CHAPTER TWO

Development of Scientific Aid

In

Criminal Justice System
"If criminal evidences are not objectively tested, analyzed and interpreted by adequate scientific methods, the search for truth will potentially be compromised, if not defeated"

-US Congress resolution 2009

Crime and Science have existed in some form or the other in the past since the human being inhabited the planet earth. With rapid advancement in human civilization, both science and crime have developed at a phenomenal rate making them the very important facets of human life. Thus when on the one hand, intelligent criminals have been quick to exploit science for their criminal acts, science has also helped law enforcement agencies to embrace all physical and natural scientific techniques in the detection and surveillance of the crime instead of relying on age old art of interrogation.

From the earliest times till the mid of nineteenth century, the primary tools in the investigation of forensic cases were observation and interpretation of physical evidence. However in the second half of the nineteenth century, science was first applied for advancing the manner in which cases were investigated thereby improving the validity of the conclusions drawn from the criminal investigation by concerned authorities. A few attempts were also made to take the aid of scientific methods in certain specialized area concerning police investigation like the processing of the evidence. Investigating authorities also used to obtain scientific information from academic departments of chemistry, biology or pharmacology at
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University level which had required knowledgeable expertise and desired technical infrastructure regarding every aspect of the criminal activity i.e. from gathering evidences at the crime scene to the finality of the criminal case concerned. It used to be the responsibility of law enforcement agencies to locate such human and technical resources and deliver the evidence for processing for quick and just conclusion.

Later, in some instances, scientific laboratories even got established within the police organizations as its integral part for ensuring the secrecy of the evidence collected. With increase in number of criminals, lot of bureaus for the identification of the offenders got developed within the law enforcement institutions for foolproof establishment of accused identity with the use of sophisticated technology. Law enforcement agencies now could no longer depend on the memory of shrewd police officers who used to know the felons in the society and their gangs so well that they could tell with accuracy as to whose handiwork was involved in a particular case. However, in these cases the role of biasness could not be completely ruled out. More and more use of technology and scientific principles became the order of the day as far as criminal investigation and prosecution was concerned.

With increasing complexity of the modern society and its dependence on the scientific and technological development, the reliance of the Criminal Justice System on scientific testimony was no less than natural phenomenon. For example just as technology has acted as a boon for society in facilitating tele-education and tele-medicine in contemporary era, scientific techniques like D.N.A. profiling, Brain finger mapping, Narco-analysis and others have brought revolution in the field of
forensic analysis. This has made our courts increasingly reliant on the use of scientific technology and scientific principles in the assessment of evidence not only during the trial but also in understanding the profundity of the crime and thereby deciding the corresponding sentence. Area of chemical, physical and biological clues for forensic investigation, with the ushering of genomic era, finger printing and DNA profiling have evolved as a major tool for crime establishment and relating the accused with the crime scene. Thus scientific proof has become one of the cornerstone around which the criminal prosecutions in modern world are relying upon.

Getting into some insight, it may be stated that Forensic Science is the application of broad spectrum of scientific principles and technologies to answer the questions of interest to the legal system enforced by the law enforcement agencies in the Criminal Justice System. This may be in relation to a criminal or to a civil action. It is essentially crime-laboratory based academics where scientist and professionals help the law enforcement agencies to analyze smallest piece of evidence for solving criminal mysteries. A forensic scientist analyzes all physical evidences found on the victim or at the scene of the crime and links it to evidences found with the suspect thereby providing expert testimony to the court of law. Forensic science is not a discipline or branch of science as the name suggest, but it is an amalgamation of many distinct area of expertise like Forensic Pathology, Psychology, Forensic Medicine, Chemistry, Biology, Toxicology, etc. Forensic Science also incorporates general advances in scientific arena and incorporates them into the Criminal Justice System in order to make the latter more relevant and sustainable. It embraces varied number of disciplines like Chemistry, Biology, Physics, Anthropology, Engineering,
Toxicology, Psychiatry, Entomology, Deontology, Toxicology, Pathology etc and applies them in the fields of Photography, Ballistics, Narcotics, DNA Profiling, Brain fingerprinting, Narco analysis etc, helping law enforcement agencies in crime control & crime prevention.

In India, the importance accorded by the Government of India to the application of scientific principles and technological solutions to different facets of governance including crime control and prevention was itself evident from the Scientific Policy Resolution adopted by the government on March 4, 1958. To quote one of the rationales of this policy could be most relevant in this context:

“"It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare state has grown. It is characteristic of the present world that the progress towards the practical realization of a welfare state differs widely from country to country in direct relation to the extent of industrialization and the effort and resources applied in the pursuit of science.”"

Similarly the Policy Vision of Science, Technology and Innovation Policy 2013 of Government of India states that:

“"The guiding vision of aspiring Indian Science, Technology and Innovation enterprise is to accelerate the pace of discovery and delivery of science-led solutions for faster, sustainable and inclusive growth.”"
Thus it is evident that the government has constantly been concerned to improve the application of scientific technology in different spheres of life including the Criminal Justice System. Constant effort to upgrade forensic caliber and capabilities of law enforcement agencies, increasing the financial outlay for modernizing and upgrading the forensic science institutions, appointment of Malimath committee for revisiting the Criminal Justice System in the country are some of the commendable steps taken by the country’s leadership in this regard. It must not be undermined that the scientific technology plays a vital role in the investigation of crime and the administration of justice if the scene of the crime is examined without any delay and exhibits are analyzed and reported immediately after the commission of the crime. The physical evidences speak the truth and explain the unopened scenario of crime. It will not be out of place to mention that the success or failure of the investigation of any crime depends mainly on effective application of scientific principles and techniques in evidence collection at the scene of crime, crime investigation and lastly justice delivery.

**Need for Scientific Aid in contemporary Criminal Justice System**

The aim of criminal law should always be to protect the rights of the individuals and to safeguard the weak against the strong, law abiding against lawless and peaceful against violent. The state in this respect should prescribe certain rules of conduct, sanctions for their violation and establish machinery to enforce sanctions and procedure to protect that machinery. Hence, it is the primary function of the
government to protect the basic rights to life and property. There can be no liberty without protection of the basic rights of the citizens by the government.

In the pursuit of the above objective, it is expedient that the government should aim to establish a Criminal Justice System that is fair, quick into action, cost effective, efficient and sustainable. Scientific technologies and techniques certainly play an important role in ensuring these attributes to the character of Criminal Justice System. The state of application of scientific technologies in the country's Criminal Justice System is also a reflection of the technological prowess of that particular country.

The application of scientific techniques find its place in the field of detection of the criminal act; collection, packaging, transportation and analysis of physical and biological evidences; establishing the links between the criminal act and the scene of crime with the accused and lastly to proof the guilt of the accused beyond reasonable doubt before the court of law. Thus the significance of scientific techniques acquires relevance right from the commissioning of crime to the adjudication of the crime. With the scientific transition in the field of Criminal Justice System from the past, a time now has arrived when nobody can get false conviction due to errors of eye witness, unreliable information, social bias, false confession, misconduct, political pressure, systemic corruption and poor legal representation.

Most apparent application of these scientific aids in the field of forensic investigation is into clinical Forensic Medicine, Forensic Pathology, Toxicology, Forensic Anthropology, Forensic Entomology, Forensic Geology, Forensic
Taphonomy, Forensic identification of biological fluids and stains, Forensic DNA Analysis, Forensic footwear evidence, Forensic Fire Impression and Track Mark. Where direct evidence is not available or if it is available not in sufficient worth, then the assistance of circumstantial evidence e.g. hair, foot and tyre marks, fingerprints, bullet imprints etc. may link the accused to the alleged crime or crime scene using these advanced techniques.

Also, many of country’s forensic science laboratories are understaffed, resource crunched and lack desired infrastructure facilities. The investigation process and the prosecution process leading to delivery of justice to the victim usually prolong for excessively long duration in the absence of appropriate witness. Witness turning hostile is not an uncommon phenomenon while coercion of witness is not a rarity to find in Indian Criminal Justice System. The criminals therefore easily manage the benefit of doubt to get acquitted even from most heinous crimes. The judicial system has been rendered useless and a constant erosion of faith in people for the judiciary is not a hard thing to perceive. This can be substantiated when there is a decline in the rate of conviction that has left the common citizenry in lurch.
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As is evident from the crime conviction statistics from National Crime Record Bureau report, it can be deduced that barring certain exception, the conviction rate has been declining over the past decade. Also the average conviction rate is averaged about 40% in the previous decade which is not only alarming but also displays the state of neglect which the Criminal Justice System is facing. The percentage of cases in which trial have been completed has also declined by almost 2% between the years 2006 and 2015. This indeed has caused a deep impact on the perception about the efficacy of Criminal Justice System prevalent across the country. One of the main reasons attributed to such a pathetic situation is the inadequate use of scientific aids in criminal investigation and administration of justice.

### Disposal of IPC crime cases by Court-Decadal Picture
(Source: Crime in India, 2015 report, NCRB)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Year</th>
<th>Total No. of cases for Trial (including previous year pending cases)</th>
<th>No. of cases</th>
<th>Percentage of cases for which Trial has completed</th>
<th>Conviction has been pronounced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tried</td>
<td>Convicted</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2006</td>
<td>71,92,451</td>
<td>10,44,120</td>
<td>4,47,516</td>
<td>14.5</td>
</tr>
<tr>
<td>2</td>
<td>2007</td>
<td>74,73,521</td>
<td>10,25,689</td>
<td>4,33,929</td>
<td>13.7</td>
</tr>
<tr>
<td>3</td>
<td>2008</td>
<td>78,33,842</td>
<td>10,52,623</td>
<td>4,48,475</td>
<td>13.4</td>
</tr>
<tr>
<td>4</td>
<td>2009</td>
<td>81,30,053</td>
<td>10,25,781</td>
<td>4,27,655</td>
<td>12.6</td>
</tr>
<tr>
<td>5</td>
<td>2010</td>
<td>85,49,655</td>
<td>11,41,031</td>
<td>4,64,128</td>
<td>13.3</td>
</tr>
<tr>
<td>6</td>
<td>2011</td>
<td>89,39,161</td>
<td>12,11,225</td>
<td>4,97,996</td>
<td>15.4</td>
</tr>
<tr>
<td>7</td>
<td>2012</td>
<td>93,28,085</td>
<td>12,52,138</td>
<td>4,82,260</td>
<td>13.4</td>
</tr>
<tr>
<td>8</td>
<td>2013</td>
<td>97,81,426</td>
<td>12,90,148</td>
<td>5,18,126</td>
<td>13.2</td>
</tr>
<tr>
<td>9</td>
<td>2014</td>
<td>99,30,625</td>
<td>13,41,386</td>
<td>6,05,144</td>
<td>13.5</td>
</tr>
<tr>
<td>10</td>
<td>2015</td>
<td>1,05,02,256</td>
<td>13,25,989</td>
<td>6,21,320</td>
<td>12.6</td>
</tr>
</tbody>
</table>
Thus in order to achieve the goal of ‘good & progressive society’, scientific techniques must constitute the core of the crime investigation process. The quantity, quality and timeliness of information are also crucial in the system involving the investigation. Information flows in this aspect can also affect the way the entire system works. Technology finds multifarious application in this context. It could undoubtedly protect the innocent and could reveal the real truth about the crime and criminals that could help in establishing a just social order. Developments like brain fingerprints and DNA profiling etc. have brought forth a revolution in this context. Many other revolutionary developments are indeed yet to emerge. Thus, the need for these scientific techniques and technology in Criminal Justice System of contemporary era is discussed in the following section as:

Lack of Coordination between different Law Enforcement agencies

It has now been a well established fact that a good communication system should exist at every stage of crime management viz preliminary investigation of a crime, crime scene examination, evidence collection, case investigation, scientific analysis and interpretation of the evidence collected and presentation of the case to the court. A partnership on trust that all the enforcement agencies are working together in the pursuit of shared aims is imperative for an efficient investigation of the crime leading to identification and prosecution of the guilty and quick elimination of the innocent from the investigation.
The involvement of various agencies like the police functionaries, district administration, forensic expert and finally the court has made the application of scientific technology an unavoidable necessity. Need is to break the existing artificial barrier so that system can work efficiently in a cost effective manner. A communicative team with a shared vision can only ensure an equitable Criminal Justice System for which technology would certainly play a central role.

**Emergence of Human Right regime at National and International level**

Until the middle of 20th century, many of the abhorrent ways of investigation like torture, third degree found its place in the arena of criminal investigation in India. These methods were more prominently and vigorously applied during the British Raj. However with the gradual advancement in the society and evolution of progressive outlook, things began to change. Torture, both physical and psychological, increasingly came to be understood as a naked violation of human rights.

The Universal declaration of Human rights in 1948 recognized all embracing ‘Human right’ to every individual by virtue of him/her being ‘Human’ and primacy of the rights of an individual for a dignified and humane existence. India, being a signatory to the convention, setup institutional mechanism like National Human right commission (NHRC) and State Human Right commission (SHRC) in ratification of the aforesaid declaration. The declaration along with many of the conventions and resolution of U.N. such as International Covenant on Civil and
Political Rights, UN General Assembly Resolution of 1984 increasingly began to play a watershed role in the transition of Criminal Justice System with a more considerate approach.

This role reversal of the Criminal Justice delivery mechanism demanded the need for adoption of more sophisticated technology in its essence to get rid of barbaric and asynchronous approach followed in the past. Whether it is a case of right to a speedy trial or right of bodily integrity or the right to have an independent sexual orientation for an individual or check on the abuse of power by the police officials, the role of scientific aids in order to prevent Human right violation has increasingly attained relevance.

Going by the statistics provided by Crime in India, 2015 compendium issued by National Crime Records Bureau, the number of custodial deaths between the years 2011-2015 stands to 521 with a total of 1465 deaths in the last 15 years. However it is considered a very conservative estimate by the government. The Asian Centre for Human rights (ACHR), a human rights watch group instead places the deaths at about ten times the government figure. The National Human Rights Commission (NHRC) reports about 12727 deaths between 2001 and 2010 across the country. Also large majority of death were a direct consequence of torture in custody. In fact the above mentioned data represent only a minuscule of the horrifying condition of prison management within the country. This indeed is a huge blot on the image of the nation which had been known for its impeccable human rights records. Thus it may not be wrong to conclude that torture remains integral, institutionalized and central to the administration of justice and counter terrorism measure in India even today when Human Rights movement is gaining order across
the nations. A sound transparent, empirical and integrated approach to scientific application in Criminal Justice System could only provide a reliable solution to this menace.

**Delay in Response Time by various Law Enforcement agencies**

The components of Criminal Justice System viz Police, Judiciary and other law enforcement agencies have gradually been feeling the concern of delayed response in a criminal situation. Lack of institutional capacity of investigation and law & order wings of the police department; poor infrastructure of police and judicial system; staff crunch at various levels in police hierarchies; poor judge/population ratio for disposing of cases; fallout in the capacity building for both police and judiciary have hampered efficient criminal justice delivery in the country.

A proper augmentation of information and communication technology; use of modern scientific equipment in investigation and prosecution; scientifically aided training and capacity augmentation; uniform and integrated system of personnel management etc can only help in fighting out above challenges in a most cost effective way.

**Emerging Scenario of Blue Collar crimes**

The industrial revolution and consequent development in the society resulted into the complete transformation of criminal activities in the 20th century. The society has seen a phenomenal change from traditional crimes to a new generation of
criminal activities more appropriately known as Blue collar crime. Bio-terrorism, Chemi-terrorism, Narco-terrorism, Economic terrorism, Hate Crime, Organ trading, Genetic manipulation, Wild life crimes, Intellectual Property Right infringements, Environment crimes are some of types of ‘Blue collar crimes’ which indeed have changed the definition of crime contrary to what it was earlier believed. Secretive deals in narcotics have spread in most of the parts in the world. Drug Barons have reportedly been maintaining a nexus with terrorist organization in different part of the globe. A special dimension has now been added to the definition of crime which poses the greatest challenge to the law enforcement agencies in responding to the national security concerns all over the world.

Thus now it requires an entirely different approach with extensive use of modern scientific technology. Tackling these crimes in most sustainable way would be the greatest challenge country could be facing in coming years. An endeavor to fight this new menace is essential, if the present society wants to leave over to the future generation a conflict and crime free environment. With the increase in population, urbanization and consumerism, appropriate skills to provide effective scientific aid in the investigation of such types of crime is the need of the hour. The situation in several developing countries like India is no less different; several of these Blue Collar crimes which have their genesis in western developed countries are posing a threat to amateur Criminal Justice system of developing countries. Scientific revolution in crime prevention and prosecution could provide answer to these complicated webs of trans-national crimes.
**Emerging Scenario of White Collar crimes**

Other than Blue collar crimes, the unintended by-product of modern day development in contemporary era are the White Collars crimes. These crimes are committed by the persons of respect and social status in the society during the course of their occupation. Tax evasion, Business burglary, Cyber crime, Market manipulation are some of dimensions under White Collar crimes. While the scene of occurrence could be accurately identified or fixed in Blue Collar crimes, the White Collar crimes are characterized by its transnational character and international ramifications.

Very strangling manifestation of such White Collar crimes have recently been revealed by London Inter Bank Offered Rate (LIBOR) Scam, Ponzi scheme scandal which involved money laundering at an international level and international cyber attacks on countries like Iran, India. In the Indian scenario, Hawala scandal, Stock exchange frauds, Satyam fiasco are some of the crimes that have surfaced mostly in a post liberalized era. Due to use of sophisticated technology in the commission of these crimes, it has really become imperative on the part of law enforcement agencies to upgrade their skills through relevant scientific aids. Reorganizing and revisiting the forensic science mechanism by integrating with newest technologies is the need of the hour. More robust monitoring system, better regulatory mechanism, fast tracking the justice delivery system are some of the aspect that can only be answered through adoption of sound and modern scientific techniques and methodology.
Growing Relevance of ‘‘Crime Scene Management’’

With modern crimes going hi-tech and criminals adopting modern technologies at an unprecedented level, crime scene management has acquired immense importance in managing crimes and punishing the culprits. Successful crime detection and punishment to the criminal is contingent upon quality crime scene management within a definite time frame. A sound proof crime scene management can not only deter a criminal from acting in a mala fide way but also can increase the efficacy of the law enforcement agencies in managing crime. Use of tyre and foot prints, DVI process, exhumation of gunshot etc sometimes has importance very similar to biological evidences like DNA related clues and physical evidences like audio-video related exhibits in a criminal investigation. With criminals trying to overcome law enforcement machinery in this 21st century, the importance of scientific technology has increased to a much greater extent.

Importance of ‘‘Court Room Management’’

Any criminal investigation has to be ultimately pass the final test in the court of law. A speedy and cost effective disposal of criminal case forms the foundation stone of the Criminal Justice Delivery system. If the forensic findings are not properly presented in the courtroom, the defence would be in a position to point out the infirmities in the prosecution case theory and the whole criminal investigation would ultimately turn out to be a farce. The court room forensics thus acquires a lot of relevance in the present day modern context. Also with increasing complication in the Criminal Justice System, more and more cases are pending before the courts which are unnecessary clogging the justice delivery mechanism.
Technology undoubtedly could provide solution to both of the problem. Focusing more on e-courts, witness’s statement through forensic tools like video recording, CCTVs, Video synthesizers can bring more authenticity to the Criminal Justice delivery system. Scientific aids unquestionably could be a useful tool in both court room forensic and cost effective case disposal thereby strengthening the Criminal Justice System.

**Managing Social Change**

The society is undergoing paradigm changes at a very rapid pace. India has transformed from a traditional colonial country to a modern, democratic nation. Sizeable industrial complexes have sprung up and the transport facilities have been revolutionized and modernized. A growing perceptible shift from a rural, agriculture based society to an urban, service and manufacturing oriented society is quite evident. These changes have made the old techniques of criminal investigation obsolete. Due to this reason, in India the investigation of crime and prosecution of persons having committed the crime are not up to the mark. This is evident from the declining rate of trial and conviction. Even in most heinous crimes, large number of criminals could not be prosecuted due to use of obsolete techniques of investigation by the law enforcement machinery leaving many loopholes. Thus many of these trials end in acquittal as a result of which numbers of criminals as well as crimes are increasing day by day. Thus modern scientific methods for investigation of crimes and connecting the criminals with the crime as well as with the crime scene are very much necessary in order to make Criminal Justice System more effective.
Increase in the Technical Knowledge of the Criminals

The technical knowledge of an average man has increased tremendously in recent years. As a result the criminal activities are getting more and more refined and sophisticated. The investigation officer thus needs the aid of modern scientific techniques to combat the modern day criminals as these globalized hi-tech criminals pose the greatest challenges to the nation’s security and peace. Hence it is imperative for the forensic investigators to instill fear among these criminals so that they shall deter from committing the crime. To do so the forensic investigators have to adopt hi-tech forensic investigation techniques so that nothing escapes their eye leaving no scope of any ambiguity in their findings.

Enhancing the Credibility of the Evidence

Earlier the judges used to rely upon the evidences of the eye witness, approvers, or from confessions for the delivery of justice. But in the contemporary era, these traditional modes of evidences are not only becoming unproductive and obsolete but are also delaying delivery of the justice and, in some cases, even are leading to miscarriages of justice. Scientific evidence has now reached to a stage where it has crossed all physical barriers as far as its analysis is concerned. Now even the tiniest clue could be analyzed to establish identity and relevant facts and to link it with the criminal, the victim, the crime scene, the weapon of offence or the vehicle used in the commission of the crime. Apart from this, the scientific evidence has other plus points:
a) It is verifiable. A second or even a third export can verify the correctness of the evidence.

b) It is objective and does not depend upon the frailties (Physical, moral and mental weakness) of the witness.

c) It is economical and saves time.

d) It is demonstrative.

**Requirement for Pre-emption of the Crime**

Pre-emption of the crime to forestall the tremendous loss of life and property due to criminal activity has become a necessity of our times. Investigation and prosecution is, like a wild goose chase, which can sometimes meet a dead end. Also often these activities sometimes prove to be unproductive in crimes of magnanimous magnitude. Scientific techniques have taken a giant leap forward and have started playing an important role in pre-empting such major devastating crimes by proactive collection of information from the suspected sources.

For example, terrorists attack comes without any warning to the citizens and to the nation and inflicts immense damage apart from crippling the normal life. Now a days terrorist are well planning their nefarious designs to inflict maximum damage in terms of causalities and property damage leaving with only a short window to respond for the law enforcement agencies. It is here that scientific techniques can aid to strengthen our intelligence capabilities for meeting the ever increasing threat to the country. Scientific techniques can help prevent terrorist attack by not only identifying terrorist but also detecting and nullifying their plans or at least help in
Reducing the damage. Scientific techniques will also be playing a major role in taking safety standards in critical infrastructure which are always on the hit list of terrorists’ attacks.

Succinctly, the present day society is characterized by inordinate growth in magnitude as well as complexities of the crime which seriously causes adverse effect on the sense of the security of the people and the efficacy of the Criminal Justice System to deliver cost effective and speedy justice. This in turn has resulted into erosion of the citizen’s faith in the system itself. In the face of inordinate delays in the disposal of criminal cases and an abysmally low rate of conviction, people's faith in the Criminal Justice System is fast declining to such an extent that it has almost reached to the verge of collapse. With the emergence of new types of crime, their level of sophistication and change in the environment of the commission of the crime, the traditional tools of Criminal Justice System have became really inadequate and outdated. Only the intrinsic appeal to science could provide a full proof solution to the emerging problems and challenges within the legal framework in all the countries including India. A multidisciplinary approach with greater scientific endeavor could provide a better prospect for the Criminal Justice System in its future encounters with the crime inflicted society.

**Development of Scientific Aid in Criminal Justice System**

The conceptualization of using scientific technology to combat crime has long sparked the imagination of law enforcement officials, criminology professionals and
the general public across the world. However it was Arthur Conan Doyle who in his Sherlock Holmes series, which begun in 1890's, fascinated readers with techniques such as cataloguing tobacco ashes to identify suspects' brands of choice. Real life soon imitated fiction and the idea of tracing and identifying an individual typewriter by peculiarities of its type first appeared in early 20th century.

Sometimes later during World War I, Edward Oscar Heinrich, known as "the American Sherlock Holmes," opened the first modern laboratory devoted to crime detection in California. Despite such developments, the adoption of scientific technology to solve complicated criminal cases had been a slow process. There were isolated and scattered attempts to upgrade the law enforcement technology in checking the proliferation of the crime. Some achieved notable success. For example, the first modern Polygraph was constructed in 1921 by a medical student. Later with the explosion of technologies during and after World War II, law enforcement agencies were able to learn a lot about scientific technologies and their application from developments in other organizations, particularly the military. For example, the Radio equipment and surveillance aircraft found their way into some large police departments post World War II. Forensic medicine also developed quite rapidly in this era. The study of questioned documents also emerged in this era. With further development of laboratory instruments and techniques, forensic toxicology and serology became important in the second half of the twentieth century.

From the above discussion it is evident that the modern forensic sciences and their practical applications originated during the middle of the twentieth century. However the history of scientific application in Criminal Justice System can be
traced back to before Common Era although it existed in very rudimentary form. In
the past, because of lack of sophistication in various disciplines like chemistry,
physics, biology, and medicine, investigation of trace evidence was largely
subjective. However with the development of photography, advances in medical
pathology, evolution of chemistry, biology as a science and application of the
microscope to the routine study of plant and animal tissues, the study of trace
evidence from the crime scene, victim, or suspect began to provide definitive
knowledge and testimony of the crime.

Notwithstanding the above fact that the forensic science developed in leaps
and bounds for ascertaining the analysis of unnatural death, its progress has not been
uniform throughout the world. In some European countries there has been a century
of development, predominantly in forensic centers devoted to the education,
physicians, lawyers, and law enforcement officials while some others have been
laggard in this respect. Nonetheless a brief account of the development of the
scientific aid in Criminal Justice System across the world with a special reference to
India is given below.

World Perspective

The oldest known Law Code of Babylon was drawn by King Hammurabi
around 2900 BCE which included provisions regarding rights and duties of medical
practitioner and laid down civil and criminal liabilities for physician’s negligent act.
Improper treatment causing death to the patient was heavily punished in ancient
Egypt. The celebrated works of Homer, Herodotus and Diodorus of ancient Egypt
also contain several medico-legal matters. The “Papyrus” of ancient Egypt, dating back to 2500 BCE, gives an account of sexual perversions, marriage customs and diagnosis of poisoning. Imhotep, a celebrated Wazir, Chief Justice and Physician to King Zoserman was the first man to combine the science of law and medicine, and is considered by many as the first medico-legal expert.

In ancient Rome, a criminal charge meant presenting the case by both the parties before the public. Both the individual, the accused of the crime and the victim, would narrate their part of the story to the public and the individual with the best convincing skill would determine the outcome of the case. Later Numa Pompilious made provisions around 600 BCE to open the body of a woman immediately after her death during confinement to ascertain any custodial crime. A medico-legal article of the Lex Aquillie in 572 B.C. dealt with lethality of wounds and expert medical opinion in assessing their gravity. The first recorded autopsy was that of Julius Caesar in 44 BCE where out of 23 injuries only one was found to be fatal. The importance of the physician in courts and in legal matters (expert witness) was clearly acknowledged under the rule of Emperor Justinian (483-565 A.D.). Under the Justinian Code, the role of medico-legal experts have been clearly defined in dealing with medico-legal problems like proving of pregnancy, sterility, impotence, rape, poisoning, and mental illness. It was also considered in ancient Rome that, ‘Physicians are not ordinary witnesses but they give judgment rather than testimony’ thus recognizing the special status of medico legalist as an impartial arbiter.
The contributions of Greeks on account of application of scientific principles in forensics can be traced back to the “Eureka” Legend of Archimedes (287-212 AD) when through the principle of water displacement & buoyancy, Archimedes demonstrated that the crown was not made up entirely of gold contrary to the fraudulent claim. The earliest account of identification of individuals based on their fingerprints was during the 7th century when an Arabic merchant, named Soleiman, used debtor’s fingerprints on the bill for lending money in order to ascertain his identity and liability. This bill was legally recognized as proof of the validity of the debt.

In ancient China too, evidences of fingerprints and thumbprints have been found on clay seals and prehistoric rock carvings. However, guilty persons were then thought to confess under torture while it was considered that God would give an innocent person the strength to resist the pain. Later the accounts of several legal-medico practitioners were found (in their ancient texts) dating back to 6th Century BCE. The earliest record of the application of forensic science has been found back in the 3rd century in China. In this particular case, a woman claimed that her husband died when he was unable to escape from a house fire. A suspicious coroner performed an experiment in which he burned one pig alive and burned another pig that was already dead. He noticed that the pig that was burnt alive had ashes inside its mouth while the dead pig did not. Upon finding the deceased man’s mouth to be free of ashes, he questioned the widow, and she confessed to murdering her husband and burning his body to destroy the evidence.

The Jewish Code of Law (Assizes of Jerusalem) framed in 1100 AD by the Crusaders incorporated provisions of a court order for the medical examination by a physician or surgeon for non-attendance in courts on health grounds and for the examination of the corpse in murder cases to find out the injuries. Similarly in France, the Bishops of Maine and Anjou had been said to have employed medical experts in their service from the 11th century. Roger II of Sicily, in 1140 AD, brought medical practice under law while in 1224 AD Frederick II ordained public examinations for physicians based on Hippocratic Oath. From 1260 AD, legal provisions were made for medical experts like surgeons and physicians to be sworn to give their testimony in courts. From the end of the 13th century, medico-legal works of different kinds including the autopsies were conducted by doctors in Bologna and other parts of Italy. The first medico-legal autopsy was done by Bartholomeo Da Varignana of Bologna in 1302. The first written account of using medicine and entomology to solve (separate) criminal cases is attributed to the book Xi Yuan Ji Lu (Translated as ‘The Washing away of Wrongs’), written in 1248 by Chinese named Song Ci. The book offers advice on how to distinguish between a drowning (water in the lungs) and strangulation (broken neck cartilage) while undergoing forensic analysis.56

Though the development of scientific techniques and their application in forensic analysis was very gradual till 15th century, it provided for sound base to the rapid application in the past five centuries. The advances in both medical and scientific knowledge contributed to a considerable extend the use of medical evidence in courts as a part of forensic analysis during this period. Before that, only

56 Supra 55 at p. 10
oral testimony was available for deciding cases and for imparting justice. Such
witnesses were not always reliable as some of them used to turn hostile, unwilling or
unobservant. A need for impartial and objective evidence was also felt which could
be relied on by the courts without hesitation. This gap was fulfilled by support
provided by rapidly developing scientific technologies and their application in the
criminal investigation.

It was in the 15th century that the first forensics textbook was published. The
textbook mentioned one of the first uses of science to identify a murder weapon. A
murder was committed and the trial judge ordered that all the sickles in the village to
be confiscated. Only one sickle attracted flies, leading the judge to conclude that it
was due to the scent of the blood and that this was the murder weapon. In 16th
century Europe, Medical Practitioners in the Army and University settings began to
gather information on causes and the manner of death. Ambroise para, a French
army surgeon, systematically studied the effect of violent death on internal organs
and laid the foundations for modern forensic pathology through his study of trauma
on human organs. Two Italian surgeons, Fortunato Fidelis and Paolo Zacchia, laid
the foundation of modern Pathology by studying changes which occurred in the
structure of the body as the result of some diseases. In the late 1700s, writing on
these pathological conditions began to appear which included ‘’A Treatise on
Forensic Medicine and Public Health’’ by French Physician Fodere and ‘’The
Complete System of Police Medicine’’ by German medical expert Johann Peter
Franck.57

57 Supra 55 at p. 11
In 1775, Swedish Chemist Carl Wilhelm Scheele devised a way of detecting Arsenous oxide or simple arsenic in corpses, although only in large quantities. This investigation was expanded, in 1806, by German Chemist Valentine Ross, who learned to detect the poison in the walls of victim’s stomach and was further enhanced by English Chemist James Marsh, who used standard scientific testing to determine that a man murdered his grandfather by arsenic poisoning in a 1836 trial and this assay is now known as the Marsh test. The perfect poison, Arsenic, which was used in crimes concerning many unnatural death got revealed to the world of forensic analyst.58

The 19th century was the century of forensic revolution. The most notable achievement was the invention of the microscope which unlocked many new areas of forensic science. It enabled the forensic investigators to inspect tiny wounds, crystals or glass, and the characteristics of hair and fibers. Human remains were identified using teeth for the first time. Military surgeons produced vast bodies of work detailing wounds and the related causes of death. During this century, development in the knowledge of Chemistry also brought forth paradigm changes in the Forensic analysis of criminal activity. The scientist in Europe subsequently made great contribution while utilizing natural and other sciences in criminal investigation. In 1820s, Eugène François Vidocq pioneered the first use of ballistics and began taking plaster casts of shoe imprints at the crime scene. Later scientist Calvin Goddard was credited with a microscopic comparison of the shell casings from the scene of the St Valentine’s Day Massacre, which led to a raid on Al ‘Scarface’ Capone’s home and the recovery of two of the weapons from the house.

58 Supra 57
of the accused. By his method it could be determined whether a particular weapon was used or not in commission of the crime.

The 1890s saw the first use of the Henry’s System for fingerprint classification. Around the same time, Edmund Locard developed 12 matching points for fingerprint comparison. He is also credited for one of the fundamental principles in forensic science known as the Locard Exchange Principle which states that when two objects come into contact with each other, they exchange materials. Thus a criminal will leave some trace on the crime scene and will take some trace away with him. This principle of cross-transfer has formed the foundation of trace evidence collection and analysis for over a century and still plays a central role in 21st century forensic science.

Toxicology, the study of poisons, emerged as one of the new forensic disciplines, highlighted by the work of Mathieu Orfila in 1840 with his investigation into the death of a Frenchman, Monsieur Lafarge. Following examination of the internal organs from the exhumed body, Orfila testified on the basis of chemical tests that these contained arsenic, which was not a contamination from his laboratory or the cemetery earth. These methods to analyze the poison by chemical test were universally accepted and are being used even today. In 1893, the famous book “Handbuch fur unterschnugsrichter” by scientist Hans Gross got translated and published in English with the title “Criminal Investigation” which is still considered as a classic book for use of scientific methods in criminal investigations. Further a development in technology of bullet matching helped the police to trace the gun

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60 Supra 55 at p.12
used in the commission of the crime with the perpetrator of the crime. Tiny flaws in bullets could be measured and matched to gun barrels to provide conclusive proofs for the crime. However, it was not until 1926 that this was used as evidence in court because of the difficulties in confirming identification.

During the latter part of 19th century, there was considerable effort in trying to devise ways for the identification of a particular individual. Forensic analysts were in search of a new type of evidences which were permanent and accurate. Though a number of scientists contributed in this pursuit in their own unique way, the contributions of scientist Alphonse Bertillon from France is most notable. He evolved a procedure for taking measurement of different part of the body to distinguish one individual from the other. Bertillon's system was based on five primary measurements viz (1) head length; (2) head breadth; (3) length of the middle finger; (4) the length of the left foot; (5) the length of the "cubit" (the forearm from the elbow to the extremity of the middle finger). Each principal heading was further subdivided into three classes of "small," "medium" and "large." The length of the little finger and the eye colour were also recorded. This scientific analysis came to be known as Anthropometry. This method combined detailed measurement and classification of unique features with frontal and profile photographs of suspect—and recorded the information on standardized cards in orderly files. This method was widely used for almost a century for the purposes of identification of individual till it was replaced by finger print identification technique. He also developed a method of identification by description given by witnesses. This method of Identification is
called “Portrait Parle”. Because of such enriching contributions, he is termed as the “Father of Criminal Identification”. ⁶¹

However, sometimes faces used to have striking similarities which cannot be distinguished with photographs without any error. Need for a more reliable method of identification was needed and the gap was filled by the technique of personal identification system through finger print examination. Although Bertillon is reported to have used latent fingerprint from a crime scene to solve a case, it was Sir William Herschel, a British Civil servant in India, and Henry Faulds who are credited with performing most of the early finger print investigations. Faulds, a Scottish Physician, is also credited with establishing the fact that fingerprints remain unchanged throughout the life of an individual. It was not until 1901 when Sir Edward Henry devised a fingerprint classification scheme for cataloguing and retrieving prints, that the full potential of personal identification system through fingerprint evidence could be used with such wide acceptability in forensic investigation.

In 1901, Karl Landsteiner had developed a methods by which blood could be grouped into different groups. Following this principle, Italian scientist Dr. Leone Latter developed a procedure in 1915 for determining the blood group of dried blood stains. This method was later adopted by criminal investigators in solving complex murder mysteries. The inclusion of the more recent Rhesus test with detection of several different enzyme systems has further improved the discrimination among individuals but because of the recent studies of the deoxyribonucleic (DNA) in

⁶¹ Supra 55 at p. 11
human chromosomes, there have been dramatic improvements in criminal investigation and prosecution.\textsuperscript{62}

The discovery of DNA analysis – identifying anyone's unique biological code – revolutionized forensic science. DNA replaced blood as the most powerful method of identification. It is invisible to the naked eye and even detectable in traces left behind by all but the most careful criminals. In 1996 a UK database of DNA was established in addition to the fingerprint records. Since then, the predictive power of forensic science has been significantly improved using computer power.

In 1910, Albert Osborn who authored the famous book called “Questioned Documents”, laid down principles for the examination of documents and is still regarded as a reference by documents experts across the world.\textsuperscript{63} With increase in White Collar and Organized crimes after World War II, many countries like USA, UK and certain Commonwealth countries established a chain of forensic laboratories where scientific methods supplementing the criminal investigation and prosecution got institutionalized.

The late 1980s and 1990s saw the development of DNA profiling and the establishment of DNA databases such as CODIS, which began to be used for comparison of DNA profiles recovered from crime scenes with that of the suspects. Along with DNA, the last two decades has also seen improvements in fingerprinting methods, portable crime labs and increased use of chemical analysis for everything varying from explosive identification to dyes and inks. The ability nowadays is to

\textsuperscript{62} Supra 59 at p. 3  
\textsuperscript{63} Supra 55 at p. 12
analyse a wide variety of materials in short period of time as a result of technological advancement which have occurred particularly in the past five decades. Many of the analytical techniques that have been devised offer unbelievable sensitivity and permit examination of minute quantities (traces) of material which cannot be observed directly by the human eye.

Rapid development in computer technology has also played an important role in advancement of forensic science. Apart from their use in controlling instrument and producing analytical data, computer permits the storage of massive amounts of information which can be processed in very less time. With computers, an era of setting up of data bases for D.N.A. fingerprints etc. has ushered to a wide level which can be used for the purpose of the identification of an individual. Those and other data can save a tremendous amount of time and effort in a case and are beneficial to both the police in their investigation and to the forensic scientists in providing evidence and information to the courts.64

**Indian Perspective**

India too was not indifferent to the application of scientific technology to the investigation of crime and administration of justice. Although our ancestors did not know forensic science in its present sophisticated form, the application of scientific methods was very much prevalent in criminal investigation and prosecution during ancient India. Its detailed reference can be in Kautilya’s “Arthashastra” which was the greatest treatise ever written on the science of statecraft. Indians were aware of various patterns of the papillary lines even thousands of years ago. Even our future

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64 Supra 59 at p. 3
predictions about the life of any individual were based on the study of these papillary lines on our hand which were distinct for each one of us. It is now believed that Indians knew about the persistency and individuality of fingerprint in the ancient times which they also used as signatures. Even Kumafus Muna Kata, a frequent contributor to “Nature”, stated that the Chinese records proved the use of fingerprints in an ancient kingdom of southern India. The Indians knew for long that the hand points, known as the “Tarija”, for every individual were distinctive and unique. The use of fingerprint as signatures by the illiterate people in India which had been prevalent for centuries and which was considered by some people as ceremonial only till date was nothing but infallible identification of the individual.

Kautilya’s Arthashastra states that death can be caused by stopping of the breathing in four ways (strangling, hanging, asphyxiation or drowning); physical injury in two ways (by beating or by throwing from a height); or by poisoning (by poisons, snake or insect bite or narcotic drugs). If death was suspected to be due to poisoning, the undigested parts of the meal from the corpse were tested by feeding it to birds. Cases of suicide by hanging were investigated by ruling out the presence of any ante-mortem injuries. Similarly, on finding the murdered body of a stranger, his personal belongings such as cloths, dress and ornaments were examined for ruling out the occurrence of any crime. Kautilya’s Arthashastra also describes the necessity of autopsy in establishing the causes of death after smearing the body with oil to bring out bruises, swellings and other injuries.\textsuperscript{65} Medical opinion was frequently applied to the requirements of the law in ancient India. By law the minimum age for the marriage of girls was fixed at 12 years; the duration of pregnancy was

\textsuperscript{65} Mathihran K Patnaik & A K. Modi’s, “Medical Jurisprudence and Toxicology-History of Forensic Medicine”, p. 3-18
recognized as being between 9 and 12 lunar months with an average of 10 months and there are also evidences that doctors had to opine on such cases.

The *Atharva Veda* provided details for curing of different medical conditions through charms. There are charms to cure wounds, burns, poisoning, snake bite, and insanity. Dissections of dead animals are also prescribed but only for the sake of knowledge. Later the *Charak Samhita*, composed around seventh century BCE, lays down an elaborate code regarding the training, duties, privilege and social status of physicians. It also gives a detailed description of various poisons, symptoms, signs and treatments of poisoning. Similarly in *Sushrut Samhita*, detailed account of inner anatomy of the body, their functioning, any discrepancy and the remedy henceforth is so carefully written that it cannot be considered any inferior to the modern knowledge of forensic science. It also contains a separate chapter on toxicology. The poisons in *Sushrut Samhita* are classified into:

a) Plant products  
b) Animal products, and  
c) Artificial.

Not only does the symptoms, signs and treatment of poisoning described in detail but also the modes of administration of poisons, character of the poison and examination of suspected poisonous materials are featured in *Sushrut Samhita*. According to *Sushrut Samhita*, a person administering poison to the victim can be known from his behaviour and movements viz. he will not answer to questions asked or will keep silent or will talk irrelevantly and so on. Poisons could be administered through food and drinks; tooth stick; oils and materials for message; medicaments;
water for bathing; articles of clothing; snuffs; Smoke or Surma. Sushrut Samhita has also the unique descriptions of injuries, pregnancy and delivery. Types of weapons and foreign objects and the symptoms they manifest on the body have also been described. Wounds and fracture of bones have been classified. Principles of cohabitation, indications for identifying woman fit for conception after periods; signs immediately after impregnation and that of pregnancy have been described in detail. Among these are darkening of areola and nipple, dropping of eyelids, vomiting without any cause, frequent salivation and frequent tiredness of the body. Delivery, abortions and foetal development during various months of pregnancy has also been very accurately described.66

Later during the Muslim period in India, the application of scientific technique in determining the civil and criminal liabilities was very much prevalent. The first recorded medico-legal autopsy was performed in India by Dr Edward Bulkley during medieval period. However the most important contribution of Britishers to India was that in the field of Modern Dactylogy (The study of fingerprints as a method of identification). It was Sir William Herschel of the Indian Civil Services, who first used the method of fingerprint identification in 1858. In 1877, at Hooghly (near Calcutta), he institutionalized the use of fingerprints on contractual deeds and registered all the government pensioners' through their fingerprints so that the collection of money by his/her relatives after the pensioner's death could be checked. Herschel also made prisoners to submit their fingerprints after sentencing of the jail term to prevent various frauds that were attempted during that time.

In 1897, a Fingerprint Bureau was established in Calcutta after the Council of the Governor General approved a committee report stating that fingerprints should be used for the classification of criminal records. Based on Herschel’s theory, Sir Francis Galton of England devised the systemic study and methods of using fingerprints for personal identification in 1892. In 1894, the Troup Committee in England, a group established by the Home Secretary to determine the best means of personal identification, accepted that no two individuals had the same fingerprints—a proposition that has never been seriously refuted till date. In 1900, another committee recommended the use of fingerprints for criminal identification. Later two Indian fingerprints experts, namely Haque and Bose, under the supervision of Sir Edward Richard Henry were credited for the primary development of a fingerprint classification system which eventually got named after their supervisor. The system called as ‘The Henry Classification System’, was accepted in England and Wales when the first United Kingdom Fingerprint Bureau was founded in Scotland Yard, the Metropolitan Police headquarters, London, in 1901.

The necessity of well equipped centers for detection and estimation of medico-legal evidences was felt more than a century ago. Dr. P Ghoshal in his treatise “Aparadh Vigyan” has given an excellent example in which a stolen gold necklace was recovered and there came two claimants for the same. The necklace was smelted and it was found to emit a mild odor of cow dung which laid the basis of its ownership. However in the recent past, the scientific endeavor in the field of

forensic science could be traced back to the beginning of the 20th century during the
British rule when small scientific laboratories in different fields were established and
institutionalized. In the post independent era many specialized institutions were
established which helped in criminal investigation through scientific established
principles and techniques. Some of the prominent one’s established across the
country are mentioned below.

a) Chemical examiners Laboratories
b) Anthropometric Bureau Calcutta
c) Fingerprint Bureau, Calcutta
d) Department of explosives, Nagpur
e) Government Examiner of Questioned Documents, Shimla
f) Serology department, Calcutta.
g) Foot Print Section of Criminal Investigation department, Calcutta
h) Ballistics laboratory, Calcutta
i) State Forensic Science Laboratory, Calcutta
j) Central Fingerprint Bureau, New Delhi
k) Central Forensic Science Laboratory, Calcutta
l) Central Forensic Institute, Calcutta
m) Central Forensic Science Laboratory, Hyderabad
n) Central Forensic Science Laboratory, Chandigarh
o) Central Forensic Science Laboratory (CBI), New Delhi
p) Institute of Criminology and Forensic Science, New Delhi
q) Bureau of Police Research and Development, New Delhi.
r) Establishment of DNA typing laboratory at CFSL Calcutta
Thus the previous century has established plethora of institutions across the country to help in criminal identification and crime investigation. Although demands for more advanced and better facilities are being made in the last decade, undoubtedly these institutes and scientific facilities have played an important role in upgrading our Criminal Justice System.

**Rainbow Principles of Scientific Aid in Criminal Justice System**

The most challenging task of the application of scientific techniques in criminal investigation is the concrete identification of person, subject, scene and actions, possibly connected to the crime. In the beginning only the testimonies of the witnesses and the traces visible to the naked eye at the crime scene served as the bases of identification of the accused of any crime. But as a result of the revolutionary development of natural sciences, the extent of forensic examination of the crime scene has increased extensively which not only can prove conclusively the presence of the accused at the crime scene but can also prove beyond reasonable doubt the involvement of the accused in a particular crime.

The most important contribution of forensic science in criminal jurisprudence is the recognition of some principles which are developed at the backdrop of thorough research and analytical study of criminal activities or the ways used (modus operandi) for such wrongful acts. The following section analyses in detail
the seven principles (Rainbow principles) of criminal investigation & prosecution in
the perspective of Forensic Science.

**Law of Individuality**

The basic premise in this principle is that anything and everything involved in
a crime has individuality of its own i.e. it is unique in itself. It therefore extends to
the fact that every object whether natural or man-made which has an individuality is
not duplicated in any other form. It is this uniqueness that helps in solving any
criminal case. Thus it can be conclusively determined that similar properties shared
by two objects is suggestive of the fact that they either have a common origin or
were produced by the same operation or that one object was produced by the other.
If the same is established with respect to the crime or scene of crime and the
criminal, both may be conclusively connected.

This principle, at first instance appears to be contrary to common belief and
observation. The grains of sand or common salt, seeds of the plants always look
exactly alike. Likewise manmade objects like coins of the same denomination made
in the same mint, currency notes printed with the same printing block, typewriters of
the same make, model and batch appear to be indistinguishable. Although the
indistinguishableness may be to the human eyes, these things in reality exhibit
individuality. The individuality may be due to small flaws in the material or in the
arrangement of crystals or imperfect stamping or due to inclusion of some
extraneous matter. This principle of individuality has been established in various
other fields also and similarly is of fundamental importance in forensic science. For
example, millions of prints have been checked but no two fingerprints, even from
two fingers of the same persons have been ever found to be identical.

**Law of Exchange**

This principle more famously known as Locard's exchange principle holds that
the perpetrator of a crime will bring something into the crime scene and leave with
something from it and that both can be used as forensic evidence. Thus this principle
can be summarized as "Every contact leaves a trace". Paul L. Kirk expressed the
principle as follows:

"Wherever he steps, whatever he touches, whatever he leaves, even unconsciously,
will serve as a silent witness against him. Not only his fingerprints or his footprints,
but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves,
the paint he scratches, the blood or semen he deposits or collects. All of these and
more bear mute witness against him. This is evidence that does not forget. It is not
confused by the excitement of the moment. It is not absent because human witnesses
are. It is factual evidence. Physical evidence cannot be wrong, it cannot perjure
itself, and it cannot be wholly absent. Only human failure to find it, study and
understand it can diminish its value."

Thus it was Locard's assertion that when any person comes into contact with
an object or another person, a cross-transfer of physical evidences occurs. By
recognizing, documenting, and examining the nature and extent of this evidentiary
exchange, Locard observed that criminals could be associated with particular
locations, items of evidence, and also with the victims. The detection of the
exchanged materials is interpreted to mean that the two objects were in contact at some point of time. This is the cause and effect principle but in reversed form i.e. the effect is observed and the cause is concluded.

This means that when a crime is committed, fragmentary or trace evidences need to be collected from the scene. A team of specialized police technicians equipped with modern scientific techniques would go to the scene of the crime and capture the same. They would record video and take photographs of the crime scene, victim (if there is one) and items of evidence. If necessary, they will undertake a firearms and ballistics examination. They would also check for shoe and tire mark impressions, examine any vehicular presence and check for fingerprints too.

Later the crime reconstruction that involves examining the available physical evidence or those materials left at or removed from the scene, victim, or offender helps in building up the set of events leading to the alleged crime. For example, the hairs and fibers, soil particles, fingerprints, footprints, genetic markers (DNA) or handwriting helps in forensically establishing contacts and these evidences are then considered in light of available and reliable witnesses, the victim, and a suspect's statements. From this, theories regarding the circumstances of the crime can be generated and established by logically applying the information of the facts to the case.

**Law of Progressive Change**

The underlying idea of this principle is that “Everything changes with the passage of time”. The rate of change varies tremendously with different objects in different situations and acquires permanency and irreversibleness. This might have
great impact on criminal investigation in case delay is caused. Thus this principle envisages prompt action in all the aspects of criminal investigation. The following three types of changes are most perceptible.

a) Changes in the Criminal itself: If the criminal is not immediately arrested or apprehended in reasonable time, he may become unrecognizable except his permanent attributes like fingerprints, bone fractures, birth marks or tone of speaking which may cause immense hardship in making the case reach to its desired conclusion.

b) Changes in the Scene of Crime: The weather phenomenon, the vegetation growth or living being (especially human being or animals) interventions can make the scene of crime change substantially in relatively short period of time. Longer delay in the investigation of the scene of crime may result into substantial loss of evidence which may subsequently cause hindrance in criminal investigation.

c) Changes in the objects involved in the crime: The firearm, metal objects, the shoes, the tyres or any other physical evidence may suffer additional wear and tear with the passage of time and may acquire an entirely new nature or character or pattern. This pattern or character may not match with the earlier variant related to scene of crime and thereby loose all practical identity vis-a-vis the particular crime.

**Law of Comparison**

According to this principle “Only the likes can be compared”. It emphasizes the necessity of providing like samples and specimens for the comparison with the
questionable items thereby establishing a link between the crime or the scene of the crime and the criminal. Some of examples that illustrate the application of this principle of comparison as an aiding tool in criminal investigation are given below:

a) In a murder case, a bullet is recovered from the deceased. The expert opines that the bullet has been fired from a firearm firing high velocity projectiles like a service rifle. It is futile to send shotguns, pistols or revolvers as the possible suspect firearm.

b) A bunch of hair is recovered from the hands of a deceased. The expert opines that the hair belong to a Negroid person. Hair from persons of white races for comparison will not be of any use in the investigation.

c) The questioned writing is found to have been written with a ball pen. To send a fountain pen is a futile exercise

**Law of Analysis**

The basic postulate in this principle states that the scientific analysis can only supplement the sample analyzed but cannot supplant it. Improper sampling or the contamination of the sample can render even the best analysis useless. This principle emphasizes on the correct sampling and packing of the physical and biological evidences by the forensic teams for the effective use by the scientific experts so that a link can be established between the crime scene and the crime with the criminal.
Law of Probability

All identifications in any criminal investigation are made, consciously or unconsciously, on the basis of probability. Probability is a mathematical concept which determines the chances of occurrences of a particular favorable or unfavorable event in a particular way out of a total number of ways in which the event can take place or fail to take place. Statistical evidence will be relevant and potentially admissible just insofar as it helps to resolve a disputed fact in issue. However probabilistic reasoning will either be indispensable in criminal proceedings for interpreting these statistical evidences or would help in drawing logical inference and common sense reasoning. In order to interpret and evaluate statistical evidence and to assess the adequacy of any probabilistic inferences which the evidence is said to support, criminal justice professionals need to be familiar with a handful of key concepts that statisticians, forensic scientists, and other expert witnesses use to express probabilities and statistical data. These key concepts include:

(a) (Absolute and Relative) frequencies;
(b) Likelihood of the evidence;
(c) The likelihood ratio;
(d) Base rates for general issues (prior probabilities);
(e) Posterior probabilities;
(f) Bayes’ Theorem; and
(g) Independence.
Law of Circumstantial Facts

The underlying concept within this principle is that “Facts do not lie, men can and do”. Thus this principle values the importance of circumstantial evidence in any criminal investigation in comparison to other oral evidences. Circumstantial evidence, by definition, is indirect information or secondary facts that allow to draw reasonable inference of the principal fact, without actually proving that such inference is true. The purpose of evidence in court of law is to prove or disprove the existence of a fact in issue. The nature of evidence presented before the court must be convincing enough to establish such fact beyond reasonable doubt, especially in criminal trial. In civil trial however, the standard of proof is often based on whether the true existence of the fact is more probable than not. Circumstantial evidence, therefore, carries different weight in criminal and civil trial.

Circumstantial evidence, in spite of its indirect nature, may be of great value for the investigation of the crime in highlighting the inconsistencies between the behaviour of a suspect and his allegations, thereby "filling in the blanks" of a probable crime scenario. For instance, although a suspect was not at the crime scene, the presence of the tyre prints of his car at the crime scene or the sighting of similar car by an eye witness in the vicinity of the crime scene around the time when the crime was committed is an important circumstantial evidence. Similarly sometime before the crime, the victim may have told his friend that he was afraid of the suspect or a neighbour may have overheard a bitter and violent argument between the victim and the suspect in the recent past is also an important circumstantial evidence that can aid the criminal investigation. Circumstantial evidence may be
presumptive and inconclusive admitting rebuttal of the other side or on the contrary, its quantity and pattern may be strong enough to substantiate a prosecution where other types of evidence are scarce and by themselves inconclusive.

Thus in fine the aforementioned principles governing the scientific aids in the criminal investigation & prosecution emanates from continuous experimentation, observation and intellectual churning bringing paradigm changes in the criminal jurisprudence. These upturns definitely contribute towards the legal system to decide the matter for the sake of upholding the ‘Rule of Law’. These new dimensions of criminal jurisprudence weaken the arguments of the defence and ensure that the culprit may not evade the punishment.

Critical Appraisal of Scientific Aid in Criminal Justice System

With increasing rate of crime in the society, growth of forensic science in criminal investigation is a natural corollary. The science that started to grow in later half of the 20th century has undergone revolutionary changes in the 21st century. The importance of forensic science can be gauged from the fact that it has played pivotal role in reducing the burden of the law enforcement agencies in criminal investigation. Despite its utility, forensic analysis is not an easy task to accomplish. It involves a lot of hindrance and challenges. The law enforcement agencies are highly dependent upon forensic to deliver justice. In a natural corollary to two faces of the coin, forensic science too has two different facets. A brief description of the
advantages along with the ethical and legal constraints involved in forensic analysis is given below in this section.

**Advantages**

There is a broad spectrum of advantages in which forensic science is useful to the law enforcement agencies. Some of the prominent ones are discussed below.

i. With the help of certain computer tools, it is possible to control cyber crime. This is done through packet sniffing (sensing critical information in the data packets), IP address tracing (to get the address from where the criminal was accessing), and email address tracing (to get the details of the email server and in cases of email bombs). This is called computer forensics.

ii. It helps in determining the cause of death by examining the post mortem changes, blunt injuries and burns on the body. If it's sudden natural death, the case is investigated by the coroner or a medical examiner.

iii. Forensic analysis is used to investigate accident cases and to determine its cause by analyzing the vehicle condition, tire and other marks, eye witnesses, calculating the vehicle's speed etc.

iv. The alcohol content in a human being can be determined by analyzing the blood and other body fluids like saliva, urine etc.

v. It can also be used in anthropology and help in sex determination.

vi. Clinical forensic analysis is useful in finding out child abuse, defensive wounds on a victim, gunshot wounds and injury patterns in domestic violence victims, self-inflicted injuries, sexual assault, and semen persistence.
vii. Biometric technology is combined with forensics, to help in identifying the fingerprint of the criminal on the objects present at the crime scene.

viii. Phonetics, which is also a part of forensics, which is used to tap the voice signals and identify the speaker. Speech enhancement, speech coding and tape authentication are other techniques used in phonetics.

ix. Other useful aspects of forensic analysis include fire investigation, forgery and fraud in payment cards, lie detection, footprint marks, voice analysis, digital imaging and photography etc.

**Disadvantages**

Despite numerous advantages, forensic analysis suffers from certain constraints which are briefly discussed below:

i. Public in general is afraid of corrupt practices of police. Due to this fear, physiological changes such as changes in blood pressure, respiration and heart beat etc. occur which may be understood so as to term the person as wrongdoer.

ii. D.N.A. analysis of a person is believed to be against human ethics as it reveals private information about an individual. Maintaining privacy and secrecy of the information gathered through forensic analysis is quite difficult.

iii. Equipments used in forensic analysis are very expensive and scientific analysis consumes lot of time because of which the verdict is delayed. It requires high level of accuracy and precision in forensic analysis and even if a minor error occurs in the analysis, it may result in wrong result or conviction.

iv. The interpretation of the results and their reliability depends upon the expertise and experience of the experts. Interpretation part is a difficult process hence, chances of
human error cannot be ruled out and generally differs from one forensic scientist to another.

v. There is no particular standard to verify the result of a forensic experiment. It requires wide knowledge and intensive study. Misconception and ignorance can mislead the experimental analysis.

vi. The forensic analysis of the evidence cannot be accessed at all times. Also the analysis sometimes is prone to manipulation, which may end up in an unrighteous verdict.

vii. Forensic scientists encounter potential danger every day, whether they’re visiting a crime scene or testing evidence in the lab. At the scene, they may come in contact with everything from broken glass to weapons to bodily fluids. In the lab, they may analyze blood and other biological substances that could carry disease. They may also examine trace evidence such as chemical residue that could be toxic. In both environments, they are exposed to health hazards which deter talented persons from pursuing this as a career option.

viii. Many of the crimes involve violence including rape, murder and assault. As part of the analysis, forensic scientist may examine bloody clothing, blood splatter and possibly view victims’ bodies. These crime scene investigators have to maintain their composure while performing their duties. Also, sometimes after long hours of work, the forensic analysis may cause physical and emotional fatigue in them.

ix. While they sometimes face unrealistic expectations, forensic scientists also encounter intense scrutiny. Based on the portrayal of forensic science in popular culture, many people see the discipline as objective and infallible. Police, prosecutors and judges often expect definitive forensic evidence. However, forensic methods have come under question in recent years, owing to several investigations revealing inaccuracies
or misconduct at forensic labs throughout the country. In addition, multiple reports have revealed that in many cases, very little forensic evidence is found and when it is found, it often has minimal impact.