10 Forensic science

HAVE YOU EVER WONDERED...

- why police record eyewitness accounts of a crime as soon as possible?
- how images of suspects are constructed?
- what police can tell from fluff collected from a crime scene?
- why DNA is considered the ultimate 'fingerprint'?
- why Australian banknotes are plastic and not paper?

After completing this chapter students should be able to:

- explain how science inquiry skills are used in forensics to investigate and evaluate evidence
- apply specific skills for the use of scientific instruments
- use modelling and simulations, including digital technology, to investigate situations and events
- outline the effect of a range of factors, such as temperature and catalysts, on the rate of chemical reactions
- describe the role of DNA as the blueprint for controlling the characteristics of organisms
- describe the impact of developments in genetic knowledge
- describe how computers have made possible the analysis of DNA sequencing
- outline the applications of gene technologies
- discuss the use of genetic testing.

10.1 Crime scene

Crime ranges from shoplifting, theft and forgery to assault and murder. All these crimes leave telltale clues that point to those most likely to have committed the crime. The analysis of these clues is the work of forensic scientists. The information that they obtain from these clues is then used against suspects in court. Sometimes these clues are used to defend them.

INQUIRY science 4 fun

Sandpit tracks

What can footprints and a track tell you?

Collect this ...

- access to a sandpit (such as a long-jump pit)
- rake

Do this ...

1. Rake over the sandpit so that it is smooth.
2. Walk slowly across the pit.
3. Walk across the pit again, parallel to your original tracks, but try:
   - a walking faster
   - b walking backwards
   - c changing direction midway.
4. Compare the:
   - a tread of the footprints with the sole of your shoes
   - b depth of the footprints (for example, did the faster run produce deeper prints?)
   - c spacing of the footprints.

Record this ...

Describe what you saw.
Explain what you think caused each of the features you saw.

First on the scene

The first authorities to arrive at a crime scene will usually be the police. They will quickly cordon off (rope off) the crime scene, call for back-up from other police, detectives, crime scene units, ambulance and fire brigade and start interviewing eyewitnesses (people who were there).

CSU

A **crime scene unit (CSU)** is a team of specialist police, photographers and forensic scientists trained in collecting and analysing evidence. Normally the CSU does not deal with less serious crimes like burglary but concentrates on more complex and serious crimes such as **homicide** (where another human is killed), terrorist attacks, **arson** (when a fire is started deliberately) or sexual assault.

Every piece of evidence from a crime scene is a clue, and the CSU thoroughly searches the area to ensure that nothing is missed. Figure 10.1.1 shows three different ways the CSU can do this. Every piece of evidence is then marked and photographed while in position.

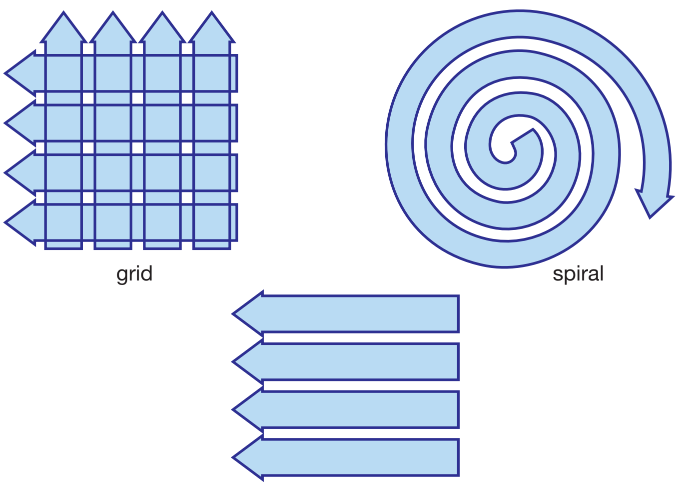

Figure 10.1.1 Three different methods are used by crime scene units to ensure that the crime scene is thoroughly searched.

The crime scene is then cleared and everything is sent away to be analysed by forensic scientists specialised in particular fields, such as **pathology** (the study of disease and cause of death), **ballistics** (the study of guns and bullets), **toxicology** (the study of the effects of poisons and chemicals on the body), fingerprints, fibres, chemistry and dentistry.

The materials found at a crime scene can be classified broadly as either physical evidence or trace evidence.

Physical evidence

Anything that is reasonably large and easy to see is **physical evidence**. It includes dead bodies, bullets, bullet-holes (like those in Figure 10.1.2), weapons, tool marks, tracks, damaged furniture, fingerprints or blood splatters.

Figure 10.1.2 Bullets and the holes they make are physical evidence.

Corpses

A **corpse** is a dead body. A corpse is easy to identify if an ID card, a driver's licence, credit cards or a Medicare card are found on or near it. Photos of the person can be matched with the body and card numbers can be checked against home addresses. A mobile phone will hold numbers of friends and relatives who can be called. They can then view the body and confirm its identity.

Even without these forms of identification, police can be reasonably certain about who the person was. For example, a body found in a burnt-out house is most likely to be one of the people who lived there. Similarly, the body in the driving seat of a badly damaged car was probably the registered owner or someone closely related to them. Hire cars are even easier to track since the driver's name and address will be left at the hire-car company.

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ICE

Many people include ICE in the directory of their mobile phone. ICE stands for **In Case** of **Emergency** and contains the number that you want police to contact if you are found ill or unconscious or have been in a serious accident. Who have you got as your ICE contact?

Evidence of time of death

A series of changes in a corpse begins immediately after death and can be used to determine how long a person has been dead. This information is vital for investigators since it will confirm the day (and possibly the hour) in which the crime was committed. This then allows police to narrow their range of suspects of who committed the murder.

One obvious change is body temperature. A healthy living human has a **core body temperature** of 37°C. After death, this falls at a rate of about 0.8°C every hour until it reaches room temperature (the exact rate of cooling depends on the victim's clothing and the surrounding temperature). This means that a body will cool completely within one day.

Other changes that can be used to determine the time of death are the:

- extent of rigor mortis (stiffening of muscles)
- colour of the skin (shown in Figure 10.1.3)
- extent of decomposition
- type and life-cycle stage of insects present on and around the body.

Figure 10.1.3 Skin takes on a greenish appearance within two days of death because bacteria are starting to decompose the body.

10.1

Tool marks

Every type of tool leaves its own characteristic impression or **tool mark**. For example, the jemmy bar being used in Figure 10.1.4 will leave scratches, dents and cuts in the window frame and sill. Different marks would have been left by a screwdriver, hammer, axe, knife or chisel.

Tool marks depend on:

- the type of tool being used
- whether the material being marked is hard (such as wood or bone) or soft (such as fabric, paper, skin, fat or muscle)
- the sharpness of the individual tool. For example, a sharp saw will produce a fine, crisp cut in wood, while a blunt one will rip the wood and produce a ragged edge
- faults in the tool such as missing teeth or heavy wear patterns.

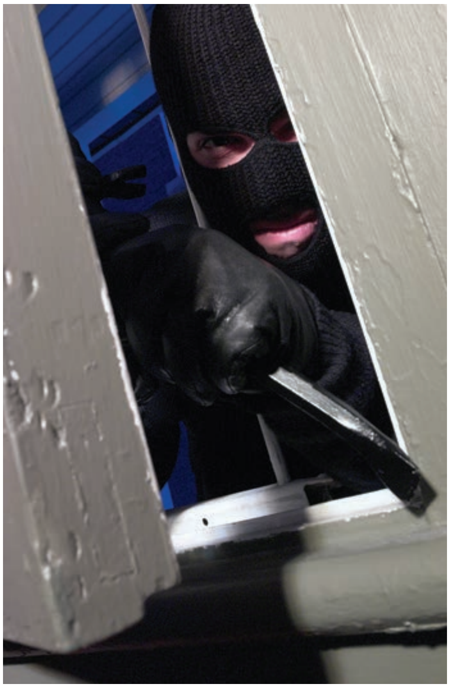

Figure 10.1.4 The marks on a window frame allow investigators to determine whether a screwdriver or a jemmy bar was used to lever open a window. These will be photographed and compared with tools collected from the suspect or the suspect's residence.

Track impressions

Footprints and impressions from shoes and tyres are often left behind at a crime scene. A **positive impression** is an image that is exactly the same as the pattern on the shoe or tyre. Positive impressions are left on hard surfaces by feet, shoes and tyres that are dirty or soaked with water, oil or blood. A **negative impression** is formed if the suspect crossed damp sand, mud, snow, grease or congealing (thickening) blood. This is because the material only gathers in gaps in the tread of the shoes or tyres.

All impressions are photographed next to a ruler to indicate their actual size. You can see this in Figure 10.1.5. Negative impressions will have wet plaster poured into them to form a mould that can be taken back to the laboratory for analysis.

Figure 10.1.5 The make and style of shoe that a criminal wore can be determined from its prints. Even more information comes from cuts, stones, scuffing and wear on the sole.

Collecting fingerprints

In the grooves of your fingerprints are glands that secrete (release) sweat, oils and amino acids. A little of these secretions is left behind as an image of the fingerprint whenever something is touched or picked up. **Non-porous** materials like metal and glass do not absorb sweat, oil or amino acids and so clear fingerprints are most likely to be found on:

- metallic objects such as doorknobs, forks, saucepans, knives and guns
- glass and ceramics such as drinking glasses, windows, mirrors, bathroom tiles, cups, mugs and plates
- the plastics that make up light switches, car dashboards, steering wheels and broom and brush handles
- painted surfaces such as cars and front doors and their surrounds
- polished or varnished surfaces of furniture and stair railings.

As Figure 10.1.6 shows, fingerprints are revealed by brushing special types of powder onto the surface so that it sticks to the oils left behind. Black carbon powder is dusted onto light-coloured and clear surfaces and white aluminium powder is brushed onto dark surfaces.

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Figure 10.1.6 Black carbon powder is brushed onto glass to show fingerprints on its surface.

Porous materials such as fabrics, stone or raw timber absorb body fluids, making it difficult to find fingerprints on them. However, fingerprints can still be revealed by brushing them with chemicals that react with the secretions of the fingerprint. For example, ninhydrin is a chemical that reacts with amino acids, turning the fingerprint a bluish purple. Light can also help to reveal fingerprints, as Figure 10.1.7 shows.

Figure 10.1.7 Some types of light cause fingerprints to fluoresce or glow. Here an investigator is searching for fingerprints left by the 2002 Bali bombers.

SciFile

Superglue fingerprints

Superglue reacts with the oils that make up fingerprints and superglue vapour is sometimes blown onto prints to make them stickier and more visible. Sealed objects such as fridges and cars can be filled with superglue vapour, revealing all the prints inside them.

Blood splatters

Drops of blood tell investigators a lot about what happened at a crime scene. As Figure 10.1.8 shows, they change shape and size depending on the height and direction they fall from.

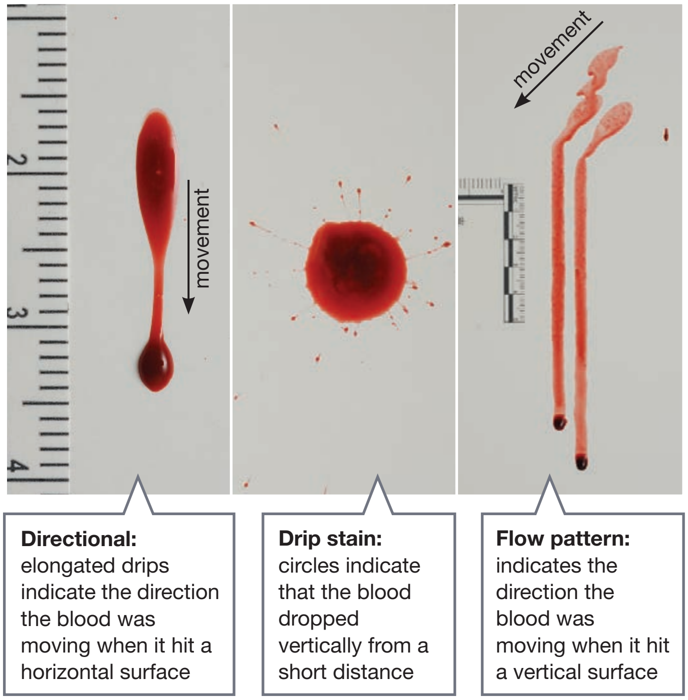

Figure 10.1.8 Blood splatters change shape depending on the direction they hit a surface

10.2

Trace evidence

Microscopic materials found at the crime scene are known as **trace evidence**. Trace evidence is incredibly useful to investigators since the criminal cannot see it and so cannot collect it or wipe it away.

Fibres

Fibres are strands of natural materials such as hair, fur, fluff, wool and cotton, and synthetics such as nylon and polyester. Wherever you go, a few hairs are likely to fall from your head and body and a few threads are likely to drop from your clothes. These get trapped in the carpet, on furniture and on other people's clothes. A violent struggle will cause even more fibres to drop. Investigators can collect these fibres by picking them up with sticky tape or by using a specialised vacuum cleaner.

A microscope is then used to compare fibres with those from other crime scenes and those of the victim and suspects. As Figure 10.1.9 shows, fibres can be identified from their characteristic surfaces.

Fibres do not prove that a particular person was at the crime scene. Many people have the same shirt, jeans or dress and the same colour and type of hair. For this reason, fibres are only **circumstantial evidence**—they point to a suspect but cannot be used as proof that they were there.

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Seeds

Microscopic grains of pollen and seeds found at a crime scene can be compared with plants nearby and in the areas in which the suspects live. This helps investigators to piece together what happened. For example, a body that has been shifted might have seeds from another area on it.

DNA

Wherever you go, you leave a little bit of yourself behind. It might be a few cells of skin, a smear of body oil, sweat, a strand of hair, a few flakes of dandruff or saliva. Saliva is being collected in Figure 10.1.10. **DNA** (deoxyribonucleic acid) is a chemical present in the nucleus of body cells. Everyone has different DNA. This makes DNA the 'ultimate fingerprint'.

Some of the DNA found at a crime scene will come from the victim, some may come from people known to be innocent and some will probably come from the suspect. This proves that the suspect was there at some time.

Figure 10.1.10 The saliva on this cigarette stub will contain the DNA of whoever smoked it.

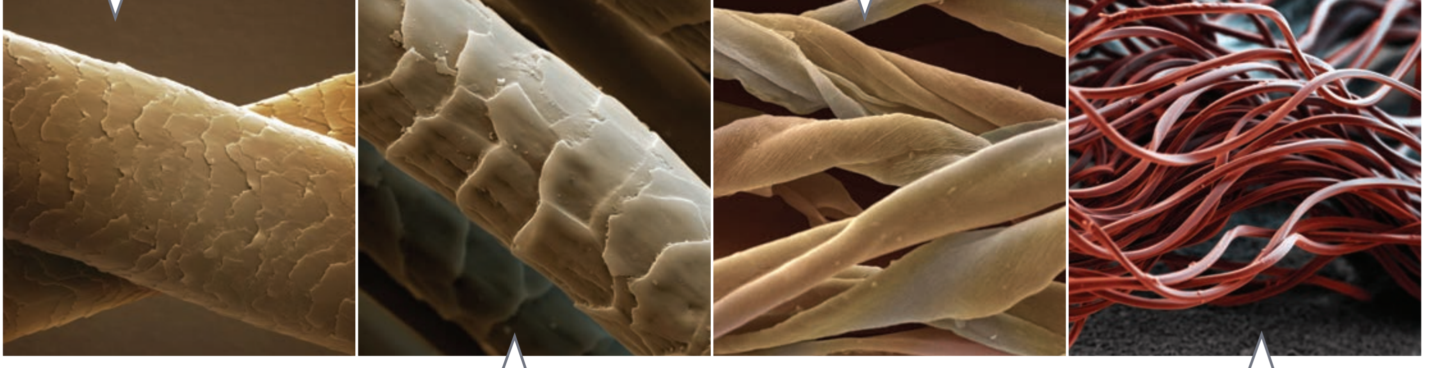


Figure 10.1.9 Fibres can be easily identified since each type has its own characteristic surface texture. These images were taken with a scanning electron microscope (SEM).

10.1 Unit review

Remembering

1 **List** the materials that are left behind on a surface that form a fingerprint.

2 **Name** the chemical used to highlight fingerprints on:
  a light-coloured surfaces
  b dark surfaces
  c porous materials.

3 Many criminals clean up a crime scene before they leave it. Even so, they probably leave behind traces that will help identify them. **List** what these traces might be.

Understanding

4 **Explain** why the CSU makes sure they search every part of a crime scene.

5 A firm, green banana has fallen off a tree.
  a **Identify** the signs that could be used to determine how long the banana has been off the tree.
  b **Explain** how these changes in a banana relate to determining the time of death of a body.

6 a **State** what the core temperature of a healthy human is.
  b **State** how much the temperature of a corpse usually drops per hour after death.
  c **Calculate** what the temperature would be at 1 hour, 2 hours, 3 hours etc. after death. Stop calculating when you reach 24 hours.

7 **Explain** why fibres can only ever be considered circumstantial evidence.

Analysing

8 **Analyse** the two crime scenes shown in Figure 10.1.11 and **list** 20 differences.

9 **Compare** the impressions the following shoe tracks would make by **listing** their similarities and differences:
  - wet shoes walking across dry concrete
  - dry shoes walking across thick grease
  - dry shoes walking across snow.

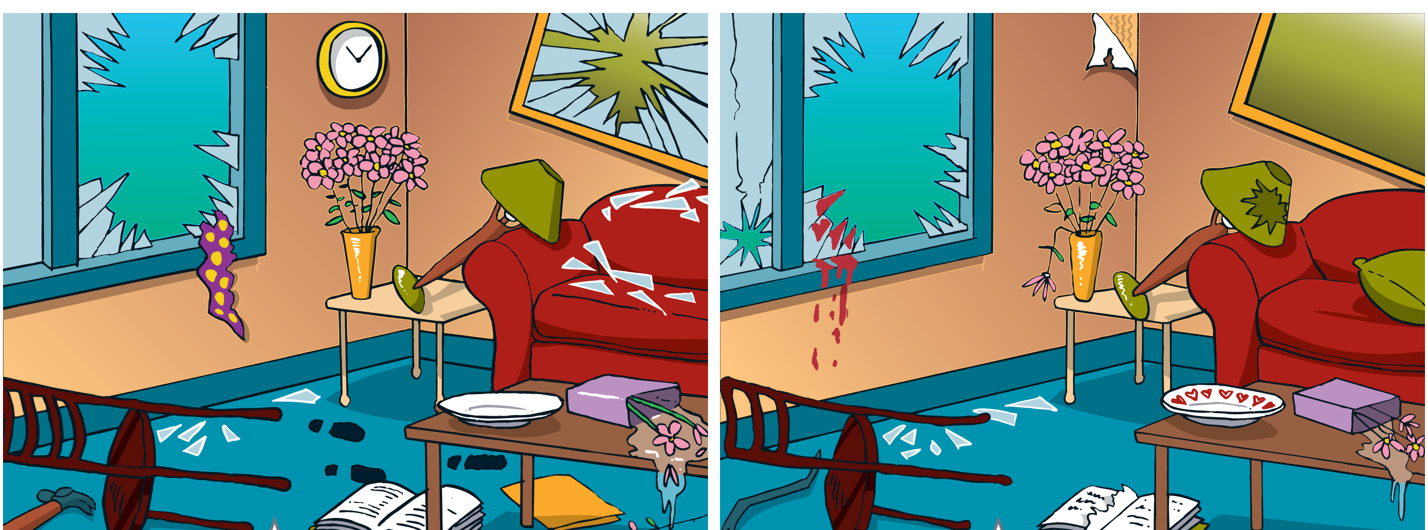
10 **Classify** the following as physical or trace evidence.
  a DNA
  b broken window
  c pollen

11 Imagine running across a sandpit. As you run, you place different pressure on different parts of your foot, producing a print of different depths. **Analyse** the distribution of pressure on your feet as you:
  a run forwards
  b run backwards
  c turn quickly.

Evaluating

12 Fingerprints are rarely found on clothes. **Propose** a reason why.

13 **Propose** what may have happened at a crime scene if the following are found.
  a broken furniture
  b only a few fingerprints and all of them smudged



Crime scene A

Crime scene B

Figure 10.1.11 Spot the differences between these two crime scenes.

14 The two people in Figure 10.1.12 were both seen at a crime scene.

a **Identify** who would be easier for an eyewitness to describe.

b **Justify** your choice.

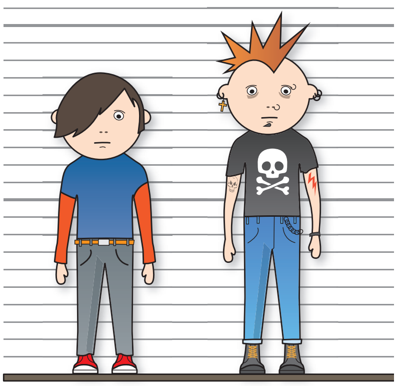


Figure 10.1.12

15 CSU teams wear gloves, masks and full body suits whenever they collect evidence that might contain DNA. **Propose** reasons why.

Creating

16 a From memory, **construct** a detailed eyewitness description of:

i your maths teacher

ii what happened between getting up and arriving at school this morning

iii your family car

iv the room in which you last had English.

b **Assess** how well you remembered in part **a**.

17 The pattern of blood splatters and drips from a wound can help investigators determine exactly where injuries happened.

a Copy Figure 10.1.13 into your workbook.

b Add lines to **construct** a diagram that locates where in the room the person was wounded. One has already been done for you.

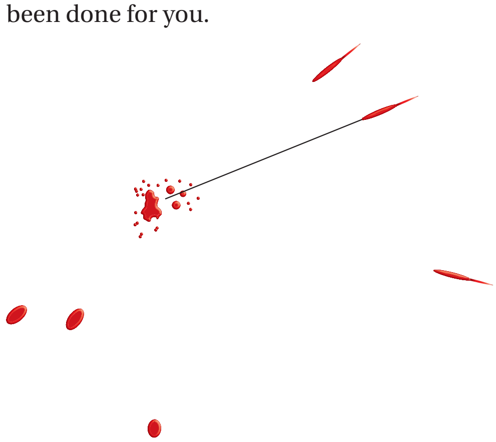


Figure 10.1.13

Inquiring

1 Many conspiracy theories surround the assassination of US President John F. Kennedy in 1963, largely because of conflicting evidence, eyewitness accounts and the strange history of the main suspect. Research and prepare a case study for this assassination. Include the following.

a Name the main suspect and describe what happened to him.

b Summarise his history.

c Propose reasons why many think that he was part of a bigger plot.

d Watch the Zapruder film and summarise what you saw in it.

e Outline the magic bullet theory.

f Describe what the *grassy knoll* is and what people said about it.

g Assess the material you found and classify it as reliable or unreliable evidence.

2 Use the key words *eyewitness games* to search the internet to find interactive games that test how accurate your memory is.

3 Use the keyword *edheads* to find games that test your skills as a forensic investigator.

4 When walking, taller people take longer steps than shorter people.

a Design a way of determining the height of someone based on the length of their steps.

b Show your plan to your teacher and get their approval to run your experiment.

5 Design an investigation that compares the stages that different fruit go through when they decompose. Take note of what happens inside it by making cuts on its surface or by taking a slice out of it. Over a week, record changes in colour, texture, odour and any insects that are seen on it.

10.1 Practical activities

1 Lifting fingerprints

Purpose
To detect fingerprints on different surfaces.

Materials
- variety of objects with different surfaces of different colours (such as glass microscope slide, white tile, glossy wrapping paper, soft-drink can, fabric)
- sheets of newspaper
- carbon powder (or manganese dioxide)
- talcum powder
- soft fine-haired brush
- plastic teaspoon
- broad, clear sticky tape
- white and black cards

Procedure
1. Cover your workbench top with newspaper.
2. Hold each different material or object in your fingertips and then place each on the newspaper.
3. Use the teaspoon to sprinkle carbon or talc onto each object. Choose carbon for light-coloured objects and talc for dark.
4. Use the brush to *gently* dust off excess powder.
5. Place a strip of sticky tape over any prints that you find.
6. *Gently* peel off the tape and stick it onto the card that will best show the print.

Discussion
1. Some of your lifted fingerprints might only be partial (not complete). **Explain** why.
2. **Identify** the types of materials on which no prints were found.
3. **Explain** why prints are difficult to lift from porous materials.

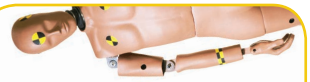
SKILL BUILDER

Using a microscope
1. Adjust the mirror or diaphragm so that the maximum amount of light is passing through the sample.
2. Select the objective lens with the lowest magnification.
3. Looking at the microscope from its side, adjust the coarse-focusing knob to bring the stage and objective lens as close to each other as possible.
4. Looking through the eyepiece, turn the coarse-focusing knob so that the stage and objective lens move further apart.
5. Keep doing this until the specimen is in focus.
6. Adjust the fine-focusing knob to sharpen the focus on the specimens.
7. If you can't focus the microscope, then go back to step 4 and start again.

2 Analysis of fibres

Purpose

To compare different types of fibres.



SAFETY

Some fabrics release poisonous gases when burning.

Do part B in a fumehood or outside.

Wear safety glasses at all times in part B.

Materials

Part A: Under the microscope

- labelled samples of different fabrics made of:
  - natural fibres (such as wool, cotton, linen, silk)
  - synthetic fibres (such as nylon, polyester, rayon)
- labelled samples of other fibres (such as human hair, fur, coir)
- clear sticky tape
- tweezers or pins
- access to stereomicroscope or monocular microscope

Part B: Flame tests

- metal tongs
- matches
- bench mat

Procedure

Part A: Under the microscope

1. Remove an individual thread (about 2 cm long) from each fabric sample.
2. Most threads are made from a number of individual fibres. Use the pin or tweezers to tease them apart.
3. Peel off a strip of clear sticky tape and pat it against the thread so that it sticks.
4. Place the stuck fibres under the microscope and focus to obtain a clear image.

Part B: Flame tests

5. Cut or tear a strip about 2×1 cm from each fabric.
6. Use tongs to hold a strip over the bench mat. Hold a lighted match under the strip.

Results

1. In your workbook sketch and label each fibre, taking note of its surface
2. Record your observations for each fabric when placed in the flame. Did it catch fire, melt or char? What colour was the flame and smoke? What was left?
3. **Compare** the surface of each fibre with the simplified diagrams shown in Figure 10.1.14 and classify each.

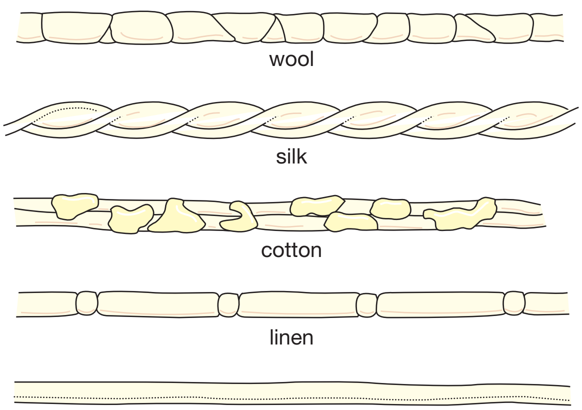


Figure 10.1.14

Discussion

1. **Explain** why fibres are considered to be trace evidence.
2. **Compare** the surfaces of the natural fibres with those of the synthetic fibres.
3. **Classify** the fibres you tested as fibres that burn, fibres that melt or fibres that char (go black but with no flame).