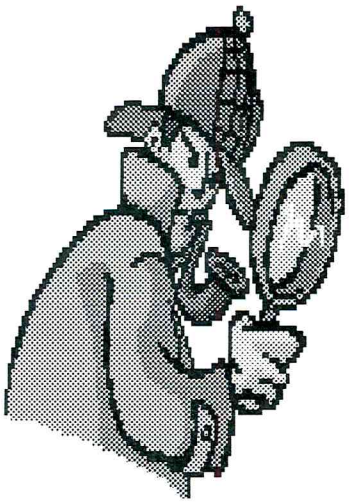

TY Science

Forensic Science Module

Teacher Handout

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2nd Edition August 2004

TY Science Project

Forensic Science Module

The first edition of this module was researched and written by Ms Sindy Meleady, a science education graduate of the University of Limerick. It was revised for the second edition by Ms. Maria Sheehan, a physical education with chemistry graduate of the University of Limerick, under the direction of Dr. Peter E. Childs, as part of the Transition Year Science Project. The project is an activity of the Schools Information Centre on the Irish Chemical Industry (SICICI) based at the University of Limerick and work on the modules was funded by donations from Pfizer Pharmaceutical and Eli Lilly.

First edition: September 2003
Second edition: August 2004

These materials were sent out for piloting in various Irish schools in the 2003-2004 school year and we would like to thank those teachers schools who took part and those who sent back comments.

Table of Contents

PUPILS-SAFETY COMES FIRST

The following is a list of general safety aspects that must be revised before carrying out the experiments.

- Personal protection equipment must be worn at all times i.e. white coat, goggles and gloves
- All long hair must be tied back
- No eating or drinking in the laboratory- never smell or taste anything in the lab
- All chemicals must be handled and disposed of with extreme care
- Any breakages should be immediately reported to the teacher
- Any spills must be cleaned up at once- including water
- Any accidents however small must be reported to the teacher
- Wash hands thoroughly before leaving the lab
- Each individual experiment has its own safety precautions as well as the ones above- note these carefully

Safety is the key to success

Symbols

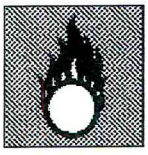
The following are symbols that you must be familiar with in order to carry out each experiment carefully.

CORROSIVE

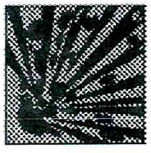
FLAMMABLE

IRRITANT

TOXIC



OXIDISING



EXPLOSIVE

Disclaimer: The authors take no responsibility for accidents or injuries that may result during activities listed in this module. It is the teacher's sole responsibility to ensure the safety of pupils.

The teacher should carry out experiments, investigations and activities prior to the class, in order to ensure that they understand what is happening and that they are prepared for whatever eventualities that may occur.

Pupils must be provided with personal protection equipment for all investigations and the safety notes accompanying each activity should be explained clearly and enforced.

Introduction

TY Science - Forensic Science Module

Introduction for Teachers

"Teaching is one of the finest and most important jobs in the world. It took thousands of years for humanity to discover that water is made up of molecules consisting of two atoms of hydrogen and one atom of oxygen. Teachers can pass that information on to a class of children in ten seconds. Without teachers, society would slide back into squalor well before the next century was out"

Ted Wragg (Irish Independent, 23/10/97)

A new definition of teaching is emerging where the teacher as a centre stage delivery figure is seen as less important. The student is becoming more active and co-operative in the learning process. Today's society has demanded a transition from the provision of 'just-in-case' traditional education to 'just-in-time' and now to 'just-for-me' customised education (OECD, 2001).

In their review of practice, science educators must ask themselves the following questions:

- Are educators keeping up with the advancing technological world?
- Are they preparing our students for the 21st century?
- Will the future work force consist of people who are adequately educated in science?
- Are teachers being kept up to date in their knowledge of science content and teaching strategies?
- Do students have access to orthodox curricula in science?
- Do administrators create an atmosphere that supports and encourages participation in the improvement of science education?

The National Committee on Science Education maintain that school science programmes should reflect science as it is practiced and that a major goal of science education should be to prepare students who understand the modes of reasoning of scientific inquiry and can use them (Haury, 1993).

With this in mind, I welcome you to this Forensic Science Module. This module has been designed to provide teachers with a series of hands-on science classes based on real life forensics.

Its aims are to:

1. Introduce students to the kind of evidence-based objective investigation that permeates science
2. Give each pupil an understanding of the relevance of current topics in chemistry
3. Promote simple, common-sense scientific methods of thought
4. Encourage accurate observation and careful recording
5. Develop sound practical laboratory skills and an ability to work co-operatively and efficiently with others
6. Improve students' manipulative skills and ability to apply understanding in a novel situation.

The module involves a series of nine investigative, high interest, forensic lab activities, the aim of which being to help students understand, apply and master chemistry concepts. Each lab activity emphasises the use of scientific inquiry as a means of thinking and problem solving, while relating scientific processes to technological and societal issues.

Each unit is designed for a single and a double class period, and there are clear links between the units. This allows them to reinforce each other and ultimately build up a coherent unit of study for the student. However, the module is also flexible enough to allow teachers to conduct forensic science classes using whatever units they deem appropriate in whichever order they wish.

The first nine units are as follows:
Unit 1 -> Pattern Recognition
Unit 2 -> Sealed with a Kiss
Unit 3 -> The Write Stuff
Unit 4 -> Dirty Deeds
Unit 5 -> Shoe Did It?
Unit 6 -> The Bloody Truth
Unit 7 -> What is it?
Unit 8 -> Trace Evidence
Unit 9 -> Crack the Code

After completing these units, each student's mastery of chemistry concepts will be assessed through assuming the role of a forensic detective, and using the chemistry skills and forensic techniques learned to collect, analyse and interpret evidence found at a crime scene. This is brought about in the final unit:
Unit 10 -> You be the Detective

Good teachers are not born so;
they are made by conscientious effort.
(Anon)

References:

- OECD. (2001). *E-Learning-The Partnership Challenge.* France: OECD Publications.
- Haury, D.L. (1993). *Teaching Science through Inquiry.* In Eric Digest ED359048. Available at http://www.ericfacility.net/ericdigests/ed359048.html (visited 01 March 2003).

Unit One

LESSON 1 ~ Pattern Recognition

(Single Class)

The aim of this unit is to teach students how to classify several fingerprints based on their recognised patterns. Pupils will also experience techniques associated with lifting a fingerprint from a piece of evidence and making invisible fingerprints visible.

Introduction

The first part of this lesson sees pupils spotting the difference between two pictures. This task is used to illustrate how spot the difference is used as a forensic technique. After the task has been completed discuss the following facts as a class:

- In 1858, William Herschel, the grandson of the famous English astronomer, thought of using a handprint as a signature on a contract, and then began to experiment with fingerprints. While working for the Indian Civil Service, one of Herschel's duties was paying government pensions. To make sure that others were not impersonating dead pensioners.Herschel began taking prints of the right first and middle fingers on receipts. Herschel employed a 'spot the difference' technique just like the one in the above activity, to help him to recognise the prints of impersonators, thereby taking the first step towards the use of fingerprints for identification.

- Fingerprints are left on any object we touch for the following reasons:

The ridges of skin on our fingertips help us to grip things. The patterns of these ridges are unique: no two individuals-even identical twins-have fingerprints that are exactly alike. We leave impressions-or prints-of these patterns on everything we touch with any pressure. The fingerprints searched for at crime scenes fall into 3 main categories: visible, plastic or latent.

Visible prints are the easiest to spot, being those made by fingers that have been in contact with a marker such as wet paint, ink, or blood.

Plastic prints are made by the fingers pressing on a material like soap, wax, or putty, which retains the image of the fingertip ridges.

Latent (invisible) prints are made when the natural oils and perspiration present between the fingertip ridges are transferred to a surface by touch. Fingerprints are taken as proof of innocence or guilt by the courts.

Development

The second part of this lesson sees pupils looking at their own fingerprints. The activity involves them using ink pads to make an impression of their own fingerprints on the table provided.

Students should be encouraged to make good, clear prints by evenly covering each finger with ink and then firmly rolling their fingers onto the chart, this will aid fingerprint classification.

Conclusion

This class will end with pupils comparing and classifying their fingerprints to the diagrams provided. Pupils should consult their friends and compare prints; they should discuss their decisions in order to ensure they have classified their fingerprints into the correct category.

Unit One ~ Pattern Recognition

LESSON 2 ~ Making Prints Visible
(Double Class)

Introduction
The first activity in this class will see pupils carrying out an investigation aimed at making latent (invisible) prints visible to the human eye. The chemistry behind this activity is explained below.

Explanation: When you perspire, fats, fatty acids and sodium chloride are released through the pores of your skin. The giving off of fats is a natural mechanism for keeping the skin moist and soft. When a fingerprint is produced, fats and fatty substances are left behind.
Iodine dissolves in fatty substances and then reacts with them. Allowing the evaporated Iodine to react with the fat can therefore produce an outline of the fingerprint. Because it is only the fat of the fingerprint that reacts with the Iodine and turns brown, the ridges of the fingerprint are shown clearly.

Development
The second part of this lesson sees pupils solving a crime of their own. The 'Finger of Suspicion' activity allows students to lift a fingerprint off a piece of evidence from a crime scene. They will then compare this fingerprint with those of five possible suspects. You will have to collect a series of five fingerprints for use in this part (using ink pads get people in the staff room to supply a fingerprint, one of these ~ the thief ~ will also have to place their fingerprint on a number of tins that the pupils are going to examine).

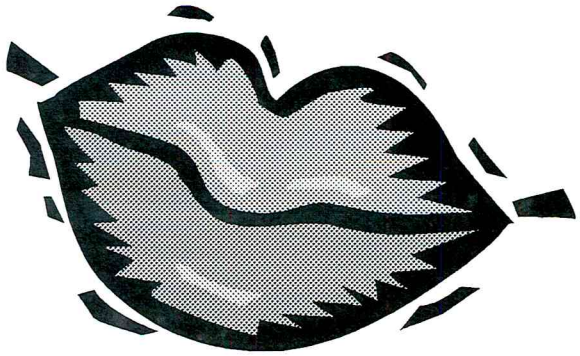
This activity will give students an opportunity to demonstrate what they have learned and its potential as a learning activity would be maximised if two or three of the five suspect prints were quite similar. Competency in this area will be assessed by each student's ability to draw deductions based upon observations and the results of activities.

Conclusion
The class will end with a discussion and debate on who the possible thief is and how the skill of lifting a print can be improved.

Relevant Links for this unit:

- http://www.cornwallis.kent.sch.uk/intranet/elearn/science/crime/crimebusters/1finger.htm
- http://www.cyberbee.com/whodunnit/fp.html
- http://www.cornwallis.kent.sch.uk/intranet/elearn/science/crime/1crime.html
- http://www.canteach.ca/elementary/life14.html
- http://www.manitobamuseum.ca/sg_fingerprints.html

Unit Two ~ Sealed With A Kiss



Unit Two

LESSON 1 ~ Sealed with a Kiss 1

(Single Class)

This unit aims to introduce students to the forensic techniques of lip print comparison and thin layer chromatography.
It also hopes to make students aware of the role pattern recognition plays in this area of forensic science.

Introduction

The first part of this lesson sees pupils being introduced to different terms associated with forensic science. They will suggest definitions for these terms by looking at the words before discussing as a class the actual meanings. The following information should be discussed as a class:

- Odontology is a branch of medicine dealing with the anatomy and development and diseases of the teeth. The science that looks at the teeth, their structure and development. Discuss how forensic scientists could use odontology in solving crimes.
- Anthropometry - measurement and study of the human body and its parts and capacities. Anthropometry involves measuring parts of people's bodies for the purpose of classification and comparison. The most famous aspect of this was the measurement of people's skulls in an effort to demonstrate that the skulls of certain races were smaller. It was also used to classify certain facial characteristics as belonging to naturally criminal people.
- Lip prints are unique to the individual and the following is a history of lip printing: In 1970, Japanese researchers conducted a study of lip prints. As part of this study, researchers examined the lip prints of 1,364 individuals, ranging from 3 to 60 years of age. In 1991 another study was conducted to compare the lip prints of 150 individuals, ranging in age from 4 to 85 years of age. This study included both genders, as well as five pairs of identical twins, and applied the same methods of classification and recording as those in the previous study. Although the methods for obtaining prints differed somewhat in the two studies, the results were the same. Their findings indicated that:
  - ✓ Every individual has unique lip prints-no two were identical in either study
  - ✓ Heredity plays an important role in lip pattern development (Similarities were found between parents and children)
  - ✓ Unique features are distinguishable (Although parents and their children have similar groove traits, the prints are not identical, even in the case of identical twins).

Development

The second part of this lesson will see pupils looking at their own lip prints and classifying them according to their shape. Encourage pupils to look at each others lip prints. This will highlight the fact that everybody has a different lip print.

Conclusion

The final part of this lesson will see pupils solving a crime. Pupils will go about solving the first part of this crime in today's lesson and will continue their investigation in the lesson that follows.

Pupils are asked what the first logical strp to take in this investigation is.

The logical first step in this investigation would be to classify both the lip prints found at the scene of the crime and those of the suspects in a chart similar to the one below.

As mentioned earlier, a lip print may be made up of a combination of groove types so it is possible that you may identify more than one groove type for each of the lip prints in this investigation.

(You will need to provide pupils with sample lip prints, again get your colleagues in the staff room to supply the prints, remember each must use a different brand lipstick and you must obtain a sample of this lipstick for the next lesson)

	Branching grooves	Short vertical grooves	Long vertical grooves	Diamond grooves	Rectangular grooves
Crime scene lip print					
Suspect 1					
Suspect 2					
Suspect 3					

Get pupils to look closely at each of the lip prints. Pupils should identify the lip print that matches the crime scene lip print.

If there is time at the end of todays lesson encourage pupils to think of a way they could definitely identify the criminal. Lip prints do not stand up in a court of law, therefore they will need to carry out a more accurate test.

It is pivotal that they become aware of the need for scientific 'backup', in this case, the need for lipstick analysis.

Students should be allowed to brainstorm as a group, when deciding what technique to use for this analysis, and, with careful guidance from their teacher, arrive at the conclusion to try chromatography.

LESSON 2 ~ Sealed with a Kiss 2
(Double Class)

Introduction

The first part of this lesson will see pupils looking at the technique of chromatography. Discuss chromatography as a class. The teacher could also provide pupils with a visual aid by using filter paper and water-based markers. This would be a helpful way of introducing pupils to chromatography as they can see the ink of the marker splitting up into its different colour components. They will then be able to use this information for the lipstick analysis.

Development

Discuss the following as a class before carrying out the second part of the investigation:

- Mixing together several coloured chemicals makes coloured lipstick. Thin Layer Chromatography can separate the mixture of coloured chemicals so you can see what colours the lipstick is actually made from. Each makeup company produces their lipstick colours using their own secret mixtures of coloured chemicals. This means we can identify what kind of lipstick the culprit was wearing and match it to that of one of the suspects.

You will have to spend some time explaining the procedure to pupils before they carry out the investigation. Pupils should work in groups of three or four.
Remember you must provide pupils with the sample lipsticks that you obtained for the last lesson.

Move from group to group while pupils are working to clarify ideas and offer assistance. The materials needed for this lesson are as follows:

- Lipstick (Students must be presented with three tubes of lipstick of the same colour, but different brand. The tubes must be labelled A, B, and C)
- 3 TLC (Thin Layer Chromatography) strips
- Prepared TLC strip containing sample of lipstick from crime scene placed in envelope marked 'lipstick: evidence'
- Acetone
- Scissors
- 4 beakers

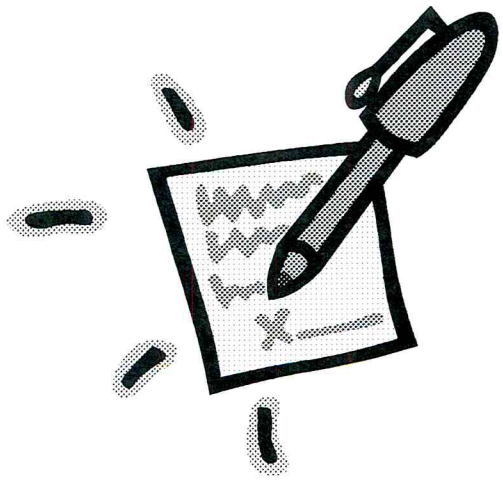
Chromatography solvent (propanone = acetone) produces unpleasant, noxious fumes and is flammable. This experiment must be carried out in a fume cupboard or in a covered container.

Conclusion

The class will end with a discussion and debate on who the culprit is. The following web links can provide additional information:

- http://www.fbi.gov/hq/lab/fsc/backissu/april2002/verdu.htm
- http://www.doggedresearch.com/chromo/chromatography.htm

Unit Three ~ The Write Stuff



Unit Three

LESSON 1 ~ The Write Stuff

(Single Class)

This unit aims to teach students how to use visual examination to identify an authentic signature from forgeries. The students will also perform experiments to make and use invisible ink and to explain the chemistry behind this. This unit also hopes to make students aware of the importance of individual differences and pattern recognition in this area of forensic science.

Introduction

The first part of the lesson will see pupils discussing the uniqueness of ones handwriting. As a class come up with a number of ways one would go about identifying a persons handwriting. The following information should be discussed:

- Just like fingerprints, no two people have the exact same handwriting.

- Handwriting analysis involves examining the following characteristics:
  - ✓ The relative size of the letters
  - ✓ The extent and direction of the slant of the letters
  - ✓ The roundness or angularity of the letters

- Though the style in which one writes varies slightly as their mood changes, and their opinions on the subject they are writing about, the general technique remains the same, and can be recognised based on specific characteristics.

Development

The purpose of the next activity, 'Catching the Secret Letter Writer', is to introduce students to forged signatures and to the visual comparison techniques (again, the recurrent theme of pattern recognition) used to determine if a signature is real or not.

The following materials are needed for this activity:

i. Note A- An authentic note from Mrs Carroll containing her signature. You should ask one of your colleagues to write a note similar to the following:

> Dear Teacher,
> Please excuse Mark from school yesterday as he had to go to the dentist.
>
> Sincerely,
> Mrs Carroll

ii. Four samples of Mrs Carroll's signature, the authenticity of which is unknown. Before the class, decide how many of the signatures you want to be real. Have the same person who wrote Note A, provide the real samples and then obtain the other samples from different people. It is important to have the signatures as close as possible so that it is difficult to determine the differences.

iii. The suspicious note- Depending on whether you want this note to be real or not, have either the 'real' Mrs Carroll or one of the 'fakers' write this note. The note should be similar to the following example:

> Dear Mr Walsh,
> Please excuse Mark from his P.E. classes, he hurt his leg in football practice.
> Mrs Carroll

Pupils should discuss how they will approach the investigation the following steps could be used:

Step 1: The first step should be to analyse the handwriting from the note we know to be written by Mrs Carroll. In doing so, one can pick out distinct characteristics of her handwriting and record them for later use.

Step 2: They should now have two questions which they must find the answers to:

1. How many, if any, of the four samples of Mrs Carroll's signature are authentic?
2. Did Mrs Carroll write the note received this morning?

Conclusion

This class should end on a discussion on whether the note is authentic. Pupils should also suggest alternative methods of identifying whether or not the note is a forgery in order to strengthen their findings. The following activity could also be carried out:

Pupils may feel that the detection of a forgery by handwriting analysis is not really conclusive. They may wish to prove a signature is a forgery by analysing, through chromatography, the ink used to make the signature.

Ballpoint pens have been in use for over 50 years and are the most common of all our writing instruments. The examination of these kinds of inks sometimes becomes important in a legal case, and in a typical crime laboratory, the analysis of the inks used on questioned documents such as contracts, wills, checks, tax returns, threat notes, etc., becomes the responsibility of the forensic chemist.

Perhaps, as a group you would like to analyse the inks used to write the documents in the above case study. If so, the information contained in module 2 should help you to devise an experiment and explain your results.

LESSON 2 ~ The Case of the Forged Documents
(Double Class)

Introduction
The first activity in this lesson is to discuss the article on forgeries. The section should direct students to realising that other methods are needed to solve this case. The scientific analysis of the inks used through chromatography is suggested as a further activity in the last lesson, but can also be carried out as an introductory activity to this lesson.

Development
The second activity in this lesson, 'The Chemistry of Invisible Inks', provides students with a fun way of writing secret messages in invisible ink as well as discovering the chemistry behind this. Share the following fact with the class:

- Artefacts from World War II are quite common, but a postcard turned up a few years ago which caught everyone's interest.
  The postcard had been sent out of Poland during the occupation. There wasn't anything of interest to the Germans on the postcard, or so they thought. Beneath a one sentence letter on the postcard was a message written in invisible ink! The message makes an urgent request for supplies, including invisible ink. It included sentences describing Nazi death camps and gas chambers. It told a story about a person we might not have even known about otherwise.

Mystery novels and spy movies often describe secret messages written in invisible inks that become visible only when treated in a certain manner.
Using it may be the work of spies, figuring out what it says the work of a sleuth; but concocting recipes for invisible ink is definitely the work of a chemist!

Pupils will then carry out a number of activities in order to make invisible ink and then read these invisible messages. Carry out activity one first as the lemon juice takes time to dry, pupils can carry out the other activities while it is drying and return to it at the end of the class.

The teacher should move from group to group offering assistance to pupils and clarifying ideas.

Conclusion
The class should end with pupils discussing the questions at the end of the handout. Encourage them to think of alternatives, if you have time try these out.

Suggested activity:
The following activity could also be carried out.
Now that pupils have been trained in ink and handwriting analysis, they should be able to examine real cases. Do they recognise the clues? Will they reach the same conclusion as the experts?

Each student should research one of the following cases, the Charles Lindbergh Junior case or the Clifford Irving forgery.

- Students researching the *Charles Lindbergh* Junior case will answer the following questions:

1. How did the ransom notes help solve the case?
2. What were the investigators looking for when they analysed the notes?
3. Were the notes useful in determining whether or not the suspect was guilty?
4. What was the conclusion that the investigators came to?

To help answer these questions they will use the following website and the links it provides:
http://www.crimelibrary.com/criminal_mind/forensics/literary/3.html?sect=21

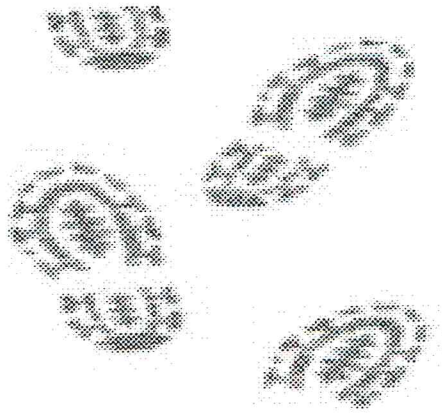
- Students researching the *Clifford Irving* forgery will answer the following questions:

1. What did Clifford Irving do?
2. Why did people believe that his writing was actually that of the billionaire Howard Hughes?
3. How did the investigators end up solving the case?

To help answer these questions they will use the following website and the links it provides:
http://www.crimelibrary.com/criminal_mind/forensics/literary/2.html?sect=21

Students researching the same case should work together in small groups and summarise the case for the rest of the class. They will then share with the class what they discovered from their research.

Unit Four ~
Dirty Deeds



Unit Four

LESSON 1 ~ Dirty Deeds 1

(Single Class)

This unit aims to teach students about the different types of soil and their properties. It also offers pupils the opportunity to conduct tests on several soil samples to determine their properties.
Finally this unit aims to make students aware of the importance of soil and its properties in forensic science and to allow students to use the information and techniques they have gained from this unit to solve a crime.

Introduction

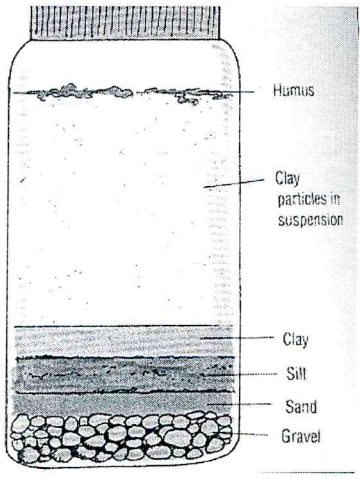
The class starts with a discussion on the information supplied on the student handout. Pupils are then asked to define exactly what soil is. The following information should be included in the discussion:

- Soil is defined as the naturally deposited material covering the earth's surface whose chemical, physical and biological properties are capable of supporting plant growth.
- Comparing soil samples can be a difficult task because there are often big differences between soils that are found only a few metres away from each other. The composition of various soils depends on their origin and the natural forces of erosion and decomposition that act upon them.

Development

Next pupils will look at density-gradient tubes in the analysis of soil. Use the following information to explain to pupils what is happening:

- When a sample of soil is poured into this density-gradient tube, each particle sinks until it reaches a layer that is of a density equal to its own, where it remains suspended in the liquid. Each soil sample consists of particles of different densities, which reveal themselves as dark bands of suspended particles in the tube's different layers.
- If a second tube is made up of identical density bands of liquid, and a second soil sample is poured into it in the same way, scientists can see whether or not the bands of particles match.
- Ensure pupils write this explanation into their handouts. The following could be used as a visual aid:



Before carrying out the scientific tests, it is important that pupils research the following types of soil and take note of their characteristics: loam, sandy loam, clay loam and humus loam. After doing this pupils are ready to carry out the tests and record their observations.

Conclusion
Pupils will then be presented with the case of farmer Jones. This activity allows students to examine a variety of properties of soil and to determine the information these properties can provide in a criminal investigation. In todays lesson pupils will perform several tests on the soil samples in the context of an investigation. They will complete the investigation in the following lesson.

For this investigation you must provide the students with 4 soil samples

- A is the soil from the crime scene.
- B, C and D are soil samples taken from the shoes of three suspects.
- B, C and D must be taken from different areas and you should try to obtain different soil types.
- Depending on who you decide the culprit is, you should then provide a second sample of the suspect's soil type as sample A.

LESSON 2 ~ Dirty Deeds 2
(Double Class)

Introduction
Today's class will start with a revision of the results we obtained in the last lesson. Pupils should also read the investigation procedures in order to ensure that they understand what is happening during the class

Development
The next part of the lesson sees pupils continuing their investigation of the soil samples. As in the previous lesson move from group to group offering advice and assistance. Ensure pupils know what they are doing before they start.

Conclusion
This lesson should end with pupils discussing and deciding who destroyed farmer Jones' roses. The following web link provides additional information:

- http://www.florence.ars.usda.gov/kidsonly/element/dirt.htm

Unit Five ~
Shoe Did It?

Unit Five

LESSON 1 ~ Shoe Did It?

(Single Class)

The unit aims to teach students about foot and shoe-prints and the information they can provide. Pupils will be able to make a cast of their own footprints and pick out any of its unique characteristics.
This unit also hopes to provide students with an opportunity to practice the skills involved in scientific inquiry by solving a typical forensics case involving footprints and their knowledge on the topic.

Introduction
The first part of this lesson sees pupils discussing the use of footprint in forensic science. The class will brainstorm and discuss ideas. The following could be included in this discussion.

- Footprints are a valuable source of information for forensic scientists also.
- In a case where an intruder has committed a crime, a detailed search of the scene and its surroundings may reveal foot/shoe prints. Prints of naked feet (like those of our primitive ancestors in Laetoli) are not often found at the scene of the crime – even the primitive brain of a criminal has evolved to wearing some form of footwear!
- However, there has been cases in which a burglar has taken off his shoes and socks, and placed the socks on his hands, so as not to leave any fingerprints – the problem? Footprints are just as identifiable!
- Shoeprints, even though are usually incomplete, can provide useful clues as to the identity of the intruder as well as indicating the size of his or her feet.
- Foot or shoeprints found at the scene of a crime may be indented in mud, sand, or other materials, in which case a cast in plaster of Paris or silicone rubber is made of them, or, if they are visible on a dusty floor, they can be photographed.
- Nowadays, with such a high level of consumer choice, footwear manufacturers cast shoes in a wide variety of patterns. The diversity of these patterns can help investigators to identify a specific make and model of shoe. Where the shoe is not new, an accurate cast may even reveal patterns of wear dictated by the owner's gait, a characteristic unique to every individual.

Development
The next activity asks students to make a cast of their own footprints. This activity aims to show students how investigators make casts of footprints at a crime scene. The period of time needed for the cast to dry is 48 hours. Pupils will therefore make their casts in this lesson and examine them in the next lesson. If there is time at the end of this lesson make a number of different prints, like those suggested in the student handout.

Conclusion
This lesson will end with pupils discussing the questions at the end of the student handout. Discuss as a class how you will remove the prints from the soil without destroying them in the next lesson, what equipment will you need (brushes to remove small particles of soil etc).

LESSON 2 ~ Shoe exactly did it?
(Double Class)

Introduction
The first part of this lesson sees pupils returning to and examining the casts they made in the previous lesson. Pupils will have already decided how they are going to treat these casts in order to remove them from the soil. Revise this and allow pupils some time to examine their prints. Get pupils to answer the questions posed in the student handout.

Development
Pupils are then going to look at different types of casts and compare them against each other. Pupils should fill in the table provided in the student handout and then discuss their opinions as a class.

The next activity is entitled 'Shoe Did It?. It gives students the opportunity to use the skills they have acquired to solve a typical case involving footprints.

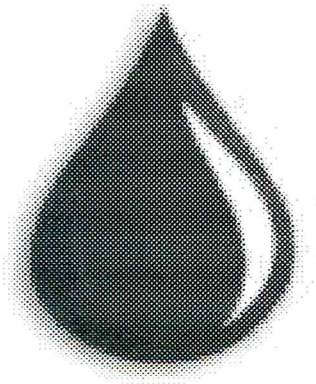
Before the lesson you will have to acquire three footprints from different people but involving the same shoe type. Probably the easiest way to find these footprints is to ask students in some of your other classes or even the school sports teams. One of your volunteers will have to provide two copies of his/her footprint, the second one being the footprint found at the crime scene. You are then required to photocopy this footprint onto some acetates (about 5 per class) in order to help students complete step 4 of this activity.

During the activity move from group to group in order to ensure pupils understand what they are doing and to provide assistance where it is needed.

Conclusion
The end of this lesson will see pupils coming together as a class to decide who committed the crime. Offer pupils the opportunity to debate ideas before telling them the correct answer.

Students are also asked at the end of the lesson to suggest any skills/ knowledge that they may have gained from other modules that may be of help to them in this lesson. It is hoped that students will discuss areas such as pattern recognition, soil analysis, trace evidence etc in their answers.

Unit Six ~ The Bloody Truth



Unit Six

LESSON 1 ~ The Bloody Truth

(Single Class)

This unit aims to introduce students to two techniques used by forensic scientists to analyse blood samples. To make students aware of blood types and the importance of knowing an individual's blood type and to provide students with an opportunity to practise critical thinking and reasoning skills.

Introduction

The first part of this lesson will see pupils revise some of the ideas they met in their junior certificate science course. Ensure pupils understand the function of each of the parts of the blood listed.

Pupils will then put their reasoning skills to the test as they attempt to list a number of substances that can be mistaken for blood at a crime scene. Discuss this section as a class.

Development

The next part of the lesson sees pupils being introduced to two methods, used at a crime scene, to test for the presence of blood. It is the teacher's responsibility to present these methods to the class in a fun way that is easy for pupils to understand. The following information should be discussed:

If examiners want to search a crime scene for blood they use two main tests:

- The first test uses a powerful light whose strong beam can often reveal traces of blood that would otherwise have remained unnoticed.
- The second test relies on a chemical called luminol, which reacts with blood to glow in the dark. Examiners darken the room in question and spray all areas with this chemical. Any blood present will emit a faint blue glow.

These test show up the presence of blood, however, to be sure the substance is indeed blood we need to carry out a number of other tests. Pupils will carry out two of these tests now. You need to make sure the material needed by pupils is available and the pupils understand what they are doing.

The chemistry behind method number one is as follows:
Blood contains an enzyme called catalase. Spend some time discussing enzymes with the class. Introduce them to the lock and key theory.
Substances that bubble with the addition of hydrogen peroxide are said to test positive for catalase. Blood tests positive for catalase and so this can be used as a chemical test to prove a substance is indeed blood.

However, criminal investigators do not typically use the catalase test at crime scenes. Other simple tests are better at detecting very dilute concentrations of blood - sometimes so dilute the human eye can no longer see the stain. Phenolphthalein is one such chemical used in this way.

******N.B For method 2 the Phenolphthalein must be in the reduced state. It must be refluxed with Zinc until its pink colour in the alkaline state is reduced. ******

LESSON 2 ~ Testing blood samples
(Double Class)

Introduction

The first activity allows students to perform and revise two chemical tests used by forensic scientists to identify blood samples. Students predict whether or not the substances provided will prove to be positive or negative for each chemical test then test their predictions. The chemical tests used are the catalase and phenolphthalein tests. While there are more sensitive tests for blood that a forensic scientist might use, these are the cheapest and easiest to use in a classroom setting.

Materials needed:

- Dropping well
- Phenolphthalein solution
- Plastic droppers
- Hydrogen peroxide
- 7 suspected solutions…The following are recommended:
  - Blood (chicken or cow) must be used for solution A. This may be obtained from a butcher or meat packing facility
  - Red paint
  - Red food colouring
  - Fresh tomato
  - Fresh beet root
  - Canned tomato juice
  - We recommend that a blood sample is diluted beforehand and used as one of the suspect solutions. This will prove negative for catalase and positive for phenolphthalein.

Note:

Students must wear gloves throughout the activity to impress upon them the dangers when working with blood.
Phenolphthalein solution may also burn or irritate the skin.

Allow pupils time to carry out their investigations and then come together as a class to determine which samples contained blood and which did not.

Development

For the second part of the class, move pupils to a computer laboratory where they can research topics that they will be discussing in more detail. This part of the lesson briefly introduces pupils to the concepts of the pattern and shape of drops of blood and DNA.

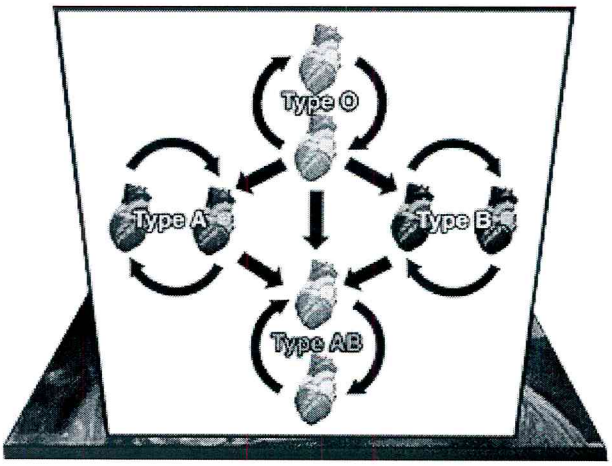
Introduce a topic and give pupils time to research it on the internet, then come together as a class and discuss what pupils have found. Spend some time discussing what information a drop of blood at a crime scene provides.

A website is provided which allows students to explore in detail the concept of DNA. (DNA and DNA fingerprinting will be covered in more detail in module 8 ~ Trace Evidence).

Conclusion

The final part of this lesson will see pupils looking at the different blood types. You will need to present the following information to the class in a manner that pupils can understand. The following information should be discussed:

- If the red blood cell had only "A" molecules on it, that blood was called type A. If the red blood cell had only "B" molecules on it, that blood was called type B. If the red blood cell had a mixture of both molecules, it was called type AB. If the red blood cell had neither molecule, that blood was called type O.
- If two different blood types are mixed together the blood cells may begin to clump together in the blood vessels, causing a potentially fatal situation. Therefore, it is important that blood types be matched before blood transfusions take place.
- A person with type A blood can donate blood to a person of type A or AB. Similarly, a person with type B blood can donate blood to a person of type B or AB. A person with type AB blood can donate blood to a person with type AB only. A person with type O blood can donate to anyone.



- A person with type A blood can receive blood from a person with type A or O. A person with type B blood can receive blood from a person with type B or O. A person with type AB blood can receive blood from anyone. A person with type O blood can receive blood from a person with type O only.

Once the above information has been received and understood by pupils get them to fill in the table provided in the student handout.

Because of these patterns, a person with type O blood is said to be a universal donor. A person with type AB blood is said to be a universal receiver.

Unit Seven ~
What is It?

Unit Seven

LESSON 1 ~ What is it????

(Single Class)

This unit aims to make students aware of the chemical tests used to identify unknown substances. It allows pupils to perform experiments to identify mystery powders and metals. This unit acts as a revision of the reactivity series and helps students to draw deductions based upon observations and the results of two scientific experiments.

Introduction

The first part of this lesson is a discussion on the different types of chromatography that exist. You must present the material to pupils and explain any queries they have. Once pupils have an understanding of the different types of chromatography get them to fill in the table provided in the student handout. The following information should be included in the discussion:

- A lot of useful information can be gained from the analysis of tiny amounts of drugs, dyes, chemicals and unidentified substances. To analyse the composition of such samples, we need to separate their components and identify the individual substances present.
- Separation techniques such as chromatography and mass spectrometry have greatly enhanced the ability of forensic scientists to detect criminal evidence. These techniques are used to solve mysteries not only by scientists in crime laboratories but also by people working in airport security services and environmental, agricultural and wildlife agencies.
- One of the most sensitive techniques available for separating and identifying the components of a mixture is chromatography.
- Thin layer chromatography can be used to identify drugs, pigments from fibres or ink from documents. High performance liquid chromatography allows scientists to analyse the drugs and pigments. Gas chromatography is used to analyse accelerants e.g. lighter fuel or petrol and to measure the alcohol levels in blood or urine.

Development

The next activity provides the students with the opportunity to perform six tests on a variety of white powders. Through these tests the students will learn how to determine the composition of each unknown mixture in the next lesson.

Ensure the materials needed by the pupils are available and that pupils understand what they are doing. Move from group to group to ensure pupils are filling in their results sheets. These sheets and the results themselves are important as they play a vital role in the next lesson.

Conclusion

End the class with a discussion of the different results. Ensure pupils agree on these test results. Spend some time discussing the reactions that were taking place in each of the above tests.

LESSON 2 ~ Powder Mystery
(Double Class)

Introduction
Introduce this class with a short discussion on the results from the previous lessons investigation. Revisit the science behind each of the tests and encourage pupils to write a word equation for each of them. (Depending on pupils abilities introduce chemical equations)

Development
The second part of the lesson will see pupils solving a crime that occurred in Jack Kielty's kitchen.

For this activity you will need to prepare a mixture of baking soda and salt and a mixture of potassium iodide and salt prior to the class. You must then label these mixtures as 'mixture 1' and 'mixture 2'. The guilty party will not of course have the potassium iodide and salt mixture, as potassium iodide is unlikely to be found in a kitchen.

Conclusion
End this class with a discussion on what other forensic techniques one could use in order to determine who the criminal is. Pupils should mention the different techniques they have been study during the course of this module e.g. fingerprints etc.

Additional lesson idea 1:

The Mystery Object

A strange looking piece of metal has been found at a crime scene. Investigators need to establish what kind of metal it is before they can hopefully work out where it came from and who owns it.

Activity: Metals' Premier League

This activity will allow pupils to examine several mystery samples of metals and their reactions. Through playing a Metals' Premier League competition you will also be able to place the metals in order of their reactivity.

The four metals to be used here are calcium, magnesium, zinc and aluminium.

Materials needed

- 4 mystery metals, marked A,B,C,D
- Water
- Dilute HCl
- Tongs
- Deflagrating spoons
- 4 Test- Tubes
- Bunsen Burner

Procedure:

1. Examine each of the four samples of metals. Record any observations you make on each metal. Is it shiny/dull? Etc.
2. Take 4 test- tubes and fill them to about one-third their volume with water.
3. Into one test- tube place a piece of metal A, into another a piece of metal B, into another a piece of metal C and into another one a piece of metal D. Write down your observations.
4. Repeat steps 2 and 3 above but this time put dilute hydrochloric acid into the test- tubes instead of water.

Safety Note:
All P.P.E must be worn during the experiments. Care must be taken when using the hotplates and/or Bunsen burners. Adding calcium to the acid during 'Metals' Premier League' must only be carried out under the teacher's direct supervision.
Warning: The addition of calcium to the acid should only be carried out under the direct supervision of your teacher. Safety glasses must be worn.Again, note your observations. Does any gas evolve? If so, what is this gas? How could you test for it?

5. Try to ignite a sample of each of the metals by holding it in the flame of a Bunsen burner. Use a deflagrating spoon for the calcium and a tongs for the other metals. Note your observations.

Discussion:

1) For each of the reactions (reactions with water and dilute HCl), any change at all is deemed to be a 'win'. But you must decide the degree of the reaction and award the points accordingly.
   4 -> Strong reaction
   3 -> Medium reaction
   2 -> Weak reaction
   1 -> No reaction
2) Add up the points. Now rank each metal according to their score and therefore their place in the 'league table'.
3) What is the order of reactivity?
4) Using the order of reactivity and the notes you made throughout the experiment, can you now identify each metal?

Additional lesson idea 2:

1. Unwanted fires, deliberately torched cars, major transport disasters-all of these result in thousands of deaths per year and a puzzle for fire and forensic departments everywhere. Traditional materials are being replaced by more dangerous accelerants increasing the risks of fire. But how does one find out what caused a fire? How can knowledge of chemistry be of benefit? Write a short report on the nature of fire and the chemistry involved using the following website as an aid:

http://www.channel4.com/science/microsites/S/science/society/fire.html

OR

2. The following is an excerpt from an article that appeared in the Irish Independent on Thursday June 26th 2003:

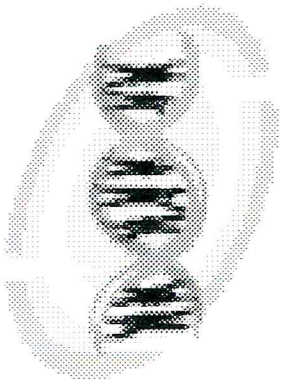
Cocaine on nearly all euro notes

Almost all euro bank notes have traces of cocaine, according to a study by German scientists.

Rolled up banknotes are often used to sniff cocaine. Because the notes are made from pure cotton, cocaine crystals stick easily to them and quickly get passed on to other notes-especially in cash dispensers, say scientists.

Drug identification is very important. Forensic science laboratories work very closely with pharmaceutical companies to produce tests for all new drugs as they are developed. Write a short report on the chemistry used in drug identification.

Unit Eight ~
Trace Evidence



Unit Eight

LESSON 1 ~ Trace Evidence

(Single Class)

The aim of this unit is to encourage students to develop observation, hand lens/microscope and data collection skills. Pupils will observe, describe, compare and classify various hairs, fibres and cloth stains.
This unit also hopes to teach students about DNA fingerprinting and perform an experiment using bar codes to model DNA samples.
Finally this unit hopes to develop the scientific skills associated with isolating nucleic acids from onion tissue.

Introduction
The first part of this class sees pupils discussing what activities can contaminate a crime scene. As a class they will then come up with a number of measures that will prevent a crime scene from being contaminated. The following information should be included in the discussion:

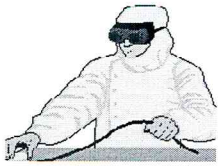
Crime Scene Contamination

- Webster's Dictionary defines contamination as; "to make impure, corrupt, by contact; pollute, taint."

- Crime scene contamination usually happens as a result of the actions of the personnel at the scene. In general, the greater number of personnel at the scene, the more likely it is that the scene/evidence will be contaminated. Scene personnel can deposit hairs, fibres or trace material from their clothing or destroy latent footwear or fingerprints.

- Environmental conditions may also play a major role in the contamination of crime scene evidence. How?

- Crime scene personnel need to be aware of their potential to bring about cross contamination. As the crime scene examiner travels from one scene to another he runs the risk of transferring hairs, fibres, and biological fluid from other scenes to the new crime scene. This contamination can be easily controlled if crime scene personnel decontaminate their equipment before and after every crime scene.



- Required PPE consists of a mask, jump suit, gloves, booties and head cover. All of these items must be disposable. The use of PPE is an effective mechanism to reduce potential contamination and subsequently, increase the investigative value of biological evidence, which may be subjected to forensic DNA analysis.

- Evidence is packaged to prevent destruction and contamination. New containers must be used to package all evidence. For some evidence, sterile containers are required. All containers must be sealed at the crime scene. This reduces the contamination potential and keeps the integrity of the evidence intact.

- If evidence is properly collected from the scene, packaged and handled correctly during transportation and storage, and decontamination procedures used, the potential for contamination will be greatly reduced. As a result, the integrity and value of the evidence will be maintained regardless of what additional analyses are developed in the future. Students should be told a few days before the class to bring in animal hairs and cloth samples for inspection.

Development
Part two of this class sees pupils examining possible examples of trace evidence that can be found at a crime scene. Ensure that the materials needed by the pupils are available and move from group to group offering assistance and advice.
For part two of the activity you must provided pupils with stains that are different in composition, but look similar in appearance. The following three stains should be used on red cloth:

- A mixture of salt and water. Once dry the salt crystals will become trapped in the cloth.
- A dilute solution of lead nitrate and potassium iodide solution. This yellow solution dries to leave yellow lead iodide crystals.
- A vegetable oil stain. This looks similar to the other two stains but students will not find any crystals.

Conclusion
End this class with a discussion on the results pupils have discovered. Ask them if there are any other methods for examining trace evidence.

LESSON 2 ~ DNA Evidence
(Double Class)

Introduction
Introduce this lesson by going through the information supplied in the student handout. Ensure pupils understand the technique involved in developing a DNA fingerprint. Ask leading questions to clarify understanding.

Development
The next part of the class sees pupils isolating DNA from onions.
This experiment allows students to mimic the major principles involved in the extraction of DNA from tissue. The ethanol used must be ice cold and will have to be placed in a plastic bottle in a freezer at least 24 hours before the activity. This procedure presents no particular safety hazards, although care should be exercised when chopping the onion or using the blender.

The next activity entitled 'Finding the perfect match' will help students to understand how DNA fingerprinting is used in the identification of a DNA sample. You should find 10 different barcodes before the class and reproduce one of these onto an acetate as that of the DNA found at the crime scene.

Conclusion
To conclude this lesson, discuss the questions asked on the student handout with the pupils. To summarise this lesson and to put this theory into context get pupils to read the case study provided on Sarah Payne.
The excerpt from the story of the murder of Sarah Payne was taken from the following website:
http://www.solvethecrime.co.uk/forensic/news/casefiles/sarah_payne.htm

There are many other sources of trace evidence. The following links provide some insight into some of these sources and the information they provide:

Minute Traces
http://www.crimelibrary.com/criminal_mind/forensics/trace/6.html?sect=21

Paint and Glass Traces
http://www.channel4.com/science/microsites/S/science/society/forensic_trace.html

Tool marks
http://www.channel4.com/science/microsites/S/science/society/forensic_marks.html

Unit Nine ~ Crack the Code

Unit Nine

LESSON 1 ~ Crack the Code

(Double Class)

The aim of this unit is to increase students' understanding of the topic of acids, bases and neutralisation reactions.
Activities aim to improve students' accuracy and precision in carrying out titrations and to develop in students an awareness of the importance of good safety practices in the lab when working with acids and bases.

Introduction
The first activity provides students with a code that they must decipher in order to find the hidden safe. The clues given are all alike in that their answers are all elements 'used in ancient times'. The answers are as follows:

1. The cheapest and most abundant of all metals, people have been using this element for at least 5,000 years IRON
2. This liquid metal has been found in 3,500 year old Egyptian tombs MERCURY
3. Commonly found as coal or soot CARBON
4. The ancient Egyptians made black eye make-up with this element ANTIMONY
5. A pale yellow material, this element can be found near volcanoes and hot springs SULPHUR
6. A soft, valuable metal, its purity is measured in carats GOLD
7. Bronze, the first alloy created by people, is a mix of copper and this metal TIN

Development
The second activity involves an experiment that students must perform to find the combination of the safe. This experiment is taken from 'The Salters' Chemistry Club Handbook, Volume 2'.

Safety Note:
When carrying out the experiment, all P.P.E must be worn.
Solutions E (0.08 mol/dm^3 NaOH) and L (0.06 mol/dm^3 NaOH) are irritants and may be corrosive
Phenolphthalein indicator solution is also highly flammable

Conclusion
End this lesson with a discussion on the different terms pupils have met. Once the discussion is finished get pupils to answer the questions posed in the student handout. Correct pupils answers in order to ensure they have the correct understanding.

Unit Ten ~ You be the Detective

Unit Nine
You be the detective

The aim of this activity is to provide students with the opportunity to demonstrate their skills developed in the previous activities and use the data collected from the tests to draw appropriate conclusions.

The emphasis is not on having students pick the correct suspect, but instead on encouraging students to engage in scientific inquiry and examine the evidence using the correct procedures.

Students are expected to organise their materials, devise their own experiments and draw reasonable conclusions that will support their results.

To decide on a guilty suspect, students will have to use all the evidence provided to determine which suspect had the motive and the opportunity to commit the crime. What will determine a suspect's guilt is the results from the evidence collected at the crime scene. The teacher can decide who the culprit is and organise the evidence to support this. This is advantageous as the culprit can be changed from year to year.

Note:
The students can choose to examine the evidence in any order they wish. As a result, all of the evidence must be available from the start. The following must be organised in advance:

(A) Analysis of note

The easiest method would be to have 3 colleagues write a note (similar to the one found in Jack's pocket) on the same type of notepaper. They must aim to have the handwriting samples as similar as possible. One of them must then provide another sample of his/her handwriting to be labelled as that found at the crime scene.

Each 'suspect' must use a different pen to write the note. Students must be presented with these pens (same colour but different brands).

Students must use their handwriting analysis skills and a brainstorming session should also remind them to try chromatography. Once this has been established, they must be provided with prepared TLC strips containing samples of the ink used to write the note found at the crime scene and the materials necessary for the experiment.

(B) Fibre Analysis

Three different blue fibres must be provided with a copy of one of the fibres included as crime scene evidence.

(C) Footprint Analysis

Try to find 2 pupils in another class of similar shoe size who are willing to provide a footprint. These can be Grettel's and Jill's footprints. A bigger footprint must be obtained for Jack. You will have to obtain a second copy from one of the volunteers, depending on whom you decide the culprit is.

(D) Fingerprint Analysis

Three suspect fingerprints should be provided and a copy of **Jill's** fingerprint labelled as that found on the pail. The teacher should then discuss with pupils whether or not this could be recognised as proof of Jill's guilt. They must acknowledge that Jill's print may be there from previous trips with Jack to fetch water.

(E) Soil Analysis

Again, Jill should have a soil sample similar to that found at the crime scene but this may be from when she was talking to Bo Peep. If she is guilty, then you should organise it so that neither of the other two suspects provides a matching soil sample. If not, then a second soil sample should match.