely places to find fibers.
Common collection methods include individual fiber collection using tweezers or vacuuming an area and sorting the materials at the laboratory. Trace evidence can also

be gathered by tape lifting, however, this is not ideal due to the destructive nature of adhesives.
Samples that potentially contain fibers should be separately bagged to prevent cross-contamination.

FINGERPRINTS

Fingerprint is the visual reproduction of the ridge patterns and furrows present on the palmar surface of the human finger. The human skin on the palmar and plantar surface of hand and foot differs from the skin on the rest of the body in texture and appearance. The skin has creases that roughly run parallel to each other but frequently change direction forming clearly defined patterns, minutiae, furrows and are completely devoid of any hairs.

There are three fundamental principles of fingerprints:

- Fingerprints are unique i.e. no two persons can have exactly the same or identical fingerprint.
- Fingerprints can be systematically classified due to definite ridge patterns or characteristics.
- Fingerprints remain permanent and do not change throughout the lifetime of an individual.

Identification on the basis of fingerprints is performed by analysing pattern types of fingers and ridge characteristics. According to the classification reported by Henry in 1900, there are four basic group of patterns recognized in fingerprints:

- *Arches*: in which the ridges run from one side to the other with lower peaks at the center.

- *Loops:* the ridges start from one side, move towards the center, curve backwards forming a hairpin and terminate on the same side. There are two fixed points in the loop pattern – the delta and the core. Loops are further classified into ulnar loop (if the curve of loop opens at the ulnar bone or little finger) or radial loop (if the curve of loop opens towards the radial bone or at the thumb).
- Whorl: These are circular or spiral arrangements of the ridges in the center. There are two deltas and one core in all whorls.
- Composite: This pattern comprises a combination of two or more of the preceding patterns such as central pocket loop, lateral pocket loop, twinned loop and accidental whorl.

According to Galton (1892), ridge characteristics may be defined as any variation from the run of the ridge as a special ridge characteristic or minutiae. For example, a ridge may end suddenly or a single ridge may divide into two ridges. Every single fingerprint has many such ridge minutiae which are distinct in their relative position, direction and

orientation with respect to the delta and the core and by comparing the ridge detail in two impressions, identity can be established as combination of such minutiae does not occur at exactly same place and in same number in any two fingerprints from two different persons in the world. Different countries follow different standards for matching ridge characteristics. In India, it is between 8-12 matching points for possible conviction and the identification became firmly established on the principles of analysis, comparison, evaluation and verification (ACE-V) of friction ridge skin.

FOOTPRINTS

The foot is considered as one of the anatomical regions that may demonstrate a high degree of individuality (Robbins, 1985; Kennedy, 1996). Identification can be established from the chance of footprints or impressions left on the foot wear or on the ground surfaces for example while stepping in the soil or in blood in the vicinity of the place of occurrence of the crime, etc.

The features of the foot print such as its shape, size, angulations, depth, interspaces of toes, ball lines, inner and outer margins, heel creases, any callosities or wounds or any accidental scars and damage provide information regarding the height of the person, length of the leg, range of body weight, gait pattern that are individualistic to that particular individual (Modi, 1977).
Dr Norman Gunn, a Canadian podiatrist, in 1972 first reported a case of identification from a foot print found on the shore of a Canadian lake and he also devised a method of comparison to demonstrate the points of individuality. Since then, there have been reports that podiatrists are involved in criminal case work such as in Australia and in New Zealand and also attempts have been taking place to develop a research database of human footprints to demonstrate the uniqueness of the human foot.
Foot identification could be especially useful in disaster situations as the foot is at an advantage over other anatomical regions through the protection offered by the encasing shoe (Smith, 1997; Robling and Ubelaker, 1997). Stature, one of the biological indicators of identification, has been shown successfully correlated with foot measurement from bare foot print impression (Kanchan et al., 2008; Sen and Ghosh, 2008; Sen et al., 2011; Hemy et al., 2013). Identification through foot print can also be performed with automated technologies with scanned images of known feet which will improve accuracy and eliminate human error.

DNA

Forensic DNA (Deoxyribonucleic acid) analysis

DNA is a chemical code which determines all the genetic attributes of a person. It is known that DNA is unique for all individuals except identical twins. Forensic DNA analysis revolves around this property of DNA. Moreover DNA can be obtained from biological samples such as blood, saliva, hair etc found at crime scene. This can be used to examine relationship between two individuals and to verify identity of deceased

person.

DNA is a double helix structure which consists of deoxyribose sugar and phosphate backbone held together by cross links based on complementary base paring between bases (Adenine pairs with thymine and guanine pairs with cytosine).

Forensic DNA analysis involves use of DNA marker obtained from biological sample found at crime scene. DNA database have been compiled by legal authorities of various countries which list abundance of a particular fragment of DNA in the population. From this information, comparison of DNA marker obtained from crime scene (either suspects or victims) with DNA marker of known suspect can be made to reveal identity of suspect. Statistical interpretations are required to estimate the thus likelihood that material obtained from crime scene belongs to particular individual aiding in individual identification.

Therefore, forensic DNA analysis aids in identification of perpetrators especially involved in crimes such as gang rape cases, disaster victims. It also plays a crucial role in paternity testing.

DNA profiling

DNA profiling basically refers to sequencing of an individual's DNA. Also known as DNA typing, it is a revolutionary technique utilized by forensic scientist for individual identification based on their DNA characteristics. It is different from full genome sequencing. DNA profiles are generated from biological material found at crime scene. DNA profile can be generated by techniques which basically utilize repetitive sequences which are highly variable such as Short Tandem Repeats (STRs).

When the DNA profile of a reference sample found at the scene of crime matches with DNA profile of a known suspect included in national forensic DNA databases, then the suspected DNA profile is termed as an "inclusion" and if DNA profile of suspect does not match profile obtained from biological sample found at crime scene then it is termed as "exclusion".

This use of DNA for identification is referred to as "DNA profiling".

Individualization

When the two samples i.e. an evidence item and reference item belong to common source of origin, then evidence item is said to have been individualized & the process is called as individualization.

It is important to differentiate between class characteristics and individualizing characteristics. Class characteristics are developed as a result of controlled process

while individualizing traits are not created by controlled process but are result of random actions.

Fingerprint of two individuals are not identical, this is true even for uniovular twins. Thus matching of latent print found at crime scene with “reference print” stored in computer database provides a means of identification of perpetrator with reduced chances of error. Similarly if DNA profiles developed from biological material, match with DNA profile of known suspects accurately, this is termed as inclusion. Mutations give rise to genetic variability in DNA and hence no two individuals have identical DNA configurations.

Therefore individualization is based on characterization of those individuals which are so rare that cannot be duplicated by chance alone.

FORENSIC ANTHROPOLOGY

Generally speaking forensic anthropology is the examination of human skeletal remains for law enforcement agencies to help with the recovery of human remains, determine the identity of unidentified human remains, interpret trauma, and estimate time since death.

Further definition of the term is necessary to understand the scope and basis of forensic anthropology. Anthropology alone is the study of man. Anthropologists are interested in culture (cultural anthropologists), language (linguistic anthropologists), the physical remains or artifacts left behind by human occupation (archaeologists), and human remains (physical anthropologists).

Forensic anthropologists are commonly portrayed in the media as forensic scientists and/or crime scene technicians, but this is not accurate.

Over the past century, physical anthropologists have developed methods to evaluate bones to understand people who lived in the past. Such questions might include: Was this individual male or female? How old were they when they died? How tall were they? Were the people in good or poor general health?

Forensic anthropology involves the application of these same methods to modern cases of unidentified human remains. Through the established methods, a forensic anthropologist can aid law enforcement in establishing a profile of the unidentified remains. The profile includes sex, age, ancestry, height, length of time since death, and sometimes the evaluation of trauma observed on bones.

In many cases after identity of an individual is made, the forensic anthropologist is called to testify in court regarding the identity of the remains and/or the trauma or wounds present on the remains.