CHAPTER 5

Forensic science

Mysterious Mary

In 1872, the *Mary Celeste* left New York. Captain Briggs took along his wife, young daughter and a small crew to deliver a cargo of barrels to Italy.

A few weeks later, the crew of another ship found the *Mary Celeste* drifting. When the second crew boarded the *Mary Celeste*, they found nobody on board. The captain, his wife, daughter and crew were all missing without a trace! An inspection of the ship found no evidence of a struggle with pirates.

Any evidence on the ship was destroyed when it was deliberately sunk in the 1880s.

A modern forensic scientist looks for clues.

1 What could have happened to the passengers and crew of the *Mary Celeste*?
2 What kind of evidence would scientists or investigators look for if this mystery had happened more recently?
3 How can evidence be used to find out what happened in a mysterious situation such as the one shown in the photo above?
4 What kinds of scientist are involved in solving mysteries and crimes?

You will discover

How dentists and insect experts help to solve crimes

That it's not just fingers that leave behind prints

How criminals can be identified

If an identical twin can get away with a crime more easily

Forensic science

Forensic science assists judges and juries to make decisions about crimes. The word 'forensic' comes from the word '**forum**' — the buildings that housed the ancient Roman courts of law. Forensic scientists solve crimes and investigate accidents. Many branches of science are involved in forensic science. Forensic scientists can be chemists, biologists, medical doctors, dentists, physicists, geologists, or any other type of scientist.

A forensic scientist might work:
- at the scene of the crime or accident
- in a laboratory
- in an office
- or at a combination of these places.

They sometimes **testify** in court.

Insects time death

Entomologists are scientists who study insects. So what does a forensic entomologist do? The answer lies in flies — or more precisely, their newly hatched eggs known as **maggots**.

Flies can lay eggs in a dead body within an hour of death, when it is still warm. The eggs hatch very quickly — usually in less than a day. When fully grown, each maggot forms a case around itself to become a **pupa**. It transforms into an adult fly which breaks out of the case.

It usually takes between one and two weeks for the egg to develop into a pupa. Therefore, a forensic entomologist can use the age of the oldest maggots or pupae in a dead body to work out when the eggs were laid. A good estimate of the time of death can then be made.

At the scene of a crime

A forensic scientist's main task at the crime scene is to gather **evidence**. Any material left at the crime scene could be a clue.

When a crime is discovered, the area is sealed off. Whenever possible, nothing is moved. Close observation is very important. Any evidence that cannot be taken away must be photographed and every detail carefully recorded in writing. Diagrams and measurements of the scene are made. **Statements** are taken from **witnesses**. This detailed recording at the crime scene is called **documenting**.

During most criminal acts there is an exchange of material between the victim, the criminal and the site. After the site is documented, evidence is collected and clearly labelled with details of where it was found. Gloves must be worn so that the evidence is not **contaminated**. Items that might be collected from a crime scene include soil, blood, **fibres** from clothing, hair, plant and animal material, flesh, fingernails and anything else that looks out of place. All **physical evidence** is sent to a laboratory to be **analysed**.

Forensic scientists examine the physical evidence in the laboratory. The examination

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involves scientific skills like sorting (classifying), observing, comparing, analysing and documenting.

When a crime or accident results in death, the body is taken to a **mortuary**. A forensic **pathologist** examines the body in an **autopsy**. The purpose of an autopsy, which is also called a post-mortem, is to find out the cause of death.

Using the evidence

After the physical evidence is examined, the results are given to detectives in charge of the investigation. These results are considered together with the other evidence, such as photographs, diagrams, measurements and witnesses' statements. The detectives, often working with the forensic scientists, make **inferences** based on all of the evidence. An inference is a proposed explanation and is not always correct. For example, if an empty wallet is found on a murder victim, at least three different inferences could be made:

- The victim was robbed.
- The victim had an empty wallet before being murdered.
- The wallet was emptied to make the crime look like a robbery gone wrong.

It is possible that none of these inferences are correct. To prove whether an inference is correct, it needs to be tested against other evidence. For example, if the victim had been seen withdrawing money at an automatic bank teller five minutes before the murder, it is more likely that the first inference is correct. But this extra evidence does not prove that the victim was robbed.

Activities

REMEMBER

1. What is forensic science?
2. How can a scientist who studies insects help a murder investigation?
3. What is physical evidence?

THINK

4. What is documenting and why is it important in the investigation of a crime?
5. Why must the scene of a crime be sealed off immediately after its discovery?
6. How is an inference different from a wild guess?
7. What is the difference between evidence and an inference?
8. What makes an inference different from proof?

LIST

9. Make a list of the items that a crime investigator would need at the crime scene to be able to gather and document evidence. Draw each of these and write about what they would be used for.

IMAGINE

10. Picture the scene of an accident where two cars have collided at a busy intersection. One car drives off immediately after the accident.
    (a) Make a list of the evidence that you think would be collected from the crime scene.
    (b) Which evidence in your list is physical evidence?
11. Forensic scientists have a wide range of scientific backgrounds. They usually have special knowledge and skills in one area of science. These areas include pathology, dentistry, psychiatry, entomology, toxicology, anthropology and serology. Select one of these fields of science that you don't know about and research it. Imagine you are a forensic scientist working in this field. Write about what you do and how you do it.

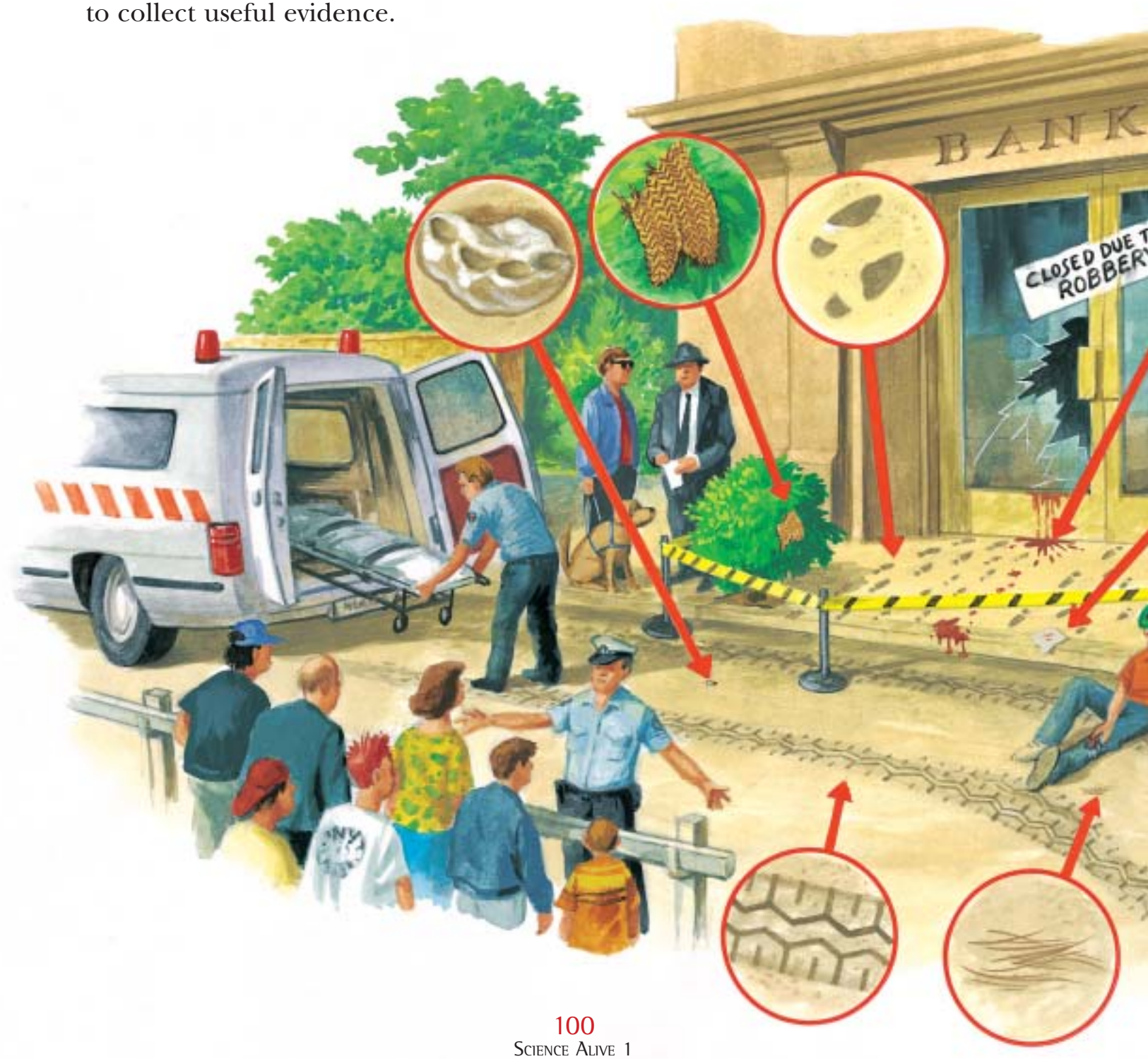
✓ checklist

I can:

- ☐ state what forensic science is
- ☐ describe how evidence is gathered at a crime scene
- ☐ define the terms evidence and inference.

Be the detective

Detectives must be thorough in their search for **evidence**. Any item found at the scene of a crime or accident could provide the police with a clue about who was there and what happened. The area is sealed off while evidence is collected so that the public cannot enter. A crime or accident scene can be **contaminated** by people removing or adding items to the scene. Once the scene is contaminated, it is more difficult to collect useful evidence.



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MI VISUAL/SPATIAL

Comparison microscopy of the paint from the tree and paint from the victim's bike.

Activities

THINK

1. Why are the police paying so much attention to a bicycle accident that involves only minor injuries?
2. Why are the people behind the barrier being kept away from the scene?
3. After investigating the crime scene, police put out an alert to panel beaters in the area. What might the alert ask panel beaters to watch out for?

IMAGINE

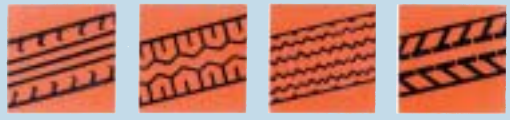
4. Imagine you are a detective at this crime scene. Write a step-by-step report detailing what you believe happened here.

BRAINSTORM

5. Write a list of information that the blind person might be able to provide.

COMPARE

6. Look at the different lip prints on page 108. What type of lip print was found on the tissue at the crime scene?
7. Which of these tyres may have left the tracks at the crime scene?



8. Which of these shoes may have left the footprints at the crime scene?

CREATE

9. Imagine you are a detective at this crime scene. Put together a multimedia presentation that includes:
   (a) a list of the people you will interview
   (b) a list of the questions you will ask each of the people you interview
   (c) a list of evidence that you can collect and physically take back to the laboratory
   (d) the items that you will need to photograph or take casts of.

✓ checklist

I can:

- ☐ understand why it is important to seal off a crime scene
- ☐ list the different types of evidence that can be gathered at a crime scene.

Eyewitness

Police and detectives use **statements** from eyewitnesses to piece together information related to a crime. **Witnesses** can be called on to tell courts and juries about what they have seen or heard. They can also help police and detectives to create computer reconstructions of criminals' faces.

Memory

Different people see things differently. Witnesses can confuse colours, vehicles, clothing and behaviour. This is because of the way we store information in our memories. Information is first stored in our short-term memory. This part of our memory holds information for only about 20–30 seconds. To be able to remember details for longer, we need to think about the information or use it. Writing down the information or telling it to someone else may help store it in our long-term memory. For this reason, an **eyewitness account** given in court needs to be backed up with other **evidence** — especially if the event occurred very quickly.

Being observant

You will need:

pen
paper
pencil case.

Part A The art room

- From memory, describe the art room in your school in as much detail as possible. Write for no more than five minutes.
- Compare your observations with those of the person next to you.
- Share your results with the class.

1. List any differences in your observations.
2. What sorts of things did everyone recall? Give reasons why these things were remembered.

Part B The pencil case

- Work in pairs. Tip out the contents of a pencil case.
- Look at the contents for one minute then cover them over.
- Write down all of the contents that you remember.
- Check how accurate you were.

Part C Another pencil case

- Repeat part B with the other person's pencil case. This time write a list of what is in the pencil case while still looking at the contents. Make sure you observe and list the items for only one minute.
- Cover the pencil case items and the written list.
- From memory, rewrite the list of objects in the pencil case.

1. Were you able to list more or fewer items using this second method?
2. The aim of part C was to see if you could remember more items after writing a list of, as well as observing, the items in the pencil case. Was this part of the experiment a fair test? Explain your answer.

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Making faces

In the past, artists created hand-drawn impressions of a suspect. In more recent years, an identification kit has often been used to help witnesses remember the facial features of a criminal.

Photofit identification kits work by building an image of a **suspect**'s face in stages. The witness needs to separately select eyes, mouth, hair, nose and so on.

Today, computers create an image that looks like a photograph. A witness selects hairstyle, chin shape, eye colour and other facial features. Other items, including hats, facial hair, wrinkles, freckles and glasses, can be added. The computer program used for this is called the 'Facial Automated Composition Editing' or F.A.C.E. system.

Investigators present images of people suspected of being involved in the 2002 Bali bombings. The images were created using the F.A.C.E. system. F.A.C.E. produces coloured, realistic images.

Activities

REMEMBER

1. For how long are we likely to remember information stored in our short-term memory?
2. How can we remember things for longer than our short-term memory usually allows?

THINK

3. What was each member of your family wearing when you last saw them?
4. Why might eyewitness accounts from different people witnessing the same event disagree?
5. List some of the advantages of the F.A.C.E. program over Photofit and hand-drawn impressions.

BRAINSTORM

6. When police ask witnesses to recall what a person at a crime scene looked like, they use certain basic questions. Create a list of basic questions that you think a police officer would ask witnesses at the scene of a road accident between two cars at an intersection.

INVESTIGATE

7. What is a mug shot?

DEBATE

8. Provide arguments for and against requiring all Australian citizens to have their photographs on record when they turn 18, and updated every few years.

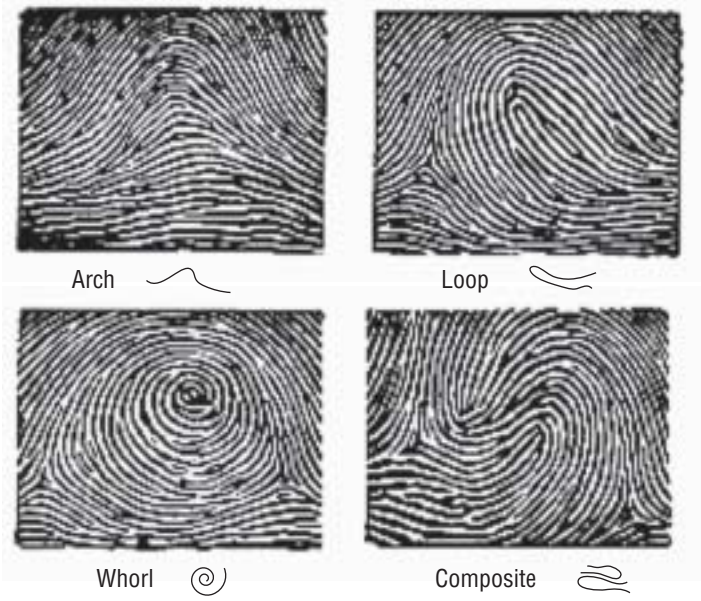
checklist

I can:

- ☐ recognise that different people remember things differently
- ☐ explain how police, with help from witnesses, put together pictures of suspects.

Fingerprints

Movies often show criminals wearing gloves to stop their fingerprints giving them away. Files of fingerprints were first set up in 1901. Since then, fingerprinting has become one of the techniques most widely used when investigating a crime.



Fingerprints are sorted into four main categories: arch, loop, whorl, and composite. Composite patterns are a combination of the other three patterns.

Patterned skin

The patterns of **friction ridges** that make up fingerprints are different for everybody — even identical twins. In fact, there are unique patterns on most areas of our skin. Fingerprints are generally used to identify people because we use our fingers for touching and holding things more than other parts of our body.

Fingerprints are formed before a baby leaves its mother's womb and they don't change as a person ages. After a person dies, their fingerprints remain until their body **decomposes**. Formed deep under the skin's surface, they will grow back even if scars **disfigure** the skin. Only damage to the deep layers, where the fingerprints form, will permanently change a person's fingerprints.

When are fingerprints useful as evidence?

Fingerprint **evidence** is very useful if there is a close match between prints found at a crime scene and those taken from a **suspect**. Accurate matching depends on a fingerprint expert identifying small details, called **minutiae.** In some countries, ten minutiae must be matched before a fingerprint can be used as evidence. In other countries, only eight are required. This isn't easy, as fingerprints found at crime scenes are often smudged.

Until recently, fingerprint experts could take weeks, or even months, to match the fingerprints left at a crime scene with those of a suspect. But computers have made the task much faster. The Australian National Automated Fingerprint Identification System (NAFIS) can compare 400 000 prints per second. The Australian system is one of the best in the world because it has a record of all the fingerprints taken across the country. In many other countries, each state or area has its own computer register; so print matching can take longer.

Leaving our mark

We leave behind fingerprints because our skin constantly releases sweat and body oils. Forensic scientists use fine, black powder to dust for prints because it sticks to the oil and sweat left behind by fingers. Prints on paper and cloth cannot be dusted, so chemicals are used to reveal these prints. Lasers and UV light can make some fingerprints easier to see.

Ancient fingerprints

Fingerprint samples, if left undisturbed, can provide clues even after a long period of time. Clear fingerprints have been taken inside 4000-year-old Egyptian pyramids and from the fingers of 2000-year-old mummies.

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MI BODILY/KINAESTHETIC

Making fingerprints

You will need:
inkpad
table like the one below
soap and towel
magnifying glass.

Right hand

Thumb	Index	Middle	Ring	Little

Left hand

Little	Ring	Middle	Index	Thumb

- Place the inkpad and the piece of paper with your fingerprint table on the edge of a bench.
- Gently roll your left thumb over the inkpad. Without pressing too hard, roll your thumb over the space on your left-hand table marked thumb.
- Repeat this for all fingers on both hands.
- Wash your hands thoroughly with soap.
- Use the magnifying glass to examine your prints.
- Draw one of your prints and label the pattern types that you have in your prints.

1. What patterns are you able to identify on your fingerprints?
2. Are any of your prints the same?
3. Compare your prints to others in your class. What do you discover?

Activities

REMEMBER

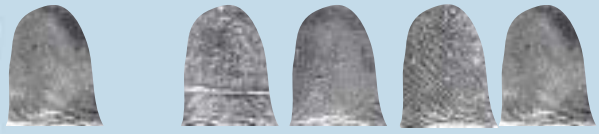
1. Why is fingerprinting a reliable way to identify a person?
2. Why do we leave fingerprints behind when we touch something?
3. How often do a person's fingerprints change in their lifetime?

THINK

4. A man in England was found guilty of burglary when his ear prints were discovered on the front doors of several homes that had been burgled. Why could the ear prints be used as proof of his identity?
5. In movies, criminals often wear gloves to avoid their fingerprints giving them away. How could gloves discarded from a crime scene be used to identify a criminal?
6. Imagine that a stolen car has been found. What parts of the car would you dust for prints?

COMPARE

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



Fingerprint from scene | Suspect 1 | Suspect 2 | Suspect 3 | Suspect 4

INVESTIGATE

8. Find out why the ridges that form our fingerprints are called 'friction ridges'.
9. Find out how many minutiae need to be matched up before a fingerprint can be used as evidence in Australian courts.
10. Find out what DNA fingerprinting is. How effective is it in identifying people?

✓ checklist

I can:
- ☐ name and sketch the four main categories of fingerprints
- ☐ explain how fingerprints are left behind
- ☐ describe, in simple terms, methods used to reveal fingerprints.

Let's magnify

At a crime scene, forensic scientists might use magnifying glasses. Back in the laboratory, scientists also use microscopes to analyse evidence.

Monocular light microscope

A monocular light microscope passes light through the specimen to allow scientists to see details that are not visible through a magnifying glass. Only very thin objects, like microscopic organisms in water or blood, can be viewed. Monocular means one eyepiece. A monocular light microscope can magnify objects by up to 1500 times their real size.

Stereo light microscope

A stereo light microscope has two eyepieces and gives a three-dimensional view of the specimen. It uses visible light that is reflected off the specimen. This means that objects that are too thick to view through a monocular light microscope can be seen through a stereo light microscope.

Red blood cells transport oxygen throughout the body.

This view of human blood comes from an electron microscope. It is magnified to 5270 times its actual size.

Comparison microscope

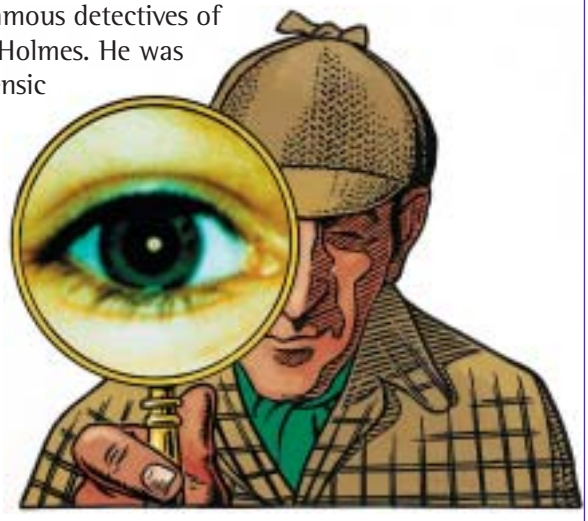
A **comparison microscope** is like two light microscopes in one. It allows two objects to be viewed at the same time. A comparison microscope is very useful for comparing specimens like hair, **fibres** from clothing, and paint fragments. It can also be used to compare the marks left on a bullet with the **cartridge** from which it was fired.

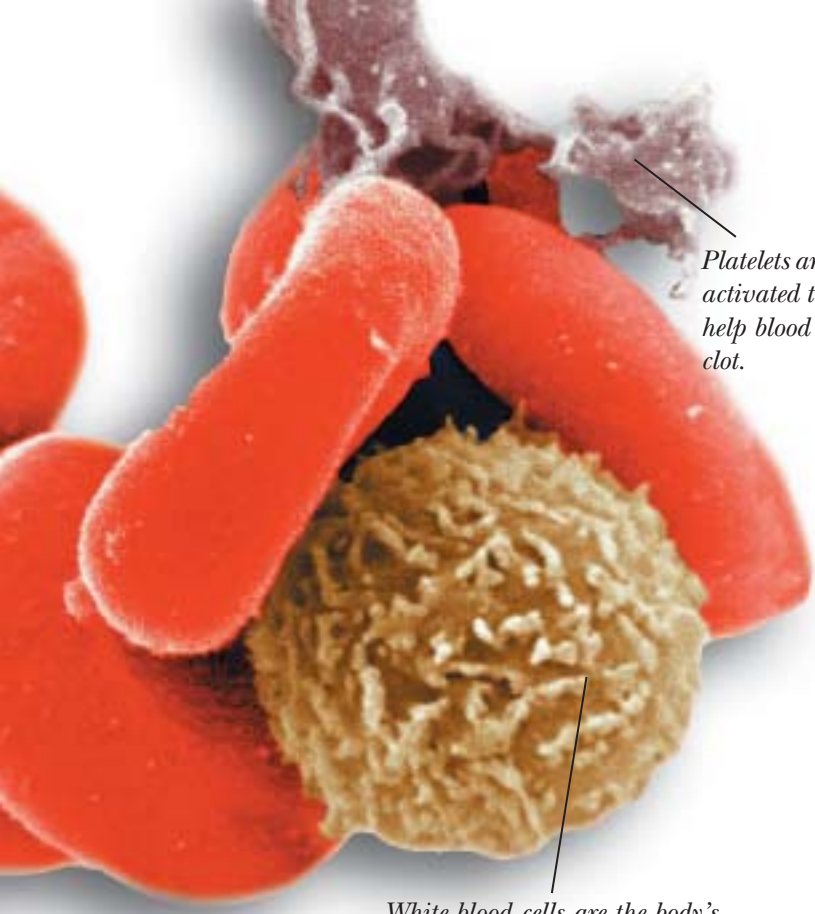
Electron microscope

An electron microscope uses beams of electrons instead of light and can magnify objects by up to one million times their real size. The residue left by a bullet might be examined under an electron microscope. Tiny traces of metals could help identify the type of bullet. Electron microscopes may also be used to examine lung tissue from a body found in water. If the victim drowned in a river, lake or the sea, **diatoms** will be found. If the victim was placed in the water after death, no diatoms will be found in the tissue.

Sherlock Holmes

One of the most famous detectives of all time was Sherlock Holmes. He was the first well-known forensic scientist. Together with his friend Dr Watson he used skills of observation and clever **inferences** to solve many crimes. One of Sherlock's 'tools of the trade' was a simple magnifying glass. Of course, Sherlock didn't really exist — or did he?





Platelets are activated to help blood clot.

White blood cells are the body's defence system against disease.

What's in your pocket?

You will need:
old toothbrush microscope slide
magnifying glass monocular microscope
stereo light microscope.

- Empty out your pockets.
- Use an old toothbrush to remove **fibres** from the seam of a pocket in your clothing.
- Carefully transfer what you have onto a microscope slide.
- View the specimen with a magnifying glass.

1. Draw what you see through the magnifying glass.

- View the slide with fibres under the monocular microscope. You can find information about using a monocular microscope in the Laboratory Toolbox on pages 241–8.

2. Draw what you see through the microscope. Remember to state the **magnification**.
3. Label anything that you can identify on your diagram.

- View the slide under a stereo light microscope.

4. How is your view through the stereo light microscope different from your view through the monocular microscope?

Activities

REMEMBER

1. List two differences between a stereo light microscope and a monocular light microscope.
2. List two differences between a light microscope and an electron microscope.
3. What makes a comparison microscope useful for comparing objects like clothing fibres?
4. List two uses for an electron microscope in forensic science.

THINK

5. What might forensic scientists look for in blood samples?
6. Which type of microscope is most likely to be used to observe:
   (a) a small, solid object (like a door key)?
   (b) the tip of a fly's wing?
   (c) a human hair (to see if it matches a hair from the crime victim)?

IMAGINE

7. Imagine you are a forensic scientist comparing a bullet found at a crime scene with a gun recovered from a suspect.
   (a) How can you get another fired bullet to compare?
   (b) What type of microscope will you use to compare the bullets?
   Look at the two bullet sections below.

   (c) Draw a sketch that highlights the marks on each bullet which suggest they were fired from the same gun.

✓ checklist

I can:
- ☐ distinguish between the different types of microscope
- ☐ relate the way a microscope works to its uses
- ☐ use a monocular light microscope and a stereo light microscope.

Prints of all kinds

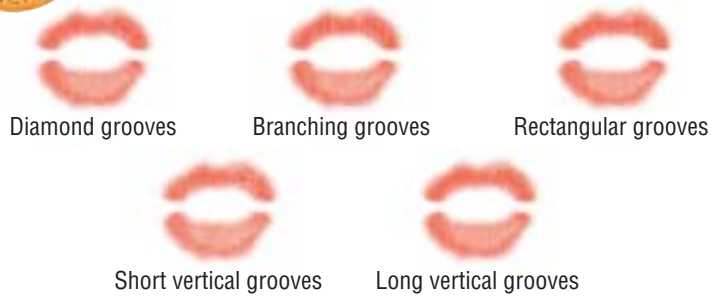
It's not just fingerprints that can be matched up and used as **evidence**. A criminal can be given away by lip prints, shoe prints or the tyre marks their car leaves behind. **Ballistics experts** and dentists are often called on to match up evidence found at the crime scene with a **suspect** or a victim.

Forensic dentists

Each person's teeth are slightly different. As we age, our teeth are made even more different by fillings and other dental work. Dentists keep detailed records of the work they perform on their patients' teeth. They may also have X-rays or **impressions** of a patient's teeth. Dental records can be used to match teeth or bite marks with those of the victim or suspect.

*A badly decayed or burnt body is difficult to identify. Teeth take longer to decay and are often the only part of the body left. Forensic dentists, also called **odontologists**, are able to match teeth recovered from crime scenes with dental records to identify a victim. If the age of the deceased person is unclear, a chemical can be added to the teeth to highlight growth lines. The number of lines provides a clue about the age of the victim.*

Lip prints



Lip prints are as unique as fingerprints and do not change during a person's life. This means that criminals can also be identified by their lip prints. **Cheiloscopy** is the study of lip prints.

You will need:
lipstick or coloured lip gloss
clean white tissues.

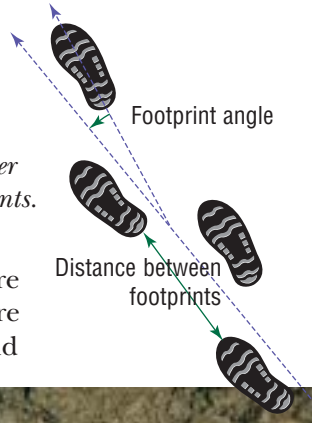
- Put some lipstick or lip gloss on your finger and wipe it onto your lips.
- Fold the tissue in half and press it firmly between your lips.

1. Look at the patterns and identify which category your lip prints fall into.
2. Would all members of your family have the same lip prints as you? Explain your answer.

Leaving the crime scene

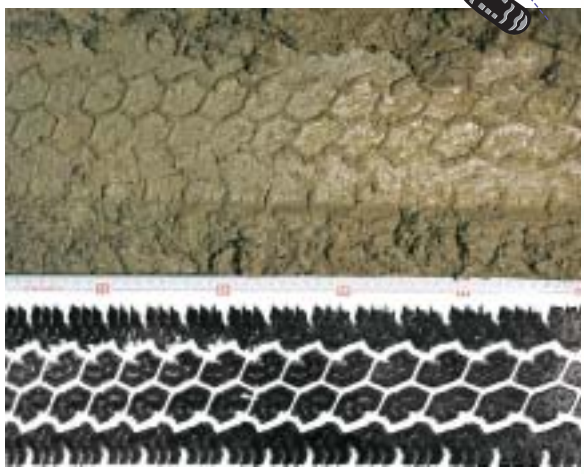
The depth of footprints in soil can tell us about a person's weight. It can even reveal whether a person was limping or carrying something.

This is a print taken from a suspect's shoe. The size, brand and wear pattern in this print were compared with footprints found at a crime scene. The results were presented in court.



The angle of people's footprints can be different. The distance between footprints shows how quickly the person was moving. Running steps are further apart and deeper than walking footprints.

The size of a getaway car and the make of a tyre can be determined by looking at the vehicle's tyre tracks. Evidence of tyre treads can also be found as bruises on hit-and-run victims.



As tyres and shoes wear out, they develop distinctive wearing patterns. Unique patterns from a tyre or shoe can be used to link evidence to a suspect. This tyre track was traced back to this tyre because the wear patterns matched up perfectly.

Making a plaster cast

Footprints and tyre tracks are important evidence. A **cast** of the **impression** can be made and taken back to the crime laboratory for analysis. Casts are more useful than photographs because they record information about the depth of the prints.

You will need:
shoebox or sand tray
shoes
soil or damp sand
prepared plaster of Paris
paintbrush
newspaper.

- Place the newspaper on the bench to catch spills.
- Place the shoebox or sand tray on the newspaper.
- Pack the shoebox or sand tray with damp soil or sand.
- Press the shoe firmly in the sand or soil to make an imprint of the sole of the shoe.
- Without disturbing the footprint, make a 2-cm-high ridge of soil or sand about 5 cm away from the print.
- Pour the plaster into the imprint, covering it completely.

!CAUTION: Dispose of the plaster in the bin, not down the sink.

- Leave the plaster to dry overnight.
- Remove the cast. Dust off soil or sand with the paintbrush.
- Observe the cast and record anything that you think would be useful in an investigation.

1. Why is a cast of a footprint more useful than a photograph?
2. What would happen if you tipped the plaster down the sink?

Activities

REMEMBER

1. What types of print from a crime scene can be collected and used as evidence?
2. Why can teeth be used to identify a burnt or decayed body?
3. What information can the depth of a footprint provide?

THINK

4. Where would you look for lip prints at a crime scene?
5. Would lip prints be as easily available as fingerprints? Explain your answer.
6. How could you make a copy of a lip print at a crime scene?

IMAGINE

7. Imagine you are the forensic scientist investigating tyre tracks found near a crime scene.
   (a) How will you make a copy of the tyre track?
   (b) What evidence will you look for on the tyre track?

INVESTIGATE

8. Design a way to check which category of lip print is more common in your class. Conduct your investigation. Record your results in a spreadsheet and display your data in a graph.

checklist

I can:
- ☐ list four types of print that could be left at a crime scene
- ☐ explain how prints can be used in investigations
- ☐ explain how and why casts of imprints are made.

Paper evidence

Even a handwritten note on a scrap of paper can be useful in solving a crime. It could be a ransom note, a signature, an address or a phone number. The handwriting can be **analysed** by looking at its size, spacing, slope, and even how hard the writer pressed on the paper. Other clues provided by a handwritten note include the type of paper and the type of pen or pencil used to write the note.

Paper chase

Forensic scientists can analyse paper to check for quality and the chemicals used to whiten or colour the paper.

Torn paper can be used as direct **evidence** to link a piece of paper to a **suspect**. No two pieces of paper tear in exactly the same way. A **comparison microscope** can be used to match torn paper found at a crime scene with a piece of paper or a note pad from which it was torn.

Handwriting analysis

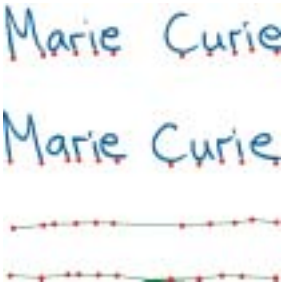
You will need:

pen or sharp pencil — sheet of paper
tracing paper — ruler.

- Sign your name twice on a sheet of paper.
- Place the tracing paper over the top of your signature.
- Make a small mark on the tracing paper at the highest point on each letter.
- Use the ruler to join each of the marks to make a zigzag pattern.

1. Compare the zigzags for each signature. How similar are they?

- Remove the tracing paper and place another sheet of tracing paper over the top of the signatures.
- Mark the lowest point on each letter.
- Use a ruler to join the marks.



2. Compare the patterns for each signature. How similar are they?

- Remove the tracing paper and place another sheet of tracing paper over the signatures.
- Make a small mark at the beginning and end of each letter in the signature.

- Use the ruler to join the mark at the end of a letter with the mark at the beginning of the next letter. The ruled lines show the length of the spaces between the letters.

3. Compare the spaces between letters in the two signatures. How similar are they?

- Remove the tracing paper and add another sheet.
- Use the ruler to make a slash through each letter of the signature on the tracing paper so that each slash has the same slant as each letter.

4. Compare the series of slanted lines for both signatures. How similar are they?
5. Is a person's signature exactly the same each time they sign it? Explain your answer.

Ink clues

Ink is made up of a number of different colours, called **pigments**. For example, black ink in a pen may be made up of blue, red and yellow. Black ink in a different brand of pen may contain a different combination of colours. To find out which pigments have been used to make the ink, scientists separate the different colours in the ink.

Chromatography can be used to separate small amounts of substances that have been mixed together, like the colours in ink. Read more about chromatography on pages 38–9.

Investigating paper and ink

You will need:

2 different types of pen of the same colour (e.g. felt and ball point)
several types of paper (copy paper, tissues, glossy paper, writing pad paper)
filter paper
eyedropper
magnifying glass
methylated spirits.

- Look closely at each piece of paper through the magnifying glass. Look for **fibres** in the paper. You may need to tear a small part off the paper to see the fibres.

1. In which types of paper are the fibres closest together?

- Write your name on each of the pieces of paper, with both pens.
- Using a magnifying glass, look closely at the writing. Notice how the ink spreads through the different paper fibres.

2. Which of the inks spread furthest through the paper fibres?
3. (a) Which type of paper allowed the ink to spread the most?
   (b) How does your answer to 3(a) relate to your answer to question 1?

- Draw a small spot in the middle of a piece of filter paper with one of the pens.
- Draw another spot on a separate piece of filter paper with the other pen.
- Add drops of methylated spirits, one at a time, to the spots. Wait for the methylated spirits to spread a little before adding the next drop.

4. What colour pigments are in each of the pens?
5. Suggest a reason why filter paper is used for this experiment. *Hint:* How easily does ink spread through filter paper?

Activities

REMEMBER

1. What are four ways that handwriting can be analysed?
2. What is chromatography?

THINK

3. Why can't an untorn piece of paper, found at a crime scene, be linked directly to the same paper found at the home of a suspect?
4. A forensic scientist compared handwriting in two signatures in four separate ways. Each way showed that the signatures were exactly alike. But the scientist came to the conclusion that the signatures were not from the same person. Give a possible reason for the scientist's conclusion.
5. List three tests that could be used to find out if these two pieces of paper (shown below) were once part of the same handwritten note.

This piece of torn paper was found at the scene of a crime.

This piece of torn paper was found in a suspect's house.

OBSERVE

6. Work in groups of four. Select one person to be the detective and one person to write a sample of handwriting. The person writing the sample writes the word RANSOM on a piece of paper. While the person selected as the detective turns away, the other three members of the group, including the sample writer, try to make copies of the sample word. The detective needs to work out which two words belong to the sample writer and which two are copies. Take turns in playing the role of the detective and the sample writer.

✓ checklist

I can:

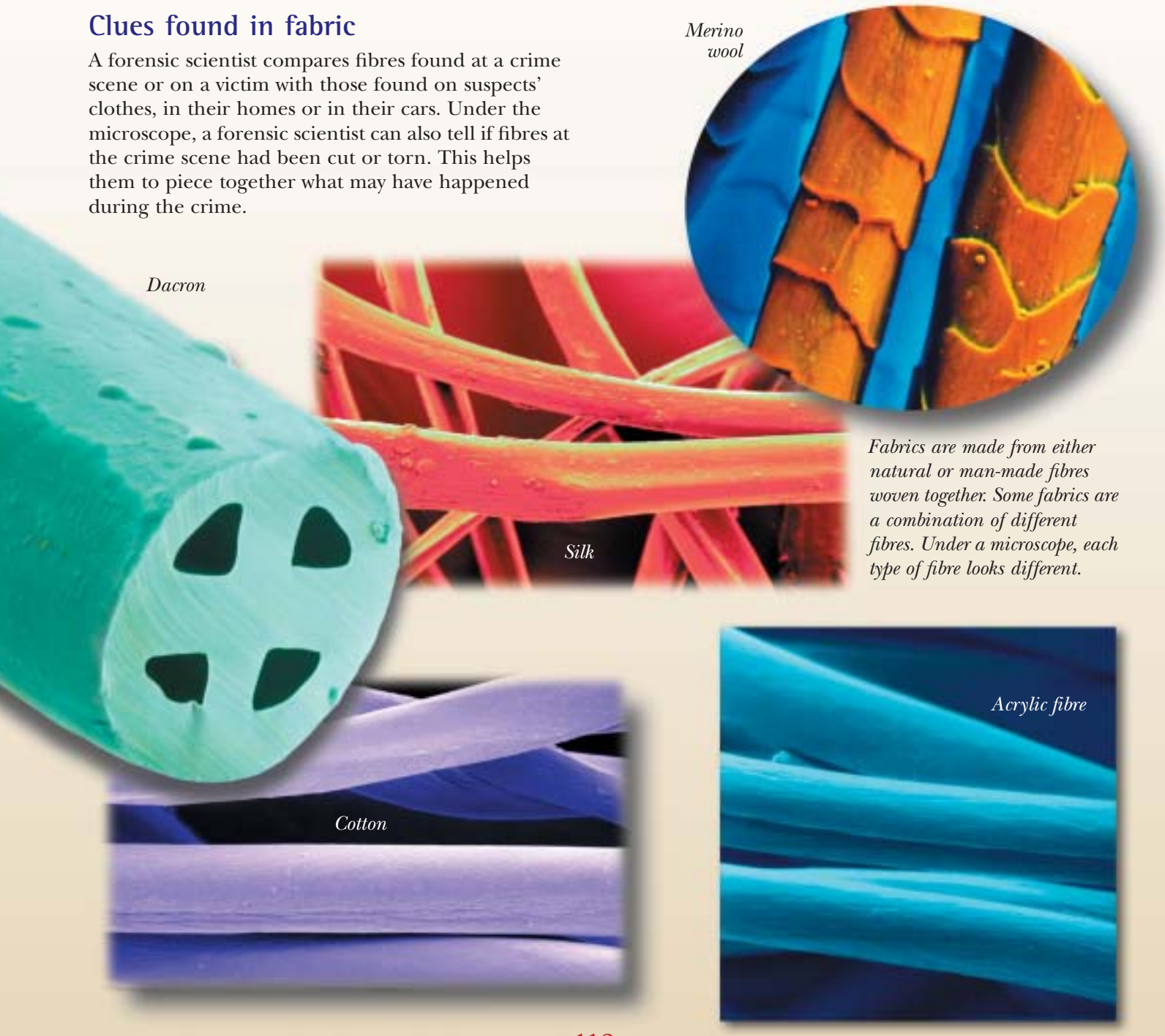
- ☐ describe four ways of analysing handwriting
- ☐ explain how analysing paper and ink can help solve a crime.

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.



Fabrics are made from either natural or man-made fibres woven together. Some fabrics are a combination of different fibres. Under a microscope, each type of fibre looks different.

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.

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.

Forensic scientists can tell if a hair sample has come from a person with curly, wavy or straight hair. Scientists can even sometimes tell the ethnic background of the person from their hair.

Comparing animal and human hair

You will need:
microscope, lamp and slides
tweezers
tape
animal hair
feather
human hair.

- Set up a microscope according to the instructions on page 247 of the Laboratory Toolbox.
- Tape a sample of animal hair, human hair and a feather to a microscope slide. You may need tweezers to help position the hairs on the slide.
- View the slides under the microscope.

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

Activities

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 at top left) is similar to one of the fabric samples (far left) shown? 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

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.

✓ checklist

I can:
- ☐ use a microscope to observe the differences between feathers, human hair, and hair or fur from other animals
- ☐ explain how hair and fibres can be used to help solve crimes.

Blood and saliva

Even a tiny amount of blood left at a crime scene can give scientists and detectives valuable information. Blood tells us who was at the crime scene and what might have happened. Saliva and dead skin cells can also be traced back to the person from whom they came.

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 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 chemical. The treated blood is easy to see under **ultraviolet light**.

Perpendicular impact

Blood falling straight down from a low height leaves an almost perfect circular drop of blood.

When blood drops from a greater height, there is a ring of small drops around the central drop of blood.

Angled impact

Blood that drops from an angle leaves a trail. The trail shows the direction in which the blood travelled.

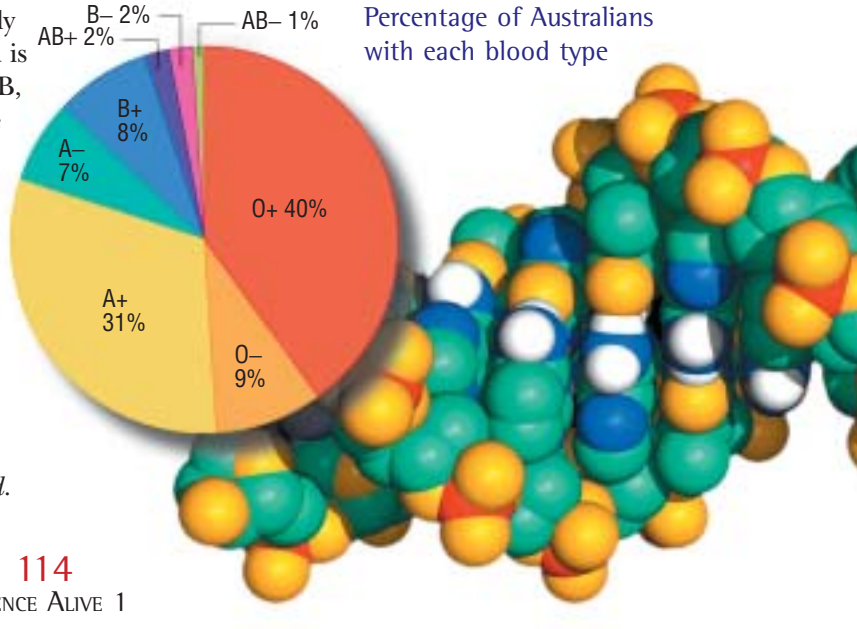
An arc of blood spatters forms when the victim pulls away from an impact. The number of arcs tells how many impacts there were to the victim. Forensic scientists can even tell if the **assailant** was left- or right-handed.

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.



Percentage of Australians with each blood type

Human codes

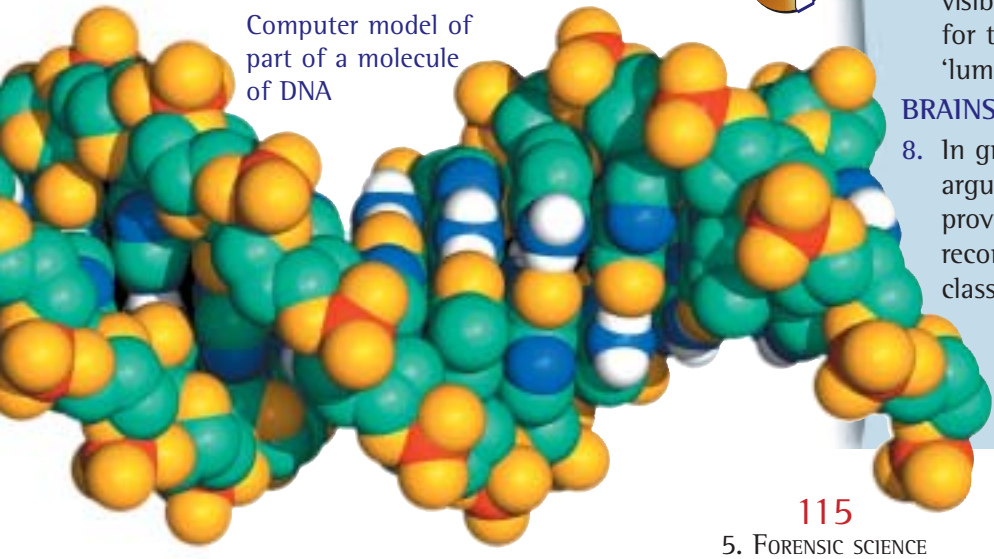
The cells that make up living things contain information. For the living thing it belongs to, this information is like a recipe. Information is stored in **DNA** (**d**eoxyribo**n**ucleic **a**cid). In humans, DNA contains information about the person's hair colour, eye colour and so on. DNA is different 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. Everybody drops hair and skin cells all the time and criminals often leave DNA **evidence** behind. Scientists can even trace the path of paper from the DNA left by people who have touched it.

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. Chemicals cut the DNA into small pieces.
- 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.
- DNA samples collected from a suspect go through the same process as the sample from the crime scene.
- People look for matching pieces of DNA from the different samples.

The pattern that DNA from the crime scene forms 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

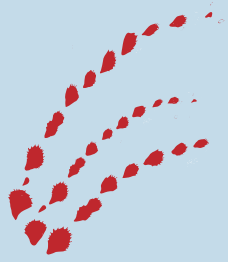
Activities

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. Which people have the same DNA?

THINK

5. The 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.

BRAINSTORM

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.

checklist

I can:

- ☐ list 8 blood groups
- ☐ explain how DNA profiling is used to solve crimes
- ☐ explain why blood at a crime scene is useful as evidence.

The Daily Goss

27 June 1996 Weather: 14°C

Celebrity caught out

Yesterday afternoon detectives questioned Julia Parker, lead actress from the movie *Fifteen Minutes of Fame*. Ms Parker was found to be in possession of a **counterfeit** $100 note.

Eva Goodeye, sales assistant in the Fab Gear fashion boutique, noticed the suspect note yesterday. She said that it was easy to tell the difference between the counterfeit and a real note. As soon as she realised the note was a fake, the sales assistant phoned police. They told her not to touch the note until they arrived at the scene.

This counterfeit claim has surfaced only a month after the release of the new $100 note. The new note is the last in the changeover from paper to **polymer** (plastic). Polymer notes will last longer, can go through the wash and are harder to counterfeit than paper money.

Detective Sargent Walker, who is in charge of the investigation, expressed surprise. 'Most counterfeit money is printed on paper. Before the introduction of polymer notes, lots of copied notes were floating through the system. People were just copying them on good quality colour photocopiers. It's a different story now', he said.

The media pack greeted Ms Parker as she entered the police station for questioning. She made a brief statement. 'I have never knowingly handled counterfeit money. It seems ridiculous that someone with my wealth and fame would need to make or use fake money. I'm just here to help the police with their investigation. That's all, I have nothing more to say.'

If Julia Parker is found guilty of knowingly using counterfeit money, she will be charged under the *Crimes (Currency) Act 1981*. *The Daily Goss* will keep you up to date on the police investigation.

Go to worksheet 25

How to tell a counterfeit note from a genuine note

- Check that the clear window of the note has the correct image:
  - $5 — eucalypt flower
  - $10 — windmill
  - $20 — nautical compass
  - $50 — Southern Cross
  - $100 — lyrebird.
- The clear window should feel smooth. It should be a part of the note and not just attached to the surface.
- There is a small diamond pattern on each side of a genuine note. Hold the note up to the light. Together, the diamond patterns from each side will form a perfect seven-pointed star in a circle.
- The printing on the main parts of a real note is raised, so you should be able to feel it.
- Genuine notes have an image that appears under the printing when the note is held up to the light.
- All notes contain very small writing around the edge ($5) or near the portrait (all other notes). The writing is visible with a magnifying glass. In a genuine note, the writing is sharp and clear.

Activities

REMEMBER

1. List two advantages polymer notes have over paper notes.

THINK

2. What is counterfeit money?
3. Coins are not usually counterfeited. Suggest a reason for this.
4. Why was the sales assistant asked not to touch the note?

USING DATA

Issue dates		Size (mm)	Average life of notes (months)	
			Polymer	Paper
$5	07/07/92 24/04/95 01/01/01	130 × 65	40	6
$10	01/11/93	137 × 65	40	8
$20	31/10/94	144 × 65	50	10
$50	04/10/95	151 × 65	About 100	24
$100	15/05/96	158 × 65	About 450	104

Reserve Bank of Australia

5. Why do the sizes of Australian currency notes differ from each other?
6. Roughly how much longer do the polymer notes last than the paper notes?
7. Suggest a reason why $5 and $10 notes do not last as long as other notes.

Australian note production (millions of notes)

1991–92	533	1996–97	195
1992–93	360	1997–98	180
1993–94	364	1998–99	189
1994–95	260	1999–00	190
1995–96	285	2000–01	73

8. How did the number of notes produced each year change from 1991 to 2001?
9. Suggest a reason for the change in the number of notes produced between 1991 and 2001.

✓ checklist

I can:

- ☐ state the meaning of the word counterfeit
- ☐ list methods used to prevent or reduce the counterfeiting of money.

Check and challenge

Forensic science

Gathering evidence

1. Make a list of the different branches of science involved in forensic science.
2. How do entomologists help to solve crimes?
3. Why is the public stopped from entering a crime scene?
4. Match the objects with the microscopes that are suitable for viewing them.

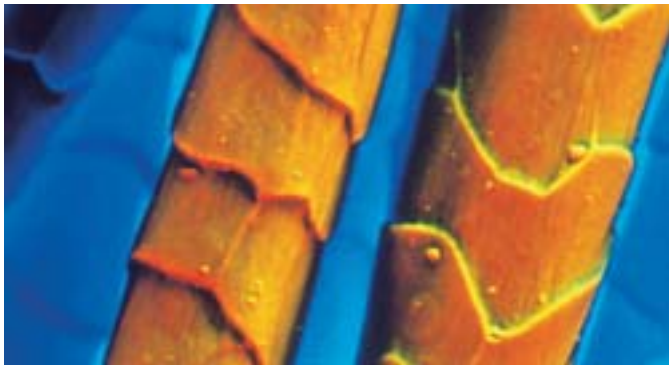
Two scratched bullets	Stereo light microscope
Thin layer of skin cells	Electron microscope
Tiny trace of dust	Comparison microscope
Iron nails	Monocular light microscope

5. Why do eyewitness accounts need to be backed up with other evidence?
6. What is the F.A.C.E. system?
7. Explain the difference between evidence and an inference.
8. Read the following sentences. Decide if the word in *italic* makes the sentence true or false. If the sentence is false, replace the word in *italic* with another word that makes the sentence true.
   (a) A *cast* of a footprint is more useful than a photograph.
   (b) A forensic *odontologist* studies insects.
   (c) The examination of a dead body is called a *mortuary*.
   (d) Ink is made up of colours called *chromatography*.
9. Look at the crime scene on pages 100–1. List:
   (a) the substances that could be DNA tested and where samples of the substances can be collected
   (b) the evidence that can be used as direct proof and the evidence that just adds to the body of evidence.

Identification

10. Identify the four patterns shown in these fingerprints.

11. Explain, in simple terms, how fingerprints are left behind.
12. How can a badly burnt body be identified?
13. What is cheiloscopy and how does it help to solve crimes?
14. The best clue to tell whether a hair belongs to an animal or a human is:
    A the roots?
    B the colour pigment?
    C the coarseness?
    D the cuticle?
    E substances stuck to the hair?
15. What type of evidence found at a crime scene can be analysed through DNA profiling?
16. Explain why matching the blood type of a suspect to that found at a crime scene does not prove that the suspect was at the scene.
17. (a) Which of these hairs has most likely come from an animal and which from a plant?



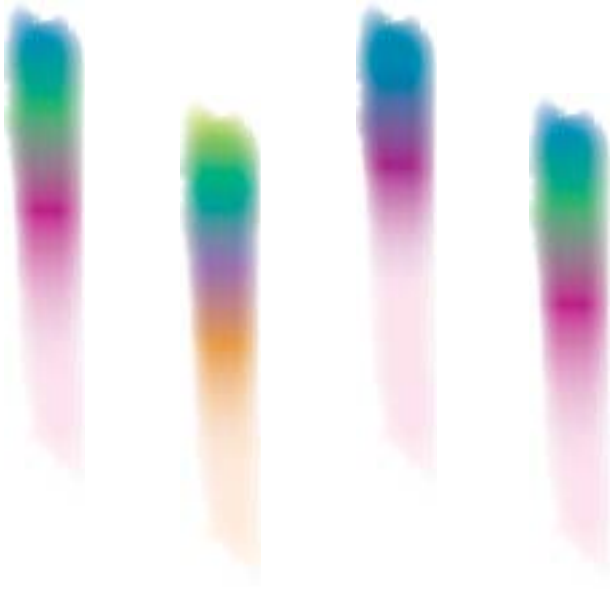
(b) Explain your answer to (a).

18. Name and describe a method police use to produce an image of a suspect from a description given by a witness.

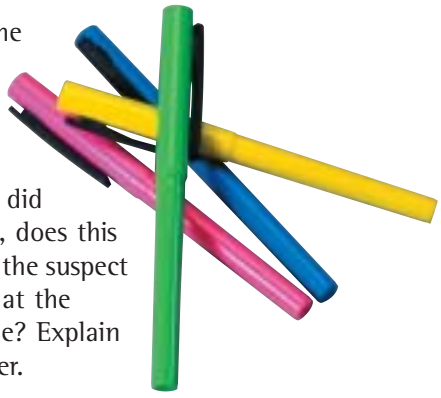
19. If identical twins were suspects in a crime, could DNA profiling be used to find out which was the criminal? Explain your answer.
20. Can fingerprinting be used to identify a criminal in a group of suspects that are all related? Explain your answer.
21. In the 1930s in America, the FBI arrested gangster John Dillinger by matching his fingerprints with those found at a crime scene. Dillinger had earlier attempted to surgically remove, and then burn off the prints from his fingers. Why was the FBI still able to fingerprint him?
22. The fingerprints of a person were found at the scene of a crime. Is that person guilty of committing the crime? Explain your answer.

Pen and paper

23. What technique can be used to compare the colours found in pen ink?
24. Which of the following inks may have come from the same pen?



25. Ink found on a ransom note exactly matched ink found in a pen at the home of a suspect.
    (a) Is this enough evidence to prove that the suspect was at the scene of the crime? Explain your answer.
    (b) If the inks did not match, does this mean that the suspect was never at the crime scene? Explain your answer.



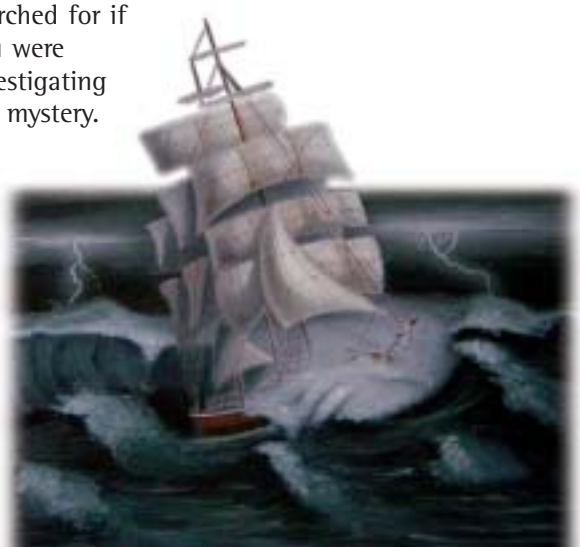
Getting away

1. The tracks left by a getaway car were identified as belonging to a particular make of tyre. All three suspects in the crime have the same make of tyre on their cars. How can the tracks be used to find out which car was at the scene of the crime?
2. What inferences can be made if black tyre marks are found at the scene of an accident where a car has hit a pedestrian?

Checking history

Forensic scientists were called in to analyse a photo of Ned Kelly that sold for over $19 000. For 40 years, the photo was believed to be of Ned Kelly. But some people were not convinced. Forensic scientists used computers to measure the ears, nose, forehead and eyebrow ridge of the person in the photo. The scientists compared the measurements with each other and with other photos of Ned Kelly. All of the forensic scientists independently decided that the photo was not Ned Kelly and the money was returned to the buyer.

3. Measurements taken from a photo are not the same as real-life measurements. A photo is much smaller than a real person. Explain why forensic scientists have to make a comparison between the measurements on one photo before comparing them with those in other photos. *Hint:* How do measurements change from one photo to the next, if one photo is close up and the other far away?
4. Forensic scientists often use techniques such as fingerprinting and DNA testing to solve crimes.
    (a) Suggest some uses, other than for solving crimes, for these techniques.
    (b) Suggest how other forensic techniques or skills could be used for purposes other than solving crimes.
5. Read the short description of the mystery of the *Mary Celeste* on page 97.
    (a) Use the Internet and other resources to find out about expert theories surrounding the mystery of the *Mary Celeste*.
    (b) Write a short story about what you believe may have happened to the *Mary Celeste* and her crew.
    (c) Make a list of the evidence you would have searched for if you were investigating the mystery.



Summary of key terms

analyse: examine closely to answer a question or solve a problem
assailant: a person who attacks another person
autopsy: examination of a dead body. An autopsy is performed to find out how the deceased person died.
ballistics experts: people who analyse bullets, firearms and their effects on victims and shooters. A ballistics expert can match bullets with the firearm from which they were shot.
cartridge: container in a firearm from which bullets are fired
cast: a form that is made by pouring liquid plaster into a mould. The cast is removed from the mould when it becomes solid.
cheiloscopy: the study of lip prints

chromatography: a separation technique that uses the difference between the solubilities of substances to separate them. This technique separates small traces of substances, such as the colours in ink.
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 that the objects can be compared
contaminated: spoiled by adding, removing or changing something at a crime scene
counterfeit: a copy
cuticle: the scaly outer covering of a hair
decomposes: rots or breaks down
diatom: microscopic organism found in fresh and salt water
disfigures: deforms or ruins
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.
documenting: recording of details at a crime scene
entomologist: a scientist who studies insects
evidence: clues that can be used to help solve crimes

eyewitness account: a description of an event, place or person supplied by an observer
facial: relating to the face
fibres: fine threads that make up fabric and paper
forum: the buildings which housed the ancient Roman courts of law
friction ridges: the pattern of ridges and valleys that form fingerprints. They help fingers to grip objects.

image: a picture or visual representation
impression: print or mark formed under pressure. Impressions include marks like fingerprints, footprints and lip prints.
inferences: reasonable conclusions made based on available evidence
maggots: newly hatched flies. Maggots have a worm-like appearance.
magnification: the number of times an object has been enlarged using a lens or lens system. For example, a magnification of two means the object has been enlarged to twice its actual size.
minutiae: small points of detail that are matched up in a fingerprint analysis
mortuary: the place where deceased bodies are kept before their burial
odontologist: a scientists who studies teeth
pathologist: a scientist who studies the cause of death and disease
physical evidence: clues that can be collected from a crime scene and analysed in a laboratory
pigment: a substance that gives an object or fabric a particular colour
polymer: a substance made up of smaller units. All plastics are polymers.
pupa: a maggot that is transforming into a fly
specimen: sample used for investigation or scientific examination
statements: verbal or written accounts
suspect: a person believed to be involved in committing a crime

testify: give evidence
ultraviolet light: light that cannot be seen with the eye
witness: a person who was present at or who knows something about an event