Using Forensic Science Effectively

Dr. Ran B. Singh,
former Director, Forensic Science Laboratories, U.P.,
Visiting faculty,
LNJN National Institute of Criminology and Forensic Science,
MHA, Govt. of India, Rohini, Delhi.

Introduction

Peace and harmony is a social order. The maintainability of this order depends upon the obedience of the rules and regulations of the society by its members. But, human nature being what it is, there will always be some who will break the rules. Thus, the society will always have criminals and will always need a Criminal Justice System to deal with them. If a wrong doer does not accept his guilt and denies the charge, the criminal justice system should provide for the holding of a trial at which the charges against the accused must be proved beyond reasonable doubts, by leading evidences. In absence of direct evidence of a crime; for example an eyewitness or if the victim is the only eyewitness, the prosecutor has to rely on indirect evidences that is the circumstances, admitted or proved. In such cases each circumstance relied upon by the court may individually establish nothing or at least very little but from an accumulation of circumstances a crucial fact may be established. The direct evidences are also influenced by human limitations and are better established if corroborated by circumstantial evidences.

The courts have always relied upon scientifically accepted procedures for assessing circumstantial evidence. However, the scientific aids to criminal justice system have now become an inseparable component of the system. Its clientele has also increased; it has now users at both the ends, the investigator at one end and the arbitrator at the other. The application of scientific knowledge to the elucidation of the doubtful questions in the court of justice is termed as forensic science. It uses the scientific knowledge developed in other disciplines but uses it in different ways to solve the complex and varied problems encountered. The problem, process and procedures to deal with them are perceptibly different; for example no other science is concerned with the process of individualization. Forensic science elucidates the specific questions posed by particular circumstances of criminal as well as civil matters rather than the fundamental questions of the nature, the main objective of basic sciences. Analytical data on different attributes of physical clues of crime are generated and the results are interpreted to corroborate or prove the circumstances of crime. A systematic attempt is made to provide answers, based on the physical evidence, to the who, what, when, where, whom, and how questions of an event. Thus, an effort is made to re-construct and describe how events of legal concern have happened in a crime.

The forensic science is a noble service to the society. Therefore, it has become a vital component of the criminal justice system as a natural consequence, and the jurisdiction of forensic science has expanded to include crime scene investigation also in addition to the court proceedings.

Crime-scene Investigation

The physical clues of crime collected from the scene of crime/victim/perpetrator are the most valuable evidences to corroborate/prove the circumstances. Thus, the collection of relevant physical clues from the scene of crime and from other sources like the victim etc. is very important. However, seemingly simple task of collecting physical clues of crimes requires a scientific approach and scientific knowledge. Hence, it is essential that the forensic scientist be made an integral part of the investigation from the earliest possible time. The evidence that is destroyed, compromised or omitted can not contribute to the solution of the crime. Scientific questions need to be framed early during the crime scene investigation. Without the right questions being thoughtfully and carefully framed there is a little hope of getting all the relevant answers to corroborate, prove, or reconstruct various circumstances of crime. If physical clues are not searched carefully and meaningful questions are not framed, in addition to the loss of valuable information, misleading information may be generated.

The importance of associating forensic scientists closely with the crime scene investigation has been realized for quite some time in the past. Close ties between the investigating officers and forensic scientists is prevalent in many countries world over, although, a lot more needs to be done in the developing countries. It is not always easy to recognize and collect physical clues from the scenes of crime. The scientist (scene of crime officer) has to be trained to develop necessary expertise in crime scene investigation. A checklist (look at, and look for) should be carefully prepared for major crimes so that a systematic search is made for potential physical clues. However, every crime scene is unique in itself, and the checklist should be only for the guidance. It can never be exhaustive in any case. One has to carefully scan and search the crime scene for all possible clues of crime.

There has been appreciable development and progress in the scene of crime technology in the recent years. Most of the progress in this field is concerned with increasing use of lighting and imaging techniques in the initial examination of crime scenes. Lasers were favored as lighting source to search and record the presence of fluorescent clue materials. However, with the development of high quality interference type barrier filters of radiation, strong sources like Xenon arc lamps are used to obtain radiation of small bandwidths in different regions of the spectrum. The availability of different frequency bands of radiation from the lighting source facilitates developing contrast/fluorescence for search of clues on different substrate in the background. Also, it allows the detection and differentiation of closely related samples. The short wave ultra violet reflection photography has also been used successfully to detect and enhance latent fingerprints on various substrates.

A number of test kits, and collection kits are in vogue for preliminary screening and collection of physical clues from the scene of crime; for example, fingerprint kit, footprint kit, blood testing kit, drug testing kit, explosive testing kit, sampling kit for gunshot residue, evidence protection kit, electrostatic dust lifters, field test (color test for iron detection) for determining whether suspects have handled firearms recently, chemical

enhancement techniques for various types of impressions (say, fingerprints, and footprints) and stains, etc.

Canines are also used to detect various kinds of material, like fire accelerants etc. However, the effectiveness of canines varies from canine to canine and handler to handler. A universal endorsement or condemnation of the use of canines for this purpose can not be made. It depends upon the canine abilities and limitations.

Portable microprocessor based appearance identification systems are available to construct pictures for identification of suspects. A number of other portable instruments (gas chromatographs etc.) are being developed for testing samples at the scenes of crime, which would be available for use in the near future.

The use of digital imaging system for direct capture of scenes of crime is on the increase. The technology is not so expensive now, and it may replace the conventional photographic methods soon. Efforts are being made to develop IT based high tech scenes of crime documentation system. It would integrate sophisticated software with a number of data collection tools including digital video and still cameras, voice recorders, bar code scanner, and specialized sensors.

The interrogation is key to investigation. The passion for human rights in the society is against the 'conventional' methods of interrogation. But, the words of the accused cannot be taken for granted more so to day, when moral values in the society are declining. It is, therefore, necessary to develop and adopt scientific aids to interrogation as well. Collecting information and intelligence regarding 'mens rea' and 'modus operandi' of crime to formulate the hypothesis of crime and to discover some of the hidden physical clues are the basics of crime investigation. Recently, the techniques of 'Narco analysis (truth Serum)', 'Brain Electrical Oscillation Signature Profiling (Brain Fingerprinting)', and 'Polygraph (Lie Detector)' are being employed to obtain information and verify the truth. In narcoanalysis the subject becomes dis-inhibitive under the influence of drugs and talks freely without inhibition. In this process a lot of information is revealed some of which may not be relevant to the crime in question. In polygraph test if the subject tries to lie there is a 'response conflict' in his mind causing various physiological reactions. The strength and rate of pulse, galvanic skin response, strength and rate of breathing, and blood pressure are recorded by the instrument to monitor the physiological changes in the human body. For interrogation, the accused is put to various questions and his physiological reactions during the question hour are recorded and analyzed to detect deception, shown by abrupt changes in physiological reactions. In brain electrical oscillation signature profiling an effort is made to differentiate between 'conceptual knowledge' and 'experiential knowledge' to make the findings more specific. Voice stress analysis could be another method to find out if a person is not telling the truth. Psychological stress evaluator detects involuntary physiological changes that occur in reaction to the stress of fear, guilt, anger, or other emotions. It is designed to selectively analyze those frequencies of the human voice that reveal the presence of suppression, or absence of the micro tremor, which are generally present in normal unstressed voice. The hypnosis has also been used to read unconscious

mind of the suspects/victims of crime. It helps to access the subconscious, which is about ninety percent of the mind, without the barrier of conscious. In this process the mind responds to external suggestions, and can recover forgotten memories as well. These methods need to be developed and perfected before their routine application to interrogation of suspects. The evidential value of these techniques in the court may not be much but these would definitely be of much help in the interrogation process and could lead to crucial physical clues of crime.

Examination of Physical clues of crime

The main objectives of the examination/analysis of physical clues of crime are: the identification/individualization of a clue material; comparison of two or more samples to determine their source correspondence; and reconstruction of the events of a crime. Although, there are some general types of materials, which are referred to in the forensic science laboratories for examination; anything under the sun (or for that matter under ground) may get involved in a crime and end up as a forensic sample. Hence, the analytic needs and necessities of a forensic science laboratory spread over the arena of all the branches of science and technology.

The nature of examinations/analyses those are undertaken, in general, in the forensic science laboratories are briefly enumerated below:

Physical examination of paint, glass, soil, ropes, strings, electrical transmission wires, textiles, lottery tickets, seals, etc., comparison of tool marks, restoration of erased identification numbers/marks, 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 element analysis for the comparison and identification of exhibits, speaker identification, audio/video tape authentication, and analysis of digital data in computers, and mobile phones etc.

Comparison of questioned writing, typewriting, printed matter, signatures with the known standards to establish genuineness or forgery; examination of documents for erasures, alterations, obliteration and secret writing, decipherment of indented writings; determination of relative age of the writings/papers, examination of the charred documents, examination of postage stamps, revenue stamps, cheques etc.

Examination of firearms for their serviceability and to find out whether they come under the purview of Arms Act, determination of probable type or make of firearms from fired bullets/cartridges, 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 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 firearm discharge residues; general examination for the reconstruction of a scene of firing etc.

Examination of opium and its alkaloids, heroin, ganja, bhang, charas, and other narcotics and psychotropic substances; examination of illicit liquors, varnish, petrol, diesel, kerosene etc.; examination of 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, explosive substances, and remnants after explosion to identify explosives used.

Examination of viscera, stomach wash, vomit, etc., for poisons of vegetable origin (dhatura, oleander, opium, madar, aconite, nux vomica, etc.), inorganic salts (arsenic, copper sulfate, cyanides etc.), acids, drugs, alkaloids, pesticides (DDT, BHC parathion, malathion, aldrin, zinc phosphide, aluminum phosphide, etc.) and other types of poisons including powdered glass, etc.

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

Chemical, microscopic and spectroscopic examination for the detection of blood, serological examination of blood stains, seminal stains, and other biological stains for their origin and grouping, examination of barr bodies for sex determination from blood stains, hair roots, saliva etc., DNA profiling for paternity tests and identification of perpetrator.

The forensic samples are not only diverse in nature; these are often in microscopic/sub-microscopic quantities and are contaminated. Hence, in addition to the sophisticated and sensitive analytical instruments, procedures and methods specially developed for forensic samples are needed. Some of the modern techniques in use, at present, for forensic analysis are: optical microscopy, IR reflection microscopy, confocal laser scanning macroscopy, scanning electron microscopy with energy dispersive x-ray analyzer, high performance thin layer chromatography, gas liquid chromatography, high performance liquid chromatography, ion chromatography, mass spectrometry, x-ray diffraction, cathode-luminescence, atomic absorption spectroscopy, atomic emission spectroscopy, electron spectroscopy for chemical analysis, Auger electron spectroscopy, electrostatic detection techniques, FT Raman and FT infrared spectroscopy, capillary electrophoresis and related techniques, DNA profiling, digital image processing (image enhancement and development, image data bases, automatic image classification, and image morphing), automatic (robotic) processing of unattended samples, etc.

There are certain comparative studies, which require instruments specially developed for forensic use. The application of computers to data analysis and manipulation has transformed the way comparison of patterns is done in forensic science to day. Comparison of tool marks, striation pattern on fired bullets, marks on spent cartridge cases, fingerprints, foot-ware impressions, footprints, signatures, handwritings, and other patterns

of interest in crime investigation require trained and experienced mind to identify the class and individual characteristics and compare them to find out whether the questioned and known marks/impressions are identical or not. The process is very laborious, tedious, tiring, and time taking, particularly when the number of inter-comparisons is very high. A number of computer based automatic comparison systems have been developed now, and are in use. These are not only helpful in handling increased workload, but have helped in finding clues to many unsolved crimes. The automated fingerprint identification systems have been in use for quite some time for efficient interrogation of fingerprint databases. Intelligent systems for the administration of foot-ware impressions and foot-ware reference images are in vogue in some of the countries. Recently, two more instruments, the Integrated Ballistic Identification System (IBIS), and the Forensic Firearms Identification System (Drugfire) have been developed for comparison studies in the area of forensic ballistics. These are automated firearm evidence comparison systems using the new technology of computerized image analysis for the identification of bullets and cartridge cases. It is now possible to build up firearm evidence database, which may be of immense advantage in the examination of bullets/cartridge cases in unsolved crimes and thus in the identification of firearms used in more than one crime. The networking of remote databases of different laboratories would further enhance the resources for the investigation of heinous firearm cases. Several groups are developing automated systems for the comparison of signatures and handwritings, and it is expected that suitable systems for the examination of questioned documents would also be available soon. It should, however, be kept in mind that the automated systems for comparison, be it for fingerprints, or for bullets and cartridge cases, or for questioned documents, or for any other patterns, like foot-ware impressions/footprints etc., would only be helpful in interrogating a database, and/or in short-listing the inter-comparisons to be made. The final opinion on the comparison of questioned and known patterns, marks, or impressions would have to be made by an experienced and trained expert in the respective field.

In order to establish link between the scene of crime/victim and the suspect/vehicle/tools etc., the physical clues collected from the scene of crime/victim are compared with the known samples obtained from the perpetrator/vehicle/tools etc. Thus, two or more samples are compared to determine if they could have originated from one source. In this effort the commonly used physicochemical methods are not of much help. However, the sophisticated and sensitive techniques of analyzing trace composition for comparison of the evidences have proved better. There has been a trend to look for sensitive techniques that help to analyze minute quantities of samples. But, as is known, the sensitivity is achieved at the cost of precision. Also, if we settle with minute sample size for analysis, the question of qualitative and quantitative uniformity of the parent material should be interrogated and settled. In case, samples are not reasonably uniform with respect to their qualitative and quantitative trace composition, it would be dangerous to rely on the results of the analysis of a speck of evidence. It means that at least two sets of methods of analysis should be developed; one for minute (microscopic) samples and other for not so minute samples, which would naturally have different precision levels of determination. Instead of doing qualitative or semi-quantitative analysis, it may be worthwhile to go for quantitative analysis so that meaningful database could be generated for assessing evidential value.

The importance of databases for the evaluation of evidences can not be over emphasized, and it is nice to be able to access distributive databases using computers. Nevertheless, the databases should not only be searchable but should also be shareable internationally. It would require validated methods and protocols of analyses, and traceability of standards used for determinations. It would also be desirable to standardize vocabulary used for expressing the value of the evidence, in the laboratory reports.

The developments in the fields of science and technology have considerable impact on the forensic applications of science be it in the form of new kind of clue material or in the form of new technique of analysis. Latest examples are: digital data as a clue material, and DNA profiling as a technique. Hence, in addition to the day to day need based research, data generation, instrumentation, and other developmental work in the field, the most important aspects of research and development in forensic science are to understand, absorb, assess, develop, and utilize the scientific and technological advancements. The laboratories should share their researches, databases, and education as well as training facilities, new methods of analysis and good laboratory practices. There should be a common approach towards quality through accreditation of our systems and procedures to international standards.

The effective use of forensic science can only be assured if the analytical facilities and necessary man power is consistently available in these laboratories. The facilities should be commensurate with the workload. The input to these laboratories has increased over the years in almost all the countries in the world. But, the proportionate increase in man power and the laboratory facilities are not always ensured in most of the countries, particularly in the developing countries, which results into considerable delay in the examination of case samples. The forensic science service has come to a status of essential service to the criminal justice system, a system for the maintenance of peace and harmony in the society. The normal budget constraints should not affect the laboratory requirements so that turn around time in the laboratories is not affected adversely.

Training and Education

The value of forensic science lies in the people who practice and use it. It is their professionalism and commitment that needs to be nourished and developed to meet the challenges of the criminal justice.

The forensic opinion (opinion for courts) on the physical clues is made on the basis of the results of their scientific examination. The scientific examination/analysis of samples requires scientific acumen, whereas, expertise is necessary for making forensic opinion, particularly in comparative studies. The forensic scientist is a blend of the two. Thus, the development of requisite competence and skill in forensic scientist is very important for maintaining desired standards in forensic science. Hence, the induction as well as in-service training should be made compulsory for all the forensic scientists and their competence should be assessed from time to time.

If the forensic opinion on the physical clues of the crime is not properly evaluated and appreciated by the courts the chances of miscarriage of justice would increase. It is, therefore, essential to educate the prosecutors, defense counsels, and judicial officers in forensic science so that they can adequately lead, challenge, and assess the forensic evidence. Similarly investigating officers should also be trained to visualize the importance of various physical clues at the outset of crime investigation.

The general public, exposed to cinema and TV serials, has imaginary and unrealistic expectations of what forensic scientists can do to solve crimes. The popular media programs make them believe that forensic scientists can pick up traces of evidence from every scene of crime and produce clinching clues of crime. This is not always true in actual life; the success of forensic science depends on, and is related to many other aspects of crime investigation, including preservation of the scene of crime to prevent further disturbances, and contamination of clue materials. Therefore, the public should also be made aware of the advantages of scientific aids to crime investigation in its proper perspective, so that necessary co-operation and support is available in the investigative process.

Presentation of Forensic science Evidence

Forensic science evidence can be broadly classified into scientific evidence - when the results of scientific experiments/observations are expressed without further interpretation; and expert evidence - when the conclusions drawn (opinion) are expressed on the basis of the interpretation of the results of scientific experiments/observations. Let us consider the case of drug analysis. A questioned sample is analyzed by appropriate analytical methods, following the standard procedures, and the results of the analyses reveal a specific drug in the sample. The results of such analysis are conclusions based on well-established scientific principles and standard procedures. Hence, the findings need not be interpreted further if only the identification of the drug is required. The test result, by itself, is the evidence of the presence of the drug in the sample and meets the purpose of inquiry by the court. This evidence can be used as such in the judicial process of decision making. Such evidences may be classified as scientific evidence. On the other hand, when the question regarding source correspondence between two or more samples or individualization of a sample is to be answered by the forensic scientists, the results of the scientific experiments, observations, and measurements on the samples are assessed and compared to draw rational and balanced inferences. This process known, in general, as interpretation, makes use of the analytical results in forming the opinion to meet the purpose of the inquiry by the court. In addition to the relevant database and other specific information on the samples, the experience and expertise of the forensic scientist plays an important role in drawing such conclusions to express the opinion in the matter. Such opinions, based on the interpretation of the results of scientific experiments/ observations, may be classified as expert evidence.

The comparison of physical properties and chemical profile, and/or the topographical features (striation patterns, marks, impressions, etc.) of the questioned and known samples form the basis of expert evidence. However, the methods and criteria

used for comparing the physical properties and chemical profile, and striation patterns, marks, impressions, etc. (topographical features) are distinguishably different. The physical properties and chemical profile (minor/trace composition) of two or more samples are studied using sophisticated and sensitive analytical techniques and the results are compared and assessed to determine if the samples could have originated from one source. Whereas, the striation patterns, marks, impressions on the samples (topographical features) are examined with the help of magnifiers and microscopes of different kinds, to study the class characteristics and individual characteristics present therein. These characteristics are compared and matched to opine on their source correspondence.

As there is no theoretical foundation for the uniqueness of either the physical properties and chemical profile, or the topographical features, except the generalized inherent variability, the best resort is the statistical evaluation of the analytical results/observations. Statistical treatment of data generated on the samples, and making use of the databases for the attributes studied, yield quantitative estimate of the significance of the scientific findings. The selection of suitable statistical procedure for treatment of the evidence data to estimate its strength would also depend on the judicial requirements for the decision making. The basic question is whether the evidence should be evaluated for the probability of guilt or for the probability of innocence of the suspect, that is, whether we should determine the discrimination potential or the association potential of a given attribute of physical evidence. The discriminative approach presumes the suspect to be innocent while the associative approach presumes him to be guilty of the crime. Taking ratio of the probability of guilt and that of innocence is another way to look at the evidential value. It may be worthwhile to debate and decide on these issues and adopt, internationally, suitable statistical methods for evaluating physical evidences.

Many forensic scientists have advocated the Bayesian approach to interpretation of forensic science evidences in the recent years. The Bayes' theorem is widely used in decision making. Bayes propounded that the probabilities should be revised when new information is available. The need to revise probabilities arises from a need to make better use of available information and thereby reduce the risk involved in decision making. In Bayesian interpretation of forensic science evidences, the likelihood ratio is evaluated. This ratio compares the likelihood of two possible hypotheses, which are mutually exclusive. Many forensic evidences have been evaluated with Bayesian perspective and various formal mathematical models have been developed. There is, in general, considerable interest in this method, at present. However, this approach to the interpretation of forensic science evidences is still viewed with skepticism by some people in view of the fact that, some times, the probabilities revised on the basis of additional information may lead to wrong decision.

The scientific evidences are expressed in a straightforward manner. But, most of the expert evidence is a matter of disciplined judgement of the forensic scientist, a subjective judgement based on objective test results. The strength of such evidences should be properly assessed, and expressed carefully in a language that is clear, concise, unambiguous, understandable, and not open to misinterpretation. The vocabulary used for

expressing the value of the evidence should be standardized. It would also be desirable to make clear what the evidence does not mean in addition to what it does.

In the case of an expert witness there exists the tendency to support the view which is favorable to the side which employs him so that it is difficult to get from him an independent opinion. A forensic scientist should consider the propositions of the prosecution as well as allegations of the defense and present a balanced view of the evidence. An expert may revise his opinion if he finds cogent reason and his evidence need not be disbelieved on this ground.