DAPTO HIGH SCHOOL

Forensic Science

Introduction to Forensic Science – Year 9 @ Dapto High….

A crime has been committed. The criminal must be brought to justice. But how?

For most of human history, this question was not easy to answer. If no one actually saw a person commit a crime, or if the person left behind no obvious clues, authorities had no way to connect the criminal to the crime. So what did they do? Often they turned to torture and superstition to get a suspect to confess!

Only in the last 200 years or so has crime detection become effective, thanks largely to modern SCIENCE. As technology has forged ahead, crime fighters have found ways of using it to solve such age old crimes as murder, robbery, and forgery.

An entire branch of science has developed that deals with crime detection. It is called **FORENSIC SCIENCE**. *Forensic* comes from the Latin word, *forensis*, that means "forum" – court of law. The evidence forensic scientists discover and carefully analyse is used in courts to convict criminals.

Forensic scientists work together with police to develop hypotheses from their observations and inferences. Modern experimental techniques are used to test these hypotheses and finally conclusions are drawn regarding the identity of the criminal. Continuing developments in this branch of science will make it increasingly difficult for criminals to avoid apprehension.

On the Scene- Collecting EVIDENCE.

Where ever possible, forensic investigations start with the examination of the scene where the crime was committed. This is where the first clues are evaluated and the initial impressions formed concerning the nature of the crime.

The first professional on the scene is usually a police officer, who closes off the site to intruders, checks bodies for signs of life and calls appropriate services.

Investigating officers search for any evidence within and beyond the immediate crime site, and mark the exact position of anything that is important to the case. This initial search usually reveals the most important details. But even if there is no obvious evidence immediately visible, modern forensic science can reveal a great deal from the tiniest traces of substances as long as they are located, identified, collected and recorded.

What are the searchers looking for? It may be fingerprints, shoeprints, tire-tracks or prints, the tiniest of bloodstains, scratches, paint flakes, hair fibers…… the list is endless

Some evidence can lifted with tape, or by dusting and brushing. When the actual pieces of evidence are too small for the searcher to spot with the naked eye, areas of the scene are covered with a vacuum cleaner, so the contents can be checked at the forensic laboratory.

Using Forensic Information from the Crime Scene.

Interpreting forensic evidence is critical. Questions Forensic scientists may ask concerning this evidence includes:

- How does forensic evidence gathered at the scene identify the victim and the offender?
- Is there evidence to indicate that the crime had a sexual component?
- Does the evidence suggest that the offender was “forensically aware” (has this person destroyed potentially incriminating evidence, worn gloves or used a condom?)
- Has physical evidence been left by the offender/
- Has anything been removed from the crime scene?
- What information has been provided by blood at the scene?
- Is there evidence to link the scene with either the victim or the offender?

<u>Accurate Crime reconstruction</u>

Accurate crime reconstruction relies on the following principal:

.... When any 2 objects come into contact, there is always transference of material from each object onto the other....

<u>For Example:</u> the victim's clothing came into contact with the carpets of the car. As a result some carpet fibres became stuck to the victim's clothing and some of the hair of the victim became stuck on the car's carpet.

Control Samples are very important in the submission of evidence eg. Soil on a suspect's boots must be compared with soil from where the suspect is alleged to have walked. Paint chips found at the scene must be matched with the suspect's car paint.

The number of articles of evidence submitted during some court cases is high, with often more than 300 separate pieces being submitted.

Forensic experts do not work alone. They are backed up by doctors, pathologists, photographers, and many other types of people depending on the crime. The forensic expect works with Police and advises them of the facts and evidence. A forensic does NOT interview or chase criminals. They may however be called on to present evidence in court.

<u>It is important to realise that scientific evidence can also be used in court to prove that a suspect could NOT have committed a crime!</u>

Forensic Scientists search through evidence, making inferences & then finally providing how, when, and by whom a crime was committed.

Fingerprints

If you look very closely at your hands and fingers you will notice very fine ridges, called fingerprints. These ridges are also found on the soles of your feet (footprints). The ridges are formed before birth and never change throughout your life.

NO TWO FINGERPRINTS IN THE WORLD ARE THE SAME!!!!

Fingerprints can be classified into four groups, depending on the overall pattern. These groups are: loop, arch, whorl, and composite. The overall pattern of the fingerprint is genetic (determined by your parents).

Arch patterns have lines that start on the one side of the print, rise towards the centre and leave on the other side of the print.

Loop patterns have lines that start on one side of the print, rise towards the centre, turn back and leave on the same side which they started.

Whorl patterns have lots of circles that do not leave either side of the print.

Composite patterns have a combination of whorl, loop and arch patterns.

The tiny individual characteristics formed on individual ridges are called MINUTIAE. These are what are used to match a fingerprint to a person. Minutiae are formed from stress from other surfaces on the unborn baby. Points of minutiae are ridge ending, bifurcation and dot.

In Australia 8 points of minutiae are needed to identify a fingerprint.

Collecting Comparison Fingerprints.

When Police record fingerprints, they take prints of all the fingers and the palms. This is done by rolling the finger from one edge to the other on an ink pad (left to right) then rolling the finger gently in the same direction on a chart.

Collecting Prints For Evidence

The sweat and oil on our hands is like an invisible ink. When we touch a surface we leave an impression of our fingerprint in sweat which is hard to see.

A fingerprint which is invisible to the naked eye is called a LATENT print.

Latent prints may be made visible with either physical or chemical means.

The most common physical method is dusting.

<u>Finding the Date of Death.</u>

In cases where a body is not found until sometime after death, the processes of decay give a reasonable indication of the length of time the body has laid undiscovered.

The action of bacteria breaking down the blood produces green staining on the belly after 2 days. 1 or 2 days later the green spreads to the arms, legs and neck and the body begins to swell….. after 1 week blisters appear on the skin.

In warmer conditions outdoors and at the right time of the year, insects provide another way of establishing time of death.

Flies normally lay their eggs on flesh, and the eggs hatch between 8 and 14 hours later, depending on temperate.

Maggots then develop through 3 stages, shedding their skin each time, until they are fully grown (10-12 days after the eggs were laid).

Forensic <u>ENTOMOLOGISTS</u> can provide accurate estimates of the date (more so than EXACT time) of death using this method.

Stages of Decomposition

Decomposition of a Corpse

Decomposition of a corpse is a continual process that can take from weeks to years, depending on the environment. Here, decomposition is divided into stages, which are characterised by particular physical conditions of the corpse and the presence of particular animals. To illustrate the process of decomposition, I have used the piglet as the model corpse.

Why piglets?

A 40 kg pig resembles a human body in its fat distribution, cover of hair and ability to attract insects. These factors make pigs the next best things to humans when it comes to understanding the process of decay of the human body.

The pigs pictured are newborn piglets (weighing about 1.5 kg) that have been accidentally crushed by their mothers - a key cause of death of piglets. Their bodies have been donated to science.

Stage 1: The living pig

A live pig is not outwardly decomposing, but its intestine contains a diversity of bacteria, protozoans and nematodes. Some of these micro-organisms are ready for a new life, should the pig die and lose its ability to keep them under control.

Stage 2: Initial decay - 0 to 3 days after death

Although the body shortly after death appears fresh from the outside, the bacteria that before death were feeding on the contents of the intestine begin to digest the intestine itself. They eventually break out of the intestine and start digesting the surrounding internal organs. The body's own digestive enzymes (normally in the intestine) also spread through the body, contributing to its decomposition.

On an even smaller scale, enzymes inside individual cells are released when the cell dies. These enzymes break down the cell and its connections with other cells. From the moment of death flies are attracted to bodies. Without the normal defences of a living animal, blowflies and house flies are able to lay eggs around wounds and natural body openings (mouth, nose, eyes, anus, genitalia). These eggs hatch and move into the body, often within 24 hours. The life cycle of a fly from egg to maggot to fly takes from two to three weeks. It can take considerably longer at low temperatures.

Stage 3: Putrefaction - 4 to 10 days after death

Bacteria break down tissues and cells, releasing fluids into body cavities. They often respire in the absence of oxygen (anaerobically) and produce various gases including hydrogen sulphide, methane, cadaverine and putrescine as by-products. People might find these gases foul smelling, but they are very attractive to a variety of insects.

The build up of gas resulting from the intense activity of the multiplying bacteria, creates pressure within the body. This pressure inflates the body and forces fluids out of cells and blood vessels and into the body cavity.

The young maggots move throughout the body, spreading bacteria, secreting digestive enzymes and tearing tissues with their mouth hooks. They move as a maggot mass benefiting from communal heat and shared digestive secretions.

The rate of decay increases, and the smells and body fluids that begin to eminate from the body attract more blowflies, flesh flies, beetles and mites. The later-arriving flies and beetles are predators, feeding on maggots as well as the decaying flesh. They are joined by parasitoid wasps that lay their eggs inside maggots and later, inside pupae.

Stage 4: Black putrefaction - 10 to 20 days after death

 The bloated body eventually collapses, leaving a flattened body whose flesh has a creamy consistency. The exposed parts of the body are black in colour and there is a very strong smell of decay.

A large volume of body fluids drain from the body at this stage and seep into the surrounding soil. Other insects and mites feed on this material.

The insects consume the bulk of the flesh and the body temperature increases with their activity. Bacterial decay is still very important, and bacteria will eventually consume the body if insects are excluded.

By this stage, several generations of maggots are present on the body and some have become fully grown. They migrate from the body and bury themselves in the soil where they become pupae. Predatory maggots are much more abundant at this stage, and the pioneer flies cease to be attracted to the corpse. Predatory beetles lay their eggs in the corpse and their larvae then hatch out and feed on the decaying flesh. Parasitoid wasps are much more common, laying their eggs inside maggots and pupae.

Stage 5: Butyric fermentation - 20 to 50 days after death

All the remaining flesh is removed over this period and the body dries out. It has a cheesy smell, caused by butyric acid, and this smell attracts a new suite of corpse organisms.

The surface of the body that is in contact with the ground becomes covered with mould as the body ferments.

The reduction in soft food makes the body less palatable to the mouth-hooks of maggots, and more suitable for the chewing mouthparts of beetles. Beetles feed on the skin and ligaments. Many of these beetles are larvae. They hatch from eggs, laid by adults, which fed on the body in earlier stages of decay.

The cheese fly consumes any remaining moist flesh at this stage, even though it is uncommon earlier in decay. Predators and parasitoids are still present at this stage including numerous wasps and beetle larvae.

Stage 6: Dry decay - 50-365 days after death

The body is now dry and decays very slowly. Eventually all the hair disappears leaving the bones only.

Animals which can feed on hair include tineid moths, and micro-organisms like bacteria. Mites, in turn, feed on these micro-organisms.

They remain on the body as long as traces of hair remain, which depends on the amount of hair that covers the particular species. Humans and pigs have relatively little hair and this stage is short for these species.

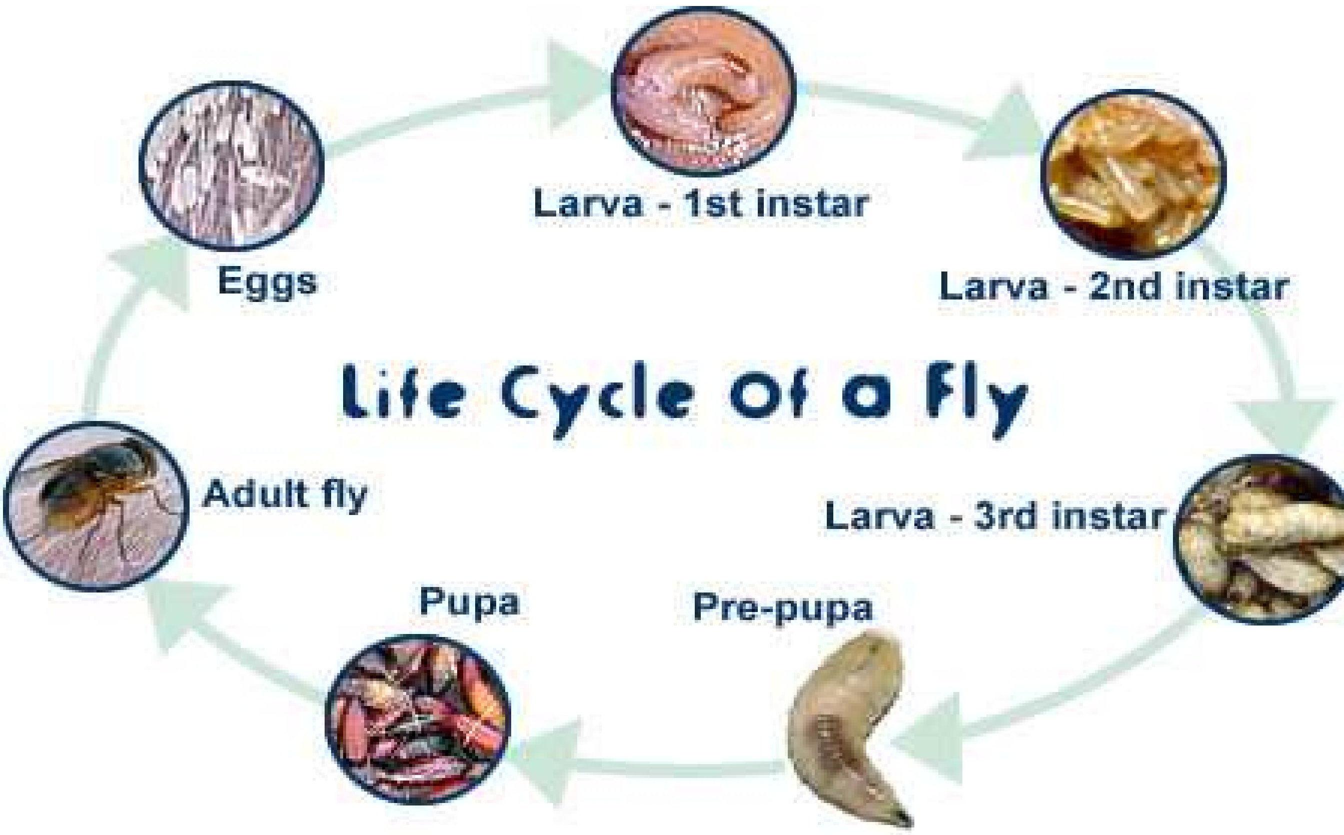
Task :

Summarise the previous passage on the six stages of decomposition in your books. Include information about insect activity and the physical state of the corpse. Glue in the correct picture under each of the stages. (see handout).






Life cycle of a fly



Eggs

- present in clumps of up to 300
- laying to hatching takes 1 day

Larva - 1st instar

- initially feeds on fluid exuded from the body
- migrates into body
- hatching to first moult takes 1 day

Larva - 2nd instar

- moves around in maggot mass
- first moult to second moult takes 1 day

Larva - 3rd instar

- still moves in mass
- greatly increases in size
- second moult to pre-pupa takes 2 days

Pre-pupa

- migrates away from the corpse seeking a suitable pupation site, (usually in soil)
- does not feed
- transforms into pupa
- pre-pupa to pupa takes 4 days

Pupa

- resides within puparium
- undergoes transformation from larval body form adult fly
- does not feed
- pupa to emergence takes 10 days

Adult fly

- mates on emergence from pupa
- feeds on protein from body fluids
- lays eggs on corpse
- emergence to egg laying takes 2 days

These development times are generalised. They vary depending on the species and the temperature.

Task:

Using the above information, jot down notes on each of the stages of the lifecycle of a fly on the handout provided. Stick this completed handout into your book.

Detailed entomological calculations

Step 1. Determine temperature history at crime scene

- Extract weather bureau records of maximum and minimum daily temperatures at the weather station nearest to crime scene, over the general period the body has been exposed.
- Set up weather station at crime scene (after body has been found) and compare temperature changes with those at the nearest weather station. Calibrate the weather bureau data for the period preceding discovery of the body, accounting for differences between crime scene and weather station.
- Calculate the average temperature that the body has been exposed to.

Step 2. Rear maggots to adulthood to identify species

- Collect a range of maggots, (particularly those that might be the oldest) from the body and rear them (on ox-liver) at constant temperature.
- Record time taken until larvae pupate.
- Keep pupae until adults emerge.
- Identify fly species from adult characteristics. (For some species, identification from larval features may be possible or they can be identified from DNA samples, if a DNA library is available.)

Step 3. Estimate time of egg laying

- Using knowledge of development rate of the particular species at rearing temperature, count back to estimate age of maggots when body found.
- Using knowledge of development rate* of the particular species at the average crime scene temperature, count back to determine date of egg laying.
- This is the latest time at which the body died. (It may have died earlier if there was a delay between death and egg laying. This depends on weather conditions and accessibility of the body to insects).

* If the development rate of the particular species at a range of temperatures is unknown (which is the case for most Australian flies), the emergent flies can be used as breeding stock. Eggs can be reared at temperature conditions corresponding to those estimated for the crime scene, to determine development rate.

Step 4. What other insect evidence is available?

- Do steps 1-3 for all the different insect types found at the crime scene to improve accuracy of determination.

Determining time of death

The time of death is a critical piece of information for investigators attempting to understand the cause of suspicious deaths.

Temperature

The temperature of a body can be used to estimate time of death during the first 24 hours. Core temperature falls gradually with time since death, and depends on body mass, fat distribution and ambient temperature. If the body is discovered before the body temperature has come into equilibrium with the ambient temperature, forensic scientists can estimate the time of death by measuring core temperature of the body.

Rigor mortis

The presence of *rigor mortis* also assists forensic scientists in determining the time of death. The body muscles will normally be in a relaxed state for the first three hours after death, stiffening between 3 hours and 36 hours, and then becoming relaxed again. However, there is considerable uncertainty in estimates derived from *rigor mortis*, because the time of onset is highly dependent on the amount of work the muscles had done immediately before death.

Insects

The presence of insects in a corpse is a critical clue towards estimating the time of death for bodies dead for longer periods of time. Because flies rapidly discover a body and their development times are predictable under particular environmental conditions, the time of death can be calculated by counting back the days from the state of development of insects living on the corpse.

For example, if a body was found in an air-conditioned building (21°C) with second instar larvae (stage of development between moulting) of *Lucilia sericata* feeding on the corpse, a forensic entomologist could calculate that those larvae had moulted from their first instar sometime in the last 12 hours. Because the eggs take 18 hours to hatch and the first instar takes 20 hours to develop, the most recent time the eggs could have been laid was 38 hours earlier, if the larvae had just moulted. If they were old larvae, about to moult into their third instar, the most recent time of death would be 50 hours prior to discovery of the body.

Usually, time determinations would not be so easy because weather conditions are more variable, and identification of most maggots to species level is difficult. Forensic scientists usually undertake more detailed entomological work to determine time of death.

Ballistics

- **Forensic ballistics is a special area that helps police in the identification of bullets fired out of guns.**

- **Bullets and their casings when fired from a gun have firing marks left on them. These marks are peculiar to that gun. As a result ballistics experts can examine these marks, usually under a microscope, and determine whether a particular bullet was in fact fired from that gun.**

- **Ballistic experts also make measurements of the size, weight and type of bullet. The material the bullet is made of is also determined.**

- **Ballistic experts always compare the bullets under study with another "control" or "test" bullet that they have fired from the suspect's gun. If the markings on the bullets match, the information can be used by Police as evidence for a conviction.**

- **Ballistic experts can also calculate how far away from the point of impact a bullet was fired from and the direction it came from.**

- **Ballistics is very exact science.**

Matching Dental Records

Sometimes when a body is found it may not have any identification with it, so police must look at the ODONTOLOGY or teeth structure of the victim. In some cases bite marks on a victim can also be studied to identify the perpetrator.

The teeth structure of a victim can be taken in two ways:

1) **The dentist can make a plaster cast of the teeth and compare it with casts of missing persons. Many people have casts made of their teeth for dental plates, mouth guards or surgery.**

2) **Dental X -rays can be used to compare teeth of victims.**

Experiment- Say Cheese- Comparing Teeth Marks

Aim: To compare your own teeth marks to that of your class mates!

Method:

Cheese bite

1) Cut a thick slice of dense cheese with a clean sharp knife.
2) Take a single bite from the cheese, trying not to break the cheese in to two. Bite the cheese so that as many teeth as possible leave their mark on the cheese.
3) Place the cheese on your exercise book and trace your bite on to the page
4) Trace 2 of your friend's bite marks onto your own exercise book.
5) Compare your impression to your friends. How are they different?

Carbon Nash

1) Place a sheet of carbon paper onto your book
2) Sink your teeth into the carbon paper sheet and bite down hard
3) Do not bite through your book!
4) Lift the carbon paper and observe your own teeth marks
5) Is your cheese bite different to your carbon paper bite? Why?

Blood, Blood, Blood

Sometimes at crime scenes investigators are faced with "too much" blood or "No" blood visible to the naked eye.
……Is it human blood?
……Is it the victim's or perpetrator's blood?
……Is it the cat's blood?!
Forensic investigators have a number of chemical tests for blood.

No visible blood

Luminol: This is used to check for blood unseen with the naked eye. Many criminals try to "clean up" a crime scene so that an area may look like a crime never occurred there. Luminol glows in the presence of blood under UV light. However, luminol can destroy many of the properties of blood stains that examiners will need to preserve for future analysis.

Checking For Blood

Phenolphthalein indicator is used to test for the presence of blood in an area. If a substance resembles blood at a crime scene or if investigators believe that blood residue may be present in an area, then phenolphthalein is used as an indicator. When phenolphthalein is mixed with hydrogen peroxide and blood, the haemoglobin in the blood will react and a vivid PINK colour will appear.......thus indicating the presence of Blood.

Identifying Human Blood

If forensic investigators find a blood stain at a crime scene and the investigators are unsure if the stain is human blood then rabbit serum is used as an indicator. Rabbit serum is produced by injecting rabbits with human blood and collecting the antibodies produced. If human blood is present at a crime scene the rabbit serum test will produce a cloudy ring at the junction of the unknown “blood” sample and the rabbit serum.

Secretors-

Sometimes other bodily fluids and materials are found at crime scenes which are not blood. Saliva, skin, muscle, semen, perspiration and vaginal fluid are commonly found on victims and at crime scenes. 80% of the population are secretors and these non blood products can still be used to pin point a perpetrator of a crime or a victim. Secretors have a small number of blood cells in their other bodily fluids which can be tested by forensic means to identify their origin.

Hot Evidence!

Many physical measurements can be used as evidence. Temperature is one of these. Temperature measurements can be used to determine the rates of heat loss from objects. Heat loss rates are very useful to forensic scientists. Eg. At death a human body stops generating heat and begins to cool. At first the cooling rate is quite rapid. For up to about 18 hours, body temperature is a reliable indicator of how long a person has been dead. The usual method of measuring a dead body's temperature is to insert a thermometer into the liver. A comparison between the body temperature and the surrounding air is used to give an approximate time of death.

Copy the following experiment in your own exercise books.

Experiment- The Heat Leak!

Aim: To measure the rate of heat loss of a cup of tea or coffee

Equipment and materials:
200ml of boiling water
1 Teaspoon of Coffee or a tea bag
Thermometer
Polystyrene cup
Watch

Method:

1) **Fill the cup with the boiling water**
2) **Add coffee or tea**
3) **Place thermometer in the liquid, start timing and every minute record the temperature for the next 20 minutes.**

Results:
Draw a table and line graph of your results in your books.

Practical: Viewing Prepared Samples under the Microscope and Bioviewers.

Aim: **To view and draw a number of pre-prepared samples under the microscope and Bioviewers.**

Method:

Microscope:

1) **Place slide on the stage of the microscope and secure with the clips.**
2) **Swing the lowest magnification objective lens into place.**
3) **Use the coarse focus knob to more the objective lens close to the slide (DO NOT DO THIS WHILE STILL LOOKING THROUGH THE EYEPIECE LENS- IT WILL BREAK THE SLIDE).**
4) **Focus the image, making sure that you are pulling the barrel of the microscope away from you.**
5) **Draw the image, label it and include the magnification you are using.**
6) **Repeat for each slide.**

Bioviewers:

1) **Take slide out of folder and insert into Bioviewer.**
2) **Draw the image.**
3) **Use the folder to include the name or title of the image and the magnification.**
4) **Draw 3 images using the Bioviewer.**

Results:

Conclusion: