Certificate Course In QD & Finger Print Analysis — **Paper-II**

UNIT NO. I

Department of Distance Education
Punjabi University, Patiala

Lesson Nos.

INTRODUCTION TO FORENSIC SCIENCE AND ITS LAWS

Overview:

- **Definitions**
- **Nature and Scope of forensic science**
- **Functions**
- **Principles**
- **Problem of proof**
- **Suggested Questions**
- **References and Suggested Books**

The word Forensic owes its origin to Latin word 'Forensis' which signifies belonging to court of justice or is any aspect of science, which relates it to the law. Typically, it is just about any area of science, which could be called into question in the court of law. Forensic means FORUM i.e. 'the public place' or 'market-place' of a city which provides an opportunity for conducting debate or to give sympathetic hearing to anyone's case. It originated when a need to identify and compare the physical evidence was felt and certain scientists develop the required principles and techniques for the purpose. Then a need was felt to develop a coherent system that could be practically applicable to criminal justice system.

Popular fictional character *Sherlock Homes* coined by Sir Arthur Covan Doyle was, perhaps; the first person who introduced scientific crime detection methods to its readers. Doyle described methods of detection much before they were discovered and implemented by the scientists in real life. He used principles of serology, fingerprinting, firearm identification, and questioned document examination in his fiction.

Definition

Broadly speaking, Forensic Science is the application of science to law. In order to realize the concept of 'society', a 'law' was needed to be reinforced by developing and applying the knowledge and technology of a science. Forensic Science gradually developed and fulfilled the requirement.

Presently, it is fast developing into a technology, which is strongly backing up the legal system to impart justice (through its various disciplines). It may be defined as the *application* of scientific methods and techniques for the purposes of justice. It has emerged as a significant element in effort to control crime while maintaining a high quality of justice and the law enforcement officials have started becoming dependent on the laboratory results.

The Forensic expert has to perform two important functions:

Scientific - The forensic scientist has to play a scientific function i.e. to collect, to analyze and to evaluate the physical evidence.

***Forensic* except :** The forensic scientist has to perform forensic function i.e. to interpret the results of scientific investigation to form an expert opinion, and communicating that opinion in layman's terms (i.e. in simplest possible language without using many technical terms) both in the form of written statements and oral presentations to the court of law.

A strong relationship exists between the crime-scene investigators and laboratory examiners for collection, preservation, packaging and analysis of evidences. The expert's role is essentially one of impartiality and the main directive is to assist the court in arriving at the truth.

As science and technology continue to advance, the capabilities and importance of Forensic Science Laboratories also continues to grow. At present, almost all the states have their own such laboratories and others are in the process of establishment. The existing laboratories are vying to improve further.

2. Nature and Scope of Forensic Science

Forensic science draws upon the principles and methods of all the traditional sciences, such as biology, physics, and chemistry. But in last few years, it has developed its own branches and disciplines like fingerprints, anthropometry, crime scene investigation, track marks, questioned document examination and forensic ballistics. These are exclusive fields of Forensic Science. Recently significant advances have been made in the field of serology, voice analysis, brain fingerprinting, criminal profiling and narco analysis test etc.

The term *forensic science* is sometimes used as a synonym for *criminalistics.* Both terms cover a diverse range of activities. Forensic science, in a broader sense, includes forensic medicine, odontology; anthropology; psychiatry; toxicology; questioned documents examination, and firearm, tool mark, and fingerprint examinations, as well as criminalistics.

The major specialty areas included in the wider definition of forensic science are discussed briefly as under:

a. Criminalistics is mainly concerned with the recognition, identification, individualization, and evaluation of physical evidence using the methods and techniques of the natural sciences in issues of legal significance. It includes examination of trace-evidence like glass, soil, fibers, hairs, blood, and physiological fluids and the reconstruction of events based on physical evidence and its analysis. Different forensic scientists define the scope of the field differently. Some include firearm and toolmark examination and questioned documents as a part of criminalistics. Despite the implications of the name, criminalistics activities are not limited to criminal matters. They are used in civil law cases and in regulatory matters also. People who are engaged in criminalistics as a profession are called *criminalists.*

Criminalistics also includes arson accelerant and explosive residues, drug identification and the interpretation of different patterns and imprints. It is the broadest of the subdivisions of forensic science.

b. ***Forensic Medicine*** (legal medicine; medical jurisprudence) is the application of medicine and medical science to legal problems. Practitioners of forensic medicine are doctors of medicine with specialty certification in pathology and forensic pathology. Most of them are medical examiners. They are concerned with determining the cause and circumstances in cases of questioned death. They have to deal with matters relating to death due to injury, accidental death, homicidal or suicidal death pertaining to insurance claims, and sometimes in cases of medical malpractice.

c. ***Forensic Odontology*** *also known as* forensic dentistry is the application of dentistry to solve human identification problems. Forensic odontologists are dentists who specialize in the forensic aspects of their field. They are concerned with the identification of persons based upon their dentition, usually in cases of unrecognizable bodies or in mass disasters. They also analyze and compare bitemark evidence in several types of cases.

d. ***Forensic Anthropology*** is related with personal identification based on bodily (particularly skeletal) remains and its practitioners are known as physical anthropologists, who are interested in forensic problems. Other areas of forensic anthropology include establishing databases on bodily structures as functions of sex, age, race, stature, and so forth. Interpretation of footprint or shoe-print evidence might also be included to estimate the height of perpetrator or suscept.

e. ***Forensic Toxicology*** has to do with the determination of toxic substances in human tissues and organs. Much of the work concerns the role of toxic agents that might have played a role in causing or contributing to the death of a person. He has to deal with qualitative and quantitative technique for identification of drugs or toxic substances which has caused the toxicity or death of an individual.

f. ***Questioned Documents examination*** includes comparisons and identification of handwriting, scripts that are mechanically produced i.e. typing, printing and photocopied material. Analysis of papers, inks, and other materials used to produce documents may also be included.

g. Firearm and Toolmark examination has to do with firearm identification, comparison of markings on bullets and other projectiles, cartridge cases, and shell cases, especially for the purpose of determining if a bullet has been fired from a particular weapon. **Toolmark** examinations are concerned with the association of particular impressions with particular tools.

h. Fingerprint examination is concerned with the classification of fingerprints and the organization of sets of prints into usable files. Development of latent prints and comparisons of known and unknown fingerprints are a part of the work as well.

Some forensic science activities can be classified under more than one of the major subdivisions above. Toolmark comparisons, for example, are sometimes considered as part of criminalistics and sometimes as part of the separate *firearms and tool marks* specialty. Similarly, hair comparison is usually considered a part of criminalistics, but it could just as well be considered a part of Forensic Biology. Any classification scheme for all the different activities is, therefore, somewhat arbitrary. No one person can be expert in all the sciences and their methods, and it is for this reason that forensic science contains *subspecialties*. The subspecialties develop around a particular type of physical evidence, or around a particular group of methods and procedures. Some forensic scientists are generalists. They have broad training and experience in most of the basic areas of criminalistics, can carry out a variety of different physical-evidence examinations knowledgeably or more importantly, refer specific aspects of a case to specialists.

The range of human activity is so diverse that almost anything can become *physical evidence* under one circumstance or another. In any civil, criminal, or regulatory matter, there can be physical evidence that, if recognized, properly handled, and knowledgeably interpreted, can contribute importantly to an understanding of the case.

3. Functions

In every forensic science investigation, the main function is to provide useful information to link the suspect and the victim with each other or with the scene of crime. Physical evidence analysis and interpretation can provide following types of information:

I. Information on the Corpus Delicti

The *corpus delicti* (literally, the "body of the crime") refers to those essential facts which show that a crime has taken place. Tool marks, broken doors or windows, ransacked rooms, and missing valuables are examples of physical evidence that would be important in establishing a burglary. Similarly, in an assault case, the victim's blood, a weapon, or torn clothing could be important pieces of physical evidence.

II. Information on the Modus Operandi

Many criminals or gangs have a particular *modus operandi* (or method of operation, MO), which consists of their characteristic way of committing a crime. Physical evidence can help in establishing an MO. In burglary cases, for example, the means used to gain entry, the tools used; types of items taken; and other telltale signs, such as urine left behind at the scene, are all important. In arson cases, the type of accelerant used and the way in which fires constitute physical evidence that helps to establish the patterns or "signature" of arsonist. Cases that have been treated separately can sometimes be connected by useful documentation of similar MO.

III. Linking a Suspect with a Victim

Physical evidence can help to establish final link between a suspect and a victim particularly in violent crime. Blood, hairs, clothing fibers, and cosmetics may be transferred from a victim to a perpetrator or vice-versa. A suspect can be found to be in possession of items, which may be linked to a victim, such as a comparison of bullets or an analysis of blood found on a knife. Trace evidence can also be transferred from a perpetrator to a victim or vice-versa. Clothing and other belongings of a suspect and a victim should be thoroughly searched for trace evidence.

IV. Linking a Person to a Crime Scene

This is another very common and significant linkage provided by physical-evidence analysis. Fingerprints, blood, semen, hairs, fibers, soil, bullets, cartridge cases, tool marks, footprints or shoe prints, tyre tracks, and objects that belonged to the criminal are examples of *deposited evidence.* Depending on the type of crime, various kinds of evidences from the 'scene' may be carried away. Stolen property is the most obvious example, but two way transfers of trace evidence can be used to link a suspect, a victim, or even a witness, to a crime scene.

V. Identification of a Suspect

One of the best evidence for identifying a suspect is a fingerprint. A fingerprint found at a scene, and later identified as belonging to a particular person, results in an unequivocal identification of that person. The term *identification* as used here really means "individualization". Although in common usage people often say "identification of a suspect" or "identification of a fingerprint," this is not strictly correct.

VI. Supporting or Disproving a Witness's Testimony

Physical evidence analysis can often indicate conclusively whether a person's version of a set of events is credible or not, e.g. a driver whose car matched the description of a hit-and-run vehicle. An examination of the car might reveal blood on the underside of the bumper. The driver explains the findings by claiming to have hit a dog. Tests on the blood can reveal whether the blood is from a dog or from a human.

VII. Providing Investigative Leads

Physical-evidence analysis can be helpful in directing an investigation along a productive path. In a hit-and-run case, for example, a chip of paint from the vehicle can be used to narrow down the number and kinds of different cars that may have been involved.

A substantial part of the work in a forensic analysis consists of making comparisons between *questioned* and *known* samples. Depending upon the degree of individuality exhibited by the samples, various conclusions can be drawn about the association between the people and the physical evidence in the case.

4. Principles

Laws and principles of all the natural sciences are the bases of forensic science however; during the course of development this science has developed its own principles. These are discussed as under:

a. The Locard's Exchange Principle

Also known as 'Contact exchanges traces', this principle was first enunciated by a French scientist Edmond Locard. It states that whenever there is contact between two surfaces, there will be a mutual exchange of matter across the contact boundary i.e. when a criminal or his instruments of crime comes in contact with the victim or the objects surrounding him, they exchange traces. It is virtually impossible for a criminal to commit a crime without leaving evidence behind and carrying away with him. Likewise, the criminal or his instruments pick up traces from same contact. If these traces are properly examined, these can establish a link between the suspect and the victim with each other or with the scene of crime.

This principle is amply demonstrated in hit and run cases and in offences against person. Tracks and trails (foot and footwear marks; tyre marks; chance finger prints, tool marks; dust; paint, and soils) are other manifestations of the same principle.

The basic requirement of the principle is the correct answer to the question 'What are the places or objects with which the criminal or his tools actually came in contact?' If the investigating officer is able to establish the points of contact he is likely to be benefited in the investigation. The most probable locations can be:

***Point of entry**:* If a criminal enters the premises through a ventilator, he leaves his footprints/fingerprints in dust on the sill.

At crime scene: while committing a crime, if he breaks a window or a door, the Jimmy (tool) leaves its mark on the wooden frame or the burglar, who opens safe by using an explosive or by any other mean, leaves the area around and the clothes (including shoes) covered with insulating material as well as some exploded and unexploded material.

Point of exit: after committing crime when a person leaves the crime scene, criminal is likely to leave and carry minute traces or his footprints at the point of exit. It is seldom that he dares or neglects to leave or carry gross objects or traces on a thorough search, (the inconspicuous traces will always be found in all types of crimes). The minute traces connect the crime and the criminals as effectively as the gross objects or traces.

b. Law of individuality

'Every object, natural or man-made, has an individuality which is not duplicated in any other object or

No two things in this universe are alike even they are manufactured in the same machine one after the other.

This principle, at first sight appears to be contrary to common beliefs and observations. The grains of sand or common salt, seeds of plants or twins look exactly alike. Similarly, man-made objects like coins of the same denomination manufactured in the mint, currency notes printed with the same printing blocks one after the other (excluding serial number) and typewriters of the same make, model and batch appear to be indistinguishable. Yet the individual characteristics are always there. There are small flaws in the materials, through mixing of raw material; fluctuation in electricity; wear and tear defects of the machine; in the arrangement of the crystals, imperfect stamping or due to inclusion of some extraneous matter. These individual characteristics can be useful in distinguishing intra and inter batch variations.

The most extensive work has been carried out in fingerprints. Millions of prints have been examined but no two fingerprints; even from two fingers of the same person have ever been found to be identical.

In a series of experiments carried out by the scientists on superimposition techniques for fingerprints, footprints, tool marks, die marks obtained from various parts of firearms, it was observed that with the best of efforts, exactly alike superimpositions even imprints from the same finger could not be produced. The fingerprints were taken one after the other, on the same paper with the same ink and by the same person; yet they failed to give perfect superimpositions. Imperfect inking, unequal pressure, slight differences in the text the surface of the paper or interferences from extraneous matter always introduced some differences.

The law of individuality has fundamental importance and make basis for forensic investigation. Anything and everything involved in a crime has individuality. If the same is established, it connects the crime and the criminal.

c. Law of progressive change

'Everything changes with the passage of time' the rate of change varies tremendously with different objects. It has immense impact on forensic science.

1. The criminals undergo progressive changes. If he is not apprehended in time, he becomes unrecognizable except perhaps through his fingerprints, bone fractures or any other characteristics of permanent nature, which may or may not be always available.
2. The scene of occurrence undergoes rapid changes. The weather, the vegetation growth, and the living beings (especially human-beings) make extensive changes in comparatively short periods (Longer the delay in examining the scene, greater will be the changes. After some time, the scene may become unrecognizable).
3. The evidences involved in crime change gradually like the firearm barrels loosen, metal objects rust, the shoes suffer additional wear and tear and the tools acquire new surface patterns. The degree of change depends upon the time, the upkeep and the use or the misuse of the particular object. In course of time the object may sometimes lose all practical identity vis-à-vis a particular crime.

The principle demands prompt action in criminal investigations.

d. Principle of Comparison

It states that 'only the likes can be compared'. It emphasizes the necessity of providing like samples and specimens for comparison with the questioned items. For example, in a murder case if a bullet is recovered from the deceased and the expert opines that the bullet has been fired from a high velocity firearm, then it becomes useless to send a shotgun or pistols or revolvers as the suspected firearm for comparison. Similarly, if a bunch of hair is recovered from the hands of a deceased and the expert opines that the hair belongs to a Negroid person, in such a case, hair from persons of white races for comparison will not be of any use. Another example can be if questioned document contain type written text, then there is no use in sending handwritten or printed specimens for comparison.

e. Principle of analysis

This principle states that the analysis can-be no better than the sample analysed. Improper sampling, contaminations render the best analysis useless. This principle emphasizes on the necessity to collect proper sample and properly packed for effective use of experts.

In a rape case, the investigating officer collects the clothes of the victim, which carry both blood, and semen stains. The investigating officer after properly drying the clothes packs them and sends them to forensic science laboratory. He wants to know if the clothes carry semen stains, if so, to which blood group does the secretor belong.

A criminal while running away from the crime scene brushes against a painted surface. Some powdered particles of paint get deposited upon his clothes. The investigating officer scraps a few grams of paint from the same surface with a penknife and sends it as control sample. The result of the analysis shows that the two paints do not match. Why?

A small amount of dust is recovered from a small sticky patch of the shoe of a culprit. The investigating officer collects about two kilograms of soil from the scene, packs it in a tin and sends it as control sample. The results of comparison are inconclusive. Why?

f. Law of probability

All identifications, definite or indefinite, are made, consciously or unconsciously, on the basis of probability.

'Probability' is mostly misunderstood. If we say that according to probability a particular fingerprint has come from the given source, the defense counsels make most of the word and plead that it is not a definite opinion. Consequently, it is not customary to talk of 'probability' or 'probability figures' in courts.

Probability is a mathematical concept, which 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 equal facility.

If P represents probability:

Ns the number of ways in which the event can successfully occur (with equal facility) and N_f the number of ways in which it can fail (with equal facility), the probability of success is given by the formula:

$$P = \frac{Ns}{N_s + N_f}.$$

If the event consists of two occurrences, which can take place independently, the probability of the second occurrence is also given by the same formula. If we denote probabilities of the first and second occurrences by attaching digits 1 and 2 to the relevant letters, the net probability (P,) are given by the formula:

$$Pt = P_1 X P_2 = \frac{N_{S1}}{N_{S1} + N_{f1}} X \frac{N_{S2}}{Ns_2 + N_{f2}}$$

5. PROBLEM OF PROOF

The question of proof in a criminal trial is becoming a difficult problem every day. It is related with *men, law and facts*. The behaviour of the *men* is habituated by their education, temperament, financial status, intelligence and their bias. The *law* varies from land to land and is composed of enactments, rulings, conventions and precedences. Changes in law are comparatively slow. The *facts* are proved or disproved by circumstances and physical evidence through witnesses. Witness may be eyewitness or they may be expert witness. The later base their findings on scientific observations. The evidence is scrutinized by counsels and evaluated by courts.

Oral Evidence

Reliance is placed on the accounts of eyewitness, though experience and experiments have repeatedly proved that sometimes they are unreliable.

Suggested Questions:

- What is forensic science?
- What is Criminalistics?
- Explain the scientific method.
- What is a hypothesis, and how is it related to a theory?
- What are the major specialty areas in forensic science and discuss their relevance to Forensic science?
- What are the ways in which forensic science differs from traditional sciences?
- Write major function of Forensic science?
- What kind of information about criminal acts and crimes can forensic science help to reveal?
- What kind of information about criminal acts and crimes can forensic science help to reveal?
- Discuss important Principles of Forensic Science and their significance.
- Explain in detail the Principles of Individuality with examples.
- Discuss major points from where the evidences can be collected.
- What is problem of proof?

- To what extent are forensic science and its findings and results used in criminal investigation and prosecution?
- What are some of the ways in which forensic science services to the justice system could be improved?

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SET UP OF FORENSIC SCIENCE LABORATORY

Overview:

Chapter-3

- **Forensic Science Laboratory set-up**
- **Suggested Questions**
- **References and Suggested Books**

Forensic Science Laboratory organization:

Laboratory organization and structure depends, to some extent, on the nature of the legal system and on the history of forensic science development in the country. In response to the rising demands of providing high technology to the crime investigation process, the forensic science laboratories were set up to achieve the following objectives:

1. Examination of crime related exhibits referred by Police, Judiciary, and other government departments and undertakings.
2. To provide knowledge about role of Forensic Science and its application to crime investigator, to police personnel; Judiciary officers and other related with it.
3. To provide scientific aids to investigation officers (I.Os) in scientific investigation of crime and to help in collecting evidences properly from scene of crime, its proper packing, sealing and forwarding to laboratory for examination.
4. To give training to personnel from police, and other forensic Institutions.
5. To give lectures on Forensic Science to trainees in various Police, Judicial and other related institutions.

An ideal Forensic Science Laboratories is generally divided into the following departments:

1. *Photography (Common for all the divisions)*
2. *Instrumental Analysis (Common for all the divisions)*
3. *Biological sciences*, which include
    - Biology unit
    - Serology unit
    - DNA unit
4. *Physical Sciences*, which include

- Physics unit
- Ballistics unit

5. *Chemical Sciences*, which include
   - Chemistry unit
   - Toxicology unit
   - Narcotics unit
   - Explosive unit
6. Medico-legal Division (Part of Forensic Medicine)
7. Documents Division
8. Fingerprint Division
9. Lie Detection including Brain Finger Printing and Narco Analysis Test
10. Voice Identification
11. Computer Forensics and Cyber Crime
12. Field Units or Mobile Laboratory

A director, who has scientific training and has spent a few years in a forensic science laboratory, heads the laboratory. In, comparatively bigger laboratories the director is assisted by an additional director (technical) and an administrative officer (non-technical).

The divisions are usually, headed by deputy director having several years' research experience. The head of the division is assisted by assistant director, senior and junior scientific officers, senior and junior scientific assistants, laboratory assistants and attendants. Non-technical staff carries out clerical work; maintenance of store, supplies and maintenance duties.

The laboratory is properly guarded against theft and loss of exhibits. There should be adequate storage space for incoming and outgoing case exhibits and should be kept in a separate room. Each police district should be given a separate storage rack so that the exhibits do not get misplaced or intermixed. The storekeeper handles only sealed packets of the exhibits.

Library

It is one of the most important parts of any forensic science laboratory. Besides having good subscriptions of national and international research journal, the library should have rich collection of the scientific (both related to basic sciences as well as of forensic science) books.

Forensic science literature has been on the increase during the past few years, so library must be well equipped with the internet facilities and well connected with other libraries of the world to keep up to date knowledge.

In addition to the above facilities, the reference works in chemistry, physics, biology, technology, and other disciplines should also be part of the library.

Forensic Museum

A well-equipped Museum should be established, which should have Medico legal models; different types of firearms (Classical and modern); cartridge cases; bullets; poisonous snakes and rare poisons. Useful charts on different aspects of forensic science should also be displayed.

Depending upon their analytical needs, the case exhibits are examined in one or more divisions of the laboratories. The natures of examinations that can be undertaken in different divisions are briefly enumerated below:

Instrumental Analysis Division:

The well-equipped centralized facilities should be available at every laboratory to examine the samples by using modern instrumental methods of analysis as per requirement of different divisions. In the present day world the laboratory should have latest sophisticated instruments like GC-MS, SEM, HPLC, Atomic Absorption Spectrophotometry and others mentioned in the previous chapter.

Photography Division

This is one of the most important centralized divisions of any forensic science laboratory, which plays important role in presenting, understanding and the authentication of the results of various divisions of the laboratories to the judges. This division also provides scientific support to all division in the examination of documents (including close-up, UV, IR photography and photomicrograph), different types of crime exhibits including murder weapons, holes in clothes, hairs, fibers, bones etc. Audio-Video and General Photography coverage of scenes of crime, close-up photography of fingerprints, bloodstains, foot prints, tire-marks, burnt subjects, scene of crime involving murders, burglary, theft, arson etc.

Biology Division:

Examination of the biological fluids like saliva, semen, sweat, urine, faecal matter etc.; histological examination of tissues of human/ animal origin; morphological examination of hair, wool, and fibers; examination of skeletal remains bones, teeth etc for determination of origin, age, sex, stature from bones etc.; examination of paper pulp; identification of plant portions such as seeds, leaf fragments, flowers, pollen grains, wood, bark, twigs etc examination, identification of minute vegetation forms e.g. diatoms and other micro organism, mould ,algae, fungi etc.

Identification of wildlife evidences like skin, meat and other body parts of the protected species of animal and plants.

Serology Division:

Chemical, Microscopical and spectroscopic examination for the detection of blood, serological examination of bloodstains and other biological stains for their origin and blood grouping in cases like murder, sexual offences (Rape/Sodomy), and of miscellaneous nature. Examination of Barr bodies for sex determination from bloodstains, Polymorphic enzyme of blood stains.

Examination of wildlife evidences like skin, meat and other body parts of the protected species of animal and plants for confirmation of species etc.

DNA Division

In this division, DNA Profile analysis of all types of biological samples (like blood, bloodstains, bones, semen, bones, tissue and wildlife evidences etc) is carried out. The laboratory should have storage facilities for biological samples, their processing and getting the output in an efficient way. The laboratory should be well equipped with all the necessary infrastructures required for the technology, which includes highly sensitive DNA sequencer, PCR machine, Ultra low temperature devices and Ultra pure water purification system.

Standardization, validation and up gradation of related technological processes should be integrated part of the laboratory.

Forensic Anthropology :

It is the branch of forensic science which mainly deals with examination and identification of human skeleton remains. Examination of bones may reveal their orgin, sex, approximate age, race and skeletal injuries. Forensic anthropologists are also helpful during the identification of victims of mass disaster such as plane crash, tsunami etc. In such cases, forensic anthropologist can help identify victims through the collection and analysis of bones and bone fragments

Physics Division:

In Physics division, different types of examinations of paint, glass, soil, lottery tickets, fibers, metallic pieces, threads and ropes, cloth pieces, struggle mark and cut marks on cloth, knot examination, examination of metallic seals, postal seals, and wax seals, deciphering of erased chassis and engine number of vehicles, registration plate of vehicles, examination of tool marks etc. is conducted. They should also carry out the examination of telephone and electric wire pieces recovered from the scene and perform contour matching of accidentally broken pieces for source correspondence; examination of broken glass pieces for the direction of impact etc., examination of counterfeit coins, trace elements analysis for the comparison and identification of exhibits etc.

Ballistics Division:

Examination of fire arms for their service ability and to find out whether they come under the preview of Arms Act, determination of probable type or make of firearms from fired bullets/ cartridges, wads/pellets etc. to determine whether two or more bullets/ cartridge cases have been fired from the same or different fire arms, to establish the linkage of a bullet/ cartridge case with a particular firearms; to examine P.M.R./Injury report / X-ray plate/ clothes with a view to determine probable type of firearm; examination of a firearm to detect evidence of firing, checking firearms against the possibility of accidental discharge, estimation of distance of firing, identification of bullet holes/ shooter by detecting fire arm discharge residues; general examination for the reconstruction of a scene of firing etc.

In some of the forensic science laboratories the materials related with explosion are examined in this division, but some of the laboratories have created an independent explosive division which is responsible for handling evidences related with explosion.

Chemistry Division:

Earlier it was a big division, but now a day in some of forensic science laboratories have separated Narcotic division as an independent division as number cases related NDPS act is increasing every day.

Presently the chemistry division examines petroleum products such as petrol, diesel, kerosene etc; examination of illicit liquors, varnish, paint, inflammable fluids and solids in suspected cases of arson; examination of alcoholic medicines etc; examination of dyes, inks, stains and other organic and inorganic chemicals.

Toxicology Division:

This division carries on examination of viscera, stomach wash, vomit, urine, faecal matter; and blood etc. for detection and estimation poisons of vegetable origin (Dhatura, oleander, opium, madar, aconite, nux vomica, etc.) inorganic salts (arsenic, copper sulphate, cyanides etc.) acids, drugs, alkaloids, pesticides ((DDT, BHC parathion, malathion, aldrin, zinc phosphide, aluminium phosphide, etc.). Examination of Alcohol (methyl & ethyl alcohol) and remaining (which are not mentioned above) poisons including powdered glass, etc. is also done.

Narcotic Division:

Examination of opium and its alkaloids, heroin, ganja, bhang, charas, and other narcotics and psychotropic substances are conducted.

Explosive Division:

Examination of explosive substances and its remnants and devices used and recovered after explosion; and examination of scenes of explosion.

Medico-legal Division:

Examination of wounds and injuries of the victim/suspects, to help experts in the Ballistics and Toxicology divisions in their work by providing them with relevant information and interpretation of post-mortem reports, and examination of Bones and Tissues for medico-legal, opinion. Such divisions are under the process of establishment. This division in actually not a part of forensic science Laboratories at state or centre level. It is a part of forensic medicine and is taken case by medico legal expects which are from the field of medicine i.e. doctors

Documents Division:

Comparison of questioned writing, typewriting, printed matter, signatures with the known standards to establish genuineness or forgery; examination of documents for physical and chemical erasures, alterations, additions, obliterations and secret writing, decipherment of indented writings; determination of relative age of the writings/ papers, examination of ink, paper and the charred documents etc. carried out.

Fingerprint Division:

Only a few forensic science laboratories have fingerprints division. Most of the states have their own Fingerprint Bureau, which provides service to the investigating agencies with reference to examination of questioned thumb impressions; chance prints/Latent prints recovered from crime scene. The fingerprints are classified according to single digit and ten digit classification system and compared with the earlier record present in the bureau or with the specimens provided by the police for the identification of culprit.

Lie Detection including Brain Finger Printing and Narco Analysis Test:

The Lie Detector division should rendered valuable polygraph aids in number of important investigations conducted by State Police, and other Investigating agencies. The Lie Detector division should maintain computerized polygraph equipments. Polygraph (Lie Detector) is based on the principles of psychosomatic interactions of an individual i.e. psychologically a change in a persons consciously held feelings produces a defense reaction in the form of physiological changes in blood pressure, pulse rate, respiration and electro-dermal response (GSR). The division has initiated action programme for induction of the state of the art technology and an Electro Encephalograph cum Event Related Potential System for Brain mapping analysis is being processed for its procurement for its application to study the memory related parameters in the scientific investigation of crime. Interrogation of suspected criminals and witnesses by *Polygraph* (Lie detector) and other new techniques like *Brain Fingerprinting* and *Narco analysis* *test are* used to find out the related information is present in the brain or not. These techniques are gaining popularity and are likely to become integral part of the forensic science laboratories.

Voice Identification Division:

In this division, the examination of voice recorded either from telephonic talk or any other device is conducted for Speaker Identification with the help of a very advanced version of computerized Voice Spectrograph namely Computerized Speech Lab.
Experiments are required to be conducted for Noise reduction/signal enhancement and Audio Tape Authentication.

Computer Forensics and Cyber Crime:

With the increasing number of cases related to computer forensics, it is desirable to establish a division related to it in every forensic science laboratory. Its main objectives are preservation, identification, extraction and documentation of computer evidence in various computer or internet related crimes forwarded to the laboratory. Computer Forensics involves the use of sophisticated tools and procedures. Using multiple software tools developed by separate and independent developers processes The accuracy of the result is of prime importance and therefore cross validation through the use of multiple tools and techniques should be standard protocols in any forensic science laboratory. Validation through the use of multiple software tools and procedures by the computer experts can eliminate the potential problem.

Field Unit/ Mobile Laboratory

The success of the analysis made in any forensic science laboratory fully depends upon the *proper* collection and preservation of important and relevant clue materials from the scenes of crime. In most of the cases, it may be possible to repeat the examination in the laboratory, but it is never possible to get relevant physical evidence from the scene of crime once it is disturbed. Keeping this in view, some of the forensic science laboratories have established Field Units at districts/ranges of the state depending upon the statistics of crime. Scientific staff posted in these assists the Investigating Officers in the scientific investigation of crime. In some of the Field Unit/ Mobile Laboratories, facilities for conducting some spot test are also provided.

The scientists of forensic science laboratory deliver lectures and practical demonstrations to the trainees of various organizations and students of the universities involve in teaching Forensic science as a subject.

The application of science to crime investigation is becoming popular with the law enforcement agencies day by day. It is clearly reflected in the increase of the number of cases referred to the forensic science laboratories during the previous years, which necessitates the opening of newer divisions or separating certain divisions from the existing divisions.

Suggested Questions:

- What are the objectives for setting of Forensic science Laboratory?
- What should be the location of any Forensic Science Laboratory?
- What are divisions necessary for any Forensic Science Laboratory?
- What is the relevance of library and museum in any Forensic Science Laboratory?
- What is the relevance of photographic and instrumentation division in any Forensic Science Laboratory?
- Discuss importance of newly added techniques like Brain Fingerprinting and Narco analysis test, how they are different then Lie Detector.
- What is the significance of Field Unit/ Mobile Laboratory?

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TOOLS AND TECHNIQUES IN FORENSIC SCIENCE

Overview:

- **Evidentiary Clues**
- **Tools and techniques**
- **Suggested Questions**
- **References and Suggested Books**

1. Evidentiary Clues

The evidences which are present at the crime scene are called Physical-evidence, analysis of which plays an important role in linking the criminal, victim and crime scene with each other. It is mainly concerned with the identification of traces of evidence, reconstruction of events from the physical-evidence record, and finally establishing a common origin of samples of evidence.

Two types of evidence might be very different in nature, for example, but the methods of analyzing them can have a great deal in common or may even be identical. Similarly, various types of patterns are analyzed and interpreted primarily as an aid to the reconstruction of events, although the patterns may have been produced by quite different events involving quite different materials.

During the examination or comparison of questioned and known samples, the following three outcomes are possible:

(1) They may match in all the properties used to compare them. In this case a common origin is possible (or, with a few kinds of evidence, like *jigsaw, physical fits* or fingerprints can be proven).

(2) They may not match at all. In this case, the possibility of common origin is excluded. Exclusions are unequivocal and provide unimpeachable evidence of non-association. Exclusionary findings can be most helpful in conducting further investigations.

(3) In some cases, the sample provided may not be sufficient to make a conclusive comparison. In such an instance, class characteristics of the samples would be noted, but a conclusion might not be reached about the possibility of a common origin.

The dimensions of a forensic science investigation may include any or all of three major activities in analyzing and interpreting the physical evidence:

(1) **Identification**

(2) **Individualization**

(3) **Reconstruction**

Identification is a process common to all the sciences and, in fact, to everyday life.

It may be regarded as a classification scheme, in which items are assigned to categories containing like items, and given names. Different items within a given category all have the same generic name. In this way, botanists identify plants by categorizing and naming them. Likewise, chemists identify chemical compounds. In forensic science, identification usually means the identification of items of physical evidence. Some types of physical evidences require that scientific tests be conducted to identify them. Drugs, arson accelerants, bloodstains, and seminal stains are examples. Objects are identified by comparing their *class characteristics* with those of known standards or previously established criteria. Class characteristics are the properties that all the members of a certain class of objects or substances produced in a single batch have in common.

Individualization is unique to forensic science and refers to the demonstration that a particular sample is unique, even among members of the same class or even manufactured in a batch (Intra batch variations). It may also refer to the demonstration that a questioned piece of physical evidence and a similar known sample have a *common origin.* Thus, in addition to class characteristics (characteristics which are common to a particular class of items), objects and materials possess *individual characteristics* (which are unique to a particular item) that can be used to distinguish members of the same class. The nature of these individual characteristics varies from one type of evidence to another, but forensic scientists try to take advantage of them in efforts to *individualize* a piece of physical evidence by some type of comparison process. Only a few types of physical evidence (primarily physical pattern evidence) can be truly individualized, but with some other types an approach to the goal of individualization is possible. We refer to these as *partial individualizations* and in some cases they are nothing more than refined identifications. The term *identification* is sometimes used to mean *personal identification* (the individualization of persons). Fingerprints, for example, can be used to "identify" an individual. The terminology is unfortunate, since this process is really individualization. Likewise, forensic odontologists can make personal individualizations in situations where dead bodies cannot be readily identified otherwise (such as in mass disasters, or in cases of victims of fires or explosions) from dental evidence and dental records.

Reconstruction refers to the process of putting the "pieces" of a case or situation together with the objective of reaching an understanding of a sequence of past events based on the record of physical evidence that has resulted from the events. Reconstructions are often desirable in criminal cases in which eyewitness evidence is absent or unreliable. They are important in many other types of cases too, such as automobile accidents. Identification and individualization of physical evidence can play important roles in providing data for reconstructions in some cases.

Forensic science, by its very nature, has to do with legal matters and legal questions. One of its main characteristics, therefore, is its interaction with the elements of the criminal justice system. This feature, among the others discussed above (such as individualization), sets it apart from traditional sciences. Many forensic scientists are concerned almost exclusively with criminal cases, and they deal almost entirely with the criminal justice system. There are many kinds of civil cases, in which physical evidence and Forensic Science have important roles to play.

2. Tools and Techniques

Different tools and techniques are used in forensic science laboratories. The distinction between destructive and nondestructive techniques is often important in forensic science. A *destructive* method is one, which destroys the sample being tested in order to analyze it, thereby preventing any further analysis of the same samples. A *nondestructive* method is one, which enables the sample to be examined or tested without irreversibly altering it for purposes of subsequent testing. The distinction has important implications for the choice of tests to be employed and for the order in which they are to be performed with a particular sample, especially if it is of limited size.

The tools and techniques used in forensic science should be well prepared to meet the following requirements in any analysis:

1. **Sensitivity**
2. **Specificity**
3. **Rapidity**
4. **Reproducibility**

These should be highly ***sensitive*** because the quantities of materials involved in forensic cases are extremely small to extent of traces. For example, a few milligrams of certain poisons are sufficient to kill a person. The quantity is distributed in the whole body. Only a few hundred grams of body material is provided for analysis. The samples contain only micro quantity of the poison. It has to be identified and estimated correctly.

Similarly evidence like body fluid, paints, soils, dusts and inks are often recovered from the scene in micro quantities and need to be identified positively; otherwise the evidentiary value of the clue material is limited.

The instruments and techniques must, therefore, be highly ***specific***. In a poisoning case, e.g. it is not sufficient to identify a poison as a barbiturate but it is necessary to find out the specific one that it is, so that source could be traced and linked to the criminal.

The number of cases requires to evaluate the clue is increasing everyday. Therefore the techniques and instruments used should be ***rapid.***

The classical examination of visceral organs is subjected to lengthy process of extraction, purification, identification, and estimation. The results are checked and crosschecked for any possible mistakes. The poison is extracted from the body parts like lungs, kidneys or blood, identified with chromatography. UV spectrophotometry can be useful for the quantitative estimation and specific poison is identified through IR spectrophotometry. The classical methods usually take days and weeks for complete analysis, whereas the above procedure identifies and estimates the clue material in a few hours. Similarly, blood alcohol in a sample (a drop or less is sufficient) may be identified and estimated through GC in a few minutes.

What so ever results have been obtained in the Forensic science laboratory (may be by any technique) should be ***reproducible*** i.e. the same test should give same result whenever and wherever it is repeated. The forensic science laboratories are currently using both classical and modern techniques and making efforts to adopt only those modern techniques, which have all the above qualities.

Refinement in the techniques has improved efficiency and accuracy considerably in recent time. For example, density gradient tubes have permitted density determination of very small amounts with high accuracy.

Examination of clue materials requires the various types of measurements like melting point (including mixed melting points), boiling point (BP curves and ranges), dimensions (length, breadth, height etc.) angle, densities, refractive Index, birefringence, polarization and fluorescence.

- **Physical Examinations and Methods**
- **Chemical Methods**
- **Chromatographic Methods**
- **Spectroscopic Methods**
- **Biological methods**
- **Immunological Methods**

- **Microscopy and Microscopical methods**

PHYSICAL EXAMINATIONS AND METHODS

Physical Matching

Some of the most definitive individualizations obtained in forensic caseworks are the result of *physical matches*. When a piece of an article is broken, torn, or cut away from the article, random processes are involved in the separation, resulting in the production of unique surface configurations at the separation line. If one of the two pieces is carried away in connection with some criminal act, the ability to rely on these random and unique configurations to demonstrate *commonality of origin* at some later stage can prove very valuable in the solution of a case. This kind of evidence is fairly common in cases like hit-and-run automobile accidents, burglaries, and crimes of violence. Collisions involving automobiles often provide a wealth of such evidence. Physical matches are usually obtained by bringing the known and questioned pieces into close *juxtaposition* to try to produce a "jigsaw" fit. It is not good procedure to attempt physical matches in the field, or at a scene. Known and questioned pieces should be kept apart and packaged separately. The extent of agreement between the corresponding surfaces of the pieces is ascertained in the laboratory.

There are two types of physical matches:

- Direct
- Indirect.

Direct physical matches are obtained when known and questioned pieces of a material or object can be fitted together in a unique manner. Direct physical matches are also called *jigsaw fit* matches, and conclusively demonstrate a common origin of questioned and known pieces.

Indirect physical matching is used in those situations where inadequate details are present to allow a direct match. Examples include cases where a smooth cut separated the pieces, or where an intervening piece is missing. If the inability to get a convincing jigsaw fit is due to a smooth cut, comparison of the continuity of surface features, surface markings, or internal inhomogeneities can be used to indicate or prove a common origin. Here, the pieces would be juxtaposed and examined by various visual, microscopic, and photographic methods. Thus, a piece of cut newspaper might be associated with the particular sheet it came from by comparing surface texture (fiber patterns), crease lines, printing, and inclusions and flaws across the cut line. If the cut extended to one or two edges, the matching of the edges would also be attempted. Similarly, if the evidence consisted of cut cloth, then thread sizes, flaws, dyes, and surface printing would be utilized.

Comparison of Markings

Comparison of markings can be used in cases where two surfaces have come in contact with one another and as a result one or both have received distinctive markings. These markings are of three kinds:

Imprints (Two dementional)

Indentations (Three dementional)

Striations (like parallel scratches)

Imprints are contact markings, which are two-dimensional. Fingerprints and typewriting are good examples of imprints. Other examples would be tyre prints, fabric pattern imprints, and foot or shoe prints on hard surfaces.

Indentations are three-dimensional contact patterns. These produced when harder material leaves its impression in a softer one without sliding. Tire tracks in soft dirt, firing-pin indentations, and certain pry marks made with tools are examples

Processes involving the movement of one or both surfaces produce ***striations***. The striation markings on a fired bullet provide a good example, similarly tool marks produced by sliding contact.

If a known object is to be associated with an unknown mark, it is required to produce a known, or *exemplar,* mark with the object so that comparison can be made directly between the two marks. Care is required in producing the exemplar, because it must be a realistic or close to realistic representation of the unknown. Attempt should be made to produce in almost similar fashion and on appropriate material that are believed to be responsible for the production of questioned mark. Thus, if an exemplar print is going to be made of a suspect's sneaker, for example, appropriate weight should be applied to it in producing the print.

Determination of Physical Properties

It is some times not possible to get physical matches, and then it becomes necessary to determine and compare *physical properties* like melting point, boiling point, density, refractive index, birefringence, color, and tensile strength etc. Although a combination of these properties can certainly be considered in attempts to establish common origin, these are basically *class characteristics* and are commonly used to aid in *identifications.* Their use in attempts to individualize an object is based on the assumption that a given combination of them is rare or unique. This assumption is true only with evidence in which the properties vary independently from each other and in which the range or variation of each property is known to be large in the overall population compared with that in a particular sample. Significant number of properties have to be determined for both the known and questioned samples to obtain a meaningful individualization.

Photography Techniques

Photography has two important and distinct purposes in forensic science. It is used as a means of documenting crime scenes and physical evidence. Another purpose is to bring out information that cannot be detected visually.

Photographic films, which are sensitive to light outside the visible range, can be more useful. Light with shorter wavelengths than the shortest visible wavelengths is called *ultraviolet,* while light with wavelengths longer than the longest visible ones is called *infrared.* These types of light radiations, which are beyond the range of sensitivity of the human eye, can be detected using special photographic films. Photographs taken with UV or IR light can reveal useful information about various types of physical evidence including questioned documents, stained garments, gunshot discharge residue, and certain imprint patterns. Bloodstains are more or less transparent in the infrared region where special IR film is sensitive. One could take advantage of this fact to "see through" bloodstains. Photograph of gunshot residue patterns, and obliterated writing can often be read in a similar fashion.

X-rays have the shortest wavelength of the three types of rays. They have greater penetration power and give fluorescence under suitable conditions. They are used in study of bullets holes, paintings, documents etc.

Visible-light photographic techniques can be used to detect or to accentuate the details, which are either invisible or very faint. Various lighting techniques, film types, filter combinations, or other contrast-enhancement techniques may be used to achieve the desired goal with different types of evidence problems. Filters are dyed gelatin films or colored glasses which can be placed over the camera lens or the light source. They are often used in black-and-white photography to alter the contrast relationships among differently colored areas of a sample.

CHEMICAL METHODS

Chemical Identification

Chemical identifications can be made by allowing an unknown sample to react with a series of reagents. The reactions observed in each case can narrow down the possibilities and ultimately lead to an identification of the unknown. The reactions that are used must be observable. Normally, this means that an easily recognizable product must be formed. This product might be a precipitate, a gas, or a distinctively colored compound.

The measurement of physical properties, such as refractive index, density, melting point, and boiling point, can also be used in connection with wet chemical identifications. These can be determined on samples before the chemical tests. Certain physical-property measurements would probably be included as an integral part of an analytical scheme.

The various wet chemical identification methods could be classified as *qualitative* tests or methods and quantitative test or methods. In analytical chemistry, the word *qualitative* is used to describe analyses in which only the identity of a sample or its components is of concern. In situations where *levels* or *amounts* are to be determined, the term *quantitative* is used. Quantitative wet chemical methods can be divided into two types: *gravimetric* and *volumetric.*

Chemical Separation Techniques

A sample may be an element, a compound, or a mixture. A sample of a pure element would contain individual atoms of only one type and that a pure compound would contain individual molecules of only one type. A *mixture* is comprised of elements and/or compounds in various proportions.

Distillation In this process a sample of liquid is heated to convert it into vapor, which is then allowed to flow to another location where it is cooled, condensing it back into a liquid. In the process of vaporization and condensation, many impurities are left behind and the sample becomes purer. Various modifications of the basic distillation process are used for specific purposes.

Sublimation This technique is almost similar to distillation, except that the solid sample is converted directly into vapor and then backs into solid. Sublimation is applicable only to solids which will sublime, that is, samples which will go directly from solid to vapor phase without melting and going through the liquid phase. When the sublimed vapor condenses on a cool surface, very pure crystals are formed.

Crystallization When the concentration of a compound (the *solute)* dissolved in a liquid (the *solvent)* reaches a certain point and no more of the solute can be dissolved in solution, then we say that the solution is *saturated.* If some solvent is lost from a saturated solution or some other step is taken to reduce the amount of solute the solvent can hold, crystals of the solute may start forming. Under properly controlled conditions, these crystals will be purer than the solute material used to make the original solution. Because only very similarly shaped molecules of the appropriate size can be incorporated into a particular crystal, while it is growing, crystals tend to be quite pure. This is the basis for purification by crystallization.

Solvent Extraction Most of the liquids are not mutually soluble. If we shake a mixture of oil and vinegar, a temporary but more or less homogeneous mixture will be formed. If it is allowed to stand undisturbed, however, a separation takes place until the oil is in a uniform layer above the vinegar. We say that the oil and the vinegar are *not miscible* or they are *immiscible*. Although some organic solvents such as alcohols and acetone are miscible with water, others such as chloroform and ether are not. Water will float on chloroform, and ether will float on water. A system of two immiscible liquids is required for the purification or separation of materials by *solvent extraction.*

Chromatographic Methods

The term *chromatography* applies to a whole family of chemical separation methods. These can be used to purify chemical substances or to aid in identification. The term *chromatography* itself may be somewhat misleading. Its Latin roots would indicate that it had something to do with "writing or painting with color." The term was first applied to procedures, which resulted in the separation of pigments from natural products. The separation yielded colored streaks or bands. Even though these same separation processes are now commonly used to separate colorless substances, but the term chromatography has been kept.

Chromatography involves the separation of substances based on their relative affinities for two phases, one stationary and one mobile. Substances which have higher affinities for the mobile phase are moved, or carried along with it, and are thus separated from those with higher affinities for the stationary phase.

Paper Chromatography

Paper chromatography is one of the simplest types of chromatography. In its most rudimentary form, the separation taking place is like that which occurs when water is accidentally spilled on a document which has been written with a water-soluble multi component ink. The ink lines will smear and run. Some of the differently colored dyes in the ink will move at different rates and will look like subtle, colored fringes at the edges of the diffused ink lines. In paper chromatography, this process is more carefully arranged and controlled. Special types of papers, which may have been subjected to pretreatments, are used. In addition, special solvents or mixtures of solvents are used to achieve the desired separation. In paper chromatography, the substances to be separated or analyzed are placed as discrete spots (spotted) at a specified distance from one edge of the paper. This edge is then dipped into the solvent. As the paper is wetted, the solvent migrates along the paper by capillary action. It may move up, down, or horizontally, depending upon the physical arrangement of the apparatus selected.

Thin-Layer Chromatography

Thin-layer chromatography (TLC) is closely analogous to paper chromatography, except that the separation takes place in a thin layer of absorbent material, such as alumina, silica gel, or cellulose, coated onto an inert backing material, such as glass plates or plastic sheets. In most TLC methods, as in paper chromatography, samples are applied as small spots, the plate or sheet is then placed in a chamber, one edge dipped into a solvent. The solvent is allowed to migrate up the plate to some predetermined height before the plate is removed from the chamber. If the components are simple dyes or pigments, the analysis may be completed by visual inspection. For other types of components, special visualization methods are necessary. These methods may entail the use of UV light examination, or of special chemical sprays, which produce colored reaction products with the invisible compounds. In some cases, several visualization methods may be applied to a single plate. TLC is very commonly used in forensic science laboratories for the analysis of drugs, inks, and textile dyes etc.

In order to standardize the TLC method, a quantity called the R_f has been defined. R_f values apply to any individual components, which can be separated by TLC in a defined solvent system under defined conditions. The R_f is the distance, which a particular component migrates, divided by the distance, which the solvent front migrates. Expressed as a formula,

R_f = Distance traveled by component (solute) /Distance traveled by solvent

The R_f is thus a constant for a particular compound under a defined set of TLC conditions.

Column Chromatography

In this technique, a vertical glass tube is filled with a granular absorbent or other substance. This substance acts as *stationary phase.* The sample is then added to the top of the column, followed by a special solvent selected as the *mobile phase.* As the solvent flows through the column under the influence of gravity or pressure, various components of the sample mixture will migrate at different rates and thus arrive at the lower end of the column at different time. Fractions collected at various intervals will thus contain the different, separated components. These fractions can then be subjected to further analysis by other methods.

Column chromatographic methods differ from one another on the basis of the principle involved in the separation, which in turn depends on the substance used to fill the column. Some materials like alumina, diatomaceous earth brings about separation on the basis of differential adsorption of various molecules in the mixture. The principle involved here is quite similar to that involved in TLC.

Ion-exchange chromatography

In this technique the molecules having a net charge (ions) can be separated. Here, inert matrix materials are chemically bonded to molecules, which have a fixed charge. In suitable forms, such *ion-exchange resins* can be packed into columns and used to bind and separate mixtures of molecules, which have the opposite charge (because unlike charges attract). In some cases, the net charge on the column material, or on the sample molecules, or both, is dependent upon pH, giving even greater flexibility. Certain types of ion-exchange chromatography are very useful in biochemistry for the separation of protein or nucleic acid molecules. *Gel permeation* (or *molecular sieve)* chromatography is a technique for separating large molecules on the basis of their size. This versatile procedure is commonly used in biochemical studies of proteins and other large molecules.

High-Performance Liquid Chromatography

High-performance liquid chromatography (HPLC) is very similar to the column chromatographic methods. Instead of an open vertical tube and gravity-induced flow, however, it utilizes a closed system and pumps to pressurize the solvent (mobile phase) and force it through the column. The pumps and column are generally contained within an instrument known as a liquid chromatograph. All instruments, however, have detectors and components for control and readout of the column pressure. Several different types of detectors can be used. These are placed at the end of the column to recognize, or detect, the components as they emerge from the column. The detector signal is then amplified and displayed on a strip-chart recorder to yield a *liquid chromatogram.* The fractions can also be collected as they are in column chromatography. HPLC can be applied to the analysis of drugs and explosives as well as other samples.

Gas Chromatography

It requires minute quantity and gives qualitative and quantitative results within minutes. The technique is applied for the analysis of gases, liquid, vaporizable solids and substance which pyrolyse to give identifiable volatile products. Gas chromatography (GC) is similar in many respects to HPLC, although it was developed and perfected earlier. In GC, the mobile phase is a gas, commonly referred to as the *carrier gas.* The stationary phase in one type of GC is an absorbent. This type is particularly useful for the analysis of simple gases.

Samples, which cannot be easily volatilized, such as high-molecular-weight polymers, can be analyzed by an ancillary technique known as *pyrolysis gas chromatography* (PGC). In this procedure, the sample is heated in an inert carrier gas to a temperature high enough to decompose it. The large numbers of small molecules produced in this way can then be separated gas chromatographically to yield a characteristic complex pattern of peaks. Samples of forensic interest, which can be analyzed by PGC, include paint chips, fibers, plastics, tars, and greases.

Spectroscopic Methods

This technique is useful in the analysis of the clue materials. Its use is limited to elemental analysis of some elements and their components. The intensities of the various curves are useful in the quantitative estimation. The technique is used in the identification of metallic poisons, paints, glass and soils etc.

The methods of chemical analysis in this category take advantage of the interaction of radiation from some portion of the electromagnetic spectrum with the sample.

Emission Spectrography

Various chemicals can alter the color of a flame. Some of the more common examples of this behavior are: Sodium salts, which yield an orange-yellow flame; strontium salts, which yield a red flame; potassium salts, which yield a delicate violet flame; and copper salts, which yield either blue or green flames. If the light from such flames is broken down into a spectrum using either a prism or diffraction grating, much more detail about the change becomes apparent. In fact, many elements, which do not appear to alter flame colors in any visually recognizable way can be identified when the light produced is broken down into a spectrum. The characteristic spectra that are produced by breaking down the light from flames or electric arcs containing atoms of a sample are known as *emission spectra.*

The spectrograph is a device for producing and recording emission spectra. It has been used in forensic science laboratories for many years. In most of these instruments, the sample is vaporized and excited in an electric arc. The resulting spectrum is registered on film or a photographic plate to produce a permanent record.

Emission spectrography is a method of analyzing for the presence of atoms of elements without regard to the molecule(s) of which the atoms are a part. For this reason, it is referred to as an *elemental* analysis method.

The chief strength of the method is its **capability for simultaneous analysis of a large number of elements at relatively low concentrations**. The major drawback for forensic applications is the fact that the quantitative **accuracy and reproducibility are relatively poor.**

Atomic Absorption Spectrophotometry

The availability of atomic absorption (AA) instrumentation is a relatively recent development. AA can be looked upon as the reverse of emission spectrography. Here, the absorption of light by the sample atoms of interest, rather than the emission, is utilized. The method is extremely sensitive for many elements and has excellent quantitative accuracy.

Its major disadvantage is that **only one or at most, two elements can be determined at one time.**

Plasma Emission Spectrophotometry

The plasma emission spectrophotometer is a very recent development. It overcomes some of the shortcomings of both the emission spectrograph and the AA spectrophotometer. Like the spectrograph, it utilizes the information contained within the emission spectrum of samples, and like the AA, the light intensities are determined photometrically. A special source, known as a plasma arc, is used to heat and excite the sample. The light produced is broken down into a spectrum and examined by separate electronic detectors placed at pre selected "locations" in the spectrum, so that up to **20 or so elements can be accurately quantitated at one time**. The forensic applications of this technique are only now being explored.

The techniques like *Ultraviolet-Visible Spectrophotometry; Infrared Spectrophotometry; Spectrophotoftuorometry* can be applied to differentiate many samples of forensic interest. They include tire rubbers, greases, new and used motor oils, and surgical adhesive tapes etc. Under the favorable circumstances, the technique is sensitive enough to work with samples as small as crankcase oil drippings or particles of rubber collected from a tire smear or a skid mark.

Neutron Activation Analysis (NAA)

Most of the elements can be made radioactive. The radioactivity is the characteristics of the elements and is studied by spectrometry.

The technique is very sensitive and specific. It has applications in the examination of hair, plant materials, paints, and soil etc.

NAA is a sensitive elemental-analysis technique that can be applied to a broad range of elements. The sample to be analyzed is placed in a source of slow-moving neutrons (thermal neutrons), such as in the core of a nuclear reactor. The neutrons combine with the nuclei of many of the atoms in the sample to produce unstable, or radioactive, nuclei (radioisotopes). The production of these radioactive atoms is the *activation* step. After a suitable activation period, the sample is removed from the reactor core and placed in a gamma-ray spectrometer. As the radioactive nuclei that were produced in the activation step decay, they give off gamma rays with energies that are characteristic of the nuclei, which produced them. A scientist can determine many of the elements originally present in the sample from a study of the gamma ray spectrum. Other rays (alpha and beta) are also given off when certain nuclei decay. In some cases, the energy distribution of the beta rays produced may also be studied.

NAA is very insensitive to lead concentrations, whereas AA is very sensitive for lead determinations. Because of these problems, NAA is now used less frequently for determination of gunshot residue.

X-Ray Fluorescence

Like SPF, x-ray fluorescence (XRF) involves the analysis of radiation emitted when higher-energy (shorter-wavelength) radiation interacts with the specimen, the characteristic x-rays can also be generated when a high energy electron beam strikes a sample. “Dispersing” them according to their wavelengths or their energies can produce a spectrum of these x-rays. Spectra of this kind yield information about the elemental composition of the specimen. The term *x-ray fluorescence* applies to instruments or techniques where shorter-wavelength x-rays induce the emission of x-rays. This technique is excellent for the elemental analysis of individual microscopic particles.

Additional Instrumental Method

Scanning Electron Microscopy

The scanning electron microscope (SEM) is a distinctly different instrument from the transmission electron microscope (TEM). The SEM is used to study surface morphology. The images produced are striking and often give the illusion of being three-dimensional. In addition, surface features at various depths within the sample region can all be in clear focus at the same time; in other words, the SEM exhibits excellent *depth of field.* SEM is thus capable of giving both morphological and compositional information from small samples, which is a great advantage in certain forensic problems. A good example is in the analysis of gunshot residue particles.

X-Ray Diffraction

The ability of X-ray diffraction (XRD) to determine the lattice spacing within crystals makes it a useful identification tool for crystalline evidence materials, including drugs, soil, minerals, and paint pigments etc.

Mass Spectrometry

In spite of the name, *mass spectrometry* (or *mass spectroscopy)* is not a spectroscopic method. Electromagnetic spectra are not involved. The so-called spectra are arrays of ionized or otherwise charged, atoms or molecules separated on the basis of their mass-to-charge ratios.

In the magnetic-sector instrument, the beam of ions enters a magnetic field. The orientation of the beam to the field is such that the charged particles in the beam follow curved paths. Ions with higher charges and lesser masses follow highly curved paths. Those with lower charges and greater masses follow straighter paths. The mass-to-charge ratios of these ions can be determined from the paths they follow.

MS instruments are becoming more widely employed in forensic laboratories for drug identifications and for identifying accelerants particularly in arson cases. For most forensic applications, the MS technique is used in conjunction with GC to yield a very powerful combination known as GC-MS. Here, the samples emerging from the GC are directly introduced into the MS source so that a complete mass spectrum can be obtained on each component of the sample separated by GC. MS also has potential for becoming a valuable individualization tool in criminalistics.

BIOLOGICAL METHODS

Morphological Methods

Since classification systems used in biology are based largely on a detailed consideration and comparison of morphological characteristics, it is not surprising that biological identifications often depend upon morphological observation. These may be macroscopic studies on large specimens using the naked eye, or they may be done with small samples utilizing microscopical observations.

Biochemical Methods

Biochemistry can be defined as the chemistry of biological systems or, more simply, as the chemistry of life processes. The reactions, syntheses, and breakdown of biochemical, such as carbohydrates, lipids, proteins, and nucleic acids, and their organization and function in living systems are the subject of biochemistry. One of the most important aspects of the field is the study of *enzymes* and of enzyme-catalyzed reactions, Enzymes are proteins, which have the special function of serving as biological *catalysts.*

Many biochemical methods used in forensic science are designed to test for the presence of particular enzymes.

Electrophoresis

Another important separation technique in biochemistry is *electrophoresis.* This can be used to separate large molecules on the basis of their net charge differences. Sample molecules are placed into a stabilizing medium across which an electric field can be applied. They will migrate toward the pole (+ or -) opposite to their own charge. Under a given set of conditions, many of the sample molecules will migrate at different rates, thus bringing about their separation. Most electrophoretic techniques used in forensic science are carried out in stabilizing support media, such as hydrolyzed starch, agarose or polyacrylamide gels, or cellulose acetate. An important application of electrophoresis in forensic science is in isoenzyme and serum-protein typing.

Another related technique, called ***isoelectric focusing***, is now being used in forensic serology for certain enzyme and serum-protein separations particularly of closely related species. In this technique, special carrier molecules are added to the medium across which electric current is applied, and separation takes place according to the isoelectric points of the sample molecules. Sometimes, separations can be obtained using isoelectric focusing, which cannot be obtained as readily by conventional electrophoretic procedures.

Immunological Methods

When an individual is exposed to a bacterium or virus, which can cause disease, body's defensive response consists of developing *antibodies,* which recognize and disable the foreign organism without harming normal body tissues. Antibodies are special protein molecules, which will specifically attach themselves to certain structural configurations on the surface of the invading organism. These configurations are known as *antigenic sites.* In this case, the foreign organism could be called the *antigen.* Antigens can also be large molecules, which are recognized by the animal body as "foreign" or "non-self". Antigens may be defined as agents or molecules, which will induce an animal body to produce antibodies specific for the inducing agent or molecule. The field of study that deals with antigen-antibody and their reactions is called *immunology.*

Forensic serologists use special antibody preparations known as *antisera* to test for specific antigens in unknown samples. Antibodies prepared in animals are used extensively to determine the species of origin of blood, to identify certain body fluids, and to measure the amounts of hormones and drugs in body fluids and tissues by a technique called ***radio immunoassay*** (RIA).

The Immunological methods are among the most powerful for dealing with many biological samples. They have the potential of being both very sensitive and very specific. All immunological methods involve tests with, or for, antigens or antibodies.

MICROSCOPY AND MICROSCOPICAL METHODS

General Considerations

Microscopy is a very important tool in forensic science. The term *microscopy* refers only to the use of the microscope, but in fact it has a much broader meaning. Microscopy is an analytical approach in which some type (or types) of microscope is used in conjunction with any and all other types of appropriate analytical instrumentation. Any number of intricate and sophisticated qualitative determinations and quantitative measurements can be made on exceedingly small samples using microscopes. In those cases in which microscopes are used along with other types of instruments, the selection of the other instruments needed and the order in which they will be used often depends on the results of the microscopical examination. One of the major strengths of microscopy is the integration of microscopical and non-microscopical instrumentation in solving problems. The only limitation of the microscopical approach is that years of training and experience are required to become an accomplished microscopist. As a result, skilled microscopists are comparatively rare.

Many varieties and types of microscopes exist. Those, which find extensive use in forensic laboratories, are discussed below:

The Simple Microscope

A simple microscope is little more than a refined magnifying glass. Examples of simple microscopes include hand lenses, linen testers, and fingerprint magnifiers. These are small, portable, and easy to use in the field. In simple microscopes, most of the elements can be made radioactive. The radioactivity is the characteristics of the elements and is studied by spectrometry.

The technique is most sensitive and specific. It has been utilized in the examination of hair, plant materials, paints, dusts; soil etc magnification takes place in a single stage. A virtual image, not a real one, is formed. The difference between real and virtual images is explained in the next section.

The Biological Microscope

The compound microscope means that the magnification takes place in two stages. The enlarged image produced by one lens system (the objective) is magnified further by a second lens system (the ocular, or eyepiece). The objective produces a *real image* of the object; the ocular then treats this real image as an actual object, and forms an enlarged *virtual image* of it. This virtual image is like the one produced by a simple microscope. The virtual image produced by a simple microscope, or by the ocular of a compound microscope, cannot be projected.

The compound microscope has a very convenient and versatile design. All the remaining types of optical (light) microscopes are compound microscopes. The so-called biological microscope is the most common example of a compound microscope.

Serologists may use this type of microscope for reading the results of dried blood-stain typing or for searching for spermatozoa in specimens from a rape case. Hair examiners may use it for examinations of scale pattern, medulla, and other comparison characteristics, and drug chemists use this instrument to examine the results of their crystal tests.

The Stereoscopic Binocular Microscope

This type of microscope provides a three-dimensional image. In reality, it consists of two compound microscopes mounted side by side in the same housing. The three dimensional imaging is possible because each eye is provided with its own individual microscope. This imaging in three dimensions is directly analogous to that employed in the binoculars used by bird watchers and others, in which two telescopes are mounted side by side in the same housing. The stereoscopic binocular microscope, or stereomicroscope, is used for low- to medium-power work only.

Forensic scientists in almost every specialty area, including questioned documents, firearms, tool marks, trace evidence, and serology, use the stereomicroscope. Many preliminary examinations, as well as sorting and sampling operations, are carried out with the stereomicroscope.

The Polarized-Light Microscope

Although stereomicroscopes are applicable to a broad range of forensic problems, the polarized-light microscope is the most versatile of all for obtaining in-depth information from a sample, especially a sample of transfer or trace evidence. Mineralogists refer to this type of microscope as a *petrographic microscope.* Historically, one of the first uses of polarized-light microscopy was the identification of minerals, and of mineral grains in soil.

The simplest polarizing microscopes are similar to biological microscopes with certain optical and mechanical refinements added. At a minimum, these would include two polarizing filters, called the *polarizer* and the *analyzer,* and a circular rotating stage. The polarizer is placed in the light path of the microscope below the sample (normally, beneath the condenser), and the analyzer is placed above the sample (above the objective). The rotating stage allows the sample to be rotated about the optical axis of the microscope.

The Comparison Microscope

Two different types of comparison microscopes are used in forensic laboratories. They are similar in optical design and general mechanical construction, but differ in the range of magnifying powers available and in the type of illumination employed. One type is used to compare opaque objects, such as bullets, cartridge cases, and tool marks. Incident light is used with this type of comparison microscope. The other type of comparison microscope is generally equivalent to having two biological, or polarized-light, microscopes connected by a prism arrangement known as a comparison bridge. This bridge arrangement, used in both types of comparison microscopes, allows the fields of view from the two separate microscopes to be juxtaposed.

Electron Microscopes

Electron microscopes exist in two primary types. They differ in a way very roughly analogous to the way light microscopes differ according to the type of illumination used (incident and transmitted).

The first type of electron microscope is known as the *transmission electron microscope* (TEM). Commercial versions of TEMs have been in use for more than 40 years. The sample needed for TEM must be very thin, or a very thin "replica" of the sample must be examined. In a TEM, the electrons used in forming the image pass through the sample, like the light through transparent samples when transmitted light is used with the light microscope.

The other type of electron microscope, which can be used with thick three-dimensional samples, is known as the *scanning electron microscope* (SEM). In this arrangement, the electron beam does not pass through the sample. Instead, the electron beam in the instrument is scanned across the sample in a raster pattern, like that used in television sets. At each point where the electron beam strikes the sample, the electrons may be reflected or scattered off the surface, or may release secondary electrons from just beneath the surface of the specimen. Either back-scattered or secondary electrons can be used in the formation of the image.

As relatively thick, three-dimensional samples can be examined, the SEM has a number of applications in forensic science. Extensive sample preparation, such as making thin sections or replicas, is not necessary with SEM (as it is for TEM). The only sample preparation that is sometimes required with SEM is the coating of nonmetallic samples with a very thin layer of conductive material (such as gold or carbon). This coating prevents the buildup of electric charge on the nonconductive sample surface. The coating is extremely thin and is applied by one of two vacuum coating techniques known as vacuum evaporation and sputtering.

The SEM can resolve finer structural detail than any other light microscope. In addition, SEM photomicrographs exhibit remarkably *high depths of field*, which cannot never be approached in normal photomicrographs.

The uses of SEM in forensic science range from examinations of tool marks, the markings on bullets and cartridge cases, to the studies of the surfaces of hairs and small particles. The particle analysis capability of the SEM has recently been applied to the problem of identifying gunshot residue. A major component of gunshot residue is small particles, which are deposited on surfaces (skin, clothing) in the vicinity of a firearm when it is discharged. Despite their high cost, SEMs are becoming more important in forensic science laboratories.

Present Day Capabilities

Three primary activities of the forensic science laboratory have already been mentioned i.e. *identification, individualization, and reconstruction*. At the present time, the first of these is more highly developed and poses fewer problems than the other two.

True individualizations are possible only in cases involving certain physical matches and patterned markings, such as tool marks and fingerprints. The sophisticated chemical techniques, as they are not sufficient to individualize evidence based upon composition. More research and development are needed to achieve perfect individualisation. In certain areas, such as in individualizing dried bloodstains, much progress has been made in recent years, but hairs, for example, are still compared by the same basic morphological techniques that have been used for over 50 years. These comparisons can yield useful results in experienced and competent hands. The number and quality of reconstructions that contribute to solutions at both investigative and adjudicative stages of cases could be greatly improved. More laboratory scientists need to become involved in reconstructions, and better communication between scene and laboratory personnel is essential.

It is necessary to distinguish between what we sometimes call the "state of the art" in physical-evidence analysis and the practical, real-world analyses that are carried out in an average laboratory. The state of the art refers to the analyses that *could be* conducted, given a completely ideal situation. There are few laboratories that have the resources, trained personnel, and time to carry out state-of-the-art analyses on every different kind of physical evidence.

Improvements are possible at every stage like search, recognition, collection, analysis, interpretation, and presentation of findings in court. As these improvements take place, more and more laboratories will be able to provide more and better services for the investigation and disposition of cases.

Suggested Questions

- What is physical evidence?
- What type of information evidences provides to achieve aim of forensic Science?
- What are the three major activities involved in analyzing and interpreting physical evidence?
- What is a class characteristic?
- What is an individual characteristic?
- What does *identification* mean?
- What does *individualization* mean?
- What does *reconstruction* mean?
- What is the general difference between criminal and civil cases?
- How is forensic science involved in criminal cases?
- How is forensic science involved in civil cases?
- Discuss in detail the characteristics of tools and techniques used in Forensic Science.
- What is a physical match? What kinds of evidence are suited to physical matching?
- Name the three kinds of markings that can be compared on physical evidence. How do these differ?
- What is a physical property of evidence?
- Name several physical properties, and explain what each of them is.
- How can physical properties be useful in the analysis of physical evidence?
- What are the principal applications of photography in forensic science?
- Why instrumentation division is important in Forensic science?
- What are chemical identifications? Name several ways in which these are done.
- What is the difference between a qualitative and a quantitative test?
- Name four chemical separation techniques and briefly describe how each works.
- What is chromatography? Name several different kinds of chromatography, and briefly explain how each works.
- What are spectroscopic methods? Explain the underlying principle on which they are based.
- Name four spectroscopic methods and briefly explain how each works.
- What is neutron activation analysis? How does it work? How is it used in forensic science?

- What is mass spectrometry? How does it work? Is it a spectroscopic method?
- What is x-ray diffraction, and how does it work? How is it used in forensic science?
- Name several biological methods used in forensic sciences.
- What is an enzyme? How are enzymes used in forensic sciences?
- What is immunology? Name several Immunological methods and explain how they are used in forensic science.
- Why is microscopy important in forensic science?
- Name four types of microscopes. Explain briefly how they-are different from one another and how each might be used in forensic science.
- What is a scanning electron microscope? How is it used in forensic science? How does it differ from a transmission electron microscope?

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ETHICS IN FORENSIC SCIENCE AND DUTIES OF FORENSIC SCIENTIST

Content overview

- Introduction
- Enforcement of the code of ethics
- Ethics to be followed
- Suggested questions
- Suggested readings

Introduction: Every organization has some rules and regulations to be followed during the course of their job and disseminating their duties which are very important to develop and professional attitude in their employees. These rules are referred as CODE OF ETHICS. These rules and regulation helps to boost the confidence in employees as well as preserve the secrecy of the casework in forensic science laboratories. An important reason to develop and adopt ethical code of conduct for forensic science laboratories is that such codes are hallmarks of professional statues. In the same way that scientists agree upon procedures for conducting scientific inquiries as professional need to agree on procedures by which we govern our professional practice. Discussions among criminalists reveal many topics about which we disagree. Eg. It is appropriate for the criminalists laboratory to take cocaine or methamphetamine samples that narcotic investigators can use for undercover operations. It is unethical for the criminalists to synthesize controlled drugs and se in such situations.

What about preparing false reports the investigator can use during investigation of suspects?
What information should be included in a report?
What is the obligation of forensic scientist to provide discovery information to opposing counsel?
Is that obligation different for criminalists reporting for law enforcement agencies, prosecution agencies or direct practices?
A code of ethics is like a code of laws has written rules governing behavior in certain circumstances. What are the ethical requirements for work done in laboratory or in the field? What are the ethical considerations that govern the criminalists relationships with the other colleagues, supervisors, lawyers, litigants, the press and the public. What is the correct response to the instructions from the court to provide a "YES" or "NO" answer to counsel's question? What should the criminalist do when an important question is not asked? Does the obligation do tell the truth,

whole truth means that the all possible, all probable, all reasonably probable, all highly probable or only the most probable alternatives must be given in response to a question?

The criminalists work may be considered by the judge, jury or lawyers who make decisions that profoundly affect others people's life. The fact the criminalist does not have to decide guilt or innocence, pass judgment of death or life without parole, or determine the amount of liability for the damage does not mean the criminalist can ignore the fact that the results of the work done in laboratory may be used sometimes correctly and sometimes incorrectly.

Enforcement of the code of ethics

The application of code of ethics to any professional activity must accomplish one of two alternatives. The specific activity under considerations must be deemed either **ethical or unethical**. The code must be constructed carefully with the understanding that behavior not explained become unethical will by default be accepted as ethical professional organization have the responsibility not only to enforce ethical behavior of their members but also to explain why actions are violation of ethical requirements.

Following Ethical Codes must be followed by forensic scientists:

1. Competence:

Code of ethics that address the issue of competence generally require that the criminalist not undertake tasks for examination that he/she is not competent to undertake. To evaluate one's own competency one must first understand how competent he/she is in a particular. Forensic experts should have some training in their laboratory and must have experience of handling the case work which increases their competence and performance.

2. Thoroughness:

It requires that necessary examination should be carried out or conducted thoroughly without leaving any test or examination. A thorough examination is must for conclusive results. Incomplete examination can ruin the reputation of laboratory as well as the expert. It sometimes becomes necessary to appear in the court to explain the findings to the jury and if expert is not able to explain the findings and is unable to answer during cross-examination it can cost the reputation of both laboratory and expert.

3. Relevance:

Examination and tests must be relevant to the issues that are involved in the investigation. Irrelevant examinations or tests result in wastage of samples and may lead to false results. Test applied to the case samples must be relevant and must have some documented proof of their reliability and authenticity.

4. Reviewability:

Tests or methods employed for examination must be reviewable. It is also legally required in some case to have a second opinion from some other laboratory so the experts are always suggested not to consume whole of the sample. Some part of the sample is always preserved for second opinion. It is also a scientific requirement as the scientist may have to prove hypothesis by verifying it experimentally. The comparison of test results with that of the standards provides the firm conclusion.

5. Interaction between the forensic scientist and the client:

The role of the laboratory technician is to conduct a request analysis, the role of the professional criminalist is to evaluate the circumstances, understand the relevant issues and advises the client what can be done to resolve any relevant question.

6. Disclosure:

The work of forensic experts is always secret as the report given by expert can cost life of individuals under trial in court. Forensic experts work in an area which is restricted for others as they should not disclose the work under observation with anyone outside the laboratory or within the laboratory. It may affect the integrity of the results.

In the Lab

7. Responsibility of the employer:

Employers rarely have the ability to judge the quality and productivity of their forensic laboratory. Therefore employers rely upon the forensic manager to develop and maintain an efficient quality forensic laboratory.

8. Managerial Competence:

Laboratory manger should display competence in direction of such activities as long term planning, management of change, group decision making and sound fiscal practices.

9. Integrity:

Lab workers must be honest and truthful with their work peers, supervisors and sub-ordinates.

10. Quality:

Quality Assurance procedures must be such that which effectively monitor and verify with the quality of the work products of their laboratory.

11. Efficiency:

Laboratory services should be provided in a manner which maximizes organizational efficiency and ensure an economic expenditure of resources and personnel.

12. Productivity:

Highest priority must be given to cover which have a potential productive outcome and which could, if successfully concluded have an effective impact on the enforcement on adjudication process.

13. Health and safety:

Routine safety inspections, maintenance of records of injuries should be carried out.

14. Security:

Laboratory security should be planned and maintained control of access both during and after business hours should be carried out.

15. Qualification:

Sufficient academic qualification and experience to provide with the fundamental scientific principles for work in a forensic laboratory.

16. Training:

Laboratory workers should be trained for principles of forensic science; training must include handling and preserving the integrity of physical evidences. Before casework is done specific training within functional area should be provided.

17. Communication:

To fulfill the objectives of forensic laboratory, a healthy communication must be there between employers and the laboratory staff. Everyone should have understanding of policy and procedures adopted by the laboratory.

18. Response to public need:

Forensic laboratory should be responsive to public input and consider the impact of actions and care priority to the public.

19. Research:

When resources permit, forensic laboratory should support the research in laboratory with various institutions and universities.

20. Preservation of test results:

It is one of the primary functions of the laboratory to preserve the evidence and the test result. It is usually in terms of work done at a crime scene or evidence collected from other items in the laboratory.

21. Confidentiality:

"Right to privacy" is a fundamental right and privacy must be preserved during forensic case work.

22. Honest and striving for objectivity:

Forensic experts must be honest and strive to achieve their objective in their case work soaks to strengthen the judicial system.

23. Misinterpretation of test results:

Interpretation of result must be done by unbiased mind. Relations and money must not hinder the results. Interpretation of results must be free from any external influence.

24. Manipulation of data:

Any correct data related to any case should not be manipulated, since it helps criminals and offenders to grow without any punishment.

25. The Profession:

Forensic experts must be aware o new techniques and developments in the field which helps to solve critical cases in the laboratory.

Duties of Forensic Scientist:

1. Gathering Evidence
2. Analyzing Evidence
3. Collaboration with police parties
4. Describing the findings

1. Gathering Evidence:

Foremost duty of the forensic scientist is to gather or collect evidence from the crime scene as now a day forensic experts are called to the crime scene to collect potential evidences which are helpful in solving the case. It become the duty of forensic experts to collect, pack and transport the potential evidences to forensic science laboratory in best possible way so that these samples can be analyzed to get good results.

2. Analyzing Evidence:

After collection of evidence, these are sent to the forensic science laboratories for analysis. Different test such as colour test, chemical tests, microscopic examination and instrumental methods are applied to analyse the samples in order to get best possible results to identify the samples.

3. Collaboration with police parties:

To solve the crime, forensic experts have to work with police parties in order to get history and background of the case in progress. Most of the cases, it is the police that demands a certain type of analysis eg. Sometimes it is only required to know that a red sample sent for analysis is blood or not? In some case full detail of the sample is required whether the red sample is blood or not? If blood, then is it human or non-human? If human, then give its blood group and DNA profile. So the collaboration of forensic experts and police parties is very important for solving different cases.

In many cases, there is a need of research to find out solutions for some unsolved crimes and to investigate and analyze the clue materials for which no specific technique is available. In such cases, collaboration of forensic experts and police personnel is essential.

4. Describing the findings:

As we all know that judges and jury is not always from science background, in such cases the forensic experts have to describe their findings in the court of law to convince the jury. Forensic experts have to justify their findings by providing literature from books and journals which strengthen their findings.

Suggested questions:

1. Define ethics?
2. What is the need of code of ethics in the field of Forensic Science?
3. Explain different ethics to be followed by the forensic experts.
4. How code of ethics helps to preserve the privacy of casework in Forensic Science Laboratories?

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