DEERING ESTATE AT CUTLER

ECO-ACADEMY for Youth and Parent Educators

Forensic Science is any science used for the purposes of the law, and therefore provides impartial scientific evidence for use in the courts of law, e.g. in a criminal investigation and trial. Forensic Science is a multidisciplinary subject, drawing principally from chemistry and biology, but also physics, geology, psychology, social science, etc.

Module: Natural Sciences

Forensic Sciences

Sunshine State Standards:

SC.2.N.1.5, SC.3.N.1.6, SC.4.N.1.3, SC.N.5.N.1.6, SC.N.5.1.5, SC.912.L.16.11

Objectives

- Learn about Forensic Science and how to apply the scientific method to solve crimes
- Use different methods to solve problems.

Vocabulary

Forensic accounting is the study and interpretation of accounting evidence.

Forensic anthropology is the application of physical anthropology in a legal setting, usually for the recovery and identification of skeletonized human remains.

Forensic archaeology is the application of a combination of archaeological techniques and forensic science, typically in law enforcement.

Forensic astronomy uses methods from astronomy to determine past celestial constellations for forensic purposes.

Forensic botany is the study of plant life in order to gain information regarding possible crimes.

Forensic chemistry is the study of detection and identification of illicit drugs, accelerants used in arson cases, explosive and gunshot residue.

Computational forensics concerns the development of algorithms and software to assist forensic examination.

Criminalistics is the application of various sciences to answer questions relating to examination and comparison of biological evidence, trace evidence, impression evidence (such as fingerprints, footwear impressions, and tire tracks), controlled substances, ballistics, firearm and toolmark examination, and other evidence in criminal investigations. In typical circumstances, evidence is processed in a crime lab.

Forensic dactyloscopy is the study of fingerprints.

Digital forensics is the application of proven scientific methods and techniques in order to recover data from electronic / digital media. Digital Forensic specialists work in the field as well as in the lab.

Forensic document examination or questioned document examination answers questions about a disputed document using a variety of scientific processes and methods. Many examinations involve a comparison of the questioned document, or components of the document, to a set of known standards. The most common type of examination involves handwriting wherein the examiner tries to address concerns about potential authorship.

Forensic DNA analysis takes advantage of the uniqueness of an individual's DNA to answer forensic questions such as paternity/maternity testing or placing a suspect at a crime scene, e.g., in a rape investigation.

Forensic engineering is the scientific examination and analysis of structures and products relating to their failure or cause of damage.

Forensic entomology deals with the examination of insects in, on, and around human remains to assist in determination of time or location of death. It is also possible to determine if the body was moved after death.

Forensic geology deals with trace evidence in the form of soils, minerals and petroleum.

Forensic limnology is the analysis of evidence collected from crime scenes in or around fresh water sources. Examination of biological organisms, in particular, diatoms, can be useful in connecting suspects with victims.

Forensic linguistics deals with issues in the legal system that requires linguistic expertise.

Forensic meteorology is a site specific analysis of past weather conditions for a point of loss.

Forensic odontology is the study of the uniqueness of dentition better known as the study of teeth.

Forensic optometry is the study of glasses and other eye wear relating to crime scenes and criminal investigations

Forensic pathology is a field in which the principles of medicine and pathology are applied to determine a cause of death or injury in the context of a legal inquiry.

Forensic psychology is the study of the mind of an individual, using forensic methods. Usually it determines the circumstances behind a criminal's behavior.

Forensic seismology is the study of techniques to distinguish the seismic signals generated by underground nuclear explosions from those generated by earthquakes.

Forensic serology is the study of the body fluids.

Forensic toxicology is the study of the effect of drugs and poisons on/in the human body.

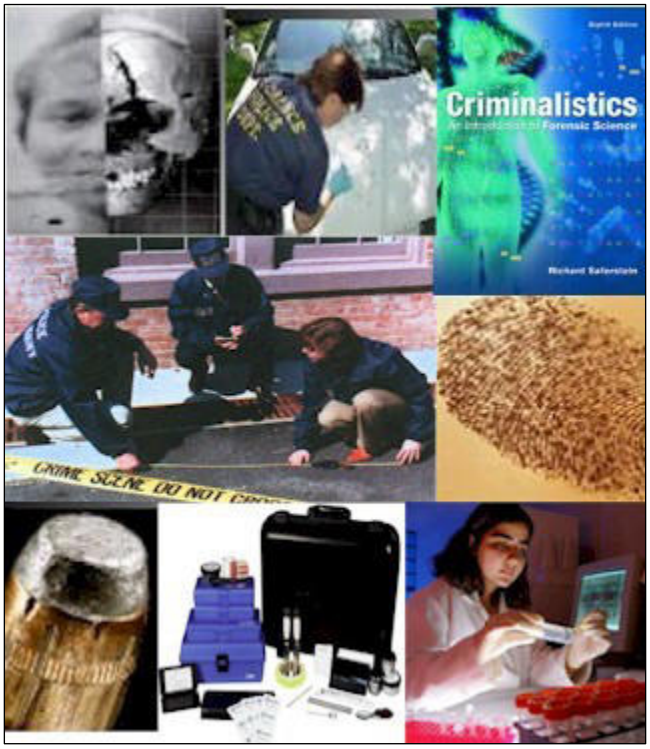
Forensic video analysis is the scientific examination, comparison, and evaluation of video in legal matters.

Mobile device forensics is the scientific examination, and evaluation of evidences found in Mobile Phone, e.g. Call History, Deleted SMS etc., also include SIM Card Forensics

Trace evidence analysis is the analysis and comparison of trace evidence including glass, paint, fibers, hair, etc.

Forensic podiatry is an application of the study of foot, footprint or footwear and their traces to analyze scene of crime and to establish personal identity in forensic examinations.

Background



Forensic Science, the application of scientific processes and method to physical evidence in situations concerning criminal or civil law, is a relatively modern phenomenon. Prior to the 1800s, there were isolated applications of scientific techniques to solve crimes, but it can be argued that forensic science was truly born in the 19th century. Since then, developments in the field of toxicology, ballistics, forensic chemistry (e.g., presumptive testes for blood), and fingerprinting as a means of identifying individuals paved the way for modern forensic analysis. The writings of Sir Arthur Conan Doyle, featuring his famous protagonist Sherlock Holmes, popularized this burgeoning field of study. As science has advanced, so too has forensics. In modern times, techniques such as DNA analysis, blood typing, fingerprinting, and impression analysis are well known and have been key elements in high-profile criminal trials. Forensic anthropology, forensic chemistry, serology, and even forensic entomology have been depicted and popularized in television shows. The courts have had to evolve to appropriately evaluate and incorporate these new elements into the legal system. For many students, forensic science has become a viable career option. There are many subspecialties for students to consider, and the number of colleges and universities offering degrees in forensic science has grown dramatically in the 21st century.

The ability to solve a forensic mystery often depends on close observations, careful comparison of samples, adherence to proper techniques for testing evidence, and utilization of sound

Forensic science (not often shortened to **forensics** because "forensics" means to debate. Forensic Science and Forensics are two absolutely different things) is the application of a broad spectrum of sciences to answer questions of interest to a legal system. This may be in relation to a crime or a civil action. In Roman times, a criminal charge meant presenting the case before a group of public individuals in the forum. Both the person accused of the crime and the accuser would give speeches based on their side of the story. The individual with the best argument and delivery would determine the outcome of the case. This origin is the source of the two modern usages of the word *forensic* – as a form of legal evidence and as a category of public presentation.

In modern use, the term "forensics" in place of "forensic science" can be considered incorrect as the term "forensic" is effectively a synonym for "legal" or "related to courts". However, the term is now so closely associated with the scientific field that many dictionaries include the meaning that equates the word "forensics" with "forensic science".

Forensic Science

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?

Crime Scene

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 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 utilised 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 behaviour 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 analysed 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.

Identifying the Crime

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.)

Below are definitions for some common crime types, which may be of reference for other parts of the site:

Burglary/Theft - Unauthorized entering of a dwelling or building to steal.

Arson - The intentional *annihilation* of a property by means of fire.

Fraud/Forgery - Deliberate *deception* via means of producing a false copy, or altering a true copy, of documentation, which is intended to be accepted as genuine.

Murder - Planned and illegal killing of another person.

Manslaughter - Unintentional killing of another person.

Kidnap - The abduction of a person against his will, often by unlawful force of fraud.

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 analyzed in a forensic laboratory.

Recording

Where memory fails, technology has replaced it, just as crime scene photography and videoing have replaced baisc 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.

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. 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.

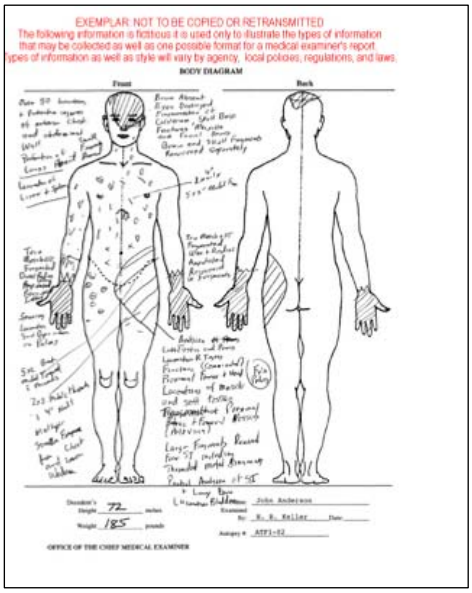
Methods of Search

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.

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.

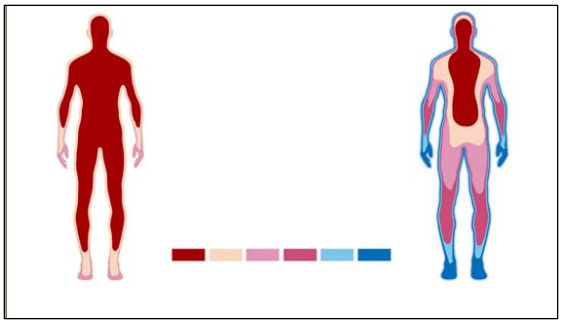
The Causes

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.

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 period since death.

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.

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 begin 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 *oesophagus* 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 Entomology

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.

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.	

Marks of Violence

A murderer will always leave marks of violence on the bodies of their victims, no matter how hard they try to hide it. During an autopsy, these marks may be difficult to find if the murder agent was drugs or poison, but these agents can still be found through blood tests. On the other end of the scale, signs that the victim suffered a violent death are immediately discovered from the external examination.

Internal/External Examinations

During an autopsy, there may be no external signs that the victim suffered from a brain *haemorrhage*. Brain scans performed during the internal examination are the only way that a coroner can reveal the fatal clots that may have been caused by a blow to the head. Changes in the appearance of skin colour may also lead to solving the crime, as some fatal agents have the ability to change the physical appearance of the body. For example, *carbon monoxide* poisoning can cause the skin to become pink in colour and smothering and the crushing of the chest can cause can cause pin sized patches of bleeding in the face. When many of these pin sized patches of bleeding occur, it can give the face a blue appearance.

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 colour 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 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.

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.

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 a unknown victim's identity.

Bloodstain 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 *fluorescein* 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. Fluorescein 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 *haemoglobin* in the blood.

Blood Patterns

Patterns in the bloodstains found at a crime scene reconstructs 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 analysed 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.

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 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

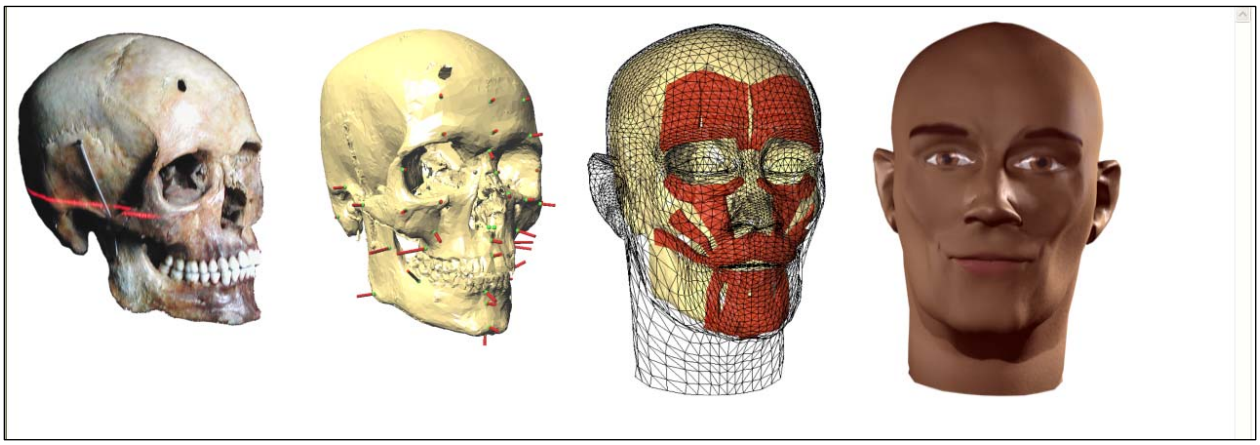
For finer results yet, the blood groups can be assigned either a + or a - figure after it to indicate the presence (+) or absence (-) of a blood protein known as the *Rh factor* (named after the Rhesus Monkey, in which it was first recognized). Using an antibody solution to the Rh protein, the same concept 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 colour on contact with SAP (*seminal* acid phosphatase), spermine and *choline*. 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.

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.

Acquiring 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.

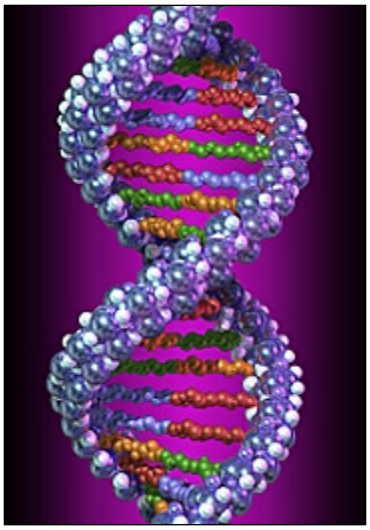
Muscle and Skin

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 anthropologist's 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.

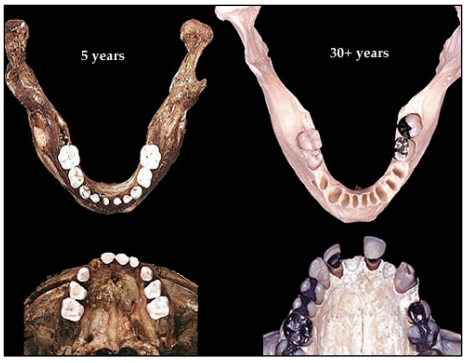
Color

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.



DNA Matching

More often heard about on television dramas than on the news, DNA is the key to solving crimes the scientific way. Although it has only been relatively recent (compared the course of forensic history) that DNA has started being used in court, its future in crime stopping is unquestionable and ever more common.



The Uses of Dental Matching

Forensic *odontologists* or in other words, forensic dentists, have the job of examining dental evidence that is left behind after a crime has been committed. Teeth are an excellent source of identification, as they hard wearing and durable. With the ability to survive fires that destroy evidence, burn human bones to ashes and melt copper and glass, teeth are able to withstand criminal's attempts to hide the crimes they've committed and the evidence held within the crime scene and dental analysis provides a cost efficient alternative to solving a crime.

Forensic Anthropology

When bones or skeletons are found, they are taken to a forensic laboratory for examination. The job of an *anthropologist*, a forensic scientist specializing in the area of bones, is to examine the bones, to possibly deduce the gender, age, height, race, as well as medical history and manner of death.

Growth Rate

Teeth that have or have not grown can also reveal the age of the skeleton, as young children will have not lost their milk teeth and at the age of 18, *wisdom teeth* first appear. During the teenage years, bones become thicker and larger and fuse together in a process known as '*ossification*'. Ossification occurs in 800 points of the body and is the best guide to revealing the age of a child's skeleton. An example of ossification occurs in the arms, where at the age of six, the two bone plates form at either end of the outer forearm (radius).

At the 17 in males and 20 in females, the lower bone plate and the *radius* fuse together and soon after, the upper bone plate and radius fuse together. The bone in the body that finishes growing last is the *collarbone*, which ceases growth at 28 years. In the bones of the elderly, degeneration begins to occur. Anthropologists will look for tiny spikes that start to appear on the edges of the *vertebrae*, the wearing of teeth due to

age and joints that show signs of arthritis. All of the bones in the body will deteriorate with age.

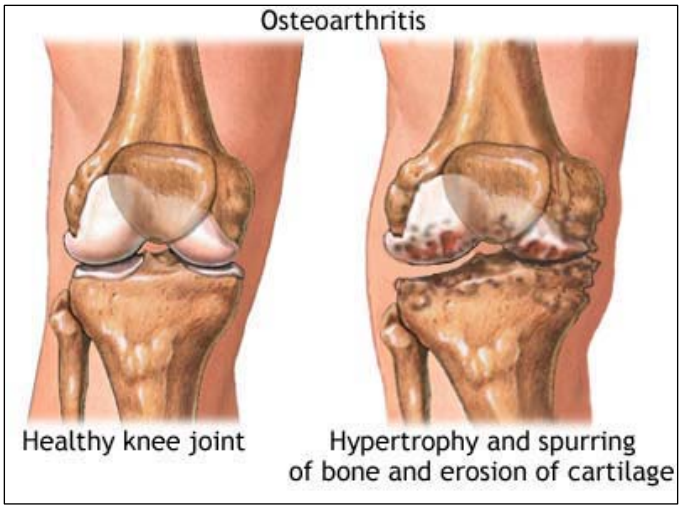
Gender

When determining male and female in a skeleton, anthropologists look at the skull and hip bones, as there lie clues to the sex of the skeleton. The skull has three points in determining gender. These are the ridges located above the eyes, the bone situated just below the ear and the *occiput*, the bone located at the lower back of the skull. The latter two bones are muscle attachment sites, all of which are more prominent in men, indicating greater strength. The difference in hips is very obvious, as a man's hip are narrower and a women's hips are wider, being built for child bearing. However there are smaller differences in other bones, which anthropologists rely on when there is no hip or skull bone.

Height

Determining the height of a skeleton involves reassembling the skeleton and measuring the length of significant bones. By adding 10-11cm or four inches onto the bone length, it accounts for the missing *tissue* and muscle. If parts of the skeleton are missing, certain individual bones are used as a height guide. The longer the bone is, the better and more accurate the estimate will be, so the femur is measured first. The human height measures roughly two and two thirds the length of the *femur*, though it also depends on the race and sex of the skeleton.

Bone Defects



Disease, injury and birth defects are also revealed in the bones. Birth defects such as *spina bifida*, some infectious diseases, poor diet and cancer can all be damaging to the bones. In the case of injuries, broken bones and mended bones are easily visible and because they are so easily visible, mended bones can reveal identity. Work and hard labour leave damage such as occupational *arthritis*, which visibly changes the appearance of affected joints. The skeletal remains of someone who has died a particularly violent death are evident in the bones. Bullet wounds leave round holes, sharp weapons cause chips to be taken out of the bone and fractures in the bones also suggest forms of violence. Distinguishing between fractures that occurred before and after death is difficult, but there are some clues that are helpful. For example, the bones of a deceased person break differently compared to the bones of a live person and healing at the edge of a fracture indicates injuries during life.

Fingerprinting

Even with the recent advancements made in the field of DNA analysis, the science of 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.

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

- Central Pocket Loop
- Double Loop
- The Plain Whorl
- The Loop
- A plain Arch
- The tented Arch
- An Accidental Print

Comparing Prints

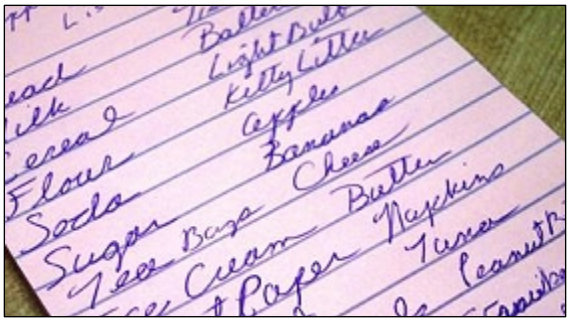
The comparison of fingerprints is a time consuming procedure and requires experience and great skill. Examiners look at the shape of the *ridges* and compare the points where the ridges start, end, join and split. The positions of short ridges, dots and any enclosed areas are also noted. Examiners also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

Handwriting and Voice Evidence

Every person's style of handwriting is unique and has its own personalised 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 analyse these aspects of suspicious documents i.e the printing style, paper and ink, all of which help to identify a forged letter.

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.

Voice Analysis

Forensic phoneticians specialise 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.

Subconscious 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 Testing

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.

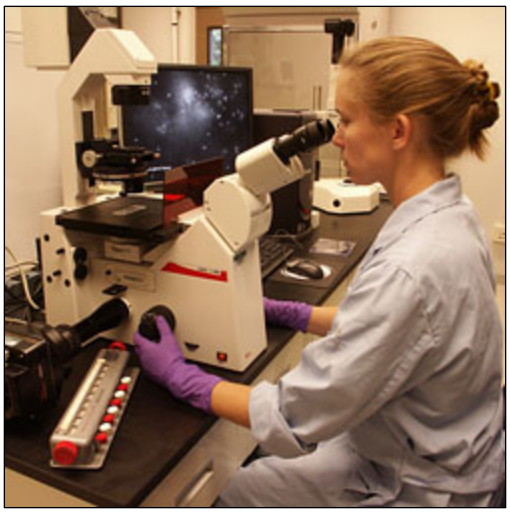
Body Language

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 is thought to be a disguised crossing of the arms, another method which prevents them from expressing what really happened.

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.

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.

Artillery

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 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

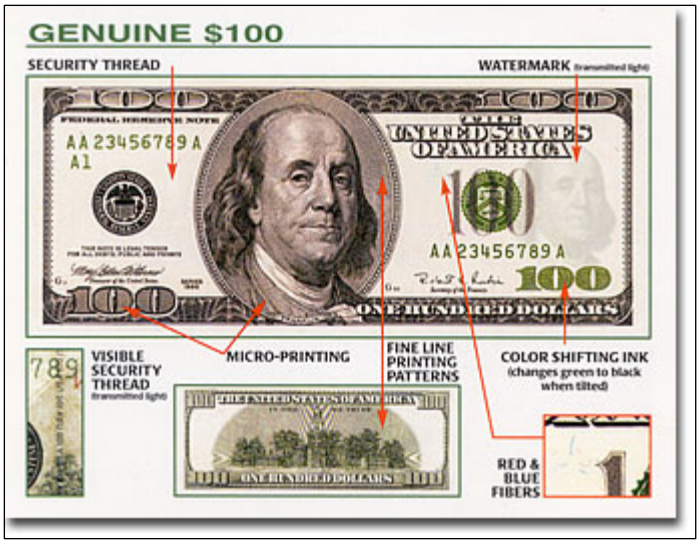
Gunshot *residue* is found in a circular shape around the victim's bullet wound and most importantly, on the suspect's hands and clothing. Residue that is found on a suspect's hand can provide proof that the suspect handled and fired a weapon recently, but the absence of residue is not enough to prove 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.

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, 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.

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.

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 labour 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.

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.

Activity: Murder Mystery: How do forensic scientists help solve murders?

- What is the first thing the police do when they arrive at a murder scene?
- What kind of evidence are they looking for?
- How is evidence gathered and stored?
- How important can crime scene material be in court?

Duration: 1 hour

Objectives:

- Learn how you can capture foot prints and simulate your own criminal investigation.

Materials:

- Plaster of Paris
- Water
- Hair spray

Discussion

Whenever a person is murdered, the police initiate a thorough investigation into the crime, crime scene and friends and family of the victim. Each aspect of the investigation is important, but often it is the physical evidence of the crime that catches and convicts the criminal.

Criminal investigations involve a variety of scientific fields and complex instrumentation. Chemistry, physics and biology are used in combination when detectives and laboratory technicians investigate a murder. Special tests include determining blood alcohol levels, using chemicals to make almost invisible blood stains very visible and typing blood to identify possible suspects. Geometry and trigonometry help the investigators evaluate critical evidence like the angles of lethal blows and the trajectory of bullets. The tools of criminal investigations include computers, sophisticated

photographic equipment, lasers, microscopes and other scientific equipment.

The study of both forensics and criminology require excellent observation skills and objectivity. The first official who arrives at the crime scene works quickly to seal off the area and preserve the scene as much as possible. Usually no one enters until the field investigator has had a chance to look about and collect every piece of evidence like hair and fiber samples, pieces of clothing or other personal belongings. Only then do other police officers or medical personnel enter the area.

When a piece of evidence is found at the scene of the crime, investigators are always careful to keep it in a labeled and sealed package until it can be safely stored in the police vault. It is only opened again when the case goes to court. This kind of evidence care-taking is especially important in drug-related cases when drugs are seized. Regardless, it is against the law to tamper with any kind of evidence.

Procedure

Scene investigators are always on the lookout for finger and foot prints. These clues can be essential in identifying or eliminating murder suspects.

1. Divide your class into investigation and criminal teams. Have the "criminals" go outside and make footprints in some soft soil. Have some people wear their shoes and have others take them off.

2. While the "criminal" team is outside, the "investigation" team should mix the Plaster of Paris with water. Try to keep the consistency thick so that the impressions can retain small details.

3. The "investigators" should then locate the "criminals" footprints and spray each with the hair spray. This will keep the soil in place when you begin to make your mold.

4. Pour the Plaster of Paris into the prepared footprints. Pour slowly from the sides and be careful not to disturb the area.

5. Allow the mold to set.

6. Have the investigation team try to match the footprints to the correct member of the "criminal" team.

Questions

1. What types of soil would tend to make better prints?

2. Would an actual footprint or a print from a shoe or boot be more distinctive? Why?

3. What conditions could keep the footprints from showing up very well? What properties does hair spray have that makes it useful for shoe printing?

Try This:

- The orientation and placement of objects can be very important in criminal investigations. Learn about drawing to scale to make your own representative drawings. Measure your class room and any large pieces of furniture in the room. If one foot equals one half inch, how could you draw the room on graph paper. Ask someone to lay down in the room. Using their height and location can you draw them into your paper crime scene?
- Collect a couple of pine cones or sea shells. Have several other people select one and study it for two minutes. Collect the pine cones or sea shells. Have everyone try to draw their particular object. Look at the group of items. Can you identify yours? After looking at someone else's drawing can you identify their item?
- Have a person very quickly run into the classroom unexpectedly for about 10 seconds. They should be dressed in an unusual way. Write down everything you remember about the person including his/her size, hair color, clothing, or other details. Compare your list with other classmates. How many clues could you list? How could you improve your observation skills?
- Practice fingerprinting by using an ink pad and white pieces of paper. Each finger should be rolled from side to side to make a good print. Be careful with the ink and your clothing. (If some of your friends do not want to take their fingerprints, be sure that you respect their privacy.) Compare everyone's fingerprints. What kind of differences do you see? Are there differences between your fingers' fingerprints?

Activity: Archaeology at Work

Duration: 1 hour

Objectives:

Students will

- discuss the definition of archaeology and its applications;
- compare two archaeological investigations; and
- write mystery about the archaeological discovery of a body.

Materials

- Paper and pencil

Procedures

1. Ask students the following questions: What is archaeology? (*The study of material remains of past activities.*) How does archaeology teach us about ancient cultures? (*Artifacts, or recovered objects, can show us how people lived.*) In addition to ancient cultures, what else do archaeologists study? (*Events in the recent past, such as crimes.*)
2. Tell students that archaeologists are like detectives. They search for evidence and analyze clues to reach a conclusion. Archaeologists often uncover evidence during digs, or excavations. Talk to students about the discoveries make in Chiribaya, Peru and Barrington, Illinois described in the table below.
3. Divide the class into two groups. Have one group focus on the Chiribaya and the other focus on the investigation in Illinois. Ask each group to describe the evidence and what each piece revealed. Have them record their answers in a chart. The charts below provide possible answers. For younger students, you could provide the evidence and have them complete the second column.

Chiribaya Mummies

Evidence	**What It Reveals**
Wool clothing	The Chiribaya used domesticated animals.
Decorated pots, beautiful jewelry, ornaments	They were craftsman, and they worked with gold and other metals.
Some bodies carefully preserved and buried with food, pots, and other objects	They believed in an afterlife.
Food offerings of corn, potatoes, peppers, and grains	These were typical foods.
A mummy buried with coca leaves inside the chest cavity	Artificially prepared body; must have been an important person.
Coca leaves' age determined by carbon 14	Death took place between 1350 and 1450.

Skeleton in Illinois

Evidence	**What It Reveals**
No zippers, elastic, or other	Body buried without clothes

objects in grave	
Body carefully laid out	Buried by someone who took care
Notch in the hipbone; larger forehead on skull	Male
Length of leg bones (femur and tibia)	Body about 1.5 meters tall
Gaps between the ends of long bones	An adolescent
Rust-colored stain (dried blood) on the right femur, which had started to heal	Old injury on right leg at the time of death
DNA from teeth	Related to the suspect and his ex-wife
Hospital record	The missing person believed to be the skeleton in an accident 6 months before disappearing.

4. Have each group share their charts with the class and fill in any missing pieces of evidence.
5. Ask students to describe the tools and technology used and the experts consulted in both investigations. (The archaeologists used shovels, spades, brushes, X-rays, endoscope, and carbon-dating; they consulted with an expert on Chiribaya culture. The investigators in Illinois used hand shovels, rubber gloves, spades, newspaper archives, DNA analysis, and hospital records; they consulted forensic anthropologists.)
6. Challenge students to write a brief mystery about the archaeological discovery of a body. They can write about a mummy from an ancient culture or a person from the recent past. Their stories should describe at least five pieces of evidence, including where they were found and what each object revealed and the resources used (tools experts consulted). Stories should be no longer than two pages.

Activity: Who did it?

Duration: 1-2 hours

Objectives:

Students will do the following:

1. Explore how forensic science is used in criminal investigations

2. Apply the principles of forensic science to a hypothetical crime

3. Use the scientific process to solve a fictional crime

Materials

The class will need the following:

- Newsprint and markers
- Plastic bags (one for each student)
- Adhesive tape (for gathering thread sample)
- White paper
- A soft pencil
- Clear tape
- Microscopes or hand lenses
- Internet access (optional but very helpful)

Each student will supply the following:

- A hair sample
- A thread sample from their clothing

Procedure:

1. Before class begins, pick one student to be the perpetrator of a fictional classroom crime. Collect a hair sample, a thread sample, and a fingerprint from that person. (See Step 6 for instructions on how to obtain fingerprints.) This is the main evidence from the crime scene. Place the evidence in a plastic bag. Although the student you choose will participate in the activity with the rest of the class, it's important to choose someone who will not reveal his or her role as the perpetrator during the two or three days of this lesson.

2. Tell students that during the next few days they will try to solve a "crime" that took place in the classroom. Make it clear to students that this is a simulation of a crime, not an actual event that took place. Tell them the story below. (Feel free to embellish the story, but stick to the basic elements of the crime.)

   Last night, a crime was committed in our classroom. Someone ransacked the teacher's desk, throwing supplies on the floor and taking some money hidden in one of the drawers. We have been lucky enough to gather evidence from the scene of the crime, which includes a fingerprint, a hair sample, and a thread from an article of clothing. The evidence has been placed in a plastic bag. Now it is up to all of us to try to solve the crime.

3. Show students the plastic bag of evidence. Then ask students how they would begin to solve this crime. How do they analyze the evidence discovered at the scene of the crime? Write students' ideas on a piece of newsprint.

4. Tell students that the Federal Bureau of Investigation—the FBI—deals with serious crimes. While the classroom crime is much less serious than those the FBI usually deals with, students may be able to learn something about solving crimes by finding out how the FBI does it.

5. If students haven't already come to this conclusion, tell them that everyone in the class is a prime suspect in the crime because they all have access. The first step is to collect the same evidence from each student as that found at the crime scene. To begin the collection process, give each student a plastic bag. Tell students to place a hair sample and a thread from their clothing into the bag. (Have students use a piece of adhesive tape to pull a piece of thread off their clothing. Alternatively, students may snip a small thread from the inside of the clothing with a pair of scissors.)

6. Tell students that they must also submit fingerprints for analysis. Each student should follow the directions below:
    - Draw a dark pencil smudge on a piece of scratch paper.
    - Beginning with the little finger on your right hand, rub your fingers on the pencil smudge until they are covered.
    - Put a small piece of clear tape on the pad of your right thumb. Gently press the tape. Carefully remove the tape and place it on one edge of a clean sheet of paper.
    - Repeat the process for the remaining fingers on your right hand, placing the pieces of tape across the sheet of paper.
      Label each piece of tape with the following abbreviations:

      T for the thumb I for the index finger M for the middle finger R for the ring finger L for the little finger.

      Then follow the same steps for your left hand.

7. After all students have collected the evidence, tell them to analyze it carefully. Ask students to use a microscope or a hand lens to observe each piece of evidence and record their findings on charts like those shown below. Each student will analyze their own evidence.

Strand of Hair

Characteristic	**Observations**
Color	
Length	

Other features	

Thread Sample

Characteristic	Observations
Color	
Size	
Texture	
Other features	

The FBI categorizes fingerprints by three different patterns: loops, arcs, and whorls. Tell students to use a hand lens or a microscope to determine their fingerprint type and then to record their results.

Fingerprint

Characteristic	Observations
Loop pattern	
Arc pattern	
Whorl pattern	

8. As students are analyzing their evidence, place the evidence from the crime scene in a prominent place. Have students mount their completed charts on a bulletin board. As a class, make observations about the criminal's evidence. Complete charts for the hair, thread, and fingerprints of the culprit, and post those completed charts on the bulletin board along with the others.

9. Ask students to compare the charts from their classmates with the evidence from the crime scene to determine who committed the crime. Have students write down who they think committed the crime, and discuss possible suspects. Were most students able to figure it out? Did the class reach a consensus? Which piece of evidence did they find the most revealing?

10. Conclude the lesson by discussing other techniques detectives use to collect and analyze evidence from a crime scene. What other evidence do they collect? What tools can they use to analyze evidence?

Activity: The case of similar substances

Duration: 1- 2 hours

Objectives:

Students will do the following:

1. Learn how science is used to help solve mysteries and crimes

2. Become familiar with two chemical tests that can be used to identify unknown substances

3. Draw deductions based upon observations and the results of two scientific experiments

Materials:

- Baking soda and cornstarch (1 measured cup of each should suffice)
- Water and vinegar
- Paper cups (six for each pair of students)
- Teaspoons (one for each pair of students)
- Coffee stirrers or toothpicks
- Paper towels

Procedures

1. Tell students that they have been asked to help the local crime-fighting unit solve a fictional mystery. Here's what happened:

The chef at a prize-winning restaurant found his kitchen ransacked. He was furious, especially because he had been preparing for a big banquet. In fact, he had been working so frantically that he had spilled flour and baking soda all over the counter. As soon as the chef reported the crime, the police got right on the job. They have narrowed the search to two suspects.
One suspect is the local caterer, a man who is competitive with the chef. He was known to be baking a cake for the banquet to try to steer some attention away from the chef. The second suspect is the woman who owns the banquet hall. Even though she hired the chef, she has never really liked him for reasons no one really knows.
The police have collected important evidence: samples of different white substances

found throughout each suspect's house. Police officers think that whoever committed this crime tracked the substance home. For this reason, police want to determine what the substances are and deduce whether they might have come from the chef's kitchen. They have labeled the substance at the caterer's house "substance 1" and the substance at the banquet hall owner's house "substance 2."

2. Tell students that they will help figure out what each substance is by performing tests to identify the substances. Have students work in pairs to conduct the tests. You will need to prepare for the lesson as follows:

- Do not reveal to the class that substance 1 is baking soda and substance 2 is cornstarch. Before class, fill one cup with baking soda and another cup with cornstarch. Label the baking soda "substance 1" and the cornstarch "substance 2."
- Put in a prominent place two paper cups for each pair of students, a jug of water, vinegar, measuring cups, and coffee stirrers or toothpicks.

3. Have one person from each pair come to the table, measure 2 tablespoons of each substance, and put them in separate paper cups. Then tell students to take a few moments to observe both substances. Suggest that they note the color of the substances, the textures, and the odors. (When smelling an unknown substance, students should move their hands over the top of the container to create a diluted but distinguishable odor.) Make sure that students do not taste the substances. After observing the substances, students can record their findings on a chart such as this one:

Substance	**Color**	**Texture**	**Odor**
Substance 1			
Substance 2			

4. After students have completed their charts, tell them to mix each substance with water. Have one student from each pair measure 2-1/2 tablespoons of water to pour into a small cup. Then tell students to put 2 tablespoons of substance 1 into the water. Have students stir the mixture with a coffee stirrer or a toothpick.

Have students repeat the steps for the second substance. Then have them record their findings on a chart such as this one:

Substance	**What Happens When Mixed with Water**
Substance 1	
Substance 2	

(Substance 1 (baking soda) dissolves in water; the liquid turns white, but there are no particles in the water. Substance 2 (cornstarch) does not dissolve in water; the liquid is thick, white, and cloudy.

5. Explain to students that this test reveals physical properties of the substances. In this case, physical properties refer to what happens when the two substances are mixed together; the basic composition of each has not been changed. Tell students that the next test will reveal chemical properties of the two substances. The basic composition of one substance will change when it is mixed with another material. An example of this occurs when iron comes into contact with oxygen and a new substance—rust—forms. Rusting is a chemical property of iron. For the next test, explain that students will mix vinegar with the unknown substances to reveal something about their chemical composition.
6. Have students follow these steps:

- Measure 2-1/2 tablespoons of vinegar into a small paper cup.
- Add 2 tablespoons of substance 1 to the cup.
- Stir the mixture.
- Repeat these steps for substance 2.

After students have completed the test for both substances, have them record their findings on a chart such as this one:

Substance	**What Happens When Mixed with Vinegar**
Substance 1	
Substance 2	

(Substance 1 (baking soda) fizzes and bubbles while dissolving in vinegar. Substance 2 (cornstarch) does not dissolve; the liquid becomes cloudy.)

7. After students have completed both tests, tell the class to examine two tables: "Physical Properties of Three Materials" and "Chemical Properties of Three Materials." Using the tables and their own test results, students should be able to determine the identity of each substance. Print out the following tables or put them on an overhead projector.

PHYSICAL PROPERTIES OF THREE MATERIALS

Substance	**What Happens When Mixed with Water**
Sugar	Dissolves; liquid is clear

Baking soda	Dissolves; liquid is clear
Cornstarch	Does not dissolve; liquid is milky

CHEMICAL PROPERTIES OF THREE MATERIALS

Substance	**What Happens When Mixed with Vinegar**
Sugar	Dissolves
Baking soda	Dissolves; makes fizzing and bubbling sounds
Cornstarch	Does not dissolve; liquid is cloudy

8. Ask students whether they can identify each substance. Using their own observations and both tests, students should deduce that substance 1 is baking soda and substance 2 is cornstarch. With this information, ask students who ransacked the chef's kitchen.*(The local caterer. He had a motive: he wanted to outshine the chef. Also, the police said the chef had spilled flour and baking soda, so the person who ransacked the kitchen would have tracked either one of those substances into his or her own house. Signs of baking soda were found in the caterer's home, while cornstarch was found in the banquet hall owner's house. It is not exactly clear why the banquet hall owner was using cornstarch, but one theory is that she mixes it with baby powder and puts it on after taking a bath. Even though the caterer had baking soda in his kitchen, too, the fact that it was found throughout the house, even at the front door, indicates that he tracked it in after ransacking the chef's kitchen. The presence of baking soda in his house is strong evidence that the caterer most likely committed the crime.)*

Resources

http://library.thinkquest.org/04oct/00206/lesson.htm

http://school.discoveryeducation.com/lessonplans/forensics.html

http://www.staffs.ac.uk/schools/sciences/forensic/whatisforsci/whatisforensicsci/

http://en.wikipedia.org/wiki/Forensic_science#Subdivisions