**Using Forensics to Solve Crimes**

**INTRODUCTION**

Forensic science has shaped the world of justice, fuelling crime investigations and signifying the progress of modern technology. Forensic science of today covers:

* Modern computer/clay facial reconstruction;
* DNA fingerprinting;
* Autopsy techniques;
* Forensic anthropology;
* Toxicology and much more.

What more reliable method is there to prove innocent or guilty other than through science?

**PART I - SCENE OF CRIME**

 Perhaps it may seem as though forensics always revolves around the laboratory, in which case it does, but one should not underestimate the importance of what takes place at the crime scene itself, for without before there is no after, just as there wouldn't be much use for forensic science if incorrect crime scene procedures led to the discredit of forensic evidence in court.

**DISCOVERING THE SCENE**

Discovering the scene is a very straightforward and obvious step in the course of a crime. Summarized below are the basic procedures taken at the crime scene for purposes of both efficiency and accuracy.

**HOW CRIMES ARE DISCOVERED**

Officials can discover crime scenes in a number of different ways. Most likely, the authorities have been informed by an everyday citizen who may have seen or heard something unusual/strange occurring and decided to report it, however police officers also come across crime scenes whilst on patrol in their designated area. Whether it is a police officer or a 911 assistant who answers the emergency calls, the details of the potential crime scene are recorded and patrolling officers closest to the scene are arranged to head over to the situation.

**ONCE AT THE SCENE OF THE CRIME**

Once officials arrive at the scene of crime, the first and foremost priority of a police officer is to assist or preserve the life of the victim (if one is present), making sure that he/she is not exposed to any danger. The officer does however; have to ensure that his/her own safety is not endangered during this process. They are then to alert senior investigating officers, reporting on the situation of the crime scene and subsequently notify ambulances and the fire department if necessary. The time of arrival on the scene must essentially be noted down as well as all other significant observations. Whilst doing all this, the officer must take care not to touch or move anything.

**THE EXTENT OF THE CRIME**

Officers must also assess the extent of the crime scene, which is the stretch of area in which the crime took place and may include more than one section. For example, in the case of a murder, there may be evidence not only where the murder was committed, but also in other parts of the murder environment and the scene where the corpse is found may not correspond to the actual scene of murder. If the body were transported elsewhere, then the mode of transport and the other locations would also become a significant part of the investigation.

**SEALING THE SCENE**

Sealing the crime scene is ultimately essential to protect any evidence it contains, for the more people that visit the crime scene, the more difficult it becomes for investigators. Not only does sealing the scene preserve important evidence, but it also helps in the identification of potential suspects/witnesses by eliminating the possibility of these people leaving/entering before officials have the scene fully detailed. The section that has to be sealed depends on the individual crime and the crime environment, but the sealed off area should be big enough to enclose not only the immediate area of the crime, but also the points of possible entry and exit.

The section then becomes accessible only to the relevant personnel involved with the case. This method makes it much easier to manage the crime scene, as it provides a protected zone for incident vehicles and also for dealing with the media. To prevent evidence contamination, personnel numbers are kept to a minimum at the scene of the crime and only one entry and exit access point is established to be utilized by all forensic and scene investigators. A log of everyone who visits the scene is kept, including arrival and departure times and any evidence shifted/taken from its original place. This is to ensure that 'evidence tampering' does not become an issue while in court.

**THE WITNESSES AND SUSPECTS**

Potential witnesses and suspects are detained and removed from the scene by police officers to be searched and questioned. Their condition, statements and behavior are all documented for further analysis later into the investigation. The police must also ensure that suspects are not allowed to return to the scene of the crime before it has fully documented, in order to prevent 'evidence tampering'. Suspects may be held at the police station for a certain period of time (varying for each state) during which the scene is analyzed and sealed off. At the same time witnesses at the scene are detained and separated from one another up until they have given statements and it is then at this point, that witnesses are free to go. This procedure is put in place to prevent the witnesses discussing what they each saw and prevents one's recollections of the incident being influenced by the ideas of another.

**IDENTIFING THE CRIME**

Crimes may be categorized into numerous crime types, arson, theft, or murder just to name a few. Different detectives are called to the crime scene depending on the type of crime. The detectives each specialize in their own respective fields, such as homicide, suicide or bombing. After the specialist detective is appointed by the senior investigating officer, it then becomes their job to take over the investigation and use their skills and experience to deduce what they can from the crime scene.

The basic outline of what they will have to undergo to solve the crime is simply find who committed it, details of when and how it happened and what evidence is there to prove the crime and the motive. (Be aware that the legal system uses the 'innocent until proven guilty' concept, meaning any suspect should be innocent until enough evidence suggests he/she is guilty.)

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**RECORDING THE CRIME**

After the crime scene has been managed and the initial assessment (recording the original situation and how it was discovered) is complete, the forensic photographers arrive on the scene. The jury cannot revisit the scene of a crime during court sessions, so photographs can help to vividly recreate the scene as well as create a lasting record of the evidence so it can be properly analysed in a forensic laboratory.

**RECORDING**

Where memory fails, technology has replaced it, just as crime scene photography and videoing have replaced basic memory-based recounts of a crime scene with vivid live shots of the aftermath. Through this, accuracy is greatly improved and the film itself becomes a form of evidence.

**THE CAMERA**

Forensic photographers usually prefer to use 35 mm cameras, or medium format, as it tends to balance the portability and ease of use with quality images. When taking close-up photos of evidence, the camera is often mounted onto a tripod for stability to ensure the necessary quality required of photographs presented as evidence in court. Some forensic labs have their own darkroom facilities, which then enable photographers to develop the pictures themselves.

**DIGITAL CAMERAS**

Digital cameras have a number of advantages when used in forensic photography as they require no chemical processing, can be displayed on the camera straight after being taken to ensure that the image was captured and the photos can be immediately transferred to a computer and stored in the database. However, digital photos are very easy to alter which therefore prevents them from being used as evidence in court.

**VIDEO CAMERAS**

Video cameras also provide an easy and inexpensive way to document crime scenes and can give the jury with a more realistic sense of the crime scene than still pictures of a room. The zoom on video cameras are however, more often digital rather than optical and thus provide pictures of slightly less clarity than actual photographs. Videos are in general a good briefing tool for police officers who have not visited the crime scene.

**TECHNIQUES**

Close-up shots of evidence have precise requirements, such as exactness, angle taken and balance, in order to achieve the best possible shots. These pictures of evidence form a factual record and must be able to be reproduced in terms of size, shape and color, thus, balance and accuracy is an absolute must. The use of basic camera flash and flood lights are quite sufficient for general crime scene photography, but close-up shots of evidence require careful lighting. Artificial sources of light have proved very useful in the photography of evidence. An example of this concerns oblique-angled light, whereby the light is angled or slanted towards the subject. This is used for bringing out the detail in textured surfaces, such as foot and shoe prints left in mud.

**LIGHT**

Light-guides, lamps can direct a narrow beam of light at the subject of the photograph to enhance the object details. Different light filters also allow for the exposure of distinct evidence. For example, *ultraviolet* light can make stains and fingerprints glow, violet makes gunshot residue and blood more visible and blue and green lights are used with enhanced fingerprints to show up fibers and urine. This is because some materials absorb the ultraviolet light, while others reflect it, causing the material to become present under the ultraviolet light and flash of the camera when the photo is taken.

A crime scene is also documented by writing down what the scene was like upon discovery, sketching, videoing, evidence tables to document artifacts found, voice recording and witness interviews.

**SEARCHING FOR EVIDENCE**

This is the most important procedure at the crime scene in terms of solving the crime, as most clues or evidence will come largely from the scene. However, like all other procedures, there are specific guidelines for this practice.

**DISTINGUISHING EVIDENCE**

 A crime scene cannot be permanently secured just to preserve the evidence contained within the scene. (Imagine if a supermarket were to be completely sealed until a robbery was solved.) So when the investigators begin their search, they search only for appropriate and relevant evidence so that the crime scene can be released as soon as possible. However, searching for relevant evidence is not an easy task. For example, samples of soil can help in determining which suspects may have been present at the scene, especially if samples found on their clothes or shoes match with the soil found at the location, but collecting every item related at the scene of crime would hide vital facts in an inundation of unrelated data. If the investigators were too selective in their search however, they could also neglect evidence that could possibly lead to solving the crime. Only experience can allow investigators to find equilibrium between accumulating too much or too little evidence. The use of video, photography and record on paper helps to control exactly how many objects must be removed from the scene.

**ORDER OF SEARCH**

Because every crime scene is different, every crime scene requires an individual approach. For example, a murder that occurred outdoors requires a search confined to a specific, relatively smaller area, whereas a bomb explosion can scatter evidence over a very large distance. However, there are certain general rules that guide the search plans for searching a crime scene.

Firstly, the type of crime can often point out the appropriate order of search. This means that outdoor zones are always the first to be searched, because the weather is likely to cause damage/alteration to evidence and public areas also hold higher search priority over private areas, as they too, are more difficult to protect.

If a body cannot be taken from the scene until the area around it is searched, then that search is given priority. A body may not be able to be removed from a scene as it may affect or destroy important evidence that must be collected first.

**METHODS OF SEARCH**

Methods of search are also customized to suit the crime scene. A large open land such as fields and parks are investigated using a line search, whereby investigators stand in a straight line and move forward together. The line search can reveal pieces of clothing, objects, weapons or human remains.

Another method of search is the grid method, which involves covering the same area twice. The searchers cross firstly in one direction, then again, this time at right angles to the initial course.

These methods of search are quite impractical indoors, where room-by-room searches are more suited. Room-by-room searches involve searching every room in a house to search for incriminating evidence. This form of search can be impractical when large building are involved, requiring a search of the rooms involved, hallways and exit and entry points.

**EVIDENCE STORAGE**

When all the evidence has been recorded and collected, it is packed and stored for analysis. Storing biodegradable evidence in spirits stops the rotting process while clothing and artifacts are stored in sealable bags. The careful handling, labeling and isolation of the evidence may be time consuming, but has become an increasingly important process, especially for Deoxyribonucleic Acid (DNA) analysis. DNA analysis can be ruined or become inaccurate if the DNA sample becomes contaminated, hence the need for responsible handling.

**PART II – THE AUTOPSY**

 An autopsy is the examination of a body after death, which may also be referred to as a post-mortem. Developed largely in Germany, the process has been refined over years of experience and scientific development to allow modern investigators to build a clear picture of the death scene.

 The autopsy is performed by a pathologist or coroner and reveals aspects such as its cause, the weapon/s used (if any are involved) and the time since death. Permission from the victim's next-of-kin needs to be obtained when the law does not require an autopsy to be performed. (Rarely the case when murder is suspected, as we will assume here) Though autopsies are more often used for purposes unrelated to crime, they play such a crucial role in murder investigations, that this field of *forensic medicine* (and subsequently, forensic science) has a large impact on where the investigation should begin.

**CAUSE OF DEATH**

The cause of death refers to why death occurred (e.g. due to excessive loss of blood) and shouldn't be confused with how the victim was killed i.e. the manner of death. A variety of measures are taken by coroners/pathologists to establish whether the manner of death was accidental, natural, suicide or murder, depending on the situation and case type.

**THE CAUSES**

An autopsy is generally the most accurate method available to determine the cause of death during murder cases and consequently, whether the fatality was innocent or in fact a disguised murder. Different measures are taken under different situations and with it being rather difficult to explain every single scenario possible, below are some common examples, which may likely perk your interest.

**Scenario One (Arson Victims)**

When dealing with a body found at the scene of a fire, the corpse is firstly examined for any traces of soot present in the breathing passage. The presence of soot would suggest that death was caused via asphyxiation, whereby the victim dies to due to a lack of oxygen. Next, blood samples are analyzed for the presence of carbon monoxide, cyanide or other poisons in the bloodstream, indicating a death caused by cyanide poisoning, generally a result of the burning of synthetic materials, usually furniture. In other cases, burns on the corpse with inflamed edges (caused by red blood cells trying to repair the burned skin), would suggest that the victim died from burns. Wounds and lacerations on the body would at first seem to have been a result of the fire, however, if signs of underlying bleeding are present, it would conclude that the victim was already dead before the fire began and the arson may have been a means to cover up a more sinister crime.

\* Victims of fire commonly die of either one of two deaths - asphyxiation or from the burn of the flames.

**Scenario Two (Victims Hanged)**

A body discovered hanging or suspended in some way, usually contains telltale signs of a death due to the lack of oxygen. These include such signs as blue skin color, burst blood vessels in the eyes and inflated lungs. Forensic pathologists examine the rope marks on the neck to determine if they contain evidently inflamed edges, a sign that the victim was alive before being hanged. However, when no inflammation marks are present, it suggests that the victim was dead before being hanged and the hanging was a form of cover up. The rope marks on the victim's neck are examined to check that they match the rope found at the scene of crime. The slightest difference of the rope impression from the actual rope itself, would undoubtedly imply that the rope was not the murder tool and where the victim did die of a lack of oxygen and does have evident bruises on the neck, the murder weapon is sought using the markings as a guide. As a general rule, all rope markings on the neck should be in the shape of an upside down V, where the knot would cause a bruise on the back of the neck, creating the point of the V.

 Other facts pointing to murder may also be revealed when an examination of the neck is carried out. Strangulation usually breaks the hyoid bone located in the neck, but the bone is very rarely broken during hanging. The breakage of the hyoid would suggest manual strangulation, whereby the victim was strangled using the hands, or via means of another implement (e.g. cord, belt etc). When strangulation is the case, death may be caused due to a lack of air, but more likely, as a result of the deliberate compression of the neck, causing a vegal inhabitation, the situation where the stimulation of the neck's vagus nerve causes the heart to stop. In cases where the hyoid bone is not broken, but bruising is evident around the nose and mouth, a death caused by smothering is indicated, thereby dying due to a lack of oxygen.

\* The rope marks (bruises) on the neck of the victim should correspond to the type of rope used.

**Scenario Three (Victims Drowned)**

Bodies discovered in the water are examined to see whether water is actually present in the airway and stomach of the victim and if the lungs have swollen up. If such signs are apparent, then the victim did actually die due to drowning, although whether it was murder or accidental will be left for investigators to determine. Further examination of the corpse will reveal if bleeding occurred in the lungs, suggesting that there was a struggle for breath during the drowning. Other signs coroners pick up are such things as leaves, twigs or other objects near the death scene, found grasped in the victims hands, indicating that the victim tried to clutch an object to save themselves.

\* An average of 9 people drown per day in the US (Poseidon: 2004).

However, in the case that an examination of the larynx reveals that a spasm occurred, the victim may have died from sudden exposure to the cold, which caused an immediate heart attack. To reveal whether bodies were alive or dead upon entering the water, an analysis of single celled algae, (known as diatoms) is performed. Certain diatoms found in the body are compared against those found in the water and if these samples match, then the body was alive upon entering the water, but if otherwise, the body was dead upon entering the water and the coroners will continue searching for other injuries that may point to murder.

In some cases, hypothermia may have been the cause of death rather than drowning. When the core temperature of the human body drops below 305K, the motion of the enzymes in the body begins to slow down and hypothermia is the eventual result of prolonged exposure to the cold. Below is a table of estimated survival times in water against the water temperature:

 **Liquid Temperature (degrees Celsius)**  **Estimated Hours of Survival**

 0 0.25 - 0.75

 0 – 4 0.5 -1.5

 4 - 10 1.0 - 3.0

 10 - 16 1.0 - 6.0

 16 - 21 2.0 -40

 21 - 27 > 3.0

 > 27 Undeterminable

**TIME SINCE DEATH**

Forensic science provides a number of solutions to solving the mystery question of when a person died. Generally, the longer it has been since the death, the less accurate the estimation given by forensic pathologists.

**BODY TEMPERATURE**

Police arriving at the scene of crime should be capable of estimating how long a person has been dead for, by judging from the body temperature and stiffness of the corpse. However, a more accurate evaluation of the time since death must be made by a forensic pathologist in the forensic laboratory. The pathologists/coroners record the temperature of the body, the temperature at the scene of crime, the weight of the victim and all other appropriate variables, which are then applied to a formula designed to predict the time since death. The core body temperature drops at an estimated rate of 0.8K each hour from the time of death, but is ever-changing dependant the surrounding temperature, humidity levels, air movement and fat levels in the body. Thus, the less time that has surpassed since the death, the less variables which will affect the prediction.

**HARDENING**

Stiffening of the corpse occurs between just 30 minutes and 3 hours after death. The process is called rigor mortis and occurs as the muscles in the body begin to stiffen from a lack of blood and oxygen. Rigor mortis first becomes apparent in the eyelids and jaws of the victim and spreads throughout the whole body in approximately 6 to 12 hours, before receding again after another 6 to 12 hours. Occasionally, stiffening of the body may not even occur if the surrounding temperatures are very low, while the process occurs a lot quicker in muscles that were quite active before death. Like body temperature, the evidence provided by the level of muscle stiffening becomes of little use after a long

**TRUTH LIES IN THE EYES**

The eyes of a victim can also hold answers to the time of death, as a thin cloudy film is developed over the eye within 3 hours after death has occurred. The eyeballs become softer as a result of less fluid pressure behind the eye and the degree to which this has occurred can be used as a measure of the time since death. Again, a less common procedure for deaths that evidently occurred out of the limit of several days

**SKIN COLOR**

The color of the corpse will also help determine the time of death from about 48 hours and onwards. From approximately 48 hours after death, bacteria begins to breed on the skin, giving the skin an evidently greenish tone. The tinge starts in the lower stomach area, spreading outwards and affecting the hands and feet last. Approximately 4-7 days after death, the skin will acquire a marble-like appearance, as the veins in the body become closer to the surface, thus becoming more easily visible.

**BLOOD POOLING**

The pooling of the blood can be a vital clue in determining the time of death and is known as hypostasis. This occurs when the blood ceases flowing, settling in the lowest parts of the body and in turn, causing the skin to become pink and red in color. This process is complete in up to 6 hours after death. The main use of blood pooling analysis actually lies in helping to determine the death manner (noting that the location of the blood pools indicates the upright position of the body at the time of blood pooling) the process does however, form a method of predicting the time since death.

**THE DIGESTIVE SYSTEM**

The digestive system and gut contents of a victim can provide important clues to the time of death of a victim. Chewed food will firstly pass through the esophagus and then down into the stomach within seconds of the initial swallowing. After 3 hours, the food then leaves the stomach and heads toward the small intestines. 6 hours after eating a meal, the food will have traveled half way through the small intestines and begin moving through the large intestine. Where the victim's small intestine is empty, it suggests that the victim ate his or her last meal approximately 8 hours before death. The digestive process usually takes a bit more than a day, but it can be affected by sickness, liquid intake, fear or drug intake.

Pathologists also briefly note that correct level of food digestion corresponds to its location in the digestive system. In the rare case that a clever murderer wishes to delude investigators by attempting to bring forward the time of the victim's last meal (giving them an explanation for where they were at the victim's time of death), he/she may manually feed processed food (resembling that of chewed food) into the victim's stomach. If this is so, the food collected in the stomach will be much less digested than normal, since the periodic motion of the stomach stops after death. The food may indeed appear slightly broken down, due to the presence of the stomach acids, but any abnormalities are otherwise detectable. In older people or in those affected by the effects mentioned earlier (sickness, fear, drug/liquid intake), the efficiency of food digestion alters and it is left to pathologists to determine if the extent of the undigested food is great enough to suggest the mentioned scenario.

**FORENSIC ETEMOLOGY**

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| Flies and maggots also provide an approximate time of death, very useful for cases where the body has been long dead. Only certain insects will feed and lay eggs on a dead corpse and forensic entomologists study these insects, their larvae cycles and thereafter can determine whether a body has been dead for just one day or up to 3 or 4 weeks.  |
| \*Larvae development is a good indicator for deaths which concern a matter of months.  |
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| **Time** | **Physical Appearance of Body** | **Insects Present at that Stage** |
| 0-3 days | 0-3 days Proteins and carbohydrates in the deceased body begin to break down. | Blowflies e.g. Bluebottle flies, Syrphidae flies |
| 4-7 days | Body is starting to decay and causes the abdomen to inflate because of the gases inside. | Fly larvae and beetle e.g. Rove Beetles |
| 8-18 days | 8-18 days Decay is well and truly setting in; the abdomen wall begins to break down. | Ants, cockroaches, beetles and flies |
| 19-30 days | The decaying body enters a stage know as 'post-decay'; in wet, humid conditions, the body is sticky and wet; in hot dry conditions, the body is dried out. | Beetles and mites e.g. Springtail beetle, Acari, Nematocera (present only during the winter months), Brachycera |
| 31 and over days | The bones, skin and hair that remain no longer give off a powerful stench and smell just like the soil surrounding it. |  |

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**THE BODY FARM**

Decay can also determine how long a person has been dead for and in Tennessee, a special research area has been set up to study exactly how and why bodies decay. The research farm, known as The Body Farm, was established in 1981 by Bill Bass, a professor of forensic anthropology. By having decaying bodies readily available to study, Bass and his students discovered a number of factors contributing to body decay. Some things they discovered include that flies and maggots will turn a body in to a skeleton in under two weeks in warmer weather and the face will always rot first because maggots prefer wet places. He has also observed how fast bodies decay when submerged in water, stored in the boot of a car, or wrapped in plastic and that when a person's head is burnt, that the skull reaches boiling point very quickly, causing the skull to explode. If the person head doesn't explode, it means that the victim may have been shot in the head, allowing the steam to escape.

**DEATH MANNER**

Forensic pathologists provide valuable information about the manner of death after the autopsy has been performed. There are four main categories regarding the manner of death. These include natural deaths, accidental deaths, homicidal deaths and suicidal deaths. The information found during the autopsy not only reveals the causes of death, how, when and where they occurred, but also shows what manner it's of.

**NATURAL AND ACCIDENTAL DEATHS**

Natural deaths are the cause of the majority of deaths that occur. The manners of death in this category include heart failure, disease, and death during sleep etc. The autopsy reveals certain aspects of the death, whether it occurred suddenly, unexpectedly or if the person was critically ill and hadn't seen a doctor in the last two weeks. Accidental deaths are common but if the police suspect that the accident was deliberate or could have been avoided, a criminal investigation will be conducted. An example of an accident that could have been avoided is a safety guard left off a dangerous piece of machinery, as would be the perfect deliberate accident.

\* Motor vehicle accidents are a large cause of death among the consequences of alcoholic consumption.

**HOMICIDE AND SUICIDE**

Homicide, meaning the killing of a human, is regarded as murder, where the criminal's intention was to deliberately cause someone's death. Some common examples of murdering include shooting, stabbing, smothering, strangling, hitting with a blunt object and burning. Each weapon leaves distinct marks on the corpse, which a pathologist may identify belongs to a certain type of weapon and thus leading investigators to the actual murder tool. Manslaughter, where death is not the intention, is however, also regarded as homicide. Suicide, meaning intentionally taking one's own life, is in fact illegal, as is assisting someone else to commit suicide. A suicide agreement between two people is when it involves both people claiming their lives together. If one person, however, survives the attempt, he/she can be charged with manslaughter, or, unintentional death.

**MARKS OF VIOLENCE**

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**INTERNAL/EXTERNAL EXAMINATIONS**

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**BRUISING**

Bruising on the skin occurs when the blood vessels are broken by some form of hard and forceful contact with the skin, usually by a blunt object. The shape of the bruise can often reveal which direction the blow was received from and the color of the bruise can indicate how long ago the injury occurred. As bruising heals, it goes red-purple, to brown, to green and finally to yellow. Bruising is not an accurate way of deciding how the victim met their fate, as interpreting bruising is different in every person, due to the fact that people bruise at different rates and bruising continues for a short while after death. Strangulation around the neck also leaves significant bruising. The hands, cords and ropes usually leave a distinct mark around the neck in the shape of the pattern on the strangling agent. If the strangling agent is very soft material, it may leave little or no marks, but the dissection of the neck area is able to show tissue bruising beneath the skin.

**CUTS**

The shape of a cut in the skin can show whether the weapon had one or two cutting edges, while the angle and direction of the cut can reveal whether a death was accidental or intentional. For example, committing a suicide would leave a wrist cut cutting towards the knife carrying hand. Also, the deepness of the wound can show how much force was used during the stabbing and can also expose whether the criminal intended to kill his victim. Cuts present on the hands can reveal if there was a struggle with a knife, meaning that the criminal who committed the crime could also be wounded. Lacerations on the skin can also provide more information on the type of weapon used, though it is often inaccurate when trying to find out the width of the blade as the weapon may have been moved after the original cut was made.

**GUNSHOTS**

Gunshot wounds can provide information on the conditions surrounding the death, for example, it may rule out suicide. The size of the wound can act as a guide to the type of gun and bullets used and burn marks around the wound can reveal whether the victim was shot at close range or from further away. A weapon fired close to the victim makes

a single large wound, but a weapon fired from far away leaves a series of individual wounds, provided several shots were fired. Using these wounds as evidence, pathologists are able to estimate an approximate distance between the victim and the person with the gun and gunpowder samples aid in identifying the actual gun responsible for the death.

\*Close range shots leave gunpowder burns

Burns discovered on the body could potentially be the cause of death, as the body may go into shock and die if not treated immediately. Small burns on the body could be a result of electrocution, but a lethal dose of electric currant can often cause severe blistering were the electric currant has first met the skin. Electrocution occurring in water often leaves the body unmarked. External injuries can often reveal internal injuries that may have been the cause of the fatality. An example of this could be bruising occurring on the body. The bruising could have been caused by a blow strong enough to incur fatal internal bleeds, causing death. Brain damage may be an exception to this as often a blow to head can leave no marks or grazes but is strong enough to lead to death by bleeding in the brain. The same applies to shaken baby syndrome, whereby a baby's head is violently shaken, causing internal bleeding in the brain and eventually leads to loss of life

**ASSAULT**

Assault leaves telltale signs such as ruptures, internal bleeding and broken bones. During an assault, the abdominal organs are most easily damaged, as the body offers no protection for these organs, unlike the heart and lungs, which are protected by the rib cage. Ruptures in the liver and spleen cause cuts in the bladder and stomach. The victim usually dies from internal bleeding into the abdominal cavity rather than organ failure. Broken bones occur most commonly in the nose, jaw and ribs as these bones are more fragile, than, for example the bones in the legs and arms. Although broken bones appear in both the left and right side of the body, they are more common on the left, as this is the side that is raised to fight off a right-handed attacker.

**EVIDENCE STORAGE**

The basis of forensic science is analysis, which emphasizes the need for uncontaminated evidence and consequently proper evidence preservation. The storage of important artifacts and objects ensures the possibilities of contamination are reduced to a minimal and therefore, give accurate clues to fuel the investigation.

**DURING AN AUTOPSY**

Properly preserving and storing the evidence is a vital part of the autopsy. At the start of the autopsy, the coroners have to make sure that everything is hygienic, so to avoid contamination of the evidence on the body and also for health reasons. Once the autopsy has begun, samples from major organs, tissues, bodily fluids, blood, hair, fingernails, mouth, sexual organs and rectum are taken and placed in contamination proofed sample containers. The major individual organs are weighed and the containers of samples are then stored in refrigerated storage areas until they can be sent away for further testing and analysis. It is important that the evidence collection and storage is done properly, as this evidence will be included in a coroner's report that will be presented in a court of law.

**THE CUSTODY CHAIN**

In terms of evidence storage in general however, the main requirement is, that one or more people will be able to testify for the item's security from the moment it was collected to the object's appearance in court, a process often referred to as the 'custody chain'. Temporary evidence storage forms the most susceptible link in the custody chain, as this is the period when evidence leaves one officer's hands (usually at the police station) to when the evidence is safely collected by another officer to be stored in the property room. During this period, the evidence should be safely stored in some form of secure storage, for example, in secure lockers with automatic locking systems to prevent the need for keys or locks.

\* Evidence must be stored in secure areas, commonly within enclosed cases

**TEMPORARY STORAGE**

If temporary storage for biological evidence such as bodily fluids or DNA sample is needed, refrigerated or frozen storage compartments may be used where appropriate to keep such evidence from evaporating. Hazardous biological materials, mainly reactive/flammable chemicals, are placed safely away from air vents and air conditioning systems and often in an airtight situation to prevent oxidization or some form of reaction.

\* Cold rooms are used to preserve biological and chemical evidence.

**LONG TERM STORAGE**

Long term evidence storage is slightly different to that of temporary evidence storage. Firearms are stored separately in a secure and confined area with the protection of a security screen and are placed in vertical racks. Vaults or safes are the storage devices for any currency evidence, as would be expected, while audio/video recordings are kept away from humid conditions, magnetic fields and direct sunlight. In general, the storage of the evidence must ensure its security and protection from any form of damage, so as to achieve the most accurate results during analysis.

**BLOOD ANALYSIS**

Blood analysis is a simple test which can be useful for many cases involving a blood stained crime scene and in the verification/identification of an unknown victim's identity.

**VERIFICATION**

When a stain is found at the scene of a crime, the first thing that has to be determined is whether the stain is blood or some other bodily fluid. This is done using a simple test involving a solution that changes color when it comes into contact with hemoglobin or peroxides in the blood. Another type of test commonly used involves luminal spray, which makes any residue containing blood, glow in the dark as well as picking up on traces of blood that may have been scrubbed away. The next step is confirming whether the bloodstain belongs to a human. Serologists, people who study blood, place the sample and a testing solution into small wells on a gel-coated glass plate, and the two will defuse towards each other. If the sample is human blood, it will contain human antigens and where the two solutions meet on the gel-coated plate, a noticeable band forms.

**BLOOD TYPES**

Determining which person the bloodstain belongs to involves an investigation of blood types. The human blood contains over 100 different antigens, therefore it would be time consuming and unpractical to test for every single one. Serologists instead use a number different blood testing techniques, but by far the most common and effective technique is the ABO system. This system is also used to determine compatibility for blood donors and recipients. The ABO blood type system involves checking the surface of the red blood cells for two antigens known as A and B, with blood type being named after the type of antigens it contains - A, B, AB and O. By noting that a blood clump forms when the same type of antigen meets the same type of antibody, an experiment can be done on the solution of blood to determine the blood type.

\*The most common blood type in the world is type 'O+' and the most rare is type 'AB-'.

**THE TEST**

The test is done using two solutions each containing antibodies to type A and type B antigens. The first solution contains type A antibodies and when mixed with type A blood, will cause it to form clumps. The same concept is used to test for B antigens, where a solution of type B antibodies would cause all type B antigens in the blood to clump together. If blood clumps under contact with both A and B antibodies, then it is of the blood type AB, since both antigens are present in the blood. O blood does not clump with any other blood type and is therefore identified because it is solitary.

**THE RH FACTOR**

For finer results yet, the blood groups can be assigned either a + or a - figure after it to indicate the presence (+) or absence (-) of a blood protein known as the Rh factor (named after the Rhesus Monkey, in which it was first recognized). Using an antibody solution to the Rh protein, the same concept is used, where blood clumping determines the absence/presence of this protein. Thus, the finer blood groups include A+, A-, B+, B-, AB+, AB-, O+ and O-.

**OTHER BODILY FLUIDS**

Blood is not the only fluid that is excreted from the body and tested by serologists. Substances like saliva, semen, urine and excrement contain DNA, can be compared with a suspect. In cases concerning rape, investigators need to be sure that the swab taken or the stain found is semen and this is confirmed using a test that changes color on contact with SAP (seminalacid phosphates), sperm and chlorine. Microscopes are also used to see individual sperm, but this technique is not accurate, as a rapist who has had a vasectomy or is sterile will not show sperm under a microscope, even if they committed the rape. However, blood, semen and urine samples all contain DNA, which is slightly more accurate (and expensive) in singling out the criminal.

**PART III- TRACING THE EVIDENCE**

Evidence constitutes the most important factor to determining a just verdict. The various analyses conducted to deduce truth from an item of evidence range from the analysis of bloodstains to that of trace evidence. Covered in this section is information regarding the technologies in a forensic laboratory and how/what clues can be taken from the results.

**THE FORENSIC LABORATORY**

The forensic laboratory is where the essence of forensic science takes place, with one objective - to deduce all of what is possible from evidence. Thus, there is the need for multiple departments, personnel and methods of analysis.

**GENERAL LOCATIONS**

Forensic laboratories contain almost all aspects of forensic science in one place, where skilled scientists and specialists who focus on specific areas of forensic science work together to unravel and solve even the most intricate of crimes. Forensic laboratories are commonly attached to universities so the scientists who work there can give students studying forensics a firsthand experience. Large police departments may have their own forensic laboratory but otherwise, forensic laboratories are independently run.

**THE PRINCIPLES**

Forensic laboratories all run following the same basic rules and regulations. Any item of evidence that enters the lab must never come into contact with anything that could contaminate it. Its progression through each of the lab's departments must therefore be fully recorded so that it can be perused at any time. Once the sample is in the lab, the most straightforward diagnosis is always carried out first i.e. to verify that the item is really what it is, before moving onto more expensive, but precise procedures to discover the evidence the item might hold. Any tests that may destroy the piece of evidence are carried out last, after all the other tests have been completed.

**THE DEPARTMENTS**

Forensic laboratories contain the most up-to-date technology and techniques for enhancing and analyzing fingerprints, shoeprints and tire marks. As specific methods of analyzing evidence at a crime scene are not practical, the objects are recovered and brought into the lab.

**TRACE EVIDENCE**

In most labs, a unit commonly known as a 'trace evidence unit' forms an area where scientists look for clues in evidence such as hair, fabric, dust, fiber and skeletal remains.

**CHEMISTRY**

A chemistry unit is present in any laboratory and is used to test samples of blood and urine for alcohol, drugs and poisoning. Chemistry sets are also used in the analysis of synthetic materials such medicines, dyes and stains. Specialists in the area of chemistry also rely on gas chromatographs, mass spectrometers and microscopes to identify chemicals.

**SEROLOGY**

The serology unit specializes in the identification and analysis of bloodstains and other bodily fluids, as well as DNA sequencing. The most common of the DNA tests, the polymers chain reaction, is now able to be performed in small laboratories, thanks to advancements in this area; however, the analysis of mitochondrial DNA is still only performed in large forensic laboratories.

**MATERIALS**

Material units are used to identify and analyze metals, paints, ceramics, soil and wood in an attempt to trace a crime back to a possible suspect. The biology unit is in charge of analyzing all biological evidence such a seeds and plants.

**FIREARMS**

Firearms units test weapons to see which weapon made the mark on an object or wounded or killed a person. To be able to carry out these tests, firearms specialists study the used bullet cartridges and use shooting baths to fire weapons, identify the bullet marks and establish the firing distance.

**PHOTOGRAPHY**

Photography plays a vital role in the forensic laboratory, as photography is used to document crime scene evidence. Processing resources and dark room services allow specialists in the area of photography to analyze photographs and bring the evidence to light.

**OTHERS**

Large labs also have arson and explosives experts as well as specialists in software, computer data, files, documents, audios and video recordings. The units available in different labs will vary from one to the other, however, the need for certain analyses and the budget of each lab determines the availability of the departments.

**EFFICIENCY AND STAFF**

Forensics laboratories are extremely complex and involve up to hundreds of people to ensure everything runs quickly and efficiently. Staff ensures that evidence is correctly booked in, prepared and stored, cleans and maintains the lab, as well as servicing the various technical equipment and keeping it looked after. Testing results from the evidence is useful in solving one crime, but when added to a worldwide database, the evidence can be linked to other crimes that the suspect may have committed.

**BLOOD STAIN ANALYSIS**

A lot of blood is lost during a violent assault and it is these bloodstains that can reveal a killer. By studying their position, shape and size, investigators can identify where the attacker stood during the assault, their height, how many times the weapon was used, and if the attacker was left/right-handed. Blood is not easily removed and therefore makes an excellent tool for reconstructing the scene.

**FINDING THE STAINS**

To be able to use bloodstains at the scene of a crime to reconstruct an attack, investigators first have to find all of the stains. Investigators commonly use a high- intensity light beam, which when filtered, produces a violet light useful in locating bloodstains. If this method does not reveal blood or if the crime scene has been cleaned, other reagents that make blood identifiable are used. Luminol and fluoresce are the most commonly used reagents and can reveal blood that has been watered down to a ratio of 12 000:1 i.e. 12000 parts water to one part blood. Luminol reveals drops of blood when sprayed in a dark room. The luminol, on contact with bloodstains, turns fluorescent, making it visible to investigators. Fluoresce is very sensitive and only glows if it is lit up with a UV light source. Both of these reagents react when they come in contact with iron that is found in hemoglobin in the blood.

**BLOOD PATTERNS**

Patterns in the bloodstains found at a crime scene reconstruct the actions that caused the blood to spill and spread. When a droplet of blood hits a surface, the shape of the mark when it lands reveals the direction in which the drop was traveling and the amount of force it was projected with. Blood that falls for a short distance creates big round droplets on the floor. Blood that is projected with a large amount of force breaks into smaller droplets. When blood hits an angled surface, the droplets run downwards which creates a tail that points in the opposite direction to the initial drop.

**THE ORIGIN OF THE STAIN**

Blood that has been found on the wall, floor and ceiling can be traced back to where the attacker and victim were situated at the time. Originally, investigators analyzed each mark and reconstructed its path using string. With present day technology being at a high standard, investigators now use computer programs that take gravity and the position of the blood into account and are able to chart an accurate flight path for the blood droplet.

Definite blood spatter marks often reveal even more information, particularly if the blood has been thrown from the tip of a weapon. Identifying whether the bloodstains curve to the left or the right reveals which hand the attacker used to hold the weapon and the width of the trail of blood can identify what type of weapon was used in the attack. Knives leave a narrow trail of blood whereas baseball bats leave a wider trail of blood.

**REVEALING INTENTIONS**

Blood that leaves the weapon can also indicate the viciousness behind the attack, as powerfully projected sprays of blood would suggest that the attack was frantic and unwavering, with the intention of killing in mind.

**SPACED PATTERNS**

The absence of bloodstains is just as revealing as bloodstains being present. A space where no blood is present suggests that there may have been an object laying where the source of blood was projected and the surface to which the blood was projected onto. The object that may have been removed by the attacker will carry the same blood spatter marks as the rest of the area.

**PART IV - PIECING TOGETHER IDENTITY**

One of the biggest problems police may face with an investigation is the need to confirm or recognize an unknown identity. This situation is commonly met with murders which involve a skeleton rather than a whole corpse or a body which has decayed beyond recognition. In dealing with these cases, forensic science has developed a variety of techniques described by the subsections listed below.

**FACIAL RECONSTRUCTION**

Uncovering skeletons used to mean very little could be done to determine who the victim was and if appropriate, who the murderer was. However, with growing technology and experience of years, facial reconstruction now provides an answer to such mysteries.

**RECONSTRUCTION IN CLAY**

Once the skin and flesh has rotted away from the skull of a corpse, their character and physical appearance disappear along with it. It then becomes the job of forensic anthropologists, sculptors and creative artists, to reconstruct a life like form of what the person looked like from the skeleton and sometimes, remaining parts of a skeleton. Clay is a common form of reconstruction.

**BEGINNING THE RECONSTRUCTION**

In order to reconstruct a life-like face, sculptors need to know the depth of skin that overlays the skull. Sculptors usually begin sculpting with 20 to 35 tissue layers, scattered all over the face. The main heavily concentrated depths are situated around the mouth and in between the eyes. Facial depth measurements are available for male and female, certain ages, racial groups, thin people and obese people. Small pegs are used as facial depth indicators and are fixed into the skull or otherwise into a cast of the skull. Strips of clay that have been made to match the height of the pegs are then placed between them and once the strips are in place, clay is used to fill the gaps between each peg.

**FACIAL FEATURES**

The sculptor is then able to start work on the eyes, mouth, ears, nose, chin, jaw and cheeks, as these are the aspects of the face that give the most character, but are also the parts that perish most quickly as the body decays. Sculptors rely on certain rules during the reconstruction of a face, for example, the width of the nose is the same as the distance between the inner corner of the eyes and the corners of a person's mouth lie below the inner boarders of the iris. Ears are seen as being roughly the same length as the nose, though elderly people usually have longer ears. Once the facial features are complete, the sculptor makes a mould from the clay head using a plaster of Paris silicone rubber.

**THE FACE**

Now, the reconstruction of the face involves the task of building the muscles around it. Sculptors must approximate the muscle structures by noting the shape and size of certain facial bones, as these will directly affect the shape of the muscles previously attached to them. Using their experience, the sculptors are able to build the face by shaping each of the muscles and then fixing each one in its place on the skull. The final step is to cover the clay muscles with a layer of clay skin, which is smoothed over so that it resembles real skin.

**LIMITATIONS**

However experienced the sculptor is, there are certain accuracy limits that occur during the reconstruction of a face. Sculptors can only guess hairstyles and cannot create the expressions on a person’s face that make the sculpture completely life like. However, a sculpture is successful if it aids in jogging someone's memory or can narrow down a search by excluding anyone whose face does not resemble the reconstructed face.

**COMPUTER FACIAL RECONSTRUCTION**

Computer facial reconstruction has developed far enough to allow a virtual form of reconstructing the face from a skull, making it easy and efficient to travel from computer to computer. Such software allows for a 3D image/structure of the finished face to be rotated and moved around on a monitor.

**AQUIRING THE SKELETAL STRUCTURE**

Using computer facial reconstruction does not require artistic skill, but it does require skills of a different sort. There is no standard method of computer facial reconstruction but the initial data and facial shape comes from a 3D scan of the skull. This process is non-destructive to the skull and involves the skull rotating on a turning table whilst a laser scanner lights up a thin perpendicular strip. Mirrors located on either side of the turning table reflect the images from the lit up area to sensors. The data that the scan produces allows a controlling program to determine the distances of each point located on the skull. This then creates a digitalized model of the skull that is easily and freely rotated on the computer screen.

**MUSCLE AND SKIN**

Applying muscle and skin to the bone requires computer tomography (CT) scans of actual living people, which acquire images showing where bones cast shadows onto the skull and record hard/soft tissue (bones and flesh) in a 3 dimensional, view. Using CT scans, data files record the shape of the skull as well as the tissue depth. Forensic anthropologists’ knowledge is also utilized in choosing an appropriate form of CT scan. Any clothing found with the bones can provide a clothing size, which is useful, as it allows scientists to adjust any tissue depth measurements to account for obesity or thinness. Merging the two scans, the CT scan is applied to the digital scan of the skull, becoming two skulls on top of each other. At this stage of the process, the two skulls are different shapes. The computer program distorts the skulls' marks on both so they match each other and at the same time, distorting the facial tissue properties, creating a facial shape that resembles the victim.

**COLOR**

CT scans cannot record vital surface detail such as hair, skin and eye color, so these aspects of persons face must be added. This involves borrowing the physical features of a living person in order to paint these features onto the 3D model. A person who has similar age, racial qualities, and build as the modeled skull is used in a 3D rendering process called 'color mapping'. This process involves photographing the face of the person with similar qualities and using software to merge the three views into one strip that is put onto the computer to complete the reconstruction. The final result can be viewed and turned on the screen. Like clay facial reconstruction, the method does have its accuracy limitation. Nose, mouth and ear shape are largely down to guessing, however, lighting conditions and the ability to view the face from any angle makes computer facial reconstruction very lifelike and helpful during investigations.

**PART V – SUSPECTS**

Suspicion alone does not render a suspect guilty and nor do some of the techniques mentioned within this section, but the main purpose of the following procedures is to eliminate unlikely suspects and single out those who are likely.

**LIST OF SUSPECTS**

When police have a collection of suspect photos and mug shots, they rely largely on witness identification to collect evidence. In court, witnesses may testify as a form of evidence, for they are often confident of what the criminal's physical appearances were. However, relying on witness accounts of an event is not always accurate and false information can lead to a wrong conviction.

**LINE UPS**

Line-ups involve known suspects standing in a line while a witness walks along the line and chooses those who they remember being responsible for the crime, based on memory of height and appearance. The witness is not visible to the suspects thanks to a reflective glass, which allows the witness to see through the glass, but only allows those on the other side to see a mirror reflection.

Line-ups are an effective method of identification if suspects are known, but when they are not known, another approach involving mug shots is taken. A witness peruses a series of mug shots of previous offenders to try and pick out a suspect, if one is present. The drawbacks to this method is mainly the fact that it's more suited to small communities, where there is a small enough number of offenders for a witness to view every mug shot. Also, as the witness is only viewing previously offending criminals, an incorrect choice can lead police to an innocent ex-offender.

**OTHER WAYS OF PICTURING**

If the above approaches are impractical or fail to reveal anything, police create a likely picture of an offender, based on eyewitness accounts. Using paint-by-number face composites computer programs, sketches, and photo composites, witnesses are able to choose appropriate facial hair, eye, skin and hair color and facial build to create a picture that resembles who they witnessed.

**LIMITATIONS**

All of the methods mentioned contain the same limitation, witness's memory. People often over-estimate their ability to recall a person's face and in the case of a violent or threatening attack, witnesses are often more busy focusing on the attacker's weapon than on their face of the attacker. In light of this, governments have brought in new legislation to tighten ID procedures and ensure that police concentrate on more solid forensic evidence.

**SURVEILLANCE CAMERAS**

Surveillance cameras are one example of measures put in place to enhance what the human memory is not able to do, but it is not always as helpful as police would like it to be. The images taken on surveillance cameras are often tarnished and unclear, making the process of trying to match faces with those on screen very difficult. To make the matching of faces difficult to challenge in court, a process called photo anthropometry is used. This involves using a program that has the ability to measure the exact distance between features on a suspect's face on the video. This can then be used later to compare with facial features on a mug shot.

**PSYCHOLOGICAL PROFILING**

As a branch of criminal science, psychological profiling is better known in practice than by name. Although no solid evidence can be obtained from this process, it provides an accurate way of guiding the direction, in which an investigation heads toward.

**WHAT IS PSYCHOLOGICAL PROFILING?**

Psychological profiling involves investigating an offender's behavior, motives and background in an attempt to further guide an investigation. Research shows that offender's that repeatedly rape or kill are driven by a heightened public fear for their actions and media attention, which could eventually lead to their arrest. Analyzing the criminal's habits and rituals allows investigators to trace similarities between previous crimes. When these details of their lifestyle are made public, friends, neighbors and colleagues may recognize them.

**THE FACTS**

The process of psychological profiling began over a century ago, but was first distinctly used as a method in America during the 1950's. Investigators discovered through research, intriguing patterns and similarities between serial killer's behaviors. Some of the patterns discovered include the killers having suffered from child abuse as youngsters, whether it is sexual or physical and that this kind of abuse led to abnormal behaviors later on. As children and teenagers, they started fires, were cruel to animals or children and then in the late teenage years to early twenties, were engaging in petty crime and defying authority.

**WHY CRIMINALS COMMIT**

Committing serious crimes usually start at around the mid to late twenties. Being able to manipulate victims and show a sense of power and domination is a main drive for criminals, as well sexual motives. Murdering victims gives them the sense of success and control that they have never felt in their lives. Some criminals have also found that they need to relive that sense of victory that was felt during the committing of the crime, so they take something from their victims, for example, jewelry, clothing and even body parts.

**INDUCTIVE PROFILING**

Investigators putting together a profile use either inductive or deductive approaches. Inductive profiling involves assuming that when a criminal commits a crime, he or she will have a similar background and motive to others who have committed a similar crime. An example of this is a re-offending rapist whose target is white women, is not likely to be black, because crimes of the past that have been similar to this one have rarely crossed racial lines. However, these statements have been questioned and have experienced a lot of publicized drawbacks.

**DEDUCTIVE PROFILING**

Deductive profiling involves a process that avoids generalizations and averages. This method involves intently studying suspects in extreme detail and adapting findings in which new evidence surfaces. A deductive profile is set up based on the offender's actions before, during and after committing the crime. For example, if the murderer used a makeshift weapon, investigators are then able to deduce that the crime was probably spontaneous. Another example involves serial murderers. Investigators are able to find out whether the murder was organized, which means that the killer carried out a planned, premeditated attack on a victim, or if the attack was disorganized, meaning that the murder was unplanned and the killer behaved in an uncertain way. Organized and planned killers often carry a tool kit containing duct tape and rope to bind their victims and gloves and a mask to hide their identity.

 Of Interest

A serial killer or rapist is defined as someone who commits 3 or more crimes with only a short period of time in between.

**SERIAL KILLERS**

Serial killers are also known to stick within their 'comfort zone', for example, their own neighborhood, before traveling further as their sense of power and domination heightens. A serial killer often leaves behind a signature or trademark of their work that is usually unnecessary, but emotionally fulfills the killer. There are usually also similar aspects, which will link the crimes together, for e.g. the method of murder or the victims may all have some form of similarity. Profilers use this to trace and link crimes committed earlier together.

**FINGERPRINTING**

Fingerprinting, dactylography, is still commonly used as a form of identification, whether it has been taken in the traditional way using ink and paper or scanned into a computer database. Fingerprint identification is based on the classification of fingerprint patterns, which can not only prove that a person was present at a crime scene, but can also be used to compare with the stored fingerprints of millions of other known criminals.

**Fingerprinting History**

Sir Francis Galton was one of the first to indulge himself into the possibilities of using fingerprints as a form of identification. His work in this field inspired the creation of an early fingerprinting filing system, known as 'icnofalagometrico', developed by an Argentinean police member, Vucetich, whom had had correspondence with Sir Francis. The first fingerprinting bureau was opened by Vucetich in 1892, the same year Sir Francis released his works on fingerprinting.

**The Ten Print System**

In 1896, an English fingerprint scientist by the name of Sir Henry Edward, who was a pupil of Galton, created the 'ten print' system of classification, which became the most commonly, used technique until the introduction of computers in the late 20th century. It was first implemented in India in 1897 and had its own unique way of classification. Edward divided the patterns in fingerprints into two groups known as value patterns, which contained whorls, and the no-value patterns, which contained loops and arches.

**Assigning Values to Prints**

A fingerprint that contains a whorl pattern was given a number value that depended on which finger the print came from. A thumb on the right hand containing a whorl is valued with number 16, but the little finger on the left hand containing a whorl was only given a value of 1. Edward then grouped together values from certain fingers, forming a fraction-like code for each set of ten fingerprints. Altogether, Edward created 1024 individual codes, his pioneering work ensured that any set of prints could be filed using this code. His system of fingerprint filing worked very well in identifying criminals working under aliases.

Suspected criminals were fingerprinted and coded before being compared against known criminals stored under the same code, making it much faster searching for a match as investigators didn't have to search through the entire collection. This system did however, have some drawbacks, as a whole and complete set of ten fingerprints was required, making it difficult to identify single prints found at a crime scene. A single print identification system was later developed in the 1930's allowing the classification and filing of single prints from individual fingers.

**Fingerprint Types**

 

A central pocket loop

The double loop

The plain whorl

The loop

A plain arch

The tented arch

An accidental print

**Improvements To The System**

If the print has an unusual shape or characteristic, it is easily and quickly matched, but in most cases, fingerprints found at a crime scene are rarely fully intact and therefore influences the quality of the search. As time progressed, fingerprint collections grew and the job of searching them became more difficult and time consuming. Finally in the 1960's, computer systems were introduced and constantly improved until they were fast and efficient and able to be used for public purposes.

**Comparing Prints**

The comparison of fingerprints is a time consuming procedure and requires experience and great skill. Examiners look at the shape of the ridges and compare the points where the ridges start, end, join and split. The positions of short ridges, dots and any enclosed areas are also noted. Examiners also search for points of similarity between the fingerprint mark and the print to try and decide if the two patterns match.

**Computer Comparison**

 The computer systems used at present are able to scan fingerprints that have been found at a crime scene and automatically find and record the ridges, whorls, arches or loops contained within. This data is then compared by the computer with information that is similar in the database and finally produces a shortlist of matches in order of likeliness. The crime scene fingerprint is compared manually by investigators with the shortlist to identify any matches

**HANDWRITING AND VOICE EVIDENCE**

Every person's style of handwriting is unique and has its own personalized touch. It is because of this reason that handwriting is very difficult to disguise and forge, making handwriting analysis an effective tool for incriminating a suspect.

Voice analysis is also a helpful way of identifying a criminal. Phonetics experts are able tell from a voice what age, race and sex the person is, as well as trace phone calls back to a particular caller.

**HANDWRITING**

The writing practices we learn during our time at school are very difficult to lose, as we get used to the particular way that we hold a pen, shape the letters we write and how we space our words and lines. These are some of the factors that prove useful during the analysis of a document. Investigators analyze these aspects of suspicious documents i.e. the printing style, paper and ink, all of which help to identify a forged letter.

**THE USE OF HANDWRITING ANALYSIS**

The handwriting section of forensic science involves the comparing and authentication of written documents such as *ransom* notes, forged contracts, forged wills, fake ID's and passports and any other form of writing or printed material. The analysis of someone's handwriting is most commonly used to prove that two documents were written by the same person. When looking at a person's handwriting, the examiners usually look for personalized characteristics under four areas including line quality, form, content and arrangement.

**WRITING COMPARISON**

The form of writing involves examining the shape of singular letters and identifying if the slant is in a certain direction, the size and how they are connected with the next letter. Unusual characteristics, such as the use of a plus sign or the ampersand (&) are also noted. Examining the content of written and printed papers is done to identify similarities between punctuation, spelling, grammar, vocabulary and paragraph phrasing.

Document examiners compare unidentified documents with a 'standard', a sample from a suspect. A standard is usually produced by the suspect under supervision. Even under supervision, the suspect still has the chance to disguise their handwriting, which is why investigators then have to collect other standards of casual handwriting from a suspect. The casual handwriting is undisguised and can therefore be compared with the unknown sample either with words that match or letter-by-letter.

\* Handwriting can be both manually examined, as well as using the computer.

**TECHNIQUES**

Initially, comparisons are done with the naked eye or with a hand held lens; however, the methods used today are by far more accurate. Special lighting can help to reveal small, but useful details about how a document was altered or created. Angled lights identify indents on the paper, which suggests that a signature was traced and also shows the roughness left on the paper after an eraser has been used. Backlighting makes areas where an eraser has been used, turn lighter and makes correction fluids dark. Examination using an infrared spectroscope can identify if ink, that appears the same color, is actually from a different source by giving each color a different cipher.

**ANALYZING PRINT**

Faxed, typed, printed and photocopied papers can also be analyzed. A typewriter whose letters have been worn down can identify a specific machine the criminal used. A laser printer accumulates small marks on its light sensitive drum that appear on every printed document as minute black dots and photocopiers also replicate these marks, as well as any dirt on the document or the copier's glass. The header on a fax document also contains details of the machine it came from and the machine it is going to. If the information in the header is forged or changed in any way, an analysis of the writing can reveal what make and model the machine is. The composition of the ink, paper, glue or fastenings can be used when comparing a number of documents and dating the document

\*Differing fonts and specific print patterns can identify a printer or typewriter.

**VOICE ANALYSIS**

Forensic phoneticians specialize in language and speech science and have been used to solve criminal cases. Phoneticians can deduce the age, sex and race just from listening to their voice, particularly accents and digitalized voices. These techniques are useful when listening to recorded phone calls and voice messages. A technique known as voice spectrography was invented in the 1960's and involves a program making a graphic representation of sound. This particular graphing system measures the amplitude and strength of sound in a person's voice. A linear line cutting horizontally across a spectrograph represents atmospheric pressure and the movement of the graph above and below this line represents an increase/decrease of pressure due to speech. Experts in this field are also able to identify different background noises, enabling them to guess where the criminal may have been at the time of the call.

**SUBCONSCIENCE EVIDENCE**

Subconscious evidence refers to the details investigators are able to deduce from a suspect's subconscious actions. Such evidence is not solid, but are useful guidelines for determining someone's emotions/honesty during an interview.

**POLYGRAPH TEST**

When police are interviewing suspects, it is often difficult to spot if someone is lying or not. The invention, created in the 1920's, known as the polygraph, has proved a very useful tool during interviews for police investigations.

Polygraph testing is used to measure the body's response to stress. It involves a pair of plates that are attached to the suspect's fingers. These are for measuring the skin's resistance or sweat levels. Rises in blood pressure and the speeding up of the pulse rate indicate stress. A sphygmomanometer is placed around the suspect's arm to measure these levels. Heavy breathing represents anxiety and is measured using pneumographs wrapped around the chest. All of these test results are recorded by the computer along with the questions that caused the response.

**LYING TO THE POLYGRAPH**

Though it may seem like the polygraph test could never be incorrect, many of the subject's responses are not clear. There are many reasons for this including alcohol and drug use and even hunger, which also affect the results. Pathological liars have their own methods of cheating the machine, including simple pain inflicting techniques such as biting their tongue. By inflicting pain on themselves, this affects the results on the machine. The fear and anticipation of having to undergo one of these polygraph tests also affects the results. Investigators often only have to threaten the use the polygraph test, also known as a 'lie-detector', for the person to change their guilty/innocent plea out of fear.

**OTHER TESTING METHODS**

Where the polygraph tests have failed to reveal the truth, newer technologies have stepped in with the answers. One new method involves testing the electrical currents that move through our brains when we think using a machine known as an electroencephalograph. Researchers who work with this technology focus on one wave in particular, the P300, or the wave that surges when we see something we recognize or remember. The P300 is monitored by showing the suspect pictures and words not associated with the crime scene and then showing them pictures of or relating to, the crime scene. When the suspect recognizes the crime scene, there is no way of cheating, as you can't stop yourself from reacting to familiar things. When falsely accused, the suspect's brain waves will stay the same throughout the entire process.

**BODY LANGUAGE**

A suspect's body language, mannerisms and gestures can often tell police when a suspect is lying to them. For example, children often cover their mouths after lying and in adults; they often touch their chin after lying. Suspects fiddling with their hands watch or sleeve cuffs are thought to be a disguised crossing of the arms, another method which prevents them from expressing what really happened.

\*Gestures, expressions and in particularly, hand fiddling, are all closely observed by police.

**PART VI – WEAPONS**

**MURDER TOOLS**

The weapon used as the murder tool often holds important evidence in terms of fingerprints, motives and/or the origin of the murderer. Guns and explosives, in particular, have become a large hazard and common murder weapon as a result of their efficiency and power to produce mass destruction. The silent killer, poisons, are also included in this section, as well as an unlikely, but compelling weapon, motor vehicles.

**TOXICOLOGY**

The area of toxicology involves testing for the use of illegal substances, poisons and alcohol. Using samples from a suspect such as hair, a toxicologist can confirm whether a person has used illegal drugs weeks ago or only yesterday. Urine and blood tests can reveal alcohol levels and whether someone was poisoned.

**PRELIMINARY TESTING**

Testing for drugs follows a certain procedure. First, a simple test is done to determine whether a chemical is present. If it is found that there is a chemical present, more complex testing is conducted to measure the quantity and type of illegal substance. The preliminary test involves an immunoassay kit which changes color when drugs in a sample of urine combine with the antibodies that are present in the kit test.

**CHROMATOGRAPHY**

Both drugs and alcohol are tested using chromatography, which involves separating chemicals based on the speed at which they move in liquid and gas. The essential testing device in the toxicology department is gas chromatography. Consisting of a narrow tube containing loosely packed solid particles, a non-reactive gas, for example, nitrogen, flows through the tube. When the sample to be tested is inserted, every individual chemical passes through the tube at varying speeds. Timing when each chemical arrives at the exit point identifies the composition of any substance mixture. These results are then placed on a computer database, where each substance appears as a peak on a graph. The peaks that are identical to a known drug make a positive result. Liquid chromatography involves the same process, substituting gas for liquid.

**TOXINS IN THE BODY**

Chromatography, as mentioned earlier, is used in identifying poisons, whether it was accidental, suicidal or homicidal. The testing is this time done on the victim using samples taken during the autopsy. The liver, as this is the part of the body that filters out the body's toxins, and blood samples are the most useful in testing for poisons, but other samples such as *bile*, which holds antidepressants, heroin and morphine are also used. Flammable substances such as solvents are present in the lungs as a result of poisoning and the victim's hair stores, a record of poisoning, as lines along the strand of hair in chronological order. These samples are analyzed using immunoassay and chromatography methods, the same as testing for substances in living individuals.

**ARTILLARY**

The research done by forensic scientists with regards to artillery is very important, particularly in countries where guns are easily obtainable. Despite what criminals think, plainly removing the gun from a crime scene does not prevent the possibility of leaving incriminating evidence at the scene.

**THE EVIDENCE**

As a criminal fires a gun, the evidence is thrown in every direction. The first piece of evidence dispersed from a gun during shooting is the most deadly of all, the bullet. The second piece of evidence is the used cartridge case that contained the bullet inside the gun. The third is the burnt gunpowder expelled from the bullet and barrel of the gun during the firing. Then lastly, the noise the gun makes as it fires its potentially fatal bullet, for those other than the victim can hear it. In order to understand how each of the pieces of evidence expelled from a gun can help forensic scientists, it's important to understand how a gun works.

**THE GUN**

Most guns work in a similar way, that is, when the trigger is pulled, it makes the firing pin hit the back of the sealed unit (bullet) and in turn, ignites the small pressure- receptive *charge* called a 'primer'. The primer then sets off an explosive powder in the bullet (or in the case of a shotgun, pellets), forcing it to move down the barrel, where it is expelled towards the target. The power of the explosion, a powerful chemical reaction, will give the bullet speed and force. Simple guns need to be reloaded after one or two shots, though most guns have a bullet holding area that can usually store up to five bullets or more. Semi-automatic weapons have an explosion that pushes the bullet out, as well as ejecting the used bullet cases. The weapon then automatically reloads a new bullet and pulls back the firing pin, in preparation for the next shot. In the case of automatic weapons, when the trigger is held back, the gun will continue firing until the bullet holding area is empty. The most common firearms come in the form of a revolver, a semi-automatic revolver, machine guns, hunting rifles and shotguns (loaded with pellets).

**THE BULLETS**

In the case of a shooting, investigators must find out how many shots were fired, where the bullets went and how each bullet got to where it is. This is done by talking to witnesses who heard the shots or saw them being fired and also looking for the used cartridges that may have been left on the ground. If the shooter dropped the weapon, it is possible to tell how many shots were fired by counting how many shots remain in the bullet holding area. Once it has been established exactly how many bullets were fired, the next step is to find all the bullets. An x-ray of the victim will show bullets lodged in the body as dark shadows. Bullets lodged in materials that are soft are especially helpful in an investigation, as the marks left behind can be useful in the identification of the weapon that fires it. If bullets are dented beyond analysis upon contact with a hard surface, it is still important to find the bullet's point of impact, as it enables investigators to trace the path from the barrel of the gun to its final resting place. This is done using lengths of rod and pieces of string, as well as lasers, but lasers can only be sighted and photographed in specific light conditions.

**GUNSHOT RESIDUE**

Gunshot residue is found in a circular shape around the victim's bullet wound and most importantly, on the suspect's hands and clothing. Residue that is found on a suspect's hand can provide proof that the suspect handled and fired a weapon recently, but the absence of residue is not enough to prove innocence. Washing the hands can remove all traces of gunshot residue and some weapons do not expel any residue at all. Because of this, investigators will often take swabs of a suspect's clothes and face to try and find traces of residue. Other traces of residue may not be just from the bullet, but also from the oil and metal that can come in contact with the hands whilst loading a gun.

**COMMON WEAPONS**

In a complex world of weapons, forensic scientists see hundreds of different wounds causes by weapons other than guns. For example, blunt trauma, sharp trauma, asphyxiation, strangulation and assault. All of these forms of murder are brutal and the wounds on the dead body left behind provide vital evidence of the type of weapon used by the criminal.

**TRAUMA**

Blunt trauma concerns injuries and death caused by blunt objects such as bats, household ornaments and rocks. If a person is the victim of blunt trauma, fractures, broken bones and external bruising are usually strong evidence for the occurrence of blunt trauma. Sharp trauma refers to injuries caused by sharp objects, such as knives, nails and swords. The type of knife wound on the body can often reveal what type of knife was used. Different types of knives include double-edged knives, single-edged knives and serrated edged knives. Double-edged knives have dagger-like cutting edges that leave obvious markings of two sharp edges. Single-edged knives have one sharp edge and often create wounds that have a boat-like shape. Serrated knives often give the wound a rough appearance around the edge.

**ASPHYXIATION**

Asphyxiation is a condition whereby a lack of oxygen and an excessive amount of carbon dioxide causes interference in breathing and subsequently choking, then eventually death. The most common cause of asphyxiation occurs in motor vehicles, where the vehicle's exhaust is channeled into the car, subsequently suffocating the victim. Strangulation, another possible form of asphyxiation, leaves marks or bruising around the neck, whether death was inflicted manually or using an object. The size and markings on the wound reveal whether the actions were repeatedly used and whether the rope or cord was twisted or flatted out around the neck. Any long, flexible and tough object is suitable as the weapon for strangulation, many of which are household items like belts, a telephone cord or a scarf.

**ARSON**

When detectives arrive at the scene of a fire, the first thing that they do is interview any witnesses to the fire, for example, the person who called the fire brigade and those who arrived before the fire department, whom may have seen how the fire began. When the fire has been controlled, the temperature falls, allowing the firefighters to make the building safe for investigation.

**THE DANGERS**

Investigators must be exceptionally careful when entering a burnt building, as the structure may collapse and there is always the hazard of breathing in poisonous chemicals such as the popular electrical insulator, toxic beryllium oxide, and the cancer causing agents such as carcinogenic combustion products. Collecting and searching for evidence under such conditions is therefore not as simple a task as other straightforward scenes.

**HOW THE FIRE BEGAN**

The investigation into how the fire started involves beginning at the lower levels, as fire travels upwards. The signs investigators search for when looking for the place the fire may have started include lingering heat, how deep the charring is, the flaking of building materials like cement and plaster, distorted plastic, metal and glass resulting from prolonged burning, damaged ceiling and structural damage. Once they have located where the fire started, investigators then begin searching for the cause of the fire. One thing that arsonist's usually always uses is an agent to speed up the burning process, such as petrol, and a fire-starting device to start the flames.

This fire-starting device can be as complicated as an electric timer set up to start the fire at a certain time or as straightforward as a smoldering cigarette. A majority of the time, the fire-starting device and the agent that speeds up the burning process manage to survive the fire. Investigators can smell unburned fuels, solvents and paint thinners, as well as being able to see irregular liquid pooling marks on the floor and trails along the edge of floorboards, showing that burning liquid once ran between them. If these signs are not present at the burnt sight, investigators use hydrocarbon detectors to detect concentrations of agents that speed up fires and if anything suspicious are found, to remove it for further analysis in a laboratory. Certain containers with 'vapor barrier screw lids' are used, as agents for speeding up fires and are extremely fragile and can evaporate if not stored properly.

**THE REASONS**

There are a lot of different reasons as to why someone would want to burn an area down. One of the most common reasons for arson is insurance fraud, whereby a failing business owner takes all the stock to another destination before burning down the warehouse. However there is one flaw in this cunning plan because as investigators search for evidence as to why the fire started, they expect to find the remains of stock, such as, for example, metal clasps, zippers, fastening and other metal traces. If these are not found it shows that the warehouse was empty upon burning and could be a case of attempting to make a fraudulent insurance claim. Another reason for arson is attempting to hide a murder by disguising it as an accidental death or hiding evidence of other crimes, such as fraud, by burning official business records. Criminals may even commit murder and arson simultaneously to destroy the scene and person at once. Some of the more uncommon reasons for arson are burning down an area as a form of revenge or to put another business owner out business, as well as simply starting a fire because of a compulsive need to create the fire and watch the flames consume the area.

**BOMBS AND EXPLOSIONS**

The need for studying bombs and explosives by forensic personnel mainly relates to mass murder cases, where bombs would obviously be the ideal weapon .Such bomb cases also have their own special methods to help deduce different forms of evidence.

**BOMBS**

Today, making a bomb is a very simple exercise, with recipes readily available on the internet and the materials easily accessible. The make-up of a bomb is very simple and easily fashioned. A timer or remote control device is used to start the primary charge, or spark, which then ignites the gas inside the bomb, triggering a much larger, high powered blast which causes the damage.

**WHAT IS A BOMB?**

The are many bomb types available, some very basic ones that yield little power and some which can cause mass destruction. But what's important is to know that an explosion from a bomb occurs as a result of an endothermic chemical reaction, which is one that releases vast amounts of heat energy and takes place very quickly, thus releasing an explosion. The chemical reactant the bomb maker decides to use reflects on the power of the bomb, since some chemical reactions release more energy than others.Noble gases and alkali metals are among some of the most reactive elements in the periodic table and their compounds are likely bomb materials for e.g. In a basic soda bomb, the use of sodium bicarbonate is the use of a sodium compound, subsequently an alkali metal.

**BOMB DEPOSITS**

When a bomb explodes, a lot of it is thrown far away from the scene. Investigators search for any possible fragments of the bomb by agents that react by changing color when it comes in contact with fuel. Fragments that carry traces of unburned fuel are taken back to the laboratory, where they are studied under microscopes. The shapes of the fuel particles are identified and are then washed in water and a colorless and inflammable liquid called *acetone*. The purpose of this process is to turn the particles into a liquid solution for further testing.

The solution is then screened and analyzed using mass spectrometry, which involves an instrument that breaks up ions. These ions are attracted into a magnetic field and when their charges are measured in contrast to the mass of the ions, it identifies the chemical composition of the solution.

Another method used is thin-layer chromatography, which involves the liquid sample being pushed in an upward direction by a specially coated plate, using an organic solvent that soaks upwards from the base. The different components in the liquid sample move up at different speeds and separate onto a plate, which then allows the solution to be identified.

**FRAGMENTS**

Even though when a bomb explodes, it is reduced tiny fragments, these fragments can still lead investigators to the bomb's creator. Occasionally, the fragments of the bomb may carry fingerprints, but in most situations, a piece of a bomb simply leads to determining where the bomb was manufactured. Explosives units around the world usually retain a large collection of frequently used bomb parts, batteries, timers, remote control devices and fuel components, which makes it possible for investigators find similarities between certain blasts.

**CARS AS WEAPONS**

Cars as weapons are less common for murder than for road accidents, but do occur from time to time. Whether the driver was drunk, on drugs or simply a reckless and homicidal driver, cars can become weapons just as fearful as loaded guns.

**RECORDED AT THE SCENE**

Forensic scientists play a vital role when it comes to collecting and analyzing evidence to reconstruct exactly what happened. Investigators look for evidence to verify how fast the car was going, in what direction the car was moving, and whether the driver tried to brake. Evidence missed during the investigation is lost forever, because if the incident occurred on a busy highway, investigators are under intense pressure to complete the investigation and allow traffic to flow again. Sketches of the road, detailing of the measurements and recording of the locations of skid-marks must be done. Photos taken from an angle can be used in certain computer software to reveal the distance of the marks left on the road. The type of car and its mass are logged for further reconstruction of the crash.

**THE DRIVER**

Identifying who was driving the car is sometimes a difficult task, as passengers can be thrown from their seats and a surviving driver may attempt to switch the blame to a passenger that died. These claims are analyzed in the laboratory, where with the help of medical examiners, the truth as to who was driving can be found out. During a crash, the airbag is expelled and traces of evidence such as hair, make-up, skin and blood are left behind. Airbags tend to cause distinct facial injuries. The pedals in the car and the driver's shoes mark each other and if the occupants of the car were wearing seatbelts, bruising on the shoulder can reveal which side of the car an occupant was sitting on.

**COMPUTER RECONSTRUCTION**

Reconstruction of the crash involves a complex computer program, for example, PC-Crash, which recreates the crash scene. The program works backwards with the data it receives, so the operator enters information such as the vehicles resting position, the mass of the vehicle, the type of vehicle, the radius and the length of the tire-marks found on the road. The program is then able to use the calculations to estimate the speed and direction of all the vehicles involved before the final impact. This reconstructed animation can be used as evidence in a court of law.

**PART VII – TRICKERY**

**CRIMES OF STEALTH**

The techniques of forensic science come into use more often with cases other than those which are murder related. Computer crimes in particular, have become an issue since the developments computers have thrived on within the past few decades. This section also covers the concepts used to catch the everyday art thief and counterfeiter.

**TRACKING COUNTERFEIT**

Counterfeit money has always been a nuisance and a problem worldwide. Criminals in charge of organizations that produce counterfeit money use home computers and printing yards to produce very real looking, and convincing counterfeit copies of currency.

**THE CURRENCY**

All currencies are vulnerable and subject to currency forgery, but the most susceptible are the currencies that circulate around the world and are able to be used globally. This makes the US dollar the most commonly and easily reproduced currency, and unfortunately, currencies that are easily reproduced tend to attract the most illegal counterfeiters.

**NOTE CREATION**

In the past, notes have been created using intricate imprinted designing techniques and featured difficult to replicate watermarks, a design imprinted into the note and only visible when a light is shone on it. They also had specific numbering patterns and fine metal threads imbedded in the note. However, it became easier for counterfeiters to forge currencies towards the end of the 1980's as higher quality color photocopiers and printers made copies look extremely convincing. Today's bank notes have new improved aspects to stop the forgery of currency. These include words that only appear when the note is heated by a copier lamp, color-changing ink that turns from green to black when the note is turned over, print that is only visible when viewed through a magnifying glass, machine readable only bar codes, shimmering ink, and holograms.

**TRACKING THE FORGER**

Finding the currency forger involves combining clues found in the paper type, printing techniques and the ink variety used. Paper banknotes are now printed on material that is of a high quality and is economically impossible to mass reproduce. Microscopes are used to recognize substituted paper forms and using this information, investigators may then be able to find the supplier. UV lights can show the metal security threads in true banknotes and reveal attempts to fake them in fake notes. X-rays show watermarks and make them clearer. The printing process can also reveal the counterfeiter, as they usually use laser and inkjet printers that are easily distinguishable against the extremely high quality methods used on authentic banknotes. Chemically analyzing the ink can be traced back to the counterfeiters using a computer database that matches the ink's characteristics.

**ART IMITATION**

Art forgery is most common in famous pieces that offer high prices, but is also common in some of the less famous pieces, as not many people know what the piece looks like, making the selling of a forged piece easy. Analysis of a painting is the most accurate method of uncovering an art forgery, as an art piece can be tested to see how old it is.

**USING THE MICROSCOPE**

In a laboratory, oil paintings can easily be tested using the simplest methods of examination. Microscopes allow scientists to see how old a painting really is. Forgers create old, cracked looking surfaces by rolling the canvas, heating and cooling it rapidly and applying a constricting varnish using a stippling brush to give it a fly-blown look. X-rays can also reveal whether the cracks appear under the surface and on every layer of the painting. In forged paintings, it is quite often found that the forger has only created a cracked appearance on the top layer and therefore, it does not match the bottom layer.

**LIGHT**

Depending on the paint composition and the age of the painting, ultraviolet light shows fluorescent blue-green if the varnish is from the 19th century. Infrared light can also reveal whether it is paint or ink used in the painting. If these tests reveal nothing out of the ordinary, scientists take a paint sample from the edge of the painting or a damaged area, placing it in cold-setting *polymer* and are thereafter able to identify its pigment underneath a microscope.

**COLORS AND COMPOSITION**

Because oil paintings began in the 15th century, certain colors did not exist at that time, for example, Prussian blue was only created in 1704. A painting that contains the Prussian blue color, therefore, cannot be more than three centuries old.

The canvas on which an oil painting was painted provides an inaccurate guide to age. The weave composition of the material may however, provide a clue, but a forger may have used an old, cleaned off canvas from another artist. Canvas frames, on the other hand can be dated using the tree ring measurement technique, which can tell how long ago exactly the wood was cut

**METALS AND CERAMICS**

Fraud metals and ceramics are difficult to spot and require some highly advanced equipment and techniques. Ceramics are hard to copy, as identical clay to the original is required in order to make them look even close to the real thing. Stone statues are almost always an original, as it requires too much time and labor for a forger to consider. Cast metals, on the other hand, are much easier to forge, but only a small handful acquires suspicion.

Ceramic is dated using a method called *thermo luminescence*, which unfortunately (to the annoyance of the purchaser) requires the removal of approximately 30 grams of clay for the process to work. The process works by measuring the natural radiation that is absorbed by the clay from the moment the piece was placed in a kiln and fired. Metal objects are dated using a different method. X-ray fluorescent analysis involves an art piece emitting an x-ray characteristic of the metal it was made of. This metal characteristic is compared with the x-ray of a genuine artifact that is from the same period.

**EMAIL CRIMES**

Emails have enabled an efficient means of communication, without the limitations of time zones, speed or cost, usually associated with many of the other forms of communication. Though advantageous in this manner, emails can easily be used for negative purposes as well, making SPAM and virus emails a problem. This section covers some basics that the everyday email user can do to trace down an offending email sender.

**AN IP ADDRESS**

IP addresses are an effective means used to track down and differentiate between different computers. Each computer's IP address is therefore, naturally unique, composed of 32 *bits* and grouped into four lots of eight bits. The IP address is recorded every time your computer makes contact with a server, including when you first log on with your ISP (internet service provider)to when you access different web pages. Different websites also have an IP address composed of bits, but for convenience, the long chain of numerals is instead interpreted into an easier-to-remember word address using a domain name service (DNS). During the trace back of an email message, the IP address of the various *protocols* used to transfer the email from one location to another can be quite useful.

**EMAIL PROGRAMS**

There is a variety of email programs used to manage, store and compose emails. Email programs such as Outlook and Eudora specialize in encoding and decoding received email messages, to make them understandable, not unlike the encryption and decryption process described in the next section, but slightly simpler. All of the encoding is mapped to an email standard, a form of coding which holds information for the posting of messages from place to place. Some common email standards are MIME (multipurpose internet mail extensions) and uuencode, of which the latter is more often used in attempts to hide information in a message, but can be easily decoded by various decoding utilities that come with major operating systems.

**EMAIL LOGS**

Email logs are generally kept on all email servers, being a record of the emails which were sent, received, the email addresses involved and the time/date of posting/receipt. However, it may be a problem if some servers use what is known as circular logging, where a certain amount of data space is allocated for the storage of log files, but once this space is full, the beginning (earliest of the log files) is overwritten and this overwritten data is deleted for good. The log files are commonly formatted into just plain text and their main use is for identifying the source of the offending email/s. Different email servers have different forms of email logs, but the information these files provide are the same.

**EMAIL HEADERS**

Email headers prove information not unlike that of an email log, but details the path the email took in terms of which protocols were used to transfer the messages and thus work backwards. The return path of the email, the email address to which your email program will send a reply, is often not the source of the message when an offender deliberately tries to disguise his/her tracks. Each email also has a unique message ID, which may correspond to data contained in message log. This information is not normally shown by default, but is easily accessible in most email programs. For example, Microsoft Outlook displays this information when the property of an email is displayed and 'view source' is chosen.

**COMPUTER CRIMES**

Computer forensics is an area of science that deals with computer crimes such as illegal computer hacking, the forging of software, creating viruses, fraud, embezzlement and child pornography. Computer crime does not only refer to computer and laptops but also mean anything that contains chips that are able to store and process data records such as mobile phones, video recorders, cameras and fax machines. The majority of computer crimes committed concern home PC's.

**FILE DELETION**

Some criminals believe that deleting a file means that it is gone forever, however, it does not remove it off a disc, it merely renames the file to hide it from the user. On the hard disk, deleting a file from the drive and even after emptying the recycle bin, will still allow a chance of recovery. When the file is deleted, the area of space previously used by the file is simply marked as 'deleted', but until data is further stored there and the area is written over, the original file stays on the hard drive. More advanced criminals are aware of glitches in this security system and prefer to use more advanced ways of hiding files such as encryption and securely deleting programs to ensure that their incriminating data stays hidden.

**IN THE RAM**

Computer systems contain memory to speed up the running ability of programs. The storing of data on a random access memory chip (RAM) makes programs respond quicker, as there is more memory. The computer operating system makes the RAM's work very difficult, as it is constantly swapping seldom used data from the RAM to a hard disc, which is much slower but contains a much higher storage volume. Undergoing this process creates a file called a 'swap file' and even if a file is completely deleted, it is possible that it may still exist inside the swap file. It does not remain there forever, as each time the computer is turned on and utilized, new files replace some of the existing old files in the swap file and everything is moved around. This evidence can be invaluable.

**FINDING WITHOUT LOSS**

Because swap files are altered each time the computer is switched on, it presents investigators with a problem. Any evidence existing on a computer's hard drive may be erased when the computer is switched on for investigation. Forensic scientists have overcome this problem with a simple solution involving equipment that can completely copy the computers contents without turning on the machine. Investigators then examine all of the information that is on the copy without the risk of destroying the data. This method also prevents the accusation of evidence tampering and allows personnel such as lawyers, to access the evidence and attempt at self-analyzing the RAM for verification.

**ENCRYPTION**

Because almost anybody can access data once it has been sent over the internet, computer users often encrypt data using a form of code. The study of cryptography has brought about two main systems of encoding which computers use, respectively asymmetric encryption (also known as public-key encryption) and symmetric encryption.

**SYMMETRIC ENCRYPTION**

As there is a key to open/lock a door, there is also a key (or code) to decode/encode a message. Symmetric encoding uses one key to encode the message and uses this same key to decipher it. This means both the computer sending the message and the computer receiving the message must have a copy of the same key code, thus the term 'symmetric' encryption.

**PUBLIC KEY ENCRYPTION**

The asymmetric encryption (public key encryption) system uses two different keys; one key to encode the message, and another to decode the message. The key used to encode the message is known as the public key, while the code used to decrypt the message is the private key, known only to the recipients themselves. The private key corresponding to the certain public key must be used to decipher the data.

**THE DECRYPTION PROCESS**

Unfortunately, there is no direct way to describe a method of decryption that forensic scientists can use in computer forensics. Particularly when data is encoded using public key encryption, finding the type of public key used and the clues for its corresponding private key, depends largely on the luck of this information having been stored on a separate disc or recorded in some way, for example, on the hard drive of the computer used for encryption. Experience and time both pay off during a decryption process, which will vary in accordance to the effectiveness/security of the encryption code.