

# 11

# Forensics

Forensic ballistic investigators use the unique bullet grooves created by individual guns to make a match between bullets and guns. They look at the indentations in cartridge cases and identify them with the chamber marks in the gun they came from. If there is no suspect bullet or gun evidence, the entry point of a bullet hole can be analysed to determine the type and size of the gun, at what angle it was shot, and the minimum and maximum firing distance. Exit bullet holes are often larger than

the bullet and can also give clues as to the type of gun used. Residue found in and around bullet holes is generally made up of gunpowder, lead, smoke and unburned particles. The clothing or material through which the bullet passed is handed over to investigators for analysis. It is microscopically examined and chemically processed to determine if there is a pattern of gunshot residue, which provides information on the order, distance and angle of the shots. All this may lead to a conviction!

## THINK ABOUT FORENSICS

- If there is no body and no gun at a crime scene, what evidence remains to give clues about what happened?
- What information can be found on a bullet?
- Look closely at the image of the bullet hole. Do you think it is an entry or an exit hole? Why?

## YOU WILL DISCOVER

- How modern technology has proven prisoners innocent after they have spent years behind bars
- A whole new world of evidence, under the microscope
- The difference between TV drama and real life



# The Forensic Herald

DATE: THURSDAY, 22 NOVEMBER

WEATHER: WARM, SHOWERS

# COFFEE SHOP SHOOT OUT: Investigations begin

Forensic investigators have begun investigations into a violent shoot out that claimed three lives and left the Victorian town of Ballarat reeling.

Police were called to the Lazy Lizard's Latte Café at 8 pm on Tuesday night, after a neighbouring resident, Ms Michael, heard shots coming from inside.





Sergeant Hurst gave a candid account of the scene, describing it as one of upheaval upon arrival.

'We found the three deceased people, a waitress and two patrons, all bound together with rope, behind the counter of the café. Each had been shot once. And we found traces of blood leading all the way out the door, and tyre marks in the street. So far eight bullet holes in the walls and two through the window have been identified, and investigators are searching for shells and casings as we speak. It was very eerie being the first person there because everything was very still and quiet, except for the ceiling fan which was blowing receipts all over the place, and a burning coffee pot.'

The entire street has been sealed off while investigators collect evidence, a process that could take another day.

'I can confirm that all of the deceased are known to have police records, and at this stage it seems the attack was a robbery as the cash register was found empty. We have no witnesses other than the neighbour who called us. She said that she heard at least six shots,' said Sergeant Hurst.

Blockades have been established at all the main roads leading out of Ballarat, and extra patrol cars are on the beat. Residents are urged to be aware of anyone acting suspiciously and to notify police about any possible information regarding the attack.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 How many bullet holes have been found so far? Why do you think this is significant?
- 2 What evidence is there that indicates at least one other person was in the café at the time?
- 3 What evidence is there that could indicate the amount of time that passed during and after the attack?

### THINK

- 4 Write down all the factors in this story that you think could be clues. Explain why they might be useful.
- 5 What evidence would you gather from the scene for analysis? Describe the type of test that could be performed on each type of evidence.
- 6 What lead would you follow up first? Why?
- 7 What physical and mental traits do you think the perpetrator would need to carry out this crime?
- 8 What sorts of questions would you ask the neighbours during your investigations?
- 9 If all the victims have criminal records, what type of information do you think police will already have on them?
- 10 Why was the entire street sealed off during the collection of evidence?

### COMMUNICATE

- 11 Write up a one-page report on your initial conclusions of what happened at the Lazy Lizard's Latte Café and present it to a small group in your class.

### DESIGN AND CREATE

- 12 Create an annotated map of the crime scene that includes the café, street and the possible location of evidence.

work  
sheet

→ 11.1 How observant are you?

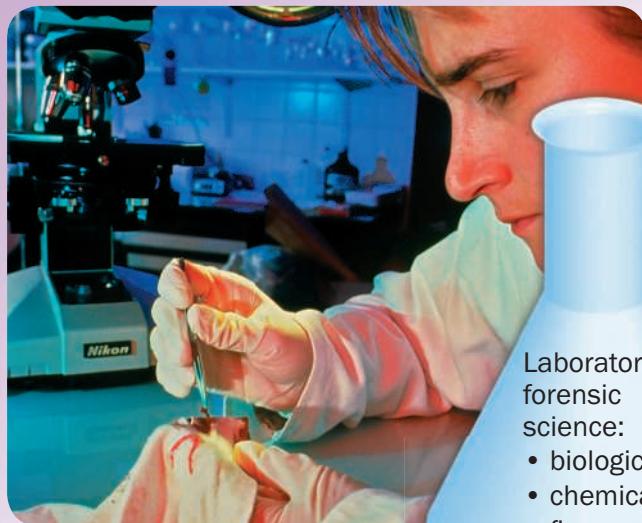
# Who knows who dunnit?

In Australia, there are two types of forensic investigator: police officers who are trained to collect certain **evidence** at a crime scene, for example, fingerprint and ballistics experts and photographers; and there are forensic scientists.

Forensic scientists are usually university trained professionals who work in their field of specialty and lend their skills to legal investigations. Forensic science is not a specific branch of science, but a general term for the many disciplines used in crime scene investigation.

## FORENSIC BIOLOGIST

Forensic **biologists** look at the **genetics** of those involved in a crime. They look at blood types and conduct DNA profiling to identify people at the scene of a crime, and to match **suspects** to evidence.



- Laboratory forensic science:
- biological
  - chemical
  - fingerprinting
  - ballistics

## FORENSIC CHEMIST

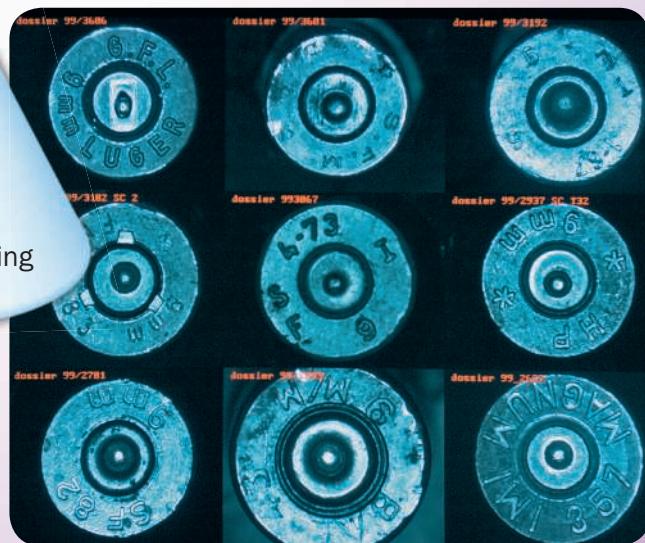
A forensic chemist will be asked to **analyse** any substances found at the scene of a crime. They may be asked to establish exactly what a substance is, for example, what type of explosive has been used. If police suspect poisoning, they will call a toxicologist, a chemist who specialises in poisons, to determine what type of drug has been seized, or what poisonous residue has been found, in a coffee cup, for instance.

The **administration** of forensic science is the responsibility of each state and territory. In smaller regions, where fewer police work at the stations, they carry out more forensic investigations themselves, while in larger areas such as cities, there are more staff who specialise in different fields. Most forensic scientists work in a number of laboratory, medical and field science situations.



## FORENSIC ODONTOLOGY

Also known as forensic **dentistry**, these investigators study the dental evidence found at a crime scene and help identify unknown corpses. Dental enamel is the hardest substance in the body. Clues can be provided as to the age and identity of a victim by comparing dental evidence to X-rays, dental casts and photographs. Forensic odontologists are called to the scene of mass casualties. They can also provide an assessment of bitemark injuries.



Nine widely different bullet casings from a database of bullets found at a crime scene. A match is an important piece of evidence.



This group of forensic scientists is discussing the evidence in a case involving a bloodstained green dress. They will work as a team on the various aspects of the case.

## FORENSIC PATHOLOGIST

These investigators are licensed **pathologists** in charge of examining bodies to determine things such as the cause of death, wounds and injuries. It is the forensic pathologist who carries out the post mortem — a medical examination of dead bodies, to determine how a person died.



- pathology
- anthropology
- psychiatry
- psychology



The facial reconstruction of a victim is built up from a plaster cast of the victim's skull. This is then covered in clay to simulate the facial muscles. The pegs that are placed in the cast correspond to the depth of the muscles; they provide a guide for the scientist when building up the muscle layers with the modelling clay.

## FORENSIC ANTHROPOLOGIST



These specialists help identify bodies that are decomposed, burned or otherwise unrecognisable. They often work in criminal cases where there are only skeletal remains. By analysing the age of the bones and the marks on them, they can help establish the time of death, and the types of wounds sustained by a victim. A forensic **anthropologist** is often called upon to identify victims of mass disasters.

## FORENSIC PSYCHIATRIST

Forensic **psychiatrists** are medically trained doctors. They evaluate a person's mental state, both at the time of an offence and during their trial. They can also be called on to give their opinion about a psychological issue; are involved in caring for prisoners, particularly mentally ill offenders; and provide psychological profiles of unknown perpetrators.

## FORENSIC PSYCHOLOGIST

Forensic psychologists are not medical doctors, but are trained in **psychology**. They perform counselling and therapy for problems relating to depression, relationship breakdown and grief, for instance. They also assist in cases such as child custody disputes and child abuse. Like forensic psychiatrists, they can advise judges on the state of defendants and victims' mental health, and provide criminal profiles. They can give their opinions on **civil court** law cases such as workers' **compensation** and wrong death suits, as well.



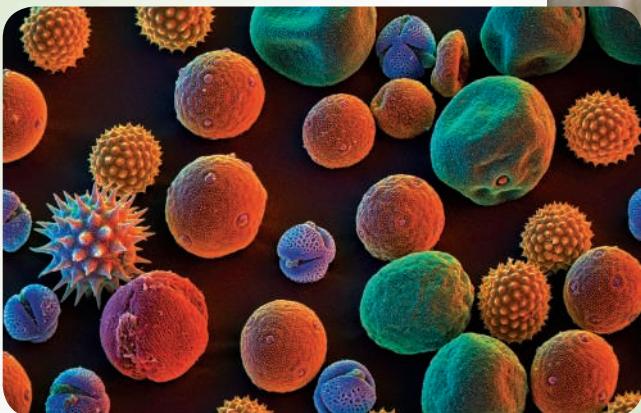
A forensic scientist takes a plaster cast of a footprint at a crime scene.

## COMPUTER FORENSICS

This is the investigation of home computers, office workstations, CDs and laptops. Investigators look at the data storage and processing equipment to determine if it has been used for illegal or unusual activities.

## FORENSIC BOTANIST

**Botanists** can use their knowledge to investigate evidence such as plants, seeds and soil to place a suspect at the scene of a crime. For example, soil from a different location could be found in a boot print at the scene. A **pollen** grain might be found within this soil that can then be traced back to a plant from a suspect's garden.



Different plant species have their own pollen grain size, shape and surface texture. The outer wall of the pollen has a shape that helps it to disperse by wind, water, or on people's clothing and shoes.

## FORENSIC ENGINEERING

This type of investigation is generally carried out for civil cases. Engineers look at materials and structures that do not operate properly. Most **engineering** disasters such as train derailments and aircraft accidents are subject to forensic investigation. Insurance companies also use forensic engineers to investigate **liability**. Appliances, industrial machinery and basic tools can all be investigated if they cause injury or property damage.

## FORENSIC ENTOMOLOGY

A forensic **entomologist** studies the life cycles of insects such as flies, which feed on corpses, to determine the approximate time of death. An entomologist can also determine whether a body has been moved to a different location, based on the types of insects found at the scene.



An image of a fly is displayed on the screen at right. The forensic scientist is examining a fly found on the corpse of a murder victim. A camera attached to the microscope helps identify the species of fly found. This can provide information on how long the body was dead before it was discovered.



## HOW ABOUT THAT!

### Entomology at work

In 2000, Australian entomologist Dr James Wallman was called on to investigate the body of an African man found in a shipping container in Adelaide. Investigators worked out that the container originated on the east coast of Africa and travelled from Dar es Salaam, in Tanzania, to Durban and then on to Freemantle by ship. It was taken to Adelaide by train. The man had apparently tried to hitch a ride down the coast of Africa, but was trapped and died of dehydration, having only a small bottle of water with him. Dr Wallman found three species of African flies on the man's body, and inspected their stages of development.

The indications were that a blowfly infestation occurred when the shipping container was near Durban, and that the death probably took place en route between Durban and Dar es Salaam.



### WHAT DOES IT MEAN?

The term *forensic* comes from the Ancient Roman word *forum*, a place where they held their courts of law. Today, the meaning of the word *forensic* is related to a court of law. Forensic investigators study the objects or evidence, and provide an expert opinion that can then be used in court.

### UNDERSTANDING AND INQUIRING

#### REMEMBER

- 1 What is a post mortem? Who performs a post mortem?
- 2 Where does the term *forensic* come from?
- 3 Name the three broad groups of forensic scientists.
- 4 Describe the difference between a botanist and an entomologist.
- 5 How do forensic odontologists identify victims?

#### THINK

- 6 Who would you call on to analyse bones found in a forest?
- 7 You have found traces of white powder in a wine glass at a crime scene. Who would you ask to analyse it, and what do you want to know about it?
- 8 What clues would the soil found on the bottom of a suspect's shoe give?
- 9 How can the environmental factors, such as the weather or scavengers, affect the rate of decomposition of a corpse?

#### ICT

- 10 Research the work of a forensic scientist and find out about one of the cases they have been involved in.



→ 11.2 If the boot fits

# Forensic toolbox

'Those were desperate times for policemen in a hostile country with unpaved streets and uneven sidewalks, sometimes miles from the police station, with little prospects of assistance in case of need ... It took nerve to be a policeman in those days.' So reported Chief Francis O'Neill of the Chicago Police Department in 1903.

## The old-school toolbox

A typical toolbox used by crime scene investigators 100 years ago was very basic compared to those used today. Although many of the basic techniques and principles remain the same, modern technology has enhanced the efficiency and accessibility of equipment. Human observation and intuition, however, are still the most important tools in forensic science.

**Fingerprinting brush and powder or crystal violet solution:** no two people have identical fingerprints and this has been an invaluable source of evidence for forensic investigators over the years. The patterns on each fingertip are formed when we are four- or five-month old embryos, and do not change throughout our entire life.

Tin containers: used to collect evidence

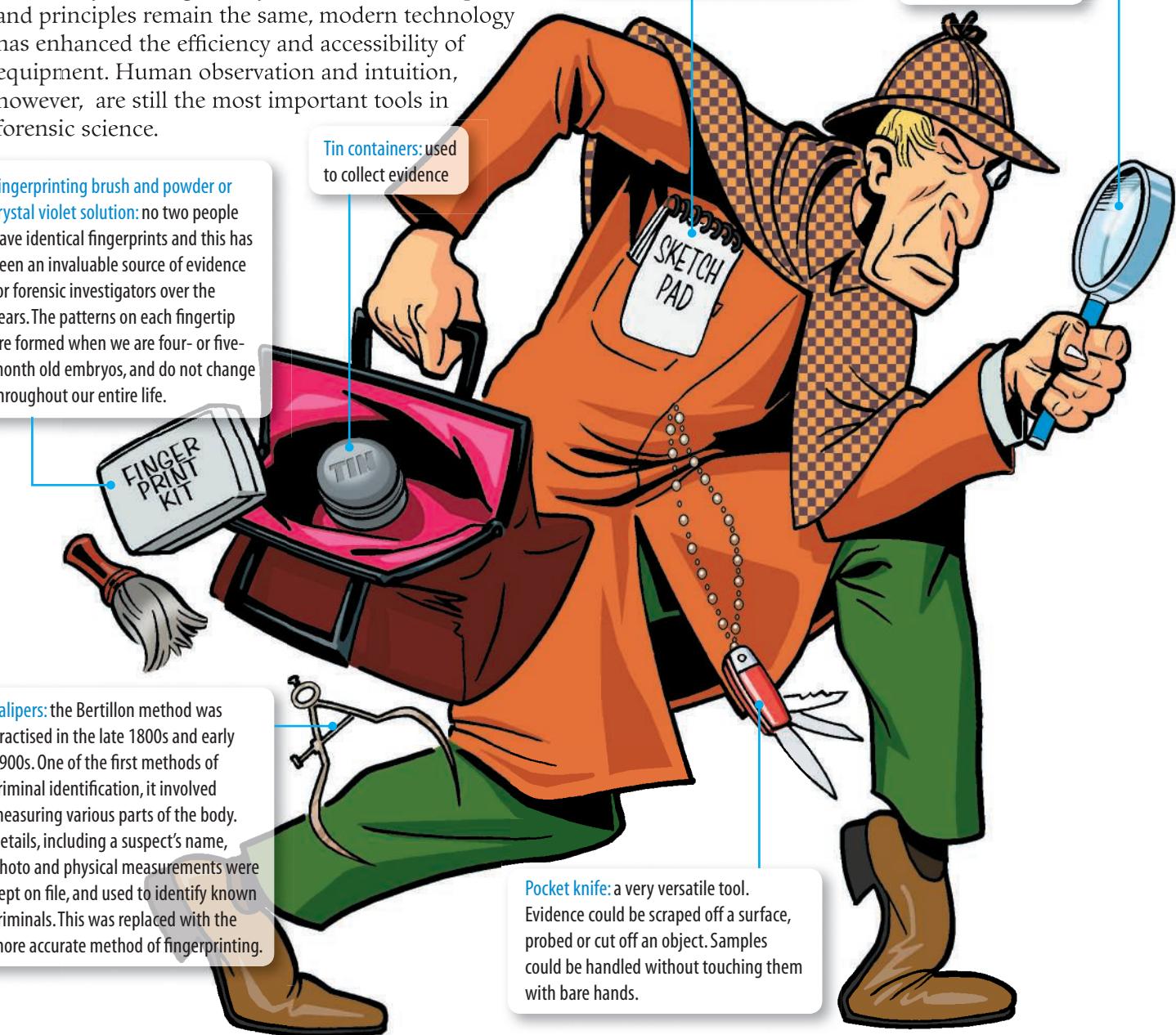


**Calipers:** the Bertillon method was practised in the late 1800s and early 1900s. One of the first methods of criminal identification, it involved measuring various parts of the body. Details, including a suspect's name, photo and physical measurements were kept on file, and used to identify known criminals. This was replaced with the more accurate method of fingerprinting.

**Sketch pad for recording the scene:** without cameras, investigators relied on artistic impressions as a record of the crime scene.

SKETCH PAD

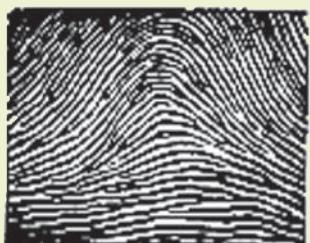
**Magnifying glass:** an essential tool for early forensic scientists, used for many types of analysis



**Pocket knife:** a very versatile tool. Evidence could be scraped off a surface, probed or cut off an object. Samples could be handled without touching them with bare hands.

## INQUIRY: INVESTIGATION 11.1

### Are you a loop, arch, whorl or composite?



Arch



Loop



Whorl



Composite

#### Equipment:

an ink pad (black or blue)  
magnifying glass

paper  
soap and towel

- On the left side of the paper write *Left*, and on the right side, write *Right*.
- Press all your fingers across the ink pad and then place the left-hand fingers on the left half of the page (ensure you use the full pads, not just the fingertips), beginning with the thumb and then the fingers.

Then do the same with the right hand on the right side of the paper.

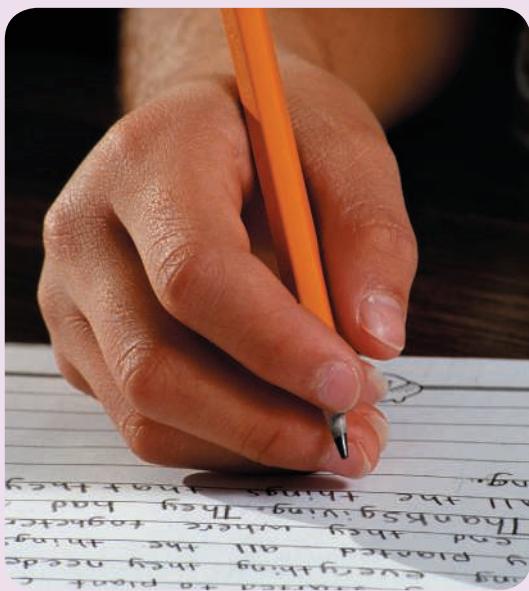
- After cleaning your hands, label each print: thumb, index finger, middle finger, ring finger and little finger.

#### DISCUSS AND EXPLAIN

- Looking at the examples above, classify each of your prints.
- Find out the most common type of fingerprint pattern in your class.

#### HOW ABOUT THAT!

A **magnifying glass** bends light rays (refraction) to make things look bigger. If you use a magnifying glass to look closely at a sample of handwriting, you will see more clearly the slant of the writing, the curls of the letters, the pressure on the paper, and the height and width of the writing. All these are characteristic of your handwriting. Look at your own signature!



#### HOW ABOUT THAT!

In 1932, the son of legendary aviator Charles Lindbergh was kidnapped from his crib. Thirteen ransom notes were sent to the family and eventually \$50 000 was handed to a man known as 'John' in return for a receipt and the details of where the child could be found. But the child was discovered dead. A massive nationwide investigation was held, and one of the methods of investigation was a thorough analysis of the ransom notes. Almost all experts who examined the notes believed they were written by the same person. They thought that the writer was of German nationality and had spent some time in America. Eventually an illegal German immigrant Bruno Richard Hauptmann was charged with the kidnapping.



# The modern toolbox

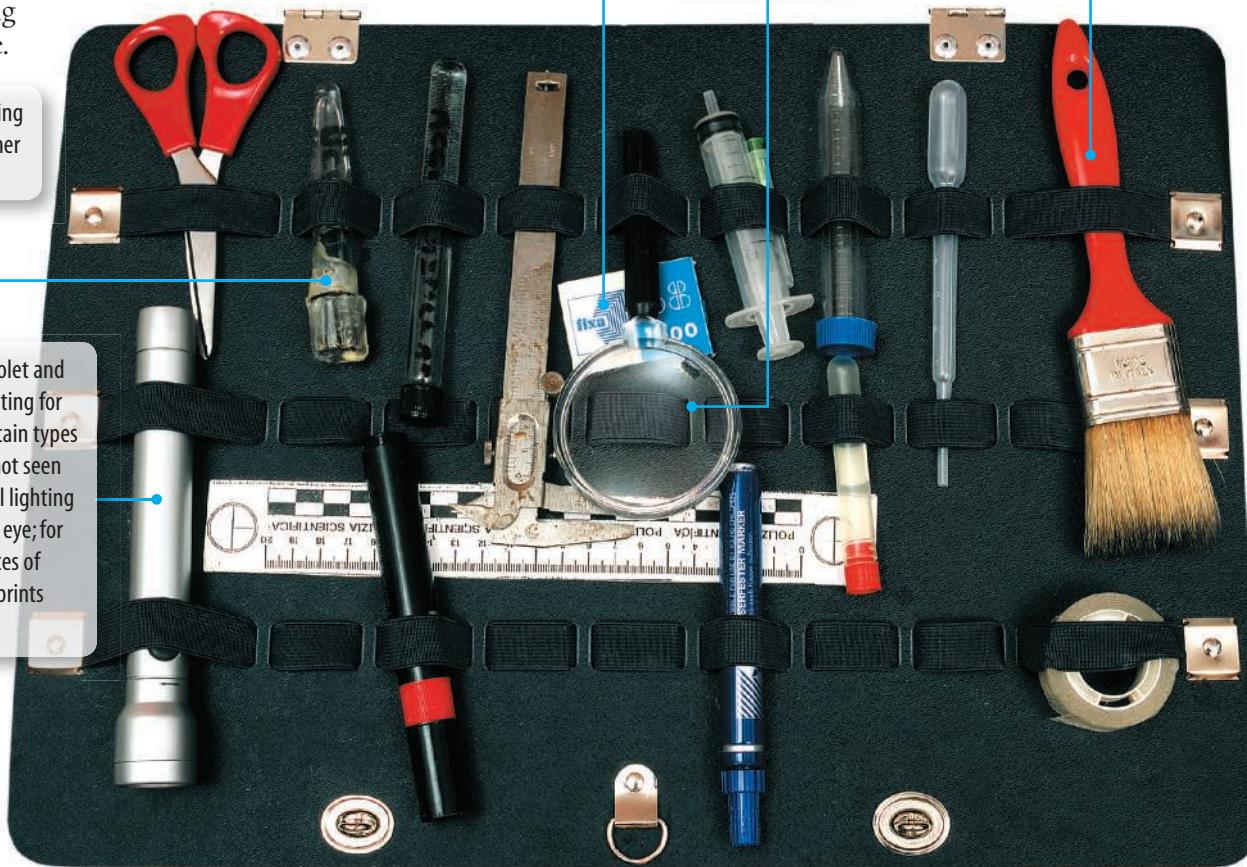
The modern toolbox is more sophisticated and complex than the one used 100 years ago. Crime laboratories were set up around the world in the 1920s, and this meant a more controlled environment was required when collecting evidence.

Kit for collecting blood and other bodily fluids

Laser: ultraviolet and infra-red lighting for exposing certain types of evidence not seen under normal lighting by the naked eye; for example, traces of blood, fingerprints and fibres.

Magnifying glass:  
for close examination

Fingerprint supplies:  
including ink, print cards,  
lifting tape and dusting  
powders



## Forensic kits also contain:

- Camera: to record the scene, with a photo documentation kit marking evidence
- Torch
- Sexual assault kit: for collecting evidence in rape or assault cases, one each for the victim and the suspect. It includes medical history forms, clothing collection bags, containers for debris such as nail scrapings, slides and boxes for swab collection, paper disk for saliva sample, and blood vials.
- Tape: to seal off the crime scene area (blue and white police tape)
- Disposable protective clothing, masks and gloves
- Notepad and pens: to record observations
- Entomology kit: for collecting and preserving insect evidence, including gloves, jars, ethyl alcohol, labels, scalpel, spatula and tweezers
- Paper, plastic bags and glass tubes: for collecting evidence
- Cast kit: with putty and frames for making casts of tyres, footwear, and tool mark impressions
- Tweezers and cotton swabs: for collecting evidence such as hair and fibres
- Labels for evidence
- Hazmat kit: for handling hazardous materials

## HOW ABOUT THAT!

### Ultraviolet light

**Ultraviolet light** is the band of wavelengths between visible light and x-rays on the electromagnetic spectrum. When exposed to this light source, many materials glow. Ultraviolet lights are used to identify many different types of evidence that cannot be seen in daylight, including fingerprints, **counterfeit** documents and **accelerants** in suspected **arson** cases. It can also be used to determine the fluorescent imprint that an **odometer** needle leaves when determining how fast a car was going at the time of collision. The oil stains left on a road may assist in discovering the type of car driven as various oils glow differently under UV light.



## HOW ABOUT THAT!

### The polygraph

The polygraph, or 'lie detector', was invented in 1921 by medical student John Larson. Police began using the test in 1924 as a measure of testing if someone was lying. It works by placing a series of sensors on parts of the body that have involuntary stress reactions when

an individual lies. When a person is asked questions, pens record measurements of pulses and perspiration, breathing and blood pressure on graph paper with each answer. Today, the sensors are much more accurate and the signals received are monitored electronically. But the polygraph still can't indicate that a suspect is lying, only that they have had a response to the question.



## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 List three items a crime scene investigator might have carried one hundred years ago.
- 2 What is the Bertillon method?
- 3 Explain how the polygraph works.
- 4 List three items a modern crime scene investigator carries in their toolbox that an investigator didn't have one hundred years ago.
- 5 Describe how ultraviolet light can be used to identify evidence.

### THINK

- 6 Investigators who relied on a magnifying glass one hundred years ago would have found it very useful. What evidence, besides handwriting, might they have examined with it?
- 7 Why do you think fingerprint evidence would be more accurate than the Bertillon method?
- 8 Looking at the contents of the two toolboxes, what methods are still in practice today and how have they changed?
- 9 How is an arch fingerprint different from a loop?

### COMPARE

- 10 Police fingerprinted four suspects. By comparing the fingerprints with the fingerprints found at the crime scene, decide which suspect was at the scene.



### INVESTIGATE

- 11 Using online resources, investigate:
  - (a) the pros and cons of the polygraph. Is it considered a reliable modern tool? Why?
  - (b) the Charles Lindbergh abduction case. What other piece of evidence left at the scene was a major factor in convicting Hauptmann? Explain the investigation.
  - (c) the tools that are contained in a Hazmat kit.

work  
sheet

→ 11.3 Read my lips

# Digging up the truth

The developments in forensic technology over the past one hundred years have helped some old mysteries be revisited, and solved.

## An old crime solved

In 1874, six prospectors became trapped in heavy snow at Lake City, Colorado. Only one prospector, Alfred Packer, made it back to civilisation. He told varying tales of how the others had died, and said that some had eaten the dead to stay alive. Packer looked fit and healthy and authorities were suspicious. Eventually he was convicted of five counts of manslaughter and sentenced to 40 years in prison. Since his conviction, there have been many rumours in the Wild West about what had really happened, with some believing Packer was innocent, while others believed he was guilty and that he had eaten his victims.

In 1989, a forensic investigator exhumed the victim's bodies, hoping to determine what had happened. Packer had sometimes said that the men died of starvation or accidents, except for one who was shot. Using modern anthropological techniques, the investigator found that the bones showed the men had died violently, trying to defend themselves, and they had been de-fleshed by knives. Four of the skulls had been struck with a blunt object. The investigator's conclusion was that Packer's plea of innocence was entirely false.

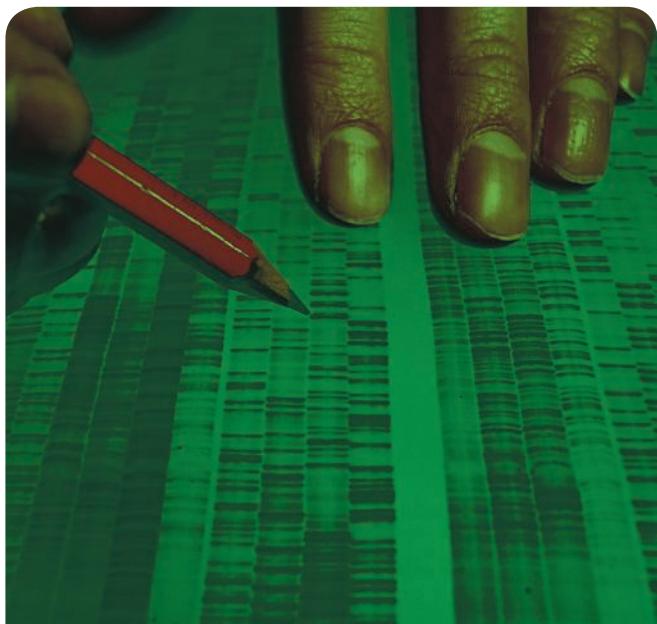
## DNA talks

One of the most powerful new forensic tools emerged in the 1980s. Deoxyribonucleic acid, or **DNA**, is the individual genetic code of each person that determines their physical makeup. This code can be found in things like bone, blood and hair. DNA is usually used to help solve a crime in two ways. If a suspect has not been identified, biological evidence can be taken from a crime scene and analysed, then it is compared to the profiles of known offenders who are already in criminal DNA databases. If a suspect has been found, then their DNA can be directly compared to that found at the crime scene.



DNA not only identifies criminals, but has been used in recent years to prove the innocence of some prisoners. There have been many cases over the past two decades where old DNA evidence, seized from a crime scene decades ago, has not matched the profile of the person in jail.

Kirk Bloodworth was the first man in the US to be exonerated for a crime for which he was sentenced to death. In 1985, he was convicted of the sexual assault and murder of nine-year-old Dawn Hamilton. He protested his innocence, but at the time DNA testing was not used. In 1992, after DNA testing had become more common, **prosecutors** agreed to let the Forensic Science Associates examine a small stain found on the victim's clothing. They concluded it did not match Kirk's genetic profile, and in 1993, he was released from prison. One year later, the stain was checked against the DNA profiles of convicted sex offenders, and a man named Kimberly Ruffner was identified — a man Kirk had lifted weights with in the prison gym.



A DNA **autograph**, being examined here, is a representation of the **compounds** found in each person's individual DNA.

# The power of a testimony

Forensic scientists are regularly called to give evidence in court on what they think happened. Sometimes, interpretations of forensic evidence are incorrect. Below is an example of how the opinions of forensic scientists first sent a woman to jail, and then later released her.

One of the most famous criminal cases in Australian history began with Lindy Chamberlain's claim, in 1980, that a 'dingo stole my baby'. Blood was found in the tent the child had been sleeping in, near Uluru, but no photos were taken. Police were suspicious of Lindy's claim, and in 1982 she was found guilty of murdering her baby. As there was no body found, no weapon, and no motive established, the case against her was built largely on the evidence of two forensic scientists.

- A forensic biologist stated she had found evidence of blood throughout Lindy's car. She took scrapings from the car, placed them on filtered paper and added a solution called orthotolidine, which is used to identify the presence of blood. They showed up bright blue and the biologist said this proved there was once blood all through the front of the vehicle, as well as on the zipper of a camera bag kept in the car.



- A forensic odontologist told the court that the damage to the jumpsuit found at the scene showed no evidence of either tooth marks or saliva from a dingo. He concluded that the jumpsuit had been cut with scissors.

- Lindy was found guilty and sentenced to life imprisonment. In 1986, the case was re-opened and two years of investigations followed. This time, different scientists came up with very different conclusions.
- Lindy's car was investigated again, this time by the Victorian Forensic Laboratory, who stated no traces of blood could be found. It was revealed that what the first forensic biologist thought was blood, was in fact sound deadener, a substance used by car manufacturers. The experiments found that orthotolidine, used by the first investigator, also picks up traces of copper oxide which is found in sound deadener.

- With the assistance of a microbiologist and a chemist, an investigator carried out months of experiments, finding that half the time dingoes tore fabric, and at other times they cut it, with their teeth.

Lindy was released from jail in 1986, and awarded \$1.3 million in compensation.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 What type of forensic scientist looked at the bones of Alfred Packer's victims?
- 2 What is DNA?
- 3 How is DNA used in forensic science?
- 4 What experiments did the first biologist and odontologist carry out in the Lindy Chamberlain case?

### THINK

- 5 Kimberly Ruffner was a convicted offender whose DNA profile was already on file. What could police have done to exonerate Kirk sooner?

- 6 What do you think the second set of forensic investigators did differently in the Lindy Chamberlain case?

### DESIGN AND CREATE

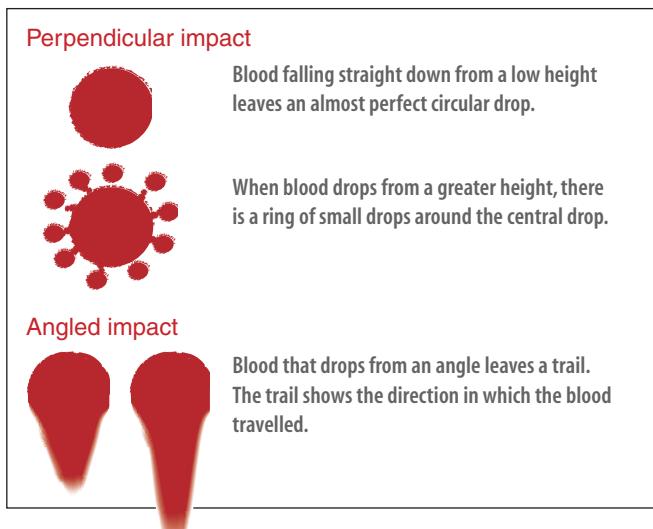
- 7 Research the Chamberlain case online. Use Inspiration or similar mind mapping software to create a chart that displays the progress of the case from the time of the crime to the exoneration.

# Blood and saliva

Even a tiny amount of blood left at a crime scene can give scientists and detectives valuable information. Bloodstains can tell investigators who was at the crime scene and what might have happened. Saliva and dead skin cells can also be traced back to an innocent bystander or a suspect.

## Splat!

Movies often show criminals cleaning up after a crime. They wash their clothes and wipe up blood spills. But forensic scientists can still detect traces of blood, even if it has been washed away. If crime-scene investigators believe that there may have been blood around, the area is treated with a fluorescent chemical. The treated blood is easy to see under ultraviolet light.



An arc of blood spatters forms when the victim pulls away from an impact. The number of arcs tells how many impacts there were on the victim. Forensic scientists can even tell if the **assailant** was left- or right-handed.

## Types of blood

All human blood looks the same, but there are actually several different types of blood. In a laboratory, blood is tested to find out which of the four main groups — A, B, AB and O — it belongs to. Each of these groups can be further sorted into positive or negative. For example, a person could be A+ or A-, B+ or B- and so on.

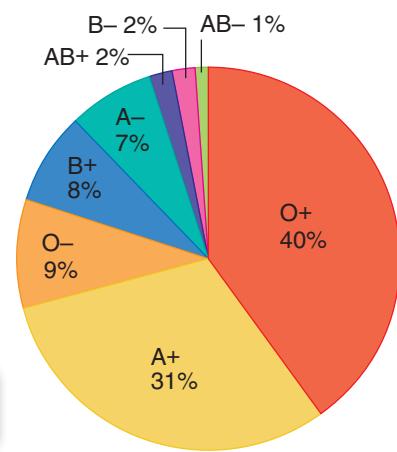
Finding a blood type at a crime scene that matches the blood type of a suspect does not mean that the suspect was there. Many people share the same blood types. But comparing blood types does narrow the search. Blood can also be analysed for diseases or other features that link the sample more closely to a suspect.

If the blood types of samples from the crime scene don't match the suspect's blood type, then the suspect can be cleared.

## Human codes

The cells that make up living things contain information. For the living thing it belongs to, this information is like a recipe. Information is stored in DNA (deoxyribonucleic acid). In humans, DNA contains information about the person's hair colour, eye colour and so on. DNA is different for different people, but the DNA in all of the cells of any one person is the same. Only identical twins have the same DNA as each other.

A single drop of blood found at a crime scene contains information about the person it came from. DNA profiling is a test that compares blood from a crime scene with that of a suspect. Actually, it's not just blood that can be used in this test. Body fluids, like saliva, hair roots and dead skin cells, can be tested as well. Humans drop hair and skin cells all the time and criminals often leave DNA evidence behind. Scientists can even trace the path of a piece of paper from the DNA left by people who have touched it.



## HOW ABOUT THAT!

### DNA profiling

- Samples of blood, body fluids or skin that are collected from the crime scene are taken to a laboratory.
- DNA is removed from the sample. Separating chemicals cut the DNA into small pieces at specific points.
- The pieces of DNA from different samples are lined up across a jelly-like substance.
- When electricity is passed through the sample, the pieces of DNA spread across the jelly-like substance. As the pieces spread, they form a pattern on the autograph.
- DNA samples collected from a suspect go through the same process as the sample from the crime scene.
- The autograph is for matching pieces of DNA from the different samples.



The pattern that DNA from the crime scene forms on an autograph is compared to the patterns of DNA from the suspects. Matching patterns can be used as evidence in court because it is very unlikely that two different people will have the same pattern.



Computer model of part of a molecule of DNA

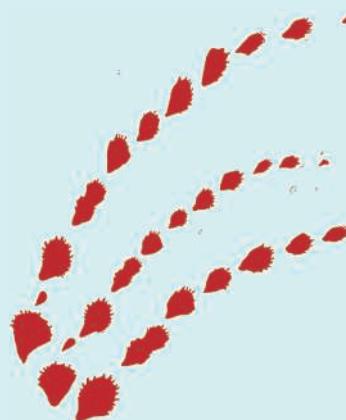
## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 A suspect has the same blood type as a sample found at a crime scene. Why is this not enough evidence to prove that the suspect was actually at the scene?
- 2 List the eight blood types that are possible with the two classification methods mentioned.
- 3 (a) What is the most common blood type in the Australian population?  
(b) What is the least common blood type in the Australian population?
- 4 Who would have the same DNA?

### THINK

- 5 This diagram shows the blood spatter pattern at a crime scene.
  - (a) Redraw the diagram. Use an arrow to show the direction in which the blood travelled.
  - (b) How many blows did the victim receive? Explain your answer.



- 6 Explain how blood at the scene could be used to show that a suspect was not at a crime scene.

### INVESTIGATE

- 7 The chemical used to make bloodstains visible is called luminol. Suggest a reason for this name.  
*(Hint: Look up the word luminous in the dictionary.)*

### COMMUNICATE

- 8 In groups of three or four, create a list of arguments for and against all people providing a DNA sample to keep on police records. Share your list with the rest of the class during a class discussion.

### ICT

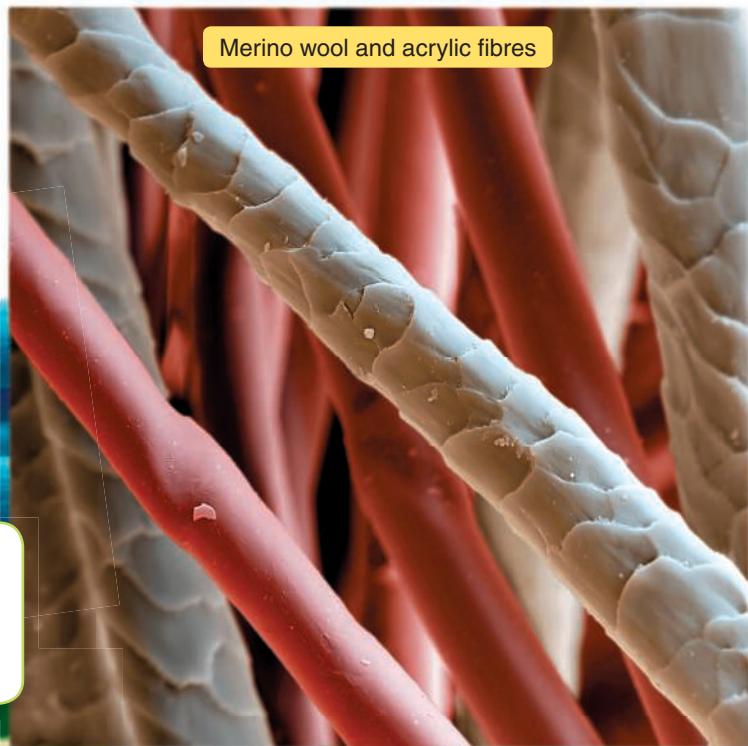
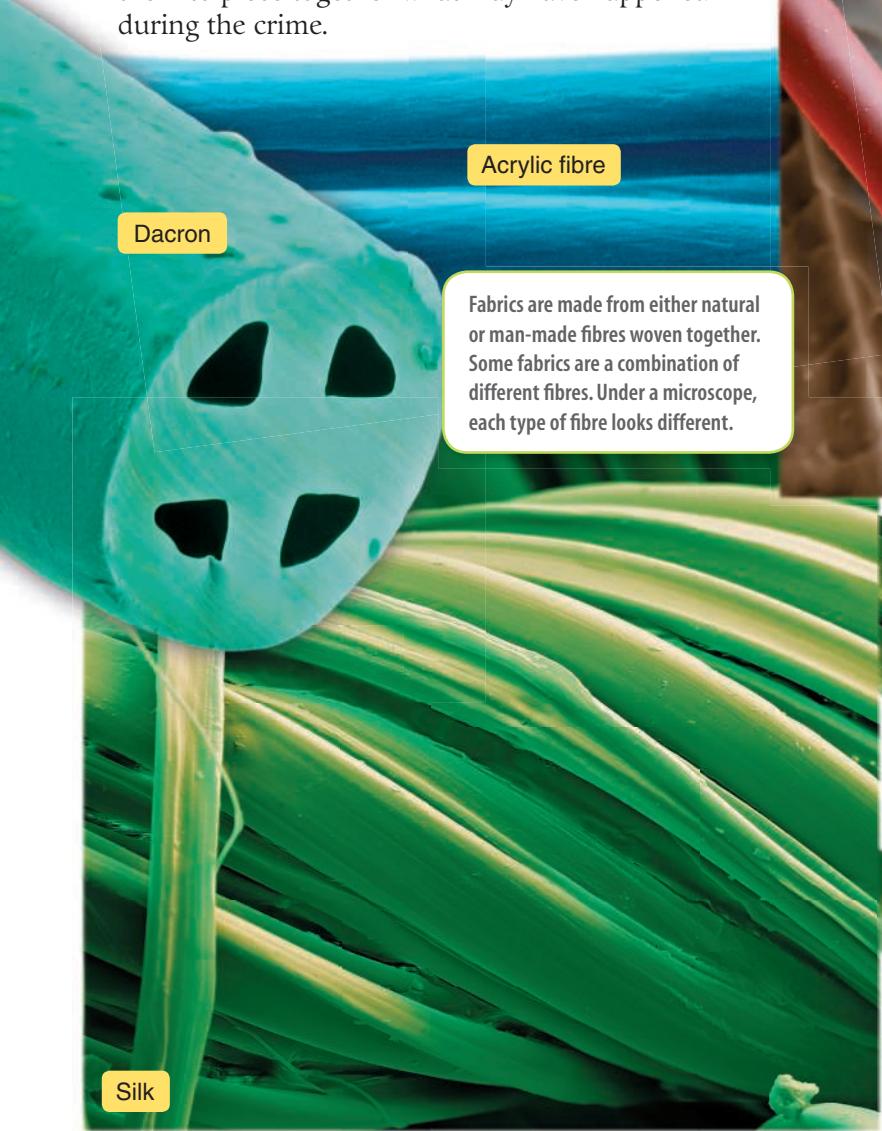
- 9 Use the internet to research how DNA profiles are produced. Find out the probability of two different DNA profiles matching.

# Hair and fibres

Wherever we go we leave some evidence behind and take some with us. Strands of hair or **fibres** from clothes, furniture and carpets can provide strong evidence that a suspect has been at a crime scene. Even the most careful criminals can't stop microscopic fibres sticking to their shoes. They may not realise that they have left a single strand of hair behind at a crime scene. Many hairs and fibres look the same, until they are examined under a microscope.

## Clues found in fabric

A forensic scientist compares fibres found at a crime scene, or on a victim, with those found on suspects' clothes, in their homes or in their cars. Under the microscope, a forensic scientist can also tell if fibres at the crime scene had been cut or torn. This helps them to piece together what may have happened during the crime.



# Hair

By looking at hair samples under a microscope, forensic scientists can tell whether the sample belongs to an animal or a human. The scaly, outer covering called a **cuticle** is different in each animal species.



Human hair

Dog hair

With a microscope, the thickness, **coarseness**, colour and structure of hair can be checked. Scientists can even tell what type of shampoo has been used to wash the hair. A strand of hair found at a crime scene can be checked with a **comparison microscope** against

hair from a suspect. A match between the hairs could be used as evidence to show that the suspect was at the scene.

Hair that has been pulled out can have skin or other substances stuck to it. DNA testing can link these hairs directly to a suspect.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Why do hairs or fibres found at a crime scene need to be compared under a microscope?
- 2 What is a cuticle?

### THINK

- 3 Which hair sample (human or dog, shown below left) is similar to one of the fabric samples shown (far left)? Suggest why this might be the case.
- 4 A detective found a small clump of human hairs at a crime scene. The hairs all showed evidence that they had been pulled out rather than falling out naturally.
  - (a) What might this suggest about what happened at the scene?
  - (b) What other tests could be applied to these hairs to help solve the crime?

A hair that has been pulled out



## INQUIRY: INVESTIGATION 11.2

### Comparing animal and human hair

#### Equipment:

microscope, lamp and slides  
tweezers  
tape

animal hair  
feather  
human hair

- Set up the microscope.
- Tape a sample of animal hair, human hair and a feather to the microscope slides. You may need tweezers to help position the hairs on the slides.
- View the slides under the microscope.

#### DISCUSS AND EXPLAIN

- 1 Draw a diagram of each of the samples. Label your diagrams.
- 2 What are the main features of the three samples?

### INVESTIGATE

- 5 Design an experiment to compare the properties of different fibres or fabrics. Properties that could be compared include:
  - (a) strength
  - (b) elasticity
  - (c) absorption ability.

# On the lab floor

## An interview with forensic scientist Rob Hayes

### **Rob loves his job because . . .**

There are three different areas I get a buzz out of. The first is discovering something that has real significance to a case: that could be finding some unique components of a paint layer and connecting it to a suspect. For instance, if somebody painted a car to disguise it, and painted it close to another car, then you might get overspray. Sometimes the colour pigments are rare, and restricted to a certain time period or model of a car. Repair paints are often very different to original finishes, and so they are easy to identify. Another major thing I like is the variety of work and being part of a team. I also love learning about the amazing forensic techniques and instruments that are being researched and developed — the futuristic stuff is so interesting!

### **Another day at the office**

Ah. A typical day, this varies a lot. A forensic scientist could be doing anything from an investigation in the lab; an example is washing a \$5 note with solvents and analysing the material that comes off it for evidence of drugs. Or, they could spend the day writing up a statement or report.

### **He can be called on to assist with all types of crimes.**

Over my career I have examined evidence from murders, assaults, thefts, burglaries, traffic incidents, drugs and re-borned cars.

I've also worked on a number of hit and run accidents. In these cases I might have to match the paint marks left on the clothing of someone who has been hit by a car to a certain type of car.



**Job title:** Innovation coordinator for Forensics

**Employer:** Victoria Police Forensics Services Department

**Qualifications:** Bachelor of Science in Chemistry and Pharmacology

**Responsibilities:** Rob is a specialist in paint and its composition, and uses his knowledge of chemistry to analyse chemical **trace evidence** in police investigations. Rob's other responsibility is to coordinate research and innovation in new techniques and technologies across many disciplines, within the lab.



A rust flake



An electron scanning micrograph of a flake of rusty paintwork; no metal is visible. The blue top layer is a layer of respray paint. It is badly bonded to the original paint which has three layers of green and orange. The bottom orange crystalline region is rust. This evidence may help to convict a criminal of re-birthing a car.

I have been involved in cases where there have been a huge number of cars stolen. We work with investigators to decide on which areas of the cars may be critical to test, instead of analysing every part of all the cars. It's a team effort. While we might compare the original paint job with the new ones, the Vehicle Examination Unit will look at the mechanical side of things to decide if the car has been re-borned.

When evidence comes into the lab, a number of forensic experts from different departments will talk to the person in charge of the case, and then we all work together to decide who needs to provide their expertise.

### **And he gets to use some high tech gear to do it.**

Most of our work is connected to microscopes because trace evidence can be very small. Tweezers and scalpels can often be used when recovering evidence.

Many of the more sophisticated instruments we work with require liquid nitrogen to keep them cool. These include infra-red spectrophotometers and a scanning electron microscope.

These instruments can help us determine what types of component items contain and some can also measure their colour.

### For forensic scientists, there are very few positions in Australia. What would you say to anyone thinking of a career in forensic science?

It's really interesting work, and when you find something you love, then it's not a job. If it is something you really want to do, then aim for it! With a little bit of luck and a lot of study and application, there's no reason why you can't succeed!

### Is what you see on TV real?

There have been many TV dramas centred on forensic investigation. Detective work is a fascinating business. But is all we see true to life?

### Too much responsibility

In most TV dramas, there are usually one or two detectives doing all the work. They attend the crime scene and seal it off, carry out spot tests and preliminary testing, collect samples,

transport them to the lab, analyse the evidence or assist with a post mortem, interview the suspect and make the arrest! TV detectives would have a tough time convincing a court they were not biased with so much direct input into the case.

In real life, forensic experts are much more confined to their specialisation and often, the lab. The forensic photographer takes the photos, the fingerprint expert dusts for prints, and the forensic toxicologist looks for evidence of poisons or drugs. Each is a puzzle piece in the evidence that is presented to court, and often each forensic expert may not have knowledge of the whole case.

### Speedy results

A lot of the scientific processes carried out by investigators in TV dramas are real to life. For example, the method of gas chromatography is used to separate components of mixtures to detect trace evidence. There are many complex,

time-consuming experiments that don't make it onto TV, however. The nature of a TV drama is that the case must be solved within a short time frame, but real life examinations may require numerous tests. For example, if police suspect a person has been poisoned, a toxicologist must carry out many tests for things like pesticides and heavy metals, and then work by a process of elimination.

The tools used by TV detectives are usually realistic, although there have been a few errors. An example was in one recent episode of a TV drama, a character used fictional computer databases. They were able to punch in trace evidence, and match it against records in a few seconds. In real life, this is usually a much longer process.

## HOW ABOUT THAT!

### The CSI effect

The CSI effect is the public's interpretation of forensic science, based on popular TV shows. For example, there are concerns that juries are beginning to have unrealistic expectations of forensic scientists during court cases, after watching TV dramas. Another concern is that TV shows are raising awareness among criminals, who are wising up and covering their tracks by taking shell casings from crime scenes, and leaving fewer fingerprints!



## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Name the examination regularly carried out by both TV investigators and real-life scientists.
- 2 What is the CSI effect?

### INVESTIGATE

- 3 Choose a TV forensic drama, and select an episode. Watch it carefully. Using the information in this chapter, and other resources, pick out as many differences as you can see between real life and the TV show. Present your findings to the class through a PowerPoint presentation, explaining what each difference is, and why.

### COMMUNICATE

- 4 Form groups of three or four. In your group discuss why TV forensic dramas are not a true reflection of real life investigations. Think about time frames and entertainment value.

work  
sheet

→ 11.4 Mystery in the house

# Forensics and the future

Forensic technology greatly improved in the last century. Modern science has re-opened old cases and solved mysteries that were hundreds of years old. Technology is still advancing quickly, and soon scientists will be able to investigate the extremely small world through nanotechnology, access a synchrotron in Victoria, and log onto fingerprint scans and DNA databases that match profiles in record time.

## Nanotechnology

Nanotechnology is an area of science that is developing across the world. It is the science of extremely small particles; engineering at the atomic and **molecular** level. Nanotechnology deals with a size scale that is one billionth of a metre. It will enable forensic scientists to analyse the tiniest trace evidence, for example, tiny stains on clothes for DNA that are still difficult to analyse with current technology.

Nanotechnology will also help scientists develop better tools, such as finer fingerprint powders, so that prints can be revealed on difficult surfaces.

## DNA developments

DNA has been one of the biggest breakthroughs in forensic technology in the last three decades. The process of matching DNA profiles is getting faster and less costly, as DNA databases such as the Australian Government's CrimTrac, continue to expand and connect to each other.

DNA profiling is no longer being restricted to humans. DNA databases of all main blowflies found in corpses are



being developed in Australia, to help entomologists identify maggots and flies faster. The correct identification of flies is crucial to a criminal investigation because each species responds differently to certain environments and temperatures, providing information on what kind of environment a body has been exposed to.

When the DNA of a fly is analysed, it is not just the DNA of the fly that is found. Anything that the fly has ingested is also found. Entomologists are developing techniques in which they can grind up maggots and flies found at a scene, where police suspect a body may once have been, and analyse them for DNA traces, proving if there was indeed a body or a dead animal present at that scene.



A larger predatory brown fly feeds on a smaller green fruit fly by puncturing the exoskeleton of the prey and sucking the soft innards out. A DNA analysis of the fly will then show the DNA of itself as well as its prey.

## HOW ABOUT THAT!

### Drugged maggots

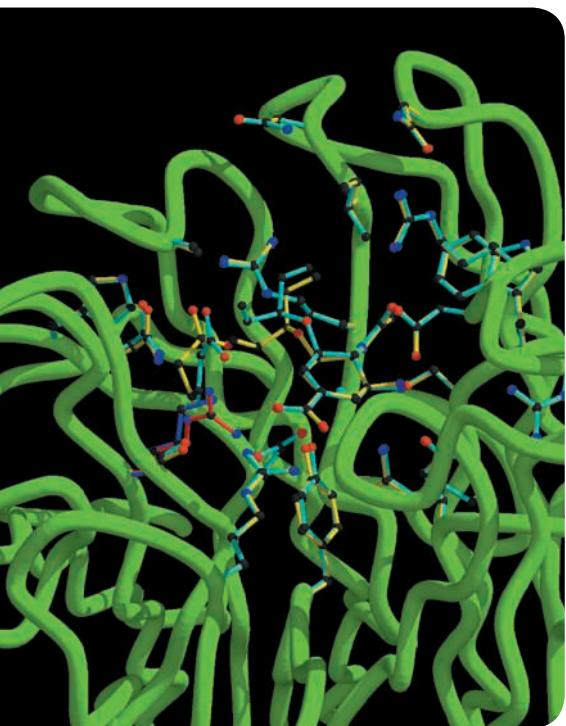
In the world of entomology, scientists are developing techniques to examine the presence of drugs in decomposed corpses. Sometimes it is difficult for toxicologists to identify drugs in tissue, but entomologists are looking at ways of analysing maggots found in corpses, for traces of drugs. Maggots consume the drugs in a body when feeding on it and this affects their development. Entomologists are examining these effects to help identify drugged maggots more easily in the future.

The head of a maggot of the bluebottle fly. The mouthparts are coloured blue in this micrograph. Any drugs that the maggot eats will affect its development.



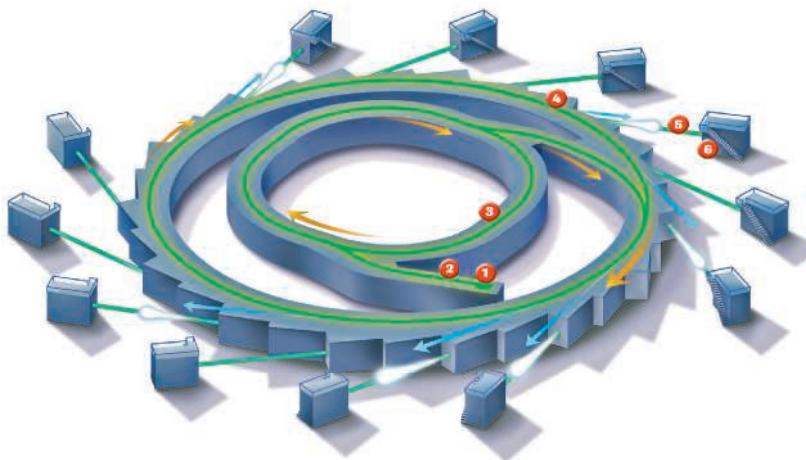
# An energy boost: the synchrotron

The synchrotron is a machine about the size of a football



field. There are very few in the world, and Australia's first synchrotron is in Clayton, Victoria. It works by accelerating electrons to almost the speed of light and deflecting them through magnetic fields so they create extremely bright light. The light is then beamed into experimental workstations, one of which will be a forensic lab. Typical forensic samples are small and complex substances. Because they are a part of the evidence in a case, they must be kept intact. Scientists are able to analyse all types of substances such as bones, gunshot residue and fibres under the intense light, and gain a better understanding of their components. For example,

Images of complex structures like this helped develop the influenza-fighting drug, Relenza™. The synchrotron can also be used to develop anti-toxins.



1. **Electron gun:** electrons are fired from a highly charged tungsten filament.
2. **Linac:** the linear accelerator accelerates the electrons to 99.9987% of the speed of light.
3. **Booster ring:** increases the energy of the electrons
4. **Storage ring:** electrons are trapped in circular orbits by large magnets which steer them around. The electrons give off electromagnetic radiation as they change direction; this is synchrotron light.
5. **Beamline:** the beams are focused to a specific wavelength needed for the particular research going on.
6. **Experiment station:** there are many of these positioned around the synchrotron, in which different samples can be analysed by different teams of scientists.

using synchrotron techniques, scientists can identify forgeries and counterfeit money by analysing the colour pigments, or distinguish car paint pigments involved in hit and run accidents.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 At what two levels does nanotechnology operate?
- 2 What is the name of the Australian government's DNA database?
- 3 Besides DNA profiles, what else can maggots tell us about a body?
- 4 What benefits will the synchrotron provide to forensic science?
- 5 How are the electrons used in the synchrotron produced?

### THINK

- 6 How would a national DNA database assist forensic investigators?

### eBookplus

### ICT

- 7 Use the **Synchrotron** weblink in your eBookPLUS to research other scientific disciplines such as medicine and archaeology. Can you think of other ways the synchrotron might be beneficial to forensic science in the future?

### INVESTIGATE

- 8 Look at a sample of human hair under a microscope. Nanotechnology deals with particles one ten-thousandth the size of your hair. Does your microscope allow you to see objects that small? How is the size of a sample measured under a microscope? How small an object can you measure using the microscope?

# LOOKING BACK

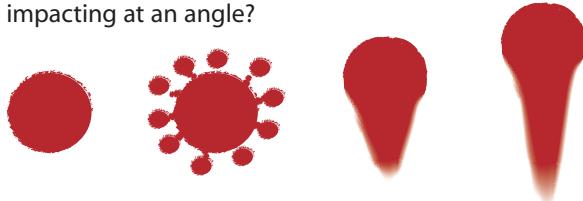
- 1 During an investigation, why is it important to interview witnesses to the crime?
- 2 Bullet exit holes are often larger than the entry holes. Why do you think this occurs?
- 3 The following evidence is collected from a crime scene. Which types of forensic scientist would investigate the:
  - (a) blood-spattered shoe
  - (b) bullet shell
  - (c) toxic liquid
  - (d) unknown victim
  - (e) computer?



- 4 List three broad groups of types of forensic scientist.
- 5 Why would it be important for a forensic entomologist to know the ambient temperature of the location in which a decomposing body was found?
- 6 How does a forensic psychiatrist differ from a forensic psychologist?
- 7 If someone said to you, 'It is important for a forensic anthropologist to work closely with a forensic odontologist', would you agree or disagree? Give your reasons.
- 8 It is a dark, murky London night and you are assisting Sherlock Holmes during his investigation of a crime. He has asked you to use the Bertillon method to record a suspect's details.
  - (a) Name three physical measurements you would record.
  - (b) Explain why each of the measurements is important.
  - (c) What are the flaws in using the Bertillon method?
- 9 Identify the four patterns shown in these fingerprints.
- 10 Where on the body would you place the polygraph sensors to monitor:
  - (a) perspiration
  - (b) pulses
  - (c) blood pressure?



- 11 Are there any other methods, apart from the polygraph, that could be used to determine if someone was lying during an investigation?
- 12 A polygraph does not provide conclusive evidence of a suspect's guilt or innocence. Why do you think this is the case?
- 13 (a) Why is a notebook an essential tool for a forensic investigation?  
(b) Explain why gloves are required.  
(c) What are three possible uses for the putty found in a forensics kit?  
(d) Why are tweezers used to collect some types of evidence?  
(e) How is fingerprint evidence collected?
- 14 What type of acid is DNA?
  - (a) Deoxynucleic
  - (b) Deoxyribonucleic
  - (c) Detoxynucleic
  - (d) Detoxyribonucleic
- 15 DNA evidence can be used to exonerate a convicted person of a crime. What does this statement mean?
- 16 In the Lindy Chamberlain case, scientific evidence did not initially provide accurate information. Explain why comparing evidence is important in all scientific experiments.
- 17 What is orthotolidine used for?
- 18 If a victim and a suspect were both injured and left type AB blood at a crime scene, how would you determine whose blood was whose?
- 19 When describing blood spatter, what is an arc?
- 20 What other details about a crime can blood evidence provide for forensic investigators? Think about pools of blood, drips of blood, spatters of blood and so on.
- 21 Which of the following blood spatters could be made by a droplet of blood:
  - (a) falling perpendicularly from a great height? Sketch your answer.
  - (b) impacting at an angle?
- 22 A criminal found a lost cheque for \$10 and decided to write in three extra zeros and the word 'thousand'. He used a blue pen, the same colour as the original writing on the cheque. When he took the cheque to the bank, the teller became suspicious and called the police.
  - (a) What steps would a forensic scientist use to prove that a different pen had been used to change the cheque?
  - (b) What other evidence could be obtained to prove that the criminal had written on the cheque?



- 23** Could this fibre (at right) be from an animal or from a plant source? Write down the features that would help you decide. List three different possible sources of this fibre that could be found at a crime scene.
- 24** What types of further investigation might be necessary to determine the source of the fibre?
- 25** Write down an example of the CSI effect.
- 26** What is the advantage of using a synchrotron for forensic analysis of evidence?
- 27** Why has a DNA database been developed for the types of blowflies found in corpses?
- 28** What reasons might a toxicologist have for investigating maggots discovered on a corpse found at a crime scene?
- 29** Imagine you are a writer for the television show *CSI: Crime Scene Investigators*. You have been asked to write an episode that focuses on the following crime — a robbery at a school. The producers have asked you to draw storyboards (pictures that are drawn to display what



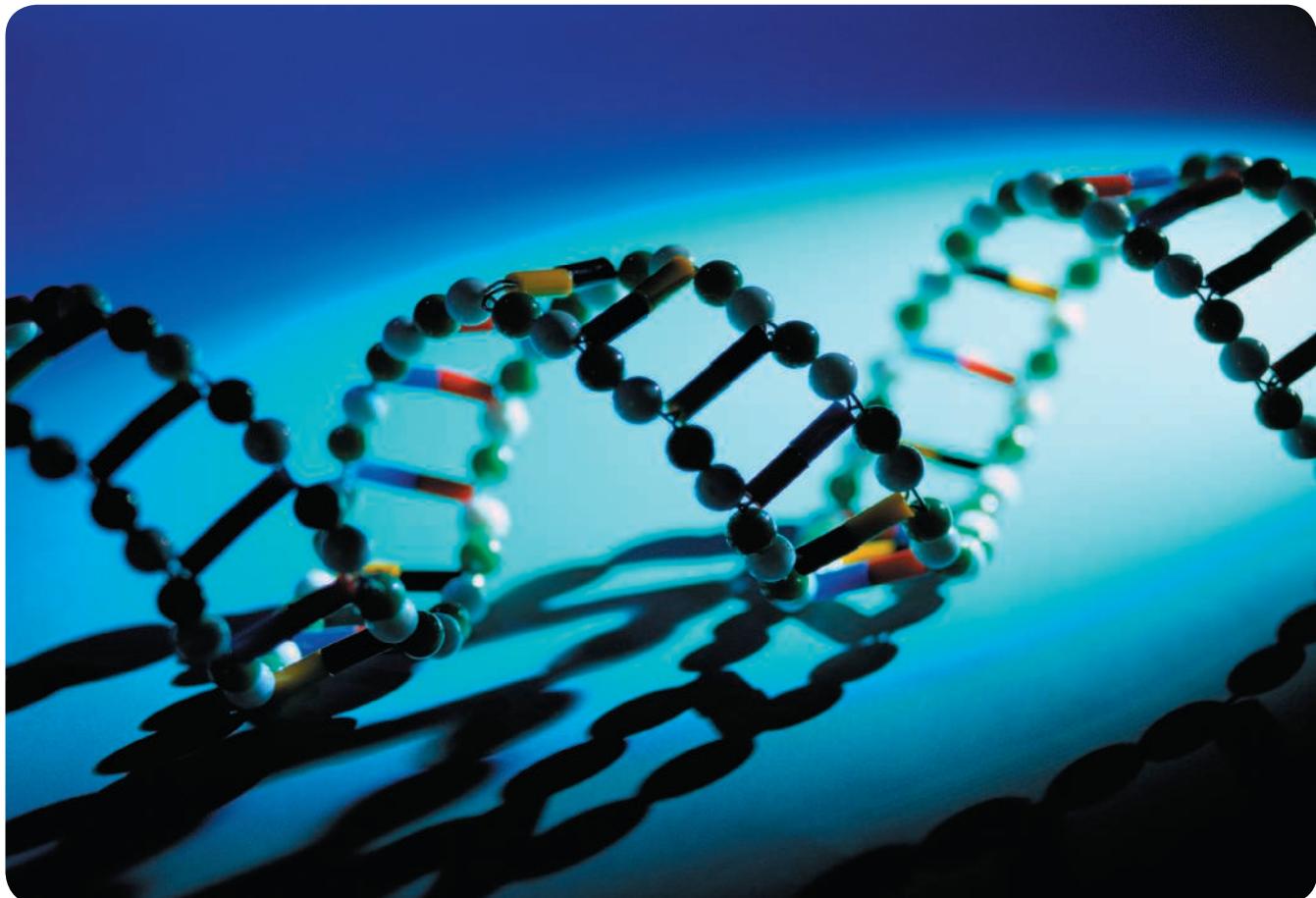
a scene will look like) for the four scenes below. Each scene needs to include labels to indicate the major features, such as the evidence. As an extra challenge, add some dialogue between the characters.

- (a) The crime scene
  - (b) The forensic investigators collecting evidence at the crime scene
  - (c) Forensic scientists analysing the evidence at a laboratory
  - (d) The dramatic arrest of the suspect
- 30** Crime investigation TV shows may reduce the number of criminals who are caught. Explain why this statement may be correct.
- 31** Some people are worried about the use of DNA databases.
  - (a) What is a DNA database?
  - (b) A database could be used to identify criminals more easily in the future. What other applications could the database be used for? (Think beyond investigations of crime.)
  - (c) Why could the DNA database cause concern among the community? Explain your answer.

**32** Consider all of the forensic techniques and tools you have looked at during this chapter. Choose one tool or technique and write a paragraph to explain how this tool or technique could be improved in the future.

work  
sheets

→ 11.5 Forensics: Summary  
11.6 Forensics: Crossword



# GLOSSARY

**accelerant:** a substance, such as petrol, that is used to start a powerful fire or explosion

**administration:** the management of an organisation, business or task to meet certain goals

**analyse:** examine closely to answer a question or solve a problem

**anthropologist:** the scientific study of humans — their origin and behaviour, as well as their physical, social, and cultural development

**arson:** the crime of deliberately setting fire to something, with the intent to damage it

**assailant:** a person who attacks another person

**autograph:** a series of patterns on a plastic film made by DNA, when processed to produce a DNA profile

**biased:** to have a preference or inclination for a particular line of reasoning

**biologist:** scientist who studies the science of life. Biology is concerned with how species came into existence and the interaction between, and behaviour of, different organisms. It is a very broad field, ranging from the study of minute atomic and molecular scales; considering genetics and hereditary patterns; and can also include studying the group behaviour of more than one individual.

**botanist:** a scientist who studies the life of plants

**civil court:** a law court that hears legal matters, usually minor, and not relating to a criminal investigation — for example, child custody battles

**coarseness:** roughness due to having a surface made up of large particles

**comparison microscope:** a microscope that allows two objects to be viewed at the same time so they can be compared

**compound:** a chemical compound is the combination of two or more elements

**counterfeit:** an imitation or copy of something that is made to deliberately deceive — for example, counterfeit money

**cuticle:** the scaly outer covering of a hair

**dentistry:** the science of teeth — their arrangement, placement and function

**DNA:** (deoxyribonucleic acid), a substance found in all living things that contains information about hair colour, eye colour etc. Only identical twins have the same DNA as each other.

**engineering:** the combination of scientific, mathematical and technical knowledge to solve human problems in design and manufacturing

**entomologist:** a scientist who studies insects

**evidence:** anything that assists with a conclusion or judgement — for example, a testimony or material sample

**fibres:** fine threads that make up fabric and paper

**genetics:** the study of genes — the encoded information in each individual determining their physical and psychological characteristics

**liability:** an obligation, responsibility, hindrance or something that causes a disadvantage

**magnifying glass:** a convex lens used to enlarge an object

**molecular:** relating to molecules — a small particle of a pure chemical substance consisting of one or more types of atoms

**odometer:** an instrument to indicate the distance travelled by a vehicle

**pathologist:** a doctor who specialises in interpreting test results and physical evidence found in samples analysed in medical laboratories, in relation to the causes of disease and other illnesses

**pollen:** a fine coarse powder produced by seed plants

**prosecutor:** a lawyer responsible for presenting the case against an individual who is charged with breaking the law

**psychiatrist:** a medically trained doctor who studies the mental condition and behaviour of patients

**psychology:** the science of mental processes, particularly emotional and behavioural characteristics. A psychologist is not medically trained and does not prescribe medicine.

**suspect:** a person believed to be involved in committing a crime

**trace evidence:** the tiny evidence found at crime scenes — this includes hair, fibres and soil

**ultraviolet light:** light that cannot be seen with the eye

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