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**IMPORTANCE OF FORENSIC SCIENCE IN ANCIENT  
AND MODERN TIMES CONCERNING MODERN  
TECHNIQUES IN CONDUCTING THE CRIMINAL  
INVESTIGATIONS**

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**ABSTRACT**

Forensic Science is concerned with a broad range of medical, legal, and ethical issues, as well as human rights. Forensic Science is the application of medical science to solve legal problems. The importance of Forensic Science and its usefulness has been widely discussed in this medico-legal journal entitled. A better understanding and cooperation have resulted and facilitated in a smoother working of both, the medical and the legal field of work. This Journal has specially explained how previously unsolvable cases are now solved with ease with the development of the field of forensic science, and it covers in its ambit, the provision of evidence for a wide range and scope of cases. It can be used to determine the paternity of a child, and also be employed in determining the identity of human bodies that have been mutilated beyond recognition in accidents like bomb blasts, and factory explosions. This medico-legal journal has fully explained how it can be appropriated to solve cases involving murder or rape, etc.

## INTRODUCTION

Forensic science signifies the application of the methods of the natural and [physical sciences](#) to investigate the matters of [criminal](#) and [civil](#) laws. [Forensic](#) science can be involved not only in the investigation and prosecution of [crimes](#) such as [rape](#), [murder](#), and drug trafficking but also in matters in which a crime has not been committed but in which someone is charged with a civil wrong, such as willful [pollution](#) of [air](#) or [water](#) or causing industrial injuries.

Forensic science is used in the investigation of crime. For example, in forensic science, a criminal case often be investigated on a piece of evidence such as hair, blood trace or footprint. In many high-profile cases have attracted enormous media attention and enhanced interest in recent years. In this way, the principle of crime scene management, thus it explores how forensic scientists work and may consider the techniques that forensic scientists use[1].

The importance of forensic science is primarily associated with crime and crime scene investigations.

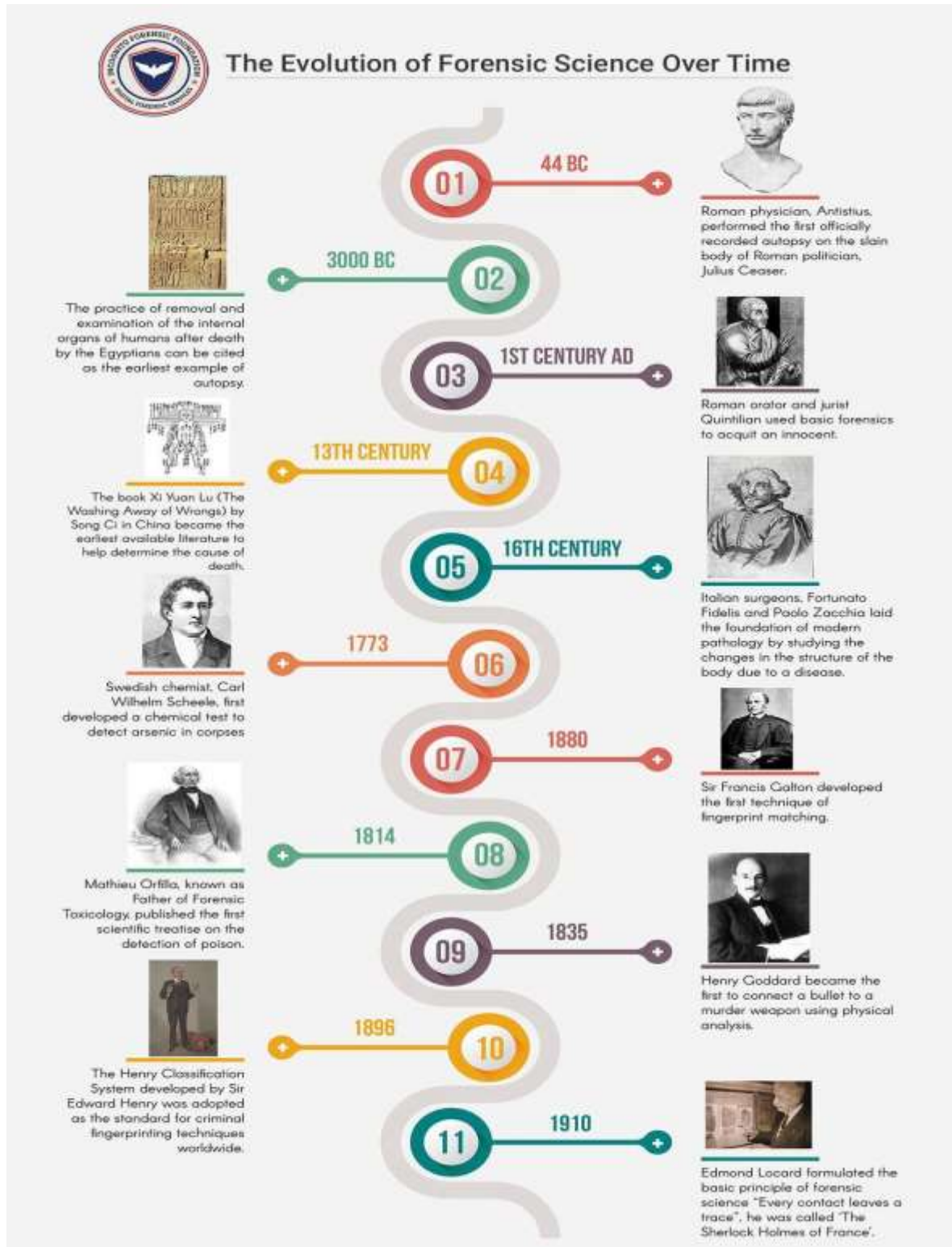
We instantly start picturizing high-tech computers, UV lights, and criminal labs furnished with high-end equipment. Well, that is the image that modern-day crime shows have created of a forensic investigator. Interested to know the importance of forensic science over the ages? We have the answers right here. Presenting the brief history of forensic science.

## TRACING THE ROOTS OF THE IMPORTANCE OF FORENSIC SCIENCE IN ANCIENT TIMES

The history of forensic science awaits exploration as forensic science as a discipline was not much spoken about until recently. On increasing the cognizance of the subtle importance of forensic science in the past, one cannot but amp up the reverence for this field of science.

The word forensic has its origin from the Latin word “forensis” which stands for a forum. Forensic Science is used in tandem with any discipline that has associations with the legal system. In a nutshell, forensic science is the application of scientific methods and principles to questions of law. Or, in layman’s terms, forensic science is a discipline used by a forensic investigator to solve crimes[2].

# THE EVOLUTION OF FORENSIC SCIENCE, OVER TIME



## **THE BUILDING BLOCKS IN THE HISTORY OF FORENSIC SCIENCE-THE ORIGIN**

Forensic science as a part of the modern-day criminal justice system is still in its formative years. Interestingly, the importance of forensic science dates back to some of the ancient civilizations. The earliest application of forensic science dates back to ancient Greek and Roman societies.

Those civilizations made significant contributions to the field of medicine, especially pharmacology. Their research on the production, use, and symptoms of toxins made the study of their use in past murders possible.

### **HISTORY OF AUTOPSY**

Did you know that the Egyptian civilization back in 3000 BC performed the first instance of an ‘autopsy’? They performed the religious practice of the removal and examination of the internal organs of humans after their death. Thus, they are the earliest civilizations to perform an autopsy. Interestingly, the first officially recorded autopsy was performed way back in 44 BC.

This was when a Roman physician, Antistius, examined the slain body of Roman politician and general, Julius Ceaser. The autopsy revealed that though stabbed 23 times, his death resulted from one wound through his chest.

### **IMPORTANCE OF FORENSIC SCIENCE IN THE EARLY ROMAN DYNASTY**

Early in the 1st century AD, Roman orator and jurist Quintilian used basic forensics to acquit an innocent. The Roman model forms the foundation of the modern-day court and legal system. Thus, the application of scientific principles in the examination of evidence in ancient Rome is not surprising. However, with the fall of the Roman Empire in the West, the applications of forensic science in criminal justice stagnated over the next millennium.

## **EARLY METHODS OF FORENSIC EXAMINATION USED BY A FORENSIC INVESTIGATOR**

The history of forensic science dates back thousands of years. Fingerprinting was one of its first applications. The ancient Chinese used finger prints to identify business documents. In 1892, a eugenicist, an adherent of the often prejudiced system of scientific classification named Sir Francis Galton established the first system for classifying finger prints. Sir Edward Henry, commissioner of the Metropolitan Police of London, developed his own system in 1896 based on the direction, flow, pattern and other characteristics in finger prints. The Henry Classification System became the standard for criminal finger printing techniques world-wide.

One of Song Ci's account in his book talks about the basic methods used to crack a murder case. First, the investigator tested various blades on an animal carcass and compared the wound to the actual one. This helped him deduce that the weapon used to commit the murder was a sickle. Next, he asked every resident of the crime area to bring their sickles to one location. Eventually, the murderer confessed when the smell of blood caused flies to gather on his sickle. The book also provided methods and logic to estimate if a death resulted from suicide, accident or murder.

## **EARLIEST APPLICATION OF THE LIE DETECTOR OR POLYGRAPH TEST BY A FORENSIC INVESTIGATOR**

The earliest precursor to the Polygraph test was the examination of the saliva, mouth, and tongue of a suspect to deduce innocence or guilt.

For example, in ancient India, the suspect's mouth was filled with some dry rice and in China with rice powder. They were then asked to spit it out. In some middle - eastern cultures, the accused would have to lick heated metal rods briefly. The principle used for these methods was that a guilty person would produce less saliva. Thus, if rice got stuck in their mouths or if their tongues got severely burnt, they were pronounced guilty.

## **THE GLORIOUS 16TH & 17TH CENTURIES IN THE HISTORY OF FORENSIC SCIENCE**

In 16th-century Europe, medical practitioners in army and university settings began to gather information on the cause and manner of death. Ambroise Paré, a French army surgeon, systematically studied the effects of violent death on internal organs. Two Italian surgeons, Fortunato Fidelis and Paolo Zacchia, laid the foundation of modern pathology by studying changes that occurred in the structure of the body as the result of disease. In the late 18th century, writings on these topics began to appear. These included A Treatise on Forensic Medicine and Public Health by the French physician Francois Immanuele Fodéré and The Complete System of Police Medicine by the German medical expert Johann Peter Frank.

In 16th century Europe, the gathering of information on the cause and manner of death was first initiated by medical practitioners. A French army surgeon, Ambroise Paré, methodically studied the effect that violent death has on internal organs.

Italian surgeons, Fortunato Fidelis and Paolo Zacchia laid the foundation of modern pathology. They achieved this through a study of the changes occurring in the structure of the body due to a disease. With the dawn of the 17th century, the importance of forensic science received a boost resulting in other advancements in science[3].

## **MODERN FORENSIC SCIENCE TECHNIQUES & AND TAKING THEIR SHAPE**

The forthcoming centuries witnessed a resurrection of forensic science with an increase in the application of science in solving crimes.

Techniques such as matching evidence like clothing fibers and footprints to those found on a suspect starting gaining popularity. Gradually, criminal investigations started revolving more around evidence-based and rational approaches. Soon, the validity of confessions under duress and belief in occult practices such as witchcraft started diminishing in the courts. Eventually, development of the technique of finger print analysis took place in 1880[4].

## ACCIDENTAL CHARACTERISTICS

Accidental characteristics are the unique marks and features that develop on any item resulting from wear and tear. Looking back at the Nike Air Jordan Running Shoe, to make a positive match of a suspect's shoe to the impression found at the crime scene, the crime scene impression would be examined for nicks, gouges, and wear patterns typically present on a worn shoe. These features would then be compared to a rolled impression of a suspect's shoe, and if the same nicks, gouges, and wear patterns could be shown in all the same locations on the suspect's shoe, a positive match could be made.

This Level Two method of comparison for things, such as shoe prints, tire prints, glove prints, and tool impressions, is the practice of physical matching. Investigators can often use these physical matchings to link the suspect back to the crime scene or the victim. Finding a suspect in possession of a shoe, a tire, or a tool that is a positive match to an impression at the criminal event is a powerful piece of circumstantial evidence. With items, such as broken glass and plastic fragments, the process of physical matching requires significantly greater levels of expertise. At Level One, these items are first matched for general characteristics, such as material color and thickness; however, the process for making the comparison of broken edges requires microscopic examination and photographic overlay comparison of broken edge features to demonstrate a positive match. For investigators, this kind of comparison can be called upon where there is broken glass at a crime scene and fragments of glass have been found on a suspect's clothing, or in cases where glass or plastic fragments are left at the scene of a hit-and-run car crash and a suspect vehicle is found with damage that includes similarly broken items[5]. Glass fracture analysis can also be used to demonstrate which side of a piece of glass received the impact that caused the fracture. This can be a helpful tool in confirming or challenging a version of events, such as insurance fraud, break-in reports, and motor vehicle crashes where the damage has been exaggerated or staged. Glass fracture analysis can also be used to demonstrate the sequence and order in which a series of bullets have passed through the glass of a window. This can be helpful for an investigator to establish the origin location of the shooter, and, in cases of a drive-by shooting, the direction of travel.

The forensic science analysis covered the following modes of analysis:

Physical Matching

Finger print Matching Hair and fiber analysis Ballistic Analysis Blood Spatter Analysis DNA

Analysis

Forensic Pathology Chemical Analysis

Forensic Anthropology Forensic Entomology Forensic Odontology Forensic Engineering

Criminal Profiling Geographic Profiling Forensic Data Analysis Forensic Document Analysis

Forensic Identification Sections Crime Detection Laboratories

Various types of physical evidence can be found at almost any crime scene. The types of evidence and where it is found can assist investigators to develop a sense of how the crime was committed. Tool marks where a door was forced open can indicate a point of entry, shoe prints can show a path of travel, and blood stains can indicate an area where conflict occurred. Each of these pieces of physical evidence is a valuable exhibit capable of providing general information about spatial relationships between objects, people, and events. In addition, the application of forensic examination and analysis could turn any of these exhibits into a potential means of solving the crime.

## **PHYSICAL MATCHING**

If we think back to the example where the Bow Street Runners made a physical match from the torn edges of one piece of wadding paper to the original sheet from which it was torn, we can appreciate that physical matching is a forensic technique that can be applied, to some extent, by the investigator personally viewing and studying details of the evidence. At this level, physical matching can be used by investigators to do on-site analysis of evidence. That said, the more sophisticated aspects of physical matching do require the expertise of a person trained in the techniques to form and articulate an opinion that the court will accept as expert evidence. During a crime investigation, physical matching is typically conducted on items, such as finger prints, shoe prints, tire prints, glove prints, tool impressions, broken glass, plastic fragments, and torn edges of items, such as paper, tape, or cloth. In these physical matchings, two levels of examination are typically considered; an examination for class characteristics and an examination for accidental characteristics.

## **FINGER PRINT MATCHING**

The forensic science of finger print has a longstanding history in policing. Finger prints have been accepted as being individually unique to each person. The courts frequently accept positive finger print matches conducted by an expert witness, as proof of identity beyond a reasonable doubt.

Prior to the modern advent of DNA analysis and biometric scanning technologies for positive identification, finger prints and dental record x-rays were the only truly positive means of making a conclusive identification.

Finger prints are unique patterns of lines and ridges that exist on the areas of our hands and finger tips, known as the plantar surfaces. These unique patterns have been classified in categories and features since the late 1800's. The various categories and features allow each digit of a person's fingers to be catalogued in a searchable system or database. These unique categories and features do not change throughout a person's life, unless they are subjected to damage through physical injury or intentional abrasion. The impressions of our finger prints are often left on items we touch because the oils our bodies produce act like an invisible ink adhering to smooth surfaces we touch, thus transferring these finger print impressions to those surfaces. These virtually invisible image transfers are commonly called latent finger prints, and they are easily made visible on most surfaces through the application of colored finger printing powder that adheres to the oils left by our fingers. The powder sticking to the oil reveals the image of lines and ridges that make up the finger print. It is also possible for a finger print impression to be exposed on surfaces, such as plastic, dry paper, or paint through a process of chemical fuming that reacts with the oils of the finger print changing their color, thereby exposing the image. Finger prints are sometimes also visible when they are transferred to an object because the finger has some foreign material on it, such as ink or blood. Other forms of visible finger prints can be found as an actual molded impression of the finger print when a person touches a malleable surface, such as clay or cheese.

The unique lines and ridges of an unknown finger print can be searched in a data base of known criminal finger prints for identification. Today, this type of search is done electronically using a biometric scanning process known as Automated Finger print Identification System (AFIS). For smaller partial prints, identification of a suspect requires sorting through possible suspects and conducting specific searches of print characteristics to make a match. If the person who left the print does not have a criminal record or their finger prints are not on file, the only way a comparison can be made is to obtain a set of finger print impressions from that person. When this is done, the print examination will be conducted by a trained finger print expert who will search the print to establish as many points of comparison between the suspect print and the known-print as possible. The general accepted standard for accepting a match is to find ten points of comparison.

The location and identification of a suspect's finger print at the scene of a crime, or on some crime-related object, is strong circumstantial evidence from which the court can draw the inference that the suspect is, in some way, connected to the crime. The investigative challenge of finding a suspect's print is to eliminate other possible ways that the print may have been left at the scene, other than through involvement in the crime[6].

## **HAIR AND FIBER ANALYSIS**

In considering once again "Locard's Theory of Evidence Transfer," it was suggested that a person cannot be at the scene of a crime without leaving something behind, and cannot leave the scene of a crime without taking something with them. Exhibits of hair and fiber fit support this theory well. As humans, we are constantly shedding materials from our bodies and our clothing. We enter a room and we leave behind strands of hair that fall from our heads, oily impressing of our finger prints as we touch objects, and fibers of our clothing materials. As we leave a room, we take away hairs from other occupants of the room or fibers from the carpet and furniture adhering to our clothing. The analysis of hair and fiber, although not an exact science, can provide corroborative evidence[7]. Hair samples can be compared by taking a shed sample at the crime scene to the hair from a suspect to establish a similarity within a limited degree of certainty. If the hair happens to have been pulled out and still has root tissue, there is a possibility for more identification using DNA analysis. Somewhat more identifiable than hair samples, fiber samples can often be narrowed down to make a higher probability comparison using microscopic examination for size, color, and type between an unknown sample and a control sample.

## **BALLISTIC ANALYSIS**

Given the number of gun-related crimes, the understanding of ballistic analysis is important for investigators. Ballistics is the study of all things that are launched into flight, how they are launched, and how they fly. In most cases, investigators find themselves dealing with several common types of firearms.

Handguns as either semi-automatic pistols or revolvers Long rifles that are single shot bolt action, automatic, or semi-automatic Shotguns that are breach loading or chambered pump action. There are techniques in ballistic science that address the unique aspects of firearms and bullets. Because ballistic comparisons seek to determine if a particular gun was the originating source of an unknown bullet or cartridge casing, this examination process is sometimes referred to as ballistic

finger printing[8]. The analogy being that if a particular gun touches a particular bullet or cartridge-casing, it will leave behind some unique identifiable marks or a ballistic fingerprint.

## **BALLISTIC FINGER PRINTS**

When a modern-day firearm is being loaded to fire, the cartridge loaded into the gun is composed of several components. The bullet portion of the cartridge is tightly pressed into a brass tube, called the casing. At the bottom of this brass casing is a round, flat base slightly larger than the casing, and this base prevents the casing from sliding completely into the cartridge chamber of the gun when being loaded. On the bottom of this flat base of the cartridge is the primer. When the trigger is pulled, the primer is the portion of the cartridge that will be struck by the firing pin of the gun. When struck, the primer ignites the gun powder contained inside the brass casing with an explosion that causes the bullet to leave the casing, travel down the gun barrel, and exit the gun.

Each of the components of the cartridge casing can be examined forensically and comparisons can be made to suspect guns. In some instances, it is possible to determine if a cartridge has been fired from the chamber of a specific gun. This can be done by examining the unique and identifiable marks left by the four aforementioned components of the gun. Like the process of physical matching, this is also a two-level process[9].

At Level One, cartridges are classified by the caliber, which is the size of the bullet, the maker of the cartridge, and the primer location; either a Centre-fire or a rim-fire cartridge on the cartridge base. For ballistic purposes, guns are classified by their caliber, chambering, ejector mechanisms, and firing pin, namely either Centre-fire or rim-fire. Eliminations of suspect weapons can often be made at Level One. For instance, a .38 caliber bullet removed from a crime scene cannot have been fired from a .22 caliber weapon. Or, that same .38 caliber bullet showing marks from an ejector mechanism could not have been fired from a .38 caliber revolver that does not have an ejector mechanism.

At Level Two, the more decisive ballistic fingerprint comparisons are often made using the following methods:

- Striations Matching;
- Chamber Markings;

- Firing-Pin Comparison; and
- Ejector markings.

## **STRIATIONS MATCHING AND CARTRIDGE CHAMBER MARKINGS**

Bullets fired from either a handgun or long rifle, other than a shotgun, fire a single projectile each time. This fired projectile is a lead or lead-composite bullet. When fired, this bullet travels down the barrel of the gun and begins to spin because the inside of the gun barrel has been intentionally machined with long gently turning grooves, called rifling. These grooves catch the soft-lead sides of the bullet spinning it like a football, and this spinning makes the bullet travel straighter and truer to the target. As a result of these grooves designed into gun barrels, every bullet fired will arrive at its target with markings etched into the bullet material from contact with the grooves in the barrel. These etched markings are called striations, and they are uniquely identifiable back to the gun they were fired from. For an investigator, these striations create an opportunity to match the bullet to the gun that fired it[10]. Recovered bullets can be recovered and compared to test bullets fired from a suspected gun. When striations of a recovered bullet are compared to known samples fired from a suspected gun, a side- by-side microscopic technique is used to match striation markings. An expert ballistic examiner can sometimes identify and illustrate matches in the striations to make a positive match.

### **CARTRIDGE CHAMBER MARKINGS**

When a cartridge is loaded into the chamber of a gun, the shiny brass casing comes into contact with the hard steel sides of the chamber. This chambering of the cartridge can leave unique and identifiable scratch marks on the side of the casing. A cartridge casing ejected or unloaded from a weapon and left at the crime scene can sometimes be matched to the suspect gun by comparing these markings.

### **FIRING PIN COMPARISON AND BLOOD SPATTER ANALYSIS**

When the firing pin of any gun strikes the primer on the bottom of a cartridge, it leaves an indentation mark. This firing pin indentation can sometimes be matched to the firing pin of a

suspect weapon. This requires microscopic examination that looks for the unique characteristics of the firing pin that becomes impressed into the soft metal of the primer when the firing contact happens.

Ejector Mechanism Markings[11].

Methods for loading and unloading weapons have evolved considerably due to different gun designs. The simplest guns allow the user to open the breach of the gun exposing the cartridge chamber to manually insert the cartridge and close the breach to make it ready for firing. There is no ejector mechanism for these guns, so there will be no ejector marks left on the base of a cartridge when it is unloaded from the weapon. Other guns have a variety of different ejector methods, including ejectors that catch the base of the cartridge casing to physically pull it from the breach and eject it away from the gun. In cases where a gun does have an ejector mechanism, these mechanisms leave very distinct and unique marks on the soft brass cartridge base. These markings can sometimes be compared and matched back to the ejector of a suspect weapon. With this broad variety of ballistic comparison techniques, an investigator has a significant number of tools that can be deployed and strategies that can be engaged to assist in matching a bullet to the gun that fired it. Considering these tools, the cartridge casing left at the scene of a shooting can be as important as a bullet removed from the body of a shooting victim. An investigator needs to keep this in mind when seizing cartridge casings as evidence. Great care needs to be exercised to document the location where each individual casing was found, and to preserve each casing in a manner that does not degrade the possible markings that could enable a match to be made. Damage can be done by placing casings into a common bag where they can rub against each other causing more characteristics and obliterating existing marks.

## **TRAJECTORY ANALYSIS**

In addition to the ballistic finger printing examinations, another area of ballistic science is known as trajectory analysis. The trajectory of a bullet is the path it travels from the time it leaves the barrel of the gun to the point where it finally loses the propulsion energy of the gunpowder and comes to rest. The flight of a bullet can be very short, as in the case of a point-blank shooting, where a victim is shot at very close range, or it can be very distant where the target is one mile away or more, as in the case in some sniper shootings.

When the bullet is travelling a longer distance, it travels that distance in an arched path or

trajectory of travel as it is pulled towards the ground by gravity. When the bullet arrives at its destination, it will have a distinct angle of entry into the target. This angle of entry can sometimes be calculated as trajectory to estimate the geographic location of the originating shot. In cases where a bullet passes through several objects, such as two walls of a house, the trajectory of the bullet can be used to determine where the shooter was located. In cases of drive-by shootings, for example, where several shots are fired, the pattern of trajectories can show if the shooter was moving and, if so, demonstrate the direction of travel.

## **BLOOD SPATTER ANALYSIS**

Blood spatter analysis, also known as blood stain pattern analysis, is a relatively new forensic specialty. The purpose of this analysis is to determine the events of a crime where blood has been shed. This is accomplished through the careful examination of how blood is distributed inside the crime scene. Studies have shown that when blood is released during an attack, certain patterns of distribution can be expected. For instance, a person being struck with a baseball bat will begin to bleed, and blood will be distributed in a droplet spatter pattern in the direction of the strike behind the victim. These droplets of blood will have a direction of travel that will be indicated by the directional slide of each droplet as the bat hits objects in its path. Blood from the victim adhering to the bat can also be distributed when the bat is on the upstroke for the next strike. This blood will be distributed in an upward directional slide pattern, for example, up a wall, onto a ceiling, or behind the attacker. Calculations of how many strikes were made may become evident from the tracking of multiple streams of droplets behind the victim and the attacker. Given this developing science, blood spatter analysis can be useful in criminal event reconstruction[12].

## **DNA ANALYSIS**

DNA, or deoxyribo nucleic acid, is a molecule that holds the genetic blueprint used in the development, functioning, and reproduction of all living organisms. As such, it carries the unique genetic information and hereditary characteristics of the cells from which living organism are formed. Except for identical twins, the DNA profile of each living organism is unique and distinct from other organisms of the same species. There are some rare cases where one person may carry two distinct types of DNA, known as Chimera where paternal twin embryo merge during gestation, or in cases where a bone marrow transplant enables the production of the marrow donor DNA in the recipient's blood. In these rare cases, a person may test for two distinct DNA profiles for different parts of their body.

In human beings, DNA comparison can enable high-probability matches to be made between discarded bodily substances and the person from whom those substances originated. Bodily substances containing cellular material, such as blood, semen, seminal fluid, saliva, skin, and even hair root tissue can often be compared and matched back to its original owner with high statistical probabilities of comparison. Sometimes, even very old bodily substances, such as dried blood, dried saliva, or seminal stains, can be analyzed for a DNA profile. The introduction of DNA analysis has allowed investigators for advocates to re-examine historical evidence and exonerate persons wrongfully convicted and imprisoned for criminal offences[13].

DNA is a very powerful tool for investigators and can be considered anytime discarded bodily material is found at a crime scene. Even very small amounts of material can yield enough material for DNA comparison. Importantly, DNA data-banks of known criminals and unsolved crimes are now becoming well-established in North America. When a person is convicted of certain criminal offences, DNA is collected and submitted to these data bases.

## **FORENSIC PATHOLOGY**

Forensic Pathology is the process of determining the cause of death by examining the dead body during an autopsy. An autopsy generally takes place in the pathology department of a hospital. In the case of a suspicious death or a confirmed homicide, police investigators will be present at an autopsy to gather information, take photographs, and seize exhibits of a non-medical nature, such as clothing, bullet fragments, and items that might identify the body. These items would include personal documents, finger prints, and DNA samples.

During an autopsy, a forensic pathologist dissects the body carefully examining, documenting, and analyzing the body parts to determine the cause of death. In the first stage of an autopsy, the pathologist examines the body for external injuries and indicators of trauma that may provide a cause of death. In this first stage of examination, the pathologist will estimate the time of death by observing evidence of four common post-mortem (after-death) indicators. These are body temperature, the degree of rigor mortis, post-mortem lividity, and progress of decomposition.

## **BODY TEMPERATURE**

Algor Mortis is the scientific name given to the loss of body temperature after death which can sometimes be used to estimate the time of death. This is a viable technique in cases where the

body is being examined within 24 hours following death. This method of estimating the time of death can vary significantly depending upon many possible variables, such as:

- Ambient room temperature being within a normal range of approximately 22° Celsius
- Pre-death body temperature of the victim not being elevated by illness or exertion
- Thickness of clothing that might insulate the body temperature escape
- The temperature and conductivity of the surface the body was located on that could artificially increase or decrease temperature loss

Considering a normal body temperature of 37° Celsius at the time of death, it can be estimated that the body will cool at a rate of 1° – 1.5° Celsius per hour. This calculation is known as the Glistler Equation. So, taking an internal rectal temperature and subtracting that from 37° Celsius will provide an estimate of the number of hours that have passed since the time of death. For example, a dead body with a measured temperature of 34° Celsius would provide a time range of 3 to 4.5 hours since the time of death.

## **RIGOR MORTIS**

Rigor mortis is a term used to describe the stiffening of the body muscles after death. A dead body will go from a flaccid or limp muscle condition to one where all the muscles become contracted and stiff causing the entire body to become constricted into a fixed position. After being in a constricted and fixed position, the muscles eventually become flaccid again. In normal room temperatures, this stiffening of muscles and the relaxing again has a predictable time progression of approximately 36 hours. In this progression, the stiffening of muscles will take approximately 12 hours, the body will remain stiff for 12 hours and will progressively become flaccid again over the next 12 hours[14].

Stiffening of muscles begins with the small muscles of the hands and face during the first 2 to 6 hours, and then progresses into the larger muscle groups of the torso, arms, and legs over the next 6 to 12 hours. These are general rules; however, the rate of rigor mortis can be different for infants, persons with extreme muscle development, or where extensive muscle activity precedes death, such as a violent struggle.

In determining the time of death in average environmental temperatures, Cox recommended that:

1. If the body feels warm and is flaccid, it has been dead for less than 3 hours
2. If the body feels warm and is stiff, it has been dead for 3 to 8 hours
3. If the body feels cold and stiff, it has been dead for 8 to 36 hours
4. If the body feels cold and is flaccid, it has been dead more than 36 hours

## **POST-MORTEM LIVIDITY**

Post-mortem lividity refers to a discoloration or staining of the skin of a dead body as the blood cells settle to the lowest part of the body due to gravity. This discoloration will occur across the entire lower side of a body; however, in places where parts of the body are in contact with the floor or another solid object, the flesh compresses and staining will not occur in that area. The staining is a reddish-purple coloring, and it starts to become visible within 1 hour of death and becomes more pronounced within 4 hours. Within the first 4 hours, lividity stains are not fixed and, if the body is moved, the blood products will shift and stain the part of the body that has become lower. In most cases, these stains become fixed between 12 and 24 hours. As such, they can be viewed as an indicator of how the body was left at the time of death. Importantly, if a body is found with post-mortem lividity stains, not at the lowest point in the body, it can be concluded that the body has been moved or repositioned after a 12 to 24-hour stain setting period[15].

## **DECOMPOSITION**

This is the final indicator a pathologist can look at to estimate the time of death. Sometimes, dead bodies are not discovered in time to use body temperature, rigor mortis, or early lividity indicators to estimate a more exact time of death. In these cases, assessing the progress of decomposition becomes important. Decomposition starts as soon as the body ceases to be alive. Subject to environmental conditions of extreme heat or cold, the readable signs of decomposition will become apparent 36 to 48 hours after death (Enki Village, 2017). These signs include bloating of the body and a marbling discoloration of the skin in a spider web pattern along surface blood vessels. As the body continues to decay, the skin surface will open and body fluids will begin to seep out. In advanced stages of decomposition, the body is often no longer identifiable by facial recognition, and DNA testing or dental records become the tools to determine identity. At very advanced stages of decomposition, flies and maggots begin to emerge, and the number of life cycles of the maggot-to-fly can be estimated by a forensic entomologist to provide the amount of time that has passed since these insect life cycles began[16].

Once these preliminary examinations have been made, the pathologist will cut the corpse open to conduct a detailed internal examination of each organ to look for signs of trauma, disease, or external indicators that might explain the cause of death, such as water in lungs or toxins in blood.

### CAUSES OF DEATH

There are a wide range of possible causes of death and pathologists are trained to look for these indicators, gather the evidence, and develop an expert opinion regarding the cause of death.

Causes of death can include:

- Laceration or Stabbing
- Shooting
- Blunt force trauma
- Asphyxiation
- Toxic substances
- Electrocution
- Depriving necessities of life

In cases of laceration or stabbing, wounds are inflicted by a sharp weapon or pointed object. The pathologist will attempt to determine if the death was caused by damaging a vital organ or by blood loss. The distinction here is that a person may be cut or stabbed in a way that causes them to bleed to death, which will be indicated to the pathologist by only a small amount of blood remaining in the body. Alternately, a laceration or stab wound may penetrate the heart, lungs, or brain in a way that causes the organ to stop functioning and causes death. In these cases, the pathologist will decide and render an opinion of fatal organ damage[17].

In cases of stabbing, the pathologist can sometimes illustrate the entry point of the wound and trace the wound path to determine an angle of entry indicating how the stab wound was inflicted. The size, depth, and width of the wound may indicate the size and type of weapon used to create the injury. Similarly, examining the characteristics of the wound can provide information to allow the pathologist to offer an expert opinion on the direction of a laceration or cut wound by illustrating the start point and the termination point. This information can be helpful for investigators in reconstructing or confirming the actual actions and weapons used in a criminal event.

In cases of shooting, the pathologist will decide whether death was caused by the fatal destruction of a vital organ or by blood loss. Recovery of a bullet or fragments of a bullet from inside the body can be helpful in ballistic analysis. Examining the entry wound can sometimes indicate the distance from which the wound was inflicted. In cases of point-blank or direct contact shootings, gunshot (burned gun powder) residue will be present at the entry point of the wound. As with stab wounds, the pathway that the bullet travelled from the entry point into the body to where it came to rest can sometimes be identified by a pathologist to determine the angle of entry. For investigators, this information can help reconstruct the criminal event and determine the location of the shooter. In cases of self-inflicted gunshot wounds, a point-blank entry point and a bullet path indicating a logical weapon position in the hand of the victim can provide some confirmation or contradiction of the self-inflicted wound theory.

In cases of blunt force trauma, the pathologist will look for indications of organ destruction or massive internal bleeding causing death. Blunt force trauma can be inflicted in many ways, such as massive sudden trauma from a fall from a great height, or a high-speed car crash that can immediately damage the brain, the heart, or the lungs to the point where they cease to function resulting in death. Other blunt force traumas, such as a strike to the head with a weapon, may not immediately cause death, but result in massive bleeding and internal accumulation of blood that can cause death. In cases of head injuries pathologists will sometimes be able to determine the contact point where the injuries were inflicted, and they will be able to point to the contrecoupe injury effect, which happens when the head is struck on one side and the brain is so traumatically moved inside the skull that it also become damaged on the opposite side and bleeding occurs at the top of the brain. This bleeding inside the skull can sometimes cause death.

In a similar effect, Shaken Baby Syndrome (SBS), (Elsevier, 2016) occurs when an infant child is violently shaken by a person and the baby's brain moves back and forth traumatically inside the skull causing bruising and sometimes fatal bleeding at the front and back of the brain. An examination by the pathologist for the contact points and internal bleeding can provide valuable clues to how the blunt force trauma was inflicted. According to An Investigator's Manual for Shaken Baby Syndrome, studies indicate that SBS is the leading cause of death in children under two years of age, and research studies in the United Kingdom and the United States indicate that SBS may occur each year as many as 24 to 30 per 100,000 children under two years of age (Smith, 2010).

In cases of asphyxiation, a pathologist will look for indicators of how the body was deprived of oxygen. Several common means include strangulation, suffocation, smoke inhalation, or drowning. For strangulation, the pathologist will look for bruising around the neck inflicted by choking hands or by a ligature. A ligature is any item, such as a rope or a belt, which could be used to restrict breathing and stop oxygenated blood going to the brain, thus causing death. If a ligature has been used and removed, it will leave a distinct abrasion line. If a dead body is found with a ligature in place, investigators should take great care to not untie the ligature, but cut it off of the victim, as this allows the ligature size to be measured and compared to the size of the neck to determine the amount of breathing that was restricted. Once the ligature is removed from a dead body, a distinct ligature mark or a groove in the flesh will sometimes be visible[18].

To determine strangulation, the pathologist will examine the eyes of the victim for the presence of small ruptured blood vessels that appear as red spots on the white of the eyeball. These spots are known as a petechial haemorrhage, and will often be visible in victims of strangulation (Jaffe, 1994).

Suffocation as a cause of asphyxiation occurs when a victim's breathing is stopped by an object, such as a pillow or a plastic bag, which restricts the ability of a victim to breathe, thus causing death. Unlike strangulation, suffocation has fewer indicators of violent trauma. Suffocation deaths are sometimes accidental and are harder for pathologist to conclusively determine. The presence of a suffocation device at the scene of the death is sometimes a first clue to this cause. Other contributing causes can be the limited ability of a victim to remove the device that accidentally obstructs their breathing, as may be found with a very young child, a handicapped person, or a frail elderly victim.

Another unique type of asphyxiation death is Auto Erotic Asphyxia (AEA). This occurs when a person is attempting to enhance their sexual arousal or pleasure while masturbating and apply self-strangulation with a ligature device. Their goal in AEA is not suicide but rather to reach a state of extreme oxygen deprivation and euphoria at the time of orgasm. This strategy can go wrong when the individual passes out and their ligature does not release causing continued strangulation and death. These cases can resemble suicide; however, they are really death by misadventure because the victim had no intent to kill themselves. AEA can sometimes be distinguished from suicide by the existence of apparent masturbation, pornography at the scene,

and ligature devices that have releasable controls.

In cases where asphyxiation is caused by smoke inhalation, a pathologist can find signs of soot blackening in the lungs and, if the air containing the smoke was sufficiently hot, the lungs will also show signs of burn trauma. Because arson is sometimes used as a means of disguising a homicide, finding a dead body in a burning building, and not finding signs of smoke in the lungs, is a red flag for possible death by homicide.

In cases where asphyxiation is caused by drowning, a pathologist will find signs of water present in the lungs. If there is a question as to the location of the drowning, it is possible to have a diatom test conducted on the victim's tissue. If the victim was drowned in fresh water, the diatom material, which is microscopic algae, will have migrated from the water in the lungs to the blood and tissue of the victim. These microscopic algae are species unique to a particular body of water. Diatom material found in a victim's lungs should match the diatom sample from the water where the body was found. If it does not match, this suggests that the victim drowned elsewhere.

In cases of toxic substances, a pathologist will test the stomach contents, the blood, eye fluid known as vitreous humor, and tissue samples from various organs in the body for poisons, drug overdose, the ingestion of toxic chemicals, or toxic gas inhalation. Any of these substances can cause death if ingested or inhaled in sufficient quantities.

In cases of electrocution, a person dies because of an electrical current passing through their body that stops the heart. A pathologist will look for signs to confirm that a current passed through the body, including contact burns where a person has touched a source of power that entered their body and existed to a grounding point. This grounding point is often at the ground through the feet, but can be through a shorter contact pathway, if another hand or part of the body was in contact with a grounded object. Burns will also be visible where the electrical current exited the body.

Cases where the necessities of life have been deprived generally occur where there is a dependent relationship between a caregiver and a victim. The victims in these cases are typically very young or very elderly persons who are unable to take care of their own needs. These cases often take place over and extended periods of time and may include other types of physical neglect or abuse.

Failing to provide necessities of life is such a significant issue that the Criminal law in Canada makes provision for this as an offence.

Duty of persons to provide necessities:

1. Everyone is under a legal duty
  - a) As a parent, foster parent, guardian or head of a family, to provide necessities of life for a child under the age of sixteen years;
  - b) To provide necessities of life to their spouse or common-law partner; and
  - c) To provide necessities of life to a person under his charge if that person
    - i. is unable, by reason of detention, age, illness, mental disorder or other cause, to withdraw himself from that charge, and
    - ii. is unable to provide himself with necessities of life.

**MARGINAL NOTE: OFFENCE**

2. Every one commits an offence who, being under a legal duty within the meaning of subsection (1), fails without lawful excuse, the proof of which lies on him, to perform that duty, if
  - a) With respect to a duty imposed by paragraph (1)(a) or (b),
    - i. The person to whom the duty is owed is in destitute or necessitous circumstances, or
    - ii. The failure to perform the duty endangers the life of the person to whom the duty is owed, or causes or is likely to cause the health of that person to be endangered permanently; or
  - b) With respect to a duty imposed by paragraph (1)(c), the failure to perform the duty endangers the life of the person to whom the duty is owed or causes or is likely to cause the health of that person to be injured permanently. (Justice Laws Canada, 2017)

**MARGINAL NOTE: PUNISHMENT**

3. Everyone who commits an offence under subsection (2)
  - a) is guilty of an indictable offence and liable to imprisonment for a term not exceeding five years; or
  - b) is guilty of an offence punishable on summary conviction and liable to imprisonment for a term not exceeding eighteen months. (Justice Laws Canada, 2017)

If the death of a person is found to be the result of failing to provide the necessities of life, the responsible caregiver can ultimately be charged with criminal negligence causing death.

## **CHEMICAL ANALYSIS**

There are a wide range of chemicals and usages that can be used in the commission of a crime or found at the scene of a crime. In addition to general chemical analysis, there are several sub-areas for analysis in cases of:

- Accelerants used in the crime of arson;
- Explosive analysis in cases of conventional crimes and terrorism;
- Toxic chemicals and biological agents used in cases of murder, industrial negligence, and terrorism;
- Drug analysis in the cases of trafficking and drug overdoses;
- Gunshot residue analysis; and
- Analysis and chemical matching of paint transfer in cases of hit-and-run motor vehicle crashes.

## **FORENSIC ARCHAEOLOGY**

Relatively new in the forensic world, forensic archaeology is the use of archaeological methods by experts to exhume crime scenes, including bodies. These forensic experts are trained to methodically excavate and record their dig. They document the recovery of artifacts (evidence), such as human remains, weapons, and other buried items, that may be relevant to the criminal event. Forensic archaeologists will often work in concert with other forensic experts in DNA, physical matching, forensic entomology, and forensic odontology in the examination of evidence[19].

## **FORENSIC ENTOMOLOGY**

Forensic entomology is a very narrow field of forensic science that focuses on the life cycle of bugs. When a dead body has been left out in the elements and allowed to decompose, the investigative challenge is not only to identify the body, but to establish the time of death. Once a body has decomposed, the process of determining time of death can be aided by a forensic entomologist. As discussed in a previous chapter, these experts look at the bugs that live on a decomposing body through the various stages of their life cycle. From these life-cycle

calculations, scientists are sometimes able to offer and estimate relative time of death.

## **FORENSIC ODONTOLOGY**

To paraphrase the description provided by Dr. Leung (2008), forensic odontology is essentially forensic dentistry and includes the expert analysis of various aspects of teeth for the purposes of investigation. Since the advent of dental x-rays, dental records have been used as a reliable source of comparison data to confirm the identity of bodies that were otherwise too damaged or too decomposed to identify through other means. The development of DNA and the ability to use DNA in the identification of badly decomposed human remains has made identity through dental records less critical. That said, even in a badly decomposed or damaged corpse, teeth can retain DNA material inside the tooth, allowing it to remain a viable source of post-mortem DNA evidence (Gaytmenn, 2003).

Beyond the identification of dead bodies, forensic odontology can sometimes also provide investigators with assistance in confirming the possible identity of a suspect responsible for a bite mark. This comparison is done by the examination and photographic preservation of the bite mark on a victim or an object, and the subsequent matching of the details in that bite mark configuration to a dental mould showing the bite configuration of a known suspect's teeth. Although bite mark comparison has been in practice for over fifty years there remain questions to the reliability for exact matching of an unknown bite mark to a suspect.

## **FORENSIC ENGINEERING**

Forensic engineering is a type of investigative engineering that examines materials, structures, and mechanical devices to answer a wide range of questions. Often used in cases of car crashes, forensic engineers can often estimate the speed of a vehicle by examining the extent of damage to a vehicle. They can also match damage between vehicles and road surfaces to determine the point of impact and speed at the time of impact. Many police agencies now have specialized traffic personnel trained in accident analysis and accident reconstruction. These officers utilize a variety of forensic engineering techniques to examine and document the dynamics of car crashes to establish how and why a crash occurred.

In cases of building collapses, forensic engineers can conduct analyses to determine the cause of a structural failure and, in the case of an intentional explosion, such as in acts of terrorism, this

can point to the location of the planted explosive device. The investigative possibilities for forensic engineering are too extensive to elaborate here, but if damage to a building, an object, or a piece of equipment poses an investigative question, the tools of forensic engineering should be used to seek answers.

## CRIMINAL PROFILING

Criminal profiling, also referred to as psychological profiling, is the study of criminal conduct to develop the most likely social and psychological profile of the person who may have committed the crime based on the actions of known criminals who have committed that same type of crime in the past (Royal Canadian Mounted Police, 2015). Criminal profiling draws on information from many sources, including historical criminal statistics of known criminals. Additionally, other information is collected about violent criminals and their modus operandi. This kind of information can shed light on details, such as preferences for luring victims, taking trophies, abduction methods, bondage preference, torture methods, means of killing, and displaying a dead body after death. With information and specific data collected from a wide assortment of offenders, psychological profilers work with investigators to examine the details of a criminal investigation, and, based upon the known historical criminal conduct data, they determine probable descriptors and characteristics that might be expected in a current suspect's profile[20].

For investigators, this kind of profiling can be helpful in focusing the investigation on the most likely persons. As an extension of these profiling techniques, a database known as Violent Crime Linkage Analysis System (ViCLAS) has been in place in Canada since the 1990s. This system documents the criminal conduct of convicted violent offenders and sex offenders, as well as certain unsolved cases, with a goal of documenting crime types and criminal conduct into a searchable database where unsolved crimes can be linked to offenders with matching profiles. According to the ViCLAS system web page, "Since the implementation of ViCLAS across the country, the database continues to swell with cases. As of April 2007, there were approximately 300,000 cases on the system and over 3,200 linkages have been made thus far" (Royal Canadian Mounted Police, 2015). Criminal profiling provides a valuable tool for sorting and prioritizing suspects identified for further investigation. In some cases, a new suspect may even be identified through the existing data within the ViCLAS database.

## **GEOGRAPHIC PROFILING**

Geographic profiling is similar to psychological profiling in that it seeks to focus on the possible conduct of an unknown criminal based on the data collected from the known past criminal conduct of others. Unlike psychological profiling, geographic profiling is focused specifically on where a suspect might reside relative to the location where his or her crimes are currently being committed.

In the late 1980's, police Detective Inspector Kim Rossmo developed a mathematical formula that began the evolution in the new forensic science of geographic profiling. Dr. Rossmo validated his mathematical formula from his observation that criminals generally seemed to live within identifiable proximity to the chosen locations where they committed their crimes (Rossmo, 1987). Applying this method, when a criminal is suspected of committing a series of offences, it is possible to have the locations of those offences examined by a geographic profiler to estimate where that suspect most likely resides. This assessment can be helpful in searching for and identifying new suspects by prioritizing suspects based on the location of their residence relative to the identified area with the highest probability for a suspect to be found[21].

## **FORENSIC DATA ANALYSIS**

In today's digital world, criminal conduct frequently includes evidence in the form of digital data. The collection of data from cellular phones as proof of a criminal conspiracy, or the message tracking of images passed in the distribution of child pornography, all require significant levels of specialized technological knowledge to collect, preserve, and analyze the exhibits. Some crimes, such as identity theft and the subsequent fraudulent misappropriation of funds, are almost entirely digital data crimes, and they cross over several fields of technological expertise. It is now incumbent upon ordinary investigators to understand the basics of how to preserve digital evidence, and to know when and if digital evidence may be present. An ordinary investigator without forensic data skills and qualifications should never attempt to recover digital data evidence without help. The destruction of evidence would be like an untrained investigator trying to lift fingerprints at a crime scene.

## FORENSIC DOCUMENT ANALYSIS

Forensic document analysis is typically done by certified forensic document examiners working as independent contractors or as employees within the service of government funded crime detection laboratories. Most often tasked within the scope of fraud investigations, these specialists examine items, such as wills, land titles, contracts, deeds, seals, stamps, bank checks, identification cards, handwritten documents and documents from photocopiers, fax machines, and printers. These documents are often examined to authenticate them as genuine or unaltered original documents where an allegation of misrepresentation or fraud has been made. Original signatures are also sometimes called into question, and these examiners can make a determination of authenticity by comparing the signature sample to samples known to be genuine. Forensic experts are also called upon to analyze threatening letters, ransom letters, or hold-up notes to make a connection to an identified suspect.

## FORENSIC IDENTIFICATION SECTIONS

Forensic identification sections are the frontline forensic specialists typically working within their own police agency. Usually, these specialists are experienced police officers who have taken forensic training in photography, fingerprint examination, physical matching, evidence collection, and crime scene management to work within this type of section. The daily work of forensic identification sections involves attending crime scenes, and conducting a variety of examinations using special fingerprint dusts, chemical fuming agents, and ultraviolet light sources to uncover impressions of fingerprint, shoeprints, tool marks or even body fluid stains not visible to the naked eye. Once the stain or the image of a forensic impression is found, these specialists can record, preserve, and recover the exhibit using photography and specialized tools for lifting the exhibit from a surface or removing the entire imprinted surface as an exhibit[22].

## CRIME DETECTION LABORATORIES

Crime Detection Laboratories, such as the RCMP labs across Canada, provide a range of specialties, including;

- **Biology** - Comparison of the suspect's and victim's body fluids and hair; most often DNA analysis
- **Chemistry** - Identifying non-biological substances found at a crime scene, such as paint, glass, liquids, fuels, and explosive substances

- **Toxicology** - The examination of body fluids to determine the level of alcohol present in the body, and providing expert opinions in relation to the extent of intoxication
- **Documents Examination** - the analysis of documents to determine authenticity for fraud allegations. Can also provide handwriting comparison
- **Firearms Ballistics** - Matching shells, casing, and fired bullets to a weapon and deciding on bullet trajectory
- **TOOL MARK EXAMINATION** - Matching tool impressions to an originating suspect tool

Scientists hired to work in these crime detection laboratories require a four-year specialized degree in the field of their choice. Once hired, they undergo an understudy period of 12 to 18 months in a laboratory with the expectation that they will become proficient enough in their chosen field to achieve expert qualification from the court. This expert status will allow them, on a case-by-case basis, to render expert opinion evidence on their examination of forensic exhibits.

For an investigator wishing to engage the services of the Crime Detection Laboratory, it is necessary to complete a request for analysis of the exhibit they wish to have examined and deliver that exhibit, either in person or by double-registered mail, directly to the Crime Detection Laboratory to ensure continuity of the exhibit. Once examined, the analyst will return the exhibit again either by calling for a personal pick up or by double registered mail along with a certificate of analysis detailing the result of the examination. The certificate of analysis can become an exhibit for disclosure to the defence in a criminal case, and, if uncontested, will be accepted by the court as evidence. If contested, the Crime Detection Laboratory Scientist will be called to attend court and provide testimony of the examination and the results as an expert witness. They are generally cross-examined by the defence to validate their expert qualifications and analyses.

This chapter outlined a wide variety of forensic tools and services available for criminal investigators. For any investigator, knowledge of forensic tools and services provides him/her with the ability to recognize and seize on evidence opportunities that would not otherwise be possible. The picture of physical evidence found at any crime scene only has face value as a collection of objects to be viewed and considered in their existing connection to the event. Analysis of those same objects using forensic tools can add significant information, making a circumstantial connection between the players and the event, and adding new insights. Forensic

analysis can make the difference between solving a crime and it becoming a cold case.

Various types of physical evidence can be found at almost any crime scene. The types of evidence and where it is found can assist investigators to develop a sense of how the crime was committed. Tool marks where a door was forced open can indicate a point of entry, shoe prints can show a path of travel, and blood stains can indicate an area where conflict occurred. Each of these pieces of physical evidence is a valuable exhibit capable of providing general information about spatial relationships between objects, people, and events. In addition, the application of forensic examination and analysis could turn any of these exhibits into a potential means of solving the crime.

## CONCLUSION

Forensic science is in a unique position among all other scientific fields because of its important social impact. Indeed, forensic science is at the interface of natural sciences and law implications in civil and criminal cases. Numerous analytical methods borrowed from chemistry and physics, such as various spectroscopic techniques and electrochemistry, have received tremendous applications in subareas of forensic science. Portable Raman and infrared (IR) spectrometers, electrochemical sensors and biosensors, and single-use paper-strip bioanalytical assays continue to become more affordable and accessible to crime investigations. Biomolecular analytical methods, including DNA analysis, proteomics, metabolomics, biomolecular computing, and *in vivo* imaging, have high importance in forensic science, but their use is not the same as in medicine, thus requiring special adaptation to the needs of forensic science. Analysis of various biomarkers found in biofluids at a crime scene, particularly based on immunoassay and multienzyme biocatalytic reactions, is progressing toward practical applications.

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