



TV Science

Forensic Science Module

Student Handout

Written by Ms Cindy Meleady
Revised by Ms Maria Sheehan
Edited By Dr. Peter. E. Childs
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.

© SICICI 2004

Table of Contents

Chapter	Page
Safety Note to Students	I-II
Introduction	1
<u>Unit 1</u> – Pattern Recognition	2
<u>Unit 2</u> – Sealed With A kiss	6
<u>Unit 3</u> – The Write Stuff	11
<u>Unit 4</u> – Dirty Deeds	14
<u>Unit 5</u> – Shoe Did It?	18
<u>Unit 6</u> – The Bloody Truth	22
<u>Unit 7</u> – What Is It?	26
<u>Unit 8</u> – Trace Evidence	30
<u>Unit 9</u> – Crack The Code	38
<u>Unit 10</u> – You Be The Detective	42



PUPILS-SAFETY COMES FIRST

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

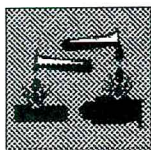


- Personal protection equipment must be worn at all times i.e. white coat, goggles and gloves
- All long hair must be tied back
- No eating or drinking in the laboratory- never smell or taste anything in the lab
- All chemicals must be handled and disposed of with extreme care
- Any breakages should 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

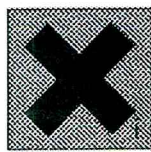
The following are symbols that you must be familiar with in order to carry out each experiment carefully.



CORROSIVE



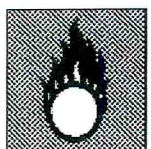
FLAMMABLE



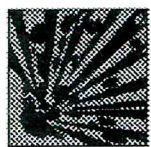
IRRITANT



TOXIC



OXIDISING



EXPLOSIVE

Introduction



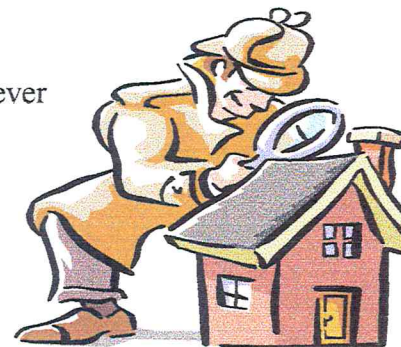
TY Science - Forensic Science Module

Introduction for Students

“Whenever you have excluded the impossible, whatever remains, however improbable, must be the truth”.

Sir Arthur Conan Doyle, The Adventures of Sherlock Holmes

Have you ever imagined being a modern-day Sherlock Holmes? Do you think you have what it takes to solve the perfect murder? If you study chemistry at school and can examine a situation with a scientific mind then you just might be the 21st century's answer to Sherlock Holmes!



The truth is discoverable at every crime scene. To find it, according to Sherlock, one must follow the rules of scientific inquiry, gathering, observing, and testing data, then formulating, modifying, and rejecting hypotheses/ideas until only one remains. Every criminal brings something to the scene of a crime and takes something away. A single human hair, fleck of paint or trace of powder from a gun is of utmost importance to the forensic scientist and may be the piece of evidence that will complete a case.

Sometimes we can feel that science has no real relevance in our lives and that chemistry is too difficult to understand, but this is not true. Every day we depend on science to improve our lives and help us to solve our problems. The police use basic scientific principles to identify different drugs, match suspects to fingerprints or even to find out if a document has been forged. Chemical reactions that can be found in any junior or senior certificate science textbook can help police catch a criminal and make the world a better place.

Still think chemistry is boring? Thought not! This Forensic Science Module will allow you to take over the role of a forensic detective and examine the part chemistry plays in areas such as fingerprinting, forgeries, identifying suspect powders, collecting evidence at a crime scene and many more. The following is a list of the units, which will help you to master the necessary skills and techniques to do this:

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

Once you have completed these units, your mission should you choose to accept it, will be to solve a crime using the chemistry skills and forensic techniques you have learned. The crime and information you need will be presented to you in the final unit.

Unit 10 - You be the Detective.

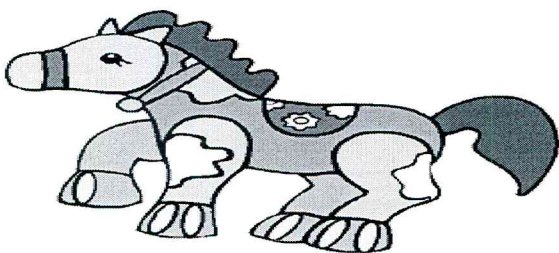
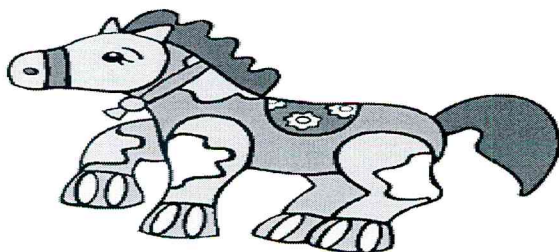
Unit One ~ Pattern Recognition



Unit One

LESSON 1 ~ Pattern Recognition

Look at the pictures below, seven changes have been made to the bottom picture, can you spot them?



‘Spot the difference’ is not just an activity for kids; it is also a technique that allows us to recognise similarities and differences between objects that may appear to be identical. Believe it or not, matching a suspect to the fingerprints he/she left at the scene of a crime is really only a case of playing spot the difference and recognising the patterns between fingerprints.

Question: What causes us to leave fingerprints on objects that we touch? Give a description of the three types of fingerprints found at a crime scene.



Fingerprinting

This activity will allow you to take your fingerprints and classify them according to the patterns of loop, arch and whorl.

Materials needed:

Inkpad

Procedure:

1. Roll your thumb lightly on the inkpad, and then roll the inked thumb onto the space on the chart below.
2. Repeat this method for each finger.

Results: Prints of my right hand:

Thumb	Index Finger	Middle Finger	Ring Finger	Little Finger



Discussion:

1. Are the prints from each finger on your hand similar to each other? Why?

2. What kind of patterns do you see? Give names to the patterns (circles, triangles, curved lines etc.)?

3. Can you classify your fingerprint using the following illustrations (are they all the same)?



Central Pocket Loop



Double Loop



Loop



Plain Whorl



Tented Arch



Plain Arch



Accidental

Fingerprint patterns are divided into three main groups consisting of: Arches, Loops and Whorls. Approximately 5% of all fingerprints are Arches, 30% are Whorls and 65% are Loops.

Thumb = _____
 Index Finger = _____
 Middle Finger = _____
 Ring Finger = _____
 Little Finger = _____

(Perhaps do your left hand if you get a chance and compare the differences)

4. Compare your fingerprints with your friends? Do you agree on the different classifications of fingerprints you have?

LESSON 2 ~ Making Prints Visible

During the last lesson we looked at the different types of fingerprints. It is easy to classify fingerprints when they can be seen but what if the print is not so obvious, what if it is invisible, a latent fingerprint? Can you think of how a detective would get fingerprints from a can of coke or piece of cloth?

There are several ways to collect fingerprints from such surfaces and some involve treating the object chemically. In this next activity, we will make an invisible fingerprint on a piece of paper and then treat the paper to make the print visible.



Making Fingerprints Visible

Materials needed:

Unlined white paper
Iodine (I_2) crystals
250 ml conical flask
Bunsen Burner
Tongs
Scissors
Transparent tape (Scotch tape etc.)

**Procedure:**

1. Cut narrow strips of paper small enough to be held in the neck of the flask.
2. Press one finger firmly on one end of the paper strip.
3. Place an amount of Iodine crystals, about 2-3 g, in the conical flask.
4. Heat gently with the Bunsen burner or on a hot plate until the Iodine begins to vapourise. (THIS STEP MUST BE PERFORMED IN THE FUME CUPBOARD).
5. Using the tongs, dip the paper strips into the flask and record your observations.
6. Preserve the fingerprint by immediately covering the print with a strip of transparent tape.
7. Try washing your hands with soap and then repeating the activity. What effect did washing have on your ability to detect fingerprints? _____

**Discussion:**

1. Can you explain what happened in the above experiment? How did the Iodine show up the fingerprint? _____



The Finger of Suspicion

The principal of St. Mary's secondary school has a problem, while she was talking to a parent; someone entered the school shop and removed the money from the tin it was kept in. Being an amateur forensic detective, Mrs Kennedy recovered a clear fingerprint from the tin. Only five people were in the vicinity of the sweet shop at the time, pupil A, pupil B, pupil C, pupil D and the janitor. All five have been fingerprinted. The aim of this activity is to match the unknown print to one of the five samples using the fingerprint classification system.

Materials needed:

Talcum Powder
Fine paintbrushes
Clear cellophane tape
Shiny black paper
Sample of the suspect's fingerprints.

Procedure:

1. Dust the talcum powder lightly on the surface of the tin. Blow on and brush the excess powder gently so all that remains is the powder that has stuck to the fingerprint. This involves a lot of precision.
2. Press a piece of tape over the print and peel it away so that the powdered print sticks to it.
3. Stick this piece of tape onto the black paper.
4. Compare this print with the prints of the five suspects and determine which person stole the money.

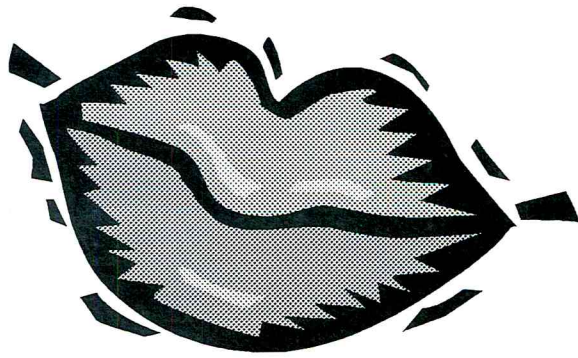


Discussion:

1. In your opinion who stole the money? Give reasons for your answer. _____

2. Can you give any tips, which you discovered during the experiment, that make lifting the print from the tin a little easier? _____

Unit Two ~
Sealed With A
Kiss



Unit Two

LESSON 1 ~ Sealed with a Kiss 1

Investigators often gain evidence through the use of odontology, anthropometry, fingerprinting and other techniques that can determine gender, approximate age, height and blood grouping.

Do you know what the underlined terms mean?

Nowadays, investigators can also rely on lip prints to identify possible suspects or to support evidence gained in an investigation.

A lip print left at the scene of a crime can be a valuable piece of trace evidence. The study of lip prints is called cheiloscopy.



Looking at Lip Prints

Experts cannot categorise a lip print as a single type, since combinations of groove types exist in nearly all cases. Instead, they designate a single lip print type based on the prominence of groove type.

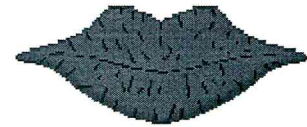
The five basic types of lip prints used by forensic scientists are:



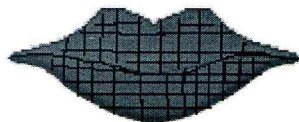
diamond grooves



long vertical grooves



short vertical grooves



rectangular grooves



Branching Grooves



Using the Lip stick provided make a print on a white piece of paper. Determine which type of lip print you have.



A Kissing Crime

Someone has been writing graffiti on the girls' bathroom mirror in your school. The culprit has been signing her work with a lip print. As of yet, we do not know who committed the crime, but the principal has seen 3 different girls leaving the bathroom around the time the crime was committed.

As amateur forensic scientists, you will have to use critical thinking to determine the culprit of the crime. So what evidence do we have?

A lipstick stain and a print were recovered from the crime scene. You will be given:

- ✓ An envelope containing a sample of the lipstick found at the scene of the crime (marked 'lipstick: evidence')
- ✓ An envelope containing a lip print transferred to a paper surface (marked 'lip print: evidence')
- ✓ Three tubes of lipstick- one tube of the brand and colour of lipstick used by each of the three suspects (marked 'A', 'B', and 'C')
- ✓ Three envelopes containing lip prints of each of the suspects on paper (marked 'Suspect A', 'Suspect B', and 'Suspect C').

What do you think the first step in this investigation should be?

Working in groups carry out the first step in this investigation. Outline the procedure below and draw out a results table.

Procedure:

Results:

--	--

LESSON 2 ~ Sealed with a Kiss 2

The use of lip prints in criminal cases is limited because the credibility of lip prints has not been firmly established in our courts. Is there anything else that can be done to further this investigation and find out who is vandalising the bathrooms?

Can you think of any technique you have studied as part of your Junior Certificate Science course that may help us? We need to be able to distinguish among the brands of lipstick used by each of the suspects and compare them to the lipstick found at the crime scene.

Chromatography is _____



A Kissing Crime ~ Lipstick Analysis

Material needed:

3 TLC (Thin Layer Chromatography) strips

Lipstick samples 'A', 'B', and 'C'

TLC strip from envelope marked 'lipstick: evidence'

Acetone CAUTION: Be careful! Acetone is flammable

Scissors

4 beakers

Note:

Chromatography solvent (Acetone) produces unpleasant, noxious fumes and is flammable. This experiment must be carried out in a fume cupboard.

Procedure:

1. Cut 3 strips of TLC paper (approx. 10cm x 2cm).
2. Using a PENCIL, draw a horizontal line 2cm from one end of each strip and label the strips 'A', 'B', and 'C'.
3. Use lipstick sample 'A' to make a good-sized dot of colour in the middle of the pencil line on strip A.
4. Repeat for samples 'B' and 'C' on strips 'B' and 'C' respectively.
5. Pour about 1cm of acetone into each of the four beakers. Acetone is the solvent that will move up the paper strip and dissolve the coloured chemicals in the lipstick.
6. Place the paper strips in the beakers-one strip per beaker. The strips should be placed with the lipstick mark toward the bottom of the beaker but not touching the acetone. Fold the strips over the lip of the beaker to keep them in place.
7. The solvent should immediately start moving up the paper strip carrying the lipstick chemicals with it.
8. When the solvent has moved more than half way up the paper strips you can remove them from the beakers and immediately mark with a pencil the highest point the solvent travelled up the paper strip.
9. Let the strips dry and then carry out the exercise below.

Exercises:

- I. Draw the pattern of bands of colour you observed on each of the chromatography strips including the line 2 cm from the bottom of each strip. Use a ruler to determine the exact location of each band. Record the distance in millimetres from the starting line to the beginning of each band. Draw a line where the solvent reached on the paper and measure the distance in millimetres from the starting line.
- II. Chromatography uses the distance travelled by different compounds. Calculate the R_f for each band in each sample. The R_f (Retardation factor) is the distance travelled by the band in question divided by the distance travelled by the solvent. Record your results below:

Sample A:

Band #	Distance travelled by band (mm)	Distance travelled by solvent (mm)	$R_f = (\text{Dist. travelled by band} / \text{Dist. travelled by solvent})$
1			
2			
3			
4			

Sample B:

Band #	Distance travelled by band (mm)	Distance travelled by solvent (mm)	$R_f = (\text{Dist. travelled by band} / \text{Dist. travelled by solvent})$
1			
2			
3			
4			

Sample C:

Band #	Distance travelled by band (mm)	Distance travelled by solvent (mm)	$R_f = (\text{Dist. travelled by band} / \text{Dist. travelled by solvent})$
1			
2			
3			
4			

Crime Scene Sample:

Band #	Distance travelled by band (mm)	Distance travelled by solvent (mm)	$R_f = (\text{Dist. travelled by band} / \text{Dist. travelled by solvent})$
1			
2			
3			
4			

**Discussion:**

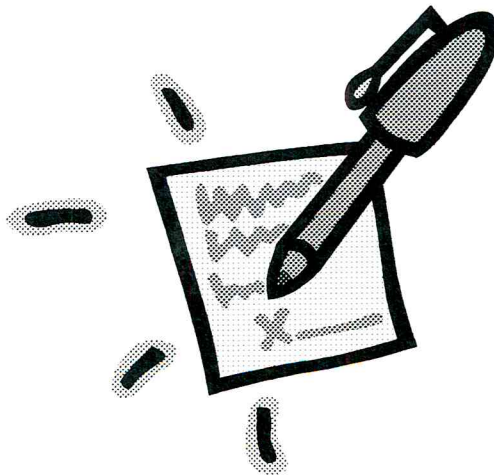
1. Use the information from these tables to compare the patterns found on each strip. Do any of the patterns appear to match the lipstick found at the crime scene? Which ones? Explain your answer.

2. What can you conclude about the suspects in this case? Which suspect(s) can you exclude (if any)? Which suspect(s) can you link to the crime scene?

3. Do these scientific results support the observations you made on the lip prints?

- ✓ Prepare a report outlining your detective work and the conclusions you have arrived at for this case. (You must present your findings from the lip prints examination in conjunction with the lipstick chemical analysis.)
- ✓ Chromatography is an important chemical technique used by forensic scientists in a variety of different cases. Can you think of any areas, other than lipstick analysis, where this technique may be used?

Unit Three ~ The Write Stuff



LESSON 2 ~ The Case of the Forged Documents

But isn't handwriting analysis enough? The following case shows that sometimes, handwriting analysis may fail.

- ❖ One of the world's most famous crimes involving paper and ink analysis was the case of the forged Hitler diaries.
- ❖ In 1981, the editor of Germany's *Stern* magazine decided to buy twenty-seven volumes of what he was assured was Hitler's personal diary. The idea was proposed by a staff journalist, Gerd Heidemman, who was secretive about his source, but who suggested that about US\$2 million would secure the documents for the magazine.
- ❖ Two handwriting experts declared that the documents were indeed authentic after comparing the handwriting with other examples of Hitler's writing.
- ❖ This was true, but the same person who had forged the diaries had also forged the samples of 'genuine' Hitler handwriting that they used for comparison.
- ❖ In 1983, the West German police subjected the diaries to a full-scale forensic analysis. Instead of checking the handwriting, the police studied paper and ink. This revealed that the documents were written on paper containing a whitening agent called blankophor, which came into use after 1954! Threads attached to the seals were made of viscose and polyester, artificial fabrics that were not used in Hitler's time.
- ❖ Chromatography identified four different ink types in the diaries. None of these had apparently been available when Hitler was alive. Further ink analysis suggested that the writing was less than a year old!
- ❖ In truth, an experienced forger, who made a living by faking Nazi memorabilia, had created the diaries.
- ❖ This man was working in league with Gerd Heidemman, the journalist, who benefited considerably from the large amounts of cash given by the editor in order to obtain the diaries.
- ❖ Both journalist and forger were imprisoned.

(Source: http://www.abc.net.au/science/forensic/bigcases/case_sample_03.htm)



Invisible Ink and Secret Messages

Invisible ink isn't just something you see in James Bond movies. In fact, prisoners of war used their own sweat and saliva as invisible ink. In this activity you will learn several ways to write secret messages with invisible inks and the chemistry that allows you to make them visible.

Materials needed:

Notepaper
Lemon juice
Cotton swabs or small art brushes
Lamp
Cornstarch
Iodine
Beaker
Phenolphthalein
Washing soda



Unit Three

LESSON 1 ~ The Write Stuff

'The Sunday Times' recently printed this statement:

"A man may lie, simulate, disown himself: a portrait may change or beautify him; a book can lie and so can a letter, but in one thing man is inseparably attached to the innermost truth of his nature - in his handwriting. Handwriting betrays a man, whether he wants it to or not, it is as unique as his personality and sometimes reveals what he conceals. Although handwriting does not betray everything, it does reveal the essential - the essence of personality, as it were, is given in a tiny abbreviation."

Handwriting Analysis: How would you go about analysing one's handwriting?



Catching the Secret Letter Writer

Mr Walsh, the school principal, has a problem. He received a note from a student's mother excusing her son from P.E. classes. Unsure as to whether the note had been written by the boy's mother or not, Mr Walsh examined several documents containing her signature on file in the school.

To help Mr Walsh decide whether the signature is authentic or not, you have been provided with the following:

- ✓ An authentic note from Mrs Carroll (marked Note A), received at an earlier date and providing you with a sample of her handwriting.
- ✓ Four copies of Mrs Carroll's signature, received throughout the year, the authenticity of which is unknown.
- ✓ The suspicious note Mr Walsh received this morning.

What do you think the steps in this investigation should be? _____

Present your findings in a report, which you can later share with the class.

The report must contain the following:

- ✓ The observations you made based on your analysis of Mrs Carroll's handwriting from Note A
- ✓ The results of the examination of each of the four signature samples and that of Note B
- ✓ How you came to the conclusion that you did and the challenges that you were faced with
- ✓ Any difficulties you may have experienced

Procedure:*Part 1 – Invisible ink that responds to heat*

1. Using a clean art brush or cotton swab, write a message on some notepaper with lemon juice.
2. Allow the paper to dry.
3. Once dry, pass the paper under a light bulb. What do you observe?

*Part 2 – Invisible inks that require chemical treatment*Type A

1. Mix some cornstarch and water in a beaker and heat gently over a Bunsen burner until the cornstarch has dissolved. Allow to cool.
2. Using a clean art brush or cotton swab, write a message on a separate sheet of paper with this solution.
3. Allow the paper to dry.
4. Once dry, dab (do not rub) the paper with a cotton swab that has been dipped in an iodine solution.
5. What do you observe and why?

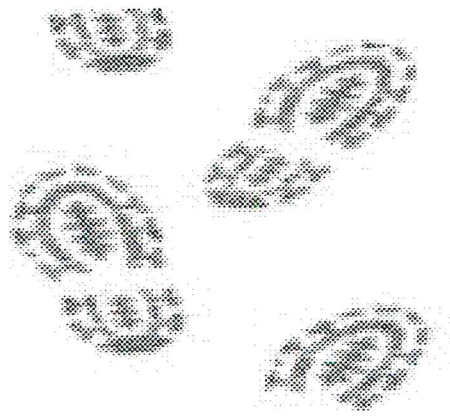
Type B

1. Write a message using phenolphthalein.
2. Allow the paper to dry.
3. Mix some washing soda and water in a beaker and heat gently over a Bunsen burner until the washing soda has dissolved. Allow to cool.
4. Dab (do not rub) the paper with the washing soda solution using a cotton swab.
5. Record your observations.

**Discussion:**

1. Describe the appearance of the inks when they are made visible.
2. How does heat make certain invisible inks visible?
3. Describe the chemistry involved in producing both sets of visible writing in part 2 of this activity.
 - a)
 - b)
4. Suggest other substances that may be used as invisible ink and how they may be made visible.

Unit Four ~ Dirty Deeds



Unit Four

LESSON 1 ~ Dirty Deeds 1

The most important theme of this unit is that many fine-grained materials can be associated with particular environments.

Traces of soil are very common forms of evidence in a case. Having taken soil samples during the search for evidence, forensic scientists can use various techniques to check traces of mud on a suspect's clothes, or on the tyres or bodywork of a suspect vehicle.



Similarly, if a person is arrested on suspicion of having committed a crime, but the scene of the crime has not yet been established, traces of soil found on the suspect, or in their living quarters or vehicle, for example, can suggest a particular locality, when unusual soil constituents are involved.

Question:

1. What is soil? _____



Identifying soil particles ~ The Budding Criminal

One of the most common techniques used to compare soil samples uses a density gradient tube. This is a long, narrow glass tube closed at one end and filled with mixtures of two chemicals of different densities.

Explain how a density-gradient tube works: _____

Farmer Jones has won 1st prize at the annual garden fair over the past three years for his roses. On the morning of this year's fair, he awoke to find his garden trampled on and his roses ruined. He has spoken with the police and provided them with the names of 3 suspects: Jim Byrne, the man who has come second in every competition and resents Jones's success, Jack Duffy, a neighbour with whom Jones had a recent argument and Dennis Smith, the little boy from next door who is always up to something.

There are no discernable footprints so, as forensic investigators you are asked to analyse the soil samples provided using the recommended tests.

The following evidence is available:

- ✓ Sample 'A' taken from Mr Jones's rose garden
- ✓ Sample 'B' from Jack Duffy's boot
- ✓ Sample 'C' taken from the tyre of Jim Byrne's car
- ✓ Sample 'D' from little Dennis's clothes

Test 1: Appearance of soil samples**Materials needed:**

- ❖ Soil Samples A, B, C and D
- ❖ 4 beakers (marked A, B, C and D)
- ❖ 4 white tiles
- ❖ Hand lenses

Procedure:

1. Take a small amount of each soil sample and put them into their corresponding beakers.
2. Place a portion of sample A onto the white tile.
3. Examine the soil for particle size and general colour.
4. Rub the soil between your fingers-how does it feel? How may the texture of this sample be described?
5. Note the presence of any vegetation or any unusual materials.
6. Repeat these steps for samples B, C and D.
7. Record all observations in the following table:

	A	B	C	D
Colour				
Particle Size				
Animal Matter				
Plant Matter				
Texture				
Possible soil type				

Test 2: Testing the pH of each soil sample**Materials needed:**

- Soil samples
- 4 test-tubes
- Spatula
- Filter paper and filter funnel
- Universal Indicator paper and water

Procedure:

1. Put 1 spatula full of sample A into a test-tube and add water. Cover the mouth of the test-tube with your thumb and shake well.
2. Fold the filter paper as directed by your teacher.
3. Put the filter paper into the funnel and position the funnel over a second test-tube using the retort stand.
4. Pour the contents of the first test-tube into the funnel.
5. When the solution has filtered through, dip a piece of universal indicator paper into it.
6. Record the observed colour and pH in the table below.
7. Repeat these steps for samples B, C and D.

	A	B	C	D
Colour change				
pH				

LESSON 2 ~ Dirty Deeds 2

In today's lesson we are going to continue our examination of the soil in order to help farmer Jones determine who destroyed his roses



Identifying soil particles ~ The Budding Criminal

Test 3: Finding the percentage of water in each sample

Materials needed:

- ❖ Soil Samples A, B, C and D
- ❖ Electronic balance
- ❖ Oven

Procedure:

1. Weigh each sample of soil.
2. Heat it in an oven at 100°C for about 30 minutes.
3. Remove the dish from the oven, cool and reweigh.
4. Re-heat for 10 more minutes and repeat until no further changes in weight occur.
5. Percentage of water = [loss in weight/ original weight] X 100%.
6. Record all observations in the following table:

	A	B	C	D
Initial mass/g				
Final mass/g				
% water				

Test 4: Finding the percentage of humus in each sample

Materials needed:

- ❖ Soil Samples A, B, C and D
- ❖ Electronic balance
- ❖ Bunsen Burner

Procedure:

1. Weigh each sample of soil.
2. Heat each sample strongly to burn off the humus.
3. Cool the samples and reweigh.
4. Percentage humus = [loss in weight/ original weight] X 100%.
5. Record all observations in the following table:

	A	B	C	D
Initial mass/g				
Final mass/g				
% humus				

Test 5: Finding the percentage of air in each sample**Materials needed:**

- ❖ Soil Samples A, B, C and D
- ❖ Four 100 ml graduated cylinders
- ❖ Water

Procedure:

1. Weigh out 20 cm³ of each soil sample in a measuring cylinder.
2. Fill each graduated cylinder with water up to the 80 cm³.
3. Add a soil sample to each of the graduated cylinders.
4. Record the volume expected when 20 cm³ of soil is added to 80 cm³ water.
5. Note the volume of the water-soil solution formed.
6. Percentage of air = [(Expected -actual volume of solution)/ Total volume] X 100%.
7. Record all observations in the following table:

	A	B	C	D
Initial soil + water/cm ³				
Final soil-water/cm ³				
% air				

**Discussion:**

1. On completion of these tests, you must now study the results. Sample A was taken from Mr Jones's rose garden. Do the tests show any of the other three samples (B,C or D) to be similar in composition to that of A? _____

2. Can you now make an informed scientific judgement as to whom the guilty party is?

- 3 Write a short report describing the relevance of each of the tests performed and the information it can provide. Indicate which of the three suspects you believe to be guilty and attempt to classify each sample by it's soil type.

Unit Five ~

Shoe Did It?



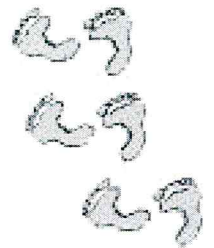
Unit Five

LESSON 1 ~ Shoe did It?

Quite a long time ago, a volcanic eruption occurred in East Africa causing a vast cloud of volcanic ash to be produced. This ash settled on the surrounding landscape and was soaked by a shower of rain.

Not long after this rainfall, three people walked across the wet ash, leaving a trail of footprints, which then set hard in the warm sunshine.

Buried and preserved the prints were only unearthed at Laetoli in Tanzania in 1978. Radioactive dating of the rock surrounding the footprints showed them to be the oldest human footprints known- over 3.5 million years old. This provided proof that our primitive ancestors had already evolved to walking upright all those millions of years ago. Examination of the relative size and shape of each footprint even showed them to belong to those adults and a child.



Question: Can you think of a number of ways that footprints are of use to forensic detectives?



Making a cast of a shoeprint

Materials needed:

- 2 beakers
- Plaster of Paris
- Water
- Tray of soil
- 100 cm³ graduated cylinder
- Plastic stirrer



Procedure:

1. Step firmly into the soil sample, making as clear a shoeprint as possible.
2. Prepare plaster of Paris by gradually adding the powder to 200 cm³ of water until the mixture is thick and creamy, but thin enough to pour. Stir carefully to avoid bubbles.
3. Pour the mixture into the shoe imprint in the soil sample. Pour carefully so that the plaster of Paris just covers the whole shoeprint (the thinner the layer of plaster, the faster it will dry).
4. Let the plaster set, this will take about 48 hours.
5. After 48 hours remove the cast and rinse under the tap.
6. You now have a cast of your own shoeprint – are there any characteristic features to your shoeprint?

**Discussion:**

1. Why is it important to wash the plaster cast before examining it?
2. What effect would air bubbles in the plaster have on the cast?
3. Which of the following would give you a good plaster cast?
 - a. Bicycle tyre prints
 - b. Shoeprint in snow
 - c. Scratches on a stone floor
 - d. Tractor tyre prints
 - e. Shoeprints in earth
 - f. Car tyre prints
 - g. Scratches on a bullet

(Maybe you could try some of these out.)

LESSON 2 ~ Shoe exactly did it?

In the previous lesson we saw how to make a plaster cast of different prints. Check to see if these casts have dried. If they have dried remove the cast from the soil and examine them.

1. Which print turned out the best?

2. Are the casts identical to what you took the print of?

3. Is there any part of the procedure you would change in order to bring about a more exact print?

Sulphur/Graphite Casts

Sometimes an investigator may need to make a cast of scratches on metal. In such cases the casts are made from a mixture of graphite and sulphur.

Such a mixture of sulphur and graphite will melt easily and solidify quickly to form very detailed casts. It may be used to form casts on very wet ground, even snow, and will set on a wet surface where plaster of Paris would not work.

Construct a table describing the advantages and disadvantages of using plaster of Paris or sulphur/carbon powder for making casts.

	Advantages	Disadvantages
Plaster of Paris Casts		
Sulphur/Graphite casts		



Shoe Did It?

A large amount of valuable tools were stolen last night from Mc Cluskey's construction site in town. In an interview, the night watchman said the following "I woke up at around 1:00am to a loud bang. I had a look around the site and all I could find was a large cat that I'd presumed had knocked something over. I did not hear or see anything else suspicious"

PC Right is on the case. Her first act was to close off all of the muddy entrances to the site. Also, she has not allowed anyone near the crime scene.

On examination of the crime scene she found a single muddy footprint. A closer look proved the pattern to be that of a work boot worn by all of the men on the site. However, the robbery had occurred at 1:00am Monday morning and most of the staff had not been on the site since Friday afternoon. The only suspects therefore were, Mr Watts the sleeping night watchman, Ken Dobbs, the foreman and a trusted friend of the owner and Jimmy Maguire, the last man to leave the site. PC Right needs your help. She has taken a cast of each of the 3 men's footprints and needs you to analyse the following:

- ❖ A partial footprint found at the crime scene (marked 'X'). PC right has made a copy of the footprint onto an acetate so it can be placed over each of the three suspect footprints and the corresponding patterns noted.
- ❖ The footprints of Mr Watts (marked 'A'), Mr Dobbs (marked 'B') and Mr Maguire (marked 'C').



Because the footprints are all of the same type and similar size you must be very accurate in your examination and when constructing a theory as to what happened.

Step 1. Write short notes on each of the three suspects – What motive has each person? Are there any further questions PC Right could ask Mr Watts?

Step 2. Complete the measurements of your own foot, filling in the table below. Using the notes you have made on the relative measurements of your footprint, try to guess the sizes of each of the footprints

	My foot	X	A	B	C
Diameter at widest part of foot					
Length					
Size					

Step 3. Analyse each of the three suspects' footprints – are there any characteristic patterns caused by the owner that may help you to match it to that of the print found at the crime scene?

Step 4. Now place the acetate of the print 'X' over each of the three prints and complete your investigation.



Discussion

What skills did you or could you have used in this investigation that you have gained from other units?

Unit Six ~
The Bloody
Truth



Unit Six

LESSON 1 ~ The Bloody truth

Blood is a liquid, which carries food, oxygen, waste materials and other substances around the body. It is composed of 3 different types of cells; red blood corpuscles, white blood cells and platelets, suspended in a watery liquid called plasma.

Question: Do you know what the underlined terms mean? What are their functions?

Red Blood Corpuscles: _____

White Blood Cells: _____

Platelets:

Plasma: _____

An adult has five litres (ten pints) of blood circulating around the body in blood vessels called arteries and veins. The blood is under pressure due to the heart's pumping action. This blood pressure causes somewhat of a problem for potential attackers. Any injury received at a crime scene that causes a cut to a blood vessel will therefore result in blood spurting out and being deposited at the crime scene.



Investigators quite often find bloodstains during their examination of a crime scene, but they also find stains that could actually be some other similar substance.

Question:

1 What other substances could be mistaken for blood?

2 How do you think you could prove that a substance is indeed blood?

There are several chemicals that can differentiate between blood and other substances with a similar appearance. When scientists use these chemicals at the scene of a crime they must take great care to avoid contamination, since some of the tests are sensitive to chemicals other than blood.

Contamination poses an obstacle to the success of forensic science but also to the chemistry you carry out in your school laboratory. What measures do you take in your science classes to minimise the risk of contamination to your experiments?

Give a description of two ways to examine a crime scene for blood.

Method One**Method two**

Proving that the stain is indeed a blood stain using two different methods.

Materials needed:

- Blood sample
- Hydrogen peroxide (H_2O_2)
- Dropper
- Petri dish
- Phenolphthalein (*must be in the reduced state*)

Procedure:**Method One**

1. Place a few drops of the blood sample (marked 'A') provided into a petri dish.
2. Now add 2-3 drops of H_2O_2 .

What Happened:

Method Two

1. Place a few drops of the blood sample (marked 'A') provided into a petri dish.
2. Add 2-3 drops of phenolphthalein solution and a drop or two of H_2O_2

What Happened:

**Discussion:**

- 1 Explain the chemistry behind the above reactions.

Method One:

Method Two:

LESSON 2 ~ Testing blood samples**Which is blood and which isn't?**

In this activity, you will be comparing the results of the catalase test using hydrogen peroxide, with the phenolphthalein test, to see how each reacts with blood and other substances.

SAFETY NOTE: Even though you will not be using any real human blood in this activity, you should wear appropriate protection such as gloves. Also, the phenolphthalein solution may burn or irritate skin so glove wearing is mandatory.

Test the seven suspect stains submitted to the forensic laboratory for analysis and record your results in the table below.

Stain	Catalase +/-	Phenolphthalein +/-
A		
B		
C		
D		
E		
F		
G		

For example: If when tested a sample produces a positive result, a '+' must be placed in the table. If not, a '-' placed instead.

**Discussion:**

- 1 Which of these stains is probably blood? Explain your answer.
- 2 Can you think of any other method for making sure that this is indeed blood?

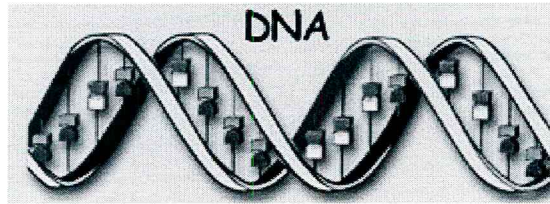
Blood Stain Analysis:

Once it is known that a stain is indeed blood, what other information could one find out from the blood?

1. **Pattern and shape:** The shape and pattern of blood drops can reveal important information about the nature of the wound from which it came. What distance did the blood drop fall? Did the blood spatter in all directions? Write a few sentences describing the information an investigator can get from examining the shape and pattern of blood drops.



2. DNA: Blood contains DNA and, depending on the size of the stain and its condition (old, new, dry, etc.) could provide the forensic scientist with enough information alone to catch a criminal. But what is DNA? The following website gives a detailed explanation of this genetic blueprint: <http://www.dnafb.org/>



3. Blood Type: In the early 20th century, an Austrian scientist named Karl Landsteiner observed two distinct chemical molecules present on the surface of red blood cells. He called one molecule "A" and the other molecule "B."

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. In an emergency, what type of blood can be given? Why?

Fill in the following table after the class discussion:

Place **Yes** in the box across from the blood type in column one if one can receive blood from the donors. Place **No** if they cannot

Column One ↓	A (donor)	B (donor)	AB (donor)	O (donor)
A (Recipient)	Yes			
B (Recipient)				
AB (Recipient)				
O (Recipient)				

- 1 Which blood type is known as the universal donor?
- 2 Which blood type is known as the universal receiver?

Unit Seven ~

What is It?



Unit Seven

LESSON 1 ~ What is it????

Fingerprints, fibres, tool-marks, tyre marks, bloodstains.... a lot of valuable pieces of information can be recovered from a crime scene. On discovering any one of the types of evidence we have discussed throughout this course, a detective is hopeful that this is the piece of evidence that will solve the case. But what if this object or substance itself is a mystery? A tiny piece of metal, its origin unknown or a white powdery substance, possibly a drug...in a case like this, the forensic scientist is called upon to identify the mystery substance or object.

	Definition	Tests for
Thin Layer Chromatography		
Gas Chromatography		
High performance liquid chromatography		



Powders

The following activity requires you to:

- ❖ Test small amounts of known white powders to determine how to perform a positive test for each white powder.
- ❖ Identify the different powders in a “mystery mixture” which will contain a mixture of at least two of the known powders.

Materials needed:

- Samples of five white powders: salt, sugar, starch, baking soda and potassium iodide.
- Black paper
- Hand lens or microscope
- Aluminium foil
- Hotplate
- Dropping well
- Vinegar, iodine solution, water and lead(II) nitrate

Procedure:

Test #1

- 1 Place a small amount of each powder on a square of black paper and observe the particles with a hand lens or microscope.
- 2 Record your observations in a table

Test #2

- 1 Place a small amount of each powder on a square of aluminium foil. Use a hot plate or medium to heat your powders. **[Be careful not to burn yourself]**
- 2 Record your observations in a table.
- 3 Please turn off the hot plate when finished and dispose of the aluminium foil and powders in the rubbish bin.

Test #3

- 1 Place a small amount of each powder in a separate well on a dropping well.
- 2 Add a drop of vinegar to each powder.
- 3 Record your observations in a table.
- 4 Clean up the dropping well



Test #4

- 1 Place a small amount of each powder in a separate well on a dropping well.
- 2 Add a drop of iodine solution to each powder.
- 3 Record your observations in a table.
- 4 Clean up the dropping well.

Test #5

- 1 Place a small amount of each powder in a separate well on a dropping well.
- 2 Add a drop of water to each powder.
- 3 Record your observations in a table.
- 4 Clean up the dropping well.

Test #6

- 1 Place a small amount of each powder in a separate well on a dropping well.
- 2 Add a drop of lead(II) nitrate to each powder.
- 3 Record your observations in a table.
- 4 Clean up the dropping well.

Results:

Substance	Salt	Sugar	Starch	Baking Soda	Potassium Iodide
Appearance					
Appearance on heating					
Reaction with Vinegar					
Reaction with iodine solution					
Reaction with water					
Reaction with Lead(II) nitrate					

LESSON 2 ~ Powder Mystery

During the last lesson you explored the properties of different white powders. You will now need these results to solve the following crime.



A Powder Mystery

Jack Kielty is renowned for his catering skills and has been asked to cater for the wedding of a very famous couple. Hours before the wedding, Jack found his kitchen ransacked and the food destroyed. He was furious and also very worried, how could he explain this to the soon to be Mr and Mrs X? As soon as he reported the crime, the police got right on the job.

Interviews with the chef and his staff have narrowed the search to two suspects.

One suspect is a local photographer, a man who is desperate to get some photographs of the top-secret event. He was found earlier by one of the staff trying to sneak into the kitchen. The second suspect is Steve Class, a famous Irish actor, and ex-fiancée of the bride. Police have collected important evidence: samples of different white mixtures found on the soles of each of the suspects' shoes. The police want to determine what the mixtures are and deduce whether they might have come from the chef's kitchen. They have labelled the mixture found on the photographer's shoe 'mixture 1' and the mixture on Steve Class's shoe 'mixture 2'.

Now that you have the results from the tests in part 1, you can analyse these two mixtures and try to identify the powders that are present in each.

Results: (Draw you own results table)

**Discussion:**

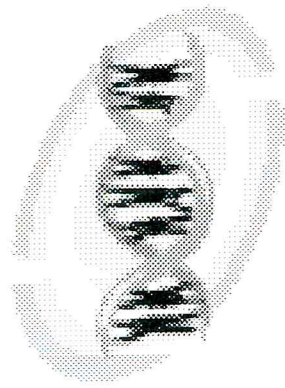
- 1 When you have determined the composition of each mixture, ask yourself if they are substances that could be found in the chef's kitchen.

- 2 Who then, is the more likely suspect? Why?

- 3 Are there any other tests you could have carried out in order to make a more accurate decision?

Unit Eight ~

Trace Evidence



Unit Eight

LESSON 1 ~ Trace Evidence

Fingerprints, footprints, bloodstains, bones etc. are well known sources of forensic evidence used to convict criminals. But there are other, lesser-known forensic sources often present at crime scenes. Criminals often leave a variety of other lesser-known pieces of evidence behind them at a crime scene.

Frenchman, Edmund Locard said in 1910, “Every Contact leaves a Trace”. What he meant was that every criminal brings something to the scene of a crime and takes something away. Hairs, fibres, particles of dust or glass, soil and other pieces of microscopic evidence can remain at a crime scene and tell investigators the true story of what really happened.

It is therefore vital that a crime scene be sealed off without any delay to preserve any evidential trace. This module aims to explore the importance of and the means by which investigators keep a crime scene free from contamination. It will also allow you to examine areas of trace evidence such as hair and fibres, DNA fingerprinting, ballistics, tool-marks, etc.



Question:

1. What can contaminate a crime scene?

2. As a police officer at the scene of a crime how would you keep the crime scene contamination free?

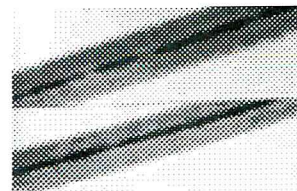
On arriving at a crime scene a forensic detective takes note of the main features e.g. the position of the body, the presence of a weapon etc. The next step involves examining the scene for trace evidence. List possible trace evidence that could be found at a crime scene.

-
-
-
-
-
-

Examining Trace Evidence

Hairs

- ❖ Hairs found at a crime scene can be very informative. Forensic analysis can determine if the hair has been dyed, cut in a certain way or pulled out, and where on the body it was located. In some cases, evidence of poisoning shows up in the hair.
- ❖ The hair shaft with a follicle can also offer genetic determinations, such as blood type or DNA. If the hair has been pulled out, it should include the follicle, and that helps to see the hair's full length.
- ❖ The shaft has three layers: the cuticle, cortex, and medulla. The cuticle has overlapping external scales, which helps in species identification: Animals are different from humans. Within the cuticle is the cortex, made up of spindle-shaped cells that contain the colour pigment, and the way the pigment is distributed helps to identify hairs from particular individuals. The centre of the shaft is the medulla, which is also valuable for species differentiation: An animal's medulla is larger than a human's is.



Fibres

- ❖ Fibres are gathered at a crime scene with tweezers, tape, or a vacuum. They generally come from clothing, drapery, wigs, carpeting, furniture, and blankets. For analysis, they are first determined to be natural, manufactured, or a mix of both.
- ❖ Natural fibres come from plants (cotton) or animals (wool). Manufactured fibres are synthetics like rayon, acetate, and polyester, which are made from long chains of molecules called polymers. To determine the shape and colour of fibres from any of these fabrics, a microscopic examination is made.
- ❖ The initial examination of a fibre is done under a microscope to determine the fibre type, for example cotton or wool. It is then checked for colour and physical features such as cross-sectional shape. The width of the fibre is recorded and it is checked to see if it contains any delustrant (used by manufacturers to determine how bright and shiny a finished garment is). All this has to be achieved before it can be said that fibres match.



Examining Trace Evidence

This activity will allow you to observe and record the characteristics of various samples of cloth fibres, stains and hair.

Materials needed:

- ❖ Cloth samples
- ❖ Stained cloth samples
- ❖ Hair samples
- ❖ Microscope
- ❖ Glass slides and cover slips



Procedure:**Part 1- Cloth Fibres**

- Obtain a sample of cloth.
- Carefully observe and draw the cloth as seen with the naked eye.
- Observe and draw the cloth as seen using a microscope. Record a description of the Cloth including colour, texture, arrangements of fibres and any other observable features.

Part 2 – Stains

- Obtain three different pieces of cloth. Each piece is numbered and will have a different stain on it.
- Observe each stain with the microscope and record any observations of the stain that you have seen.

Question: The three stains look similar when viewed with the naked eye but how do they differ when viewed under a microscope?

Part 3- Hair Analysis

- Obtain three samples of hair- one of your own, one from a friend and an animal hair.
- Make a wet mount slide of each of the hairs.
- Using the microscope observe each hair and record its characteristics including colour, thickness, texture and any unique characteristics. Ensure that you observe both ends of the hair.
- Repeat this procedure for the other two hair samples.

Question: Are there any differences between human and animal hair?

Results: (Make your own results table)

LESSON 2 ~ DNA Evidence

During the last lesson we looked at three different types of trace evidence. In today's class we are going to look at another type. This type of trace evidence is DNA

DNA Fingerprinting

- This technique compares samples of DNA. It is used in:
 - Forensic work- to check DNA from suspects against DNA from the scene of the crime, looking for a match.
 - Paternity cases-compares the DNA of a child with the DNA of his/her supposed father; a child receives half of its genetic information from its father so half of the bands in the child should match half of the bands in the father.
 - Preservation of wildlife-DNA fingerprinting is often used as a means of confirming the origins of captive animals and identifying them as those taken illegally from the wild.
- Unlike a conventional fingerprint that occurs only on the fingertips, a DNA fingerprint is the same for every cell, tissue, and organ of a person. It cannot be altered by any known treatment.
- Because no two individuals (except identical twins) have identical DNA, the probability of any two individuals producing the same pattern of bands is close to zero.
- Developing a person's DNA fingerprint requires the following steps:

1: Isolation of DNA

DNA must be recovered from the cells or tissues of the body. Only a small amount of tissue - like blood, hair, or skin - is needed, (even the amount of DNA that can be found at the root of one hair is sufficient!).

2: Cutting, sizing, and sorting

Special enzymes called restriction enzymes are used to cut the DNA at specific places. The DNA pieces are then sorted according to size using gel electrophoresis.

3: Transfer of DNA to nylon.

The distribution of DNA pieces is transferred to a nylon sheet by placing the sheet on the gel and soaking them overnight.

4: Probing.

Adding radioactive or coloured probes to the nylon sheet stains the fragments and produces a pattern called the DNA fingerprint.

5: DNA fingerprint.

The final DNA fingerprint consists of a pattern of bands that are very similar to those in the bar codes used to identify different products at a supermarket checkout.

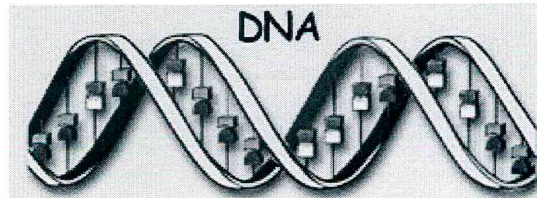


Isolation of DNA from onions

(The essential purpose of this activity is to demonstrate the major principles involved in the extraction of DNA from tissue)

Materials needed

- 10 cm³ washing -up liquid
- 3 g table salt
- 10 cm³ water
- 1 medium- sized onion (chop into 1 cm x 1 cm pieces)
- Beaker
- Water bath
- Blender
- Jug of ice
- Coffee filter paper
- Funnel
- Test-tube
- Trypsin (protease enzyme)
- Ice-cold ethanol

**Procedure:**

1. Add the table salt to the washing -up liquid. Make up to 100 cm³ with water. Stir well to dissolve the salt.
2. Add the chopped onion to the salty washing-up liquid solution. The washing-up liquid breaks down the cell membranes- releasing DNA from the nucleus inside each cell.
3. Stand the beaker in hot water at 60°C for 15 minutes. Hot conditions speed up the process and denature Dnases that might degrade the DNA.
4. Cool the mixture by standing the beaker in a jug of ice for a few minutes.
5. Blend for no more than 5 seconds. The blender helps to break open the onion cells, but don't blend for too long or you'll shear the DNA.
6. Filter the blended mixture using coffee filter paper. This separates the cell wall material from the DNA and proteins, which are now in solution.
7. Add 2-3 drops of protease enzyme Trypsin to about 6 cm³ of the onion extract. The protease breaks down the protein in the solution.
8. Very quickly pour an equal volume (6 cm³) of ice-cold ethanol onto the surface of the onion extract.
9. DNA forms in the upper (ethanol) layer. (DNA doesn't dissolve in ethanol, so it comes out of solution into the upper layer).

**Discussion**

Place this DNA extract on a glass slide and describe what you see under the microscope:



Finding the Perfect match

This activity will allow you to use bar codes to model how DNA fingerprinting is used in the identification of a DNA sample.

Materials needed

- DNA fingerprint produced from hair found at crime scene (reproduced on acetate)
- DNA fingerprints of 10 possible suspects

Procedure:

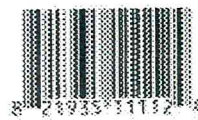
1. Collect the DNA fingerprint found at the crime scene
2. Now compare this with each suspects DNA fingerprints
3. Can you now identify the culprit?
4. Prepare a report in which you describe DNA fingerprinting, its advantages and how you were able to identify the culprit.



Discussion

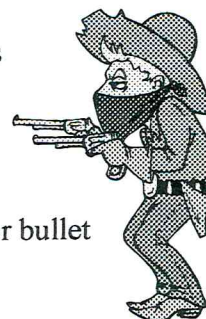
Answer the following questions as part of your report:

1. What is DNA and where is it found?
2. Why does DNA fingerprinting enable you to identify a specific individual?
3. Why was using barcodes a good model to illustrate how DNA fingerprinting works?
4. Identify the present problems with DNA fingerprinting. What do you see in the future for DNA fingerprinting?



Ballistics

- ❖ The detective at the scene of the crime picks up a revolver with his handkerchief and says to his sidekick “Take this to ballistics”. We’ve all seen it happen in the movies, but what exactly does he mean by ‘ballistics’.
- ❖ Ballistics is the study of the flight of an unpowered body. In a more specialised sense, ballistics looks at what happens inside gun barrels and at the impact of bullets. The ballistics department will tell the detective whether the gun fired the lethal shot or not.



Activity: Get ready to go ballistic

Use the following website to find out what really happens when a gun or bullet is presented to the forensics department:

http://home.iprimus.com.au/ararapaj/craigslea_testbed/Forensic%20Web%20Test%20Site/ballistics.htm

Case Study: Sarah Payne

The murder of Sarah Payne sparked one of the most high-profile police enquiries in recent years. The following is the true story of how trace evidence was used to solve this tragic case.

The background

Eight-year-old Sarah went missing on 1 July 2000 while visiting her grandparents in Kingston Gorse in Sussex. A local man on the sex offenders' register soon became a suspect and his van was seized and exhibits sent for forensic examination. After 17 months of intricate forensic work and a trial that lasted more than three weeks, Roy Whiting was finally found guilty of the murder and kidnapping of Sarah Payne following evidence of fibres and a single hair.

Following a targeted approach, the first breakthrough came in December 2000 when a link was made from fibres on Sarah's shoe to Roy Whiting's red sweatshirt. Further work was able to provide more damning evidence. This included fibres from items in Whiting's van, in Sarah's hair at the gravesite and DNA tests proving that a hair found on the red sweatshirt was Sarah's.

The exhaustive scientific work

More than 500 items were submitted for forensic analysis. Over 20 forensic experts were employed during the inquiry in the fields of entomology, pathology, geology, archaeology, environmental profiling and oil/lubricant analysis. The investigation involved a thousand personnel and cost more than £2 million. A full DNA profile was obtained from muscle and matched to a full profile obtained from a milk tooth saved by Sarah's mother.

The van

Shortly after Sarah had disappeared a witness noticed a white transit van passing along the lane. Roy Whiting bought a white van a week before Sarah disappeared. When police seized it they removed all the contents, which included a red sweatshirt, a pair of socks, a checked shirt, and a petrol receipt showing that Whiting had been only a few miles from where Sarah's body was found.

The shoe

The only piece of Sarah's clothing to be found was a black shoe with a Velcro strap, which had trapped 350 fibres. Evidence that it was Sarah's shoe came from blue polyester and cotton fibres found on it that matched her school sweatshirt.

Later when a scientist was looking at the tapings from the red sweatshirt she realised that the constituent sweatshirt fibres were unusually dark red and that they shed very readily. She then examined the fibres that had been picked off the Velcro of the shoe and saw four dark red fibres.

After mounting a sample from the sweatshirt and comparing them under a high-power microscope, they were found to match and this was the first tangible evidence to link Sarah to the van.

After finding these matching fibres all the fair hairs from the curtain and the sweatshirt were sent for DNA testing in January last year. From 40 hairs found only one gave a result - a full profile matching Sarah.

The sweatshirt

A red sweatshirt was found on the front seat of Whiting's van. The garment was taped for fibres and hairs and screened for body fluids (blood, semen and saliva).

The tapings taken from the sweatshirt were examined for blue fibres of the type that it was speculated Sarah's missing dress was made of. All the fair hairs from the tapings were prepared for DNA testing. The collar and cuffs were also tested and gave a full profile matching Whiting.

The hair

Several strands of Sarah's hair were retrieved from the burial site. A number of fibres were retrieved from them and from the body bag. From one of them, fibres were found matching the red sweatshirt and a pair of Whiting's socks. In the second clump there were fibres matching the sweatshirt, socks, and one fibre from the passenger seat of the van. One sock fibre and one from the driver's seat of the van were also found in the body bag.

Contamination

During the trial the defence barrister tried to discredit the forensic evidence in a number of ways. She claimed:

- **The sweatshirt had been contaminated during its first examination.**

Two hairbrushes taken from the Payne family home had been sent to the lab. A Sussex Police scene of crime officer had put them in a tube and then in a bag on the floor. Although the seal was intact, some of the orange adhesive was exposed and human and animal hairs from the Payne's carpet were found stuck to it. During cross-examination the defence argued that as a result of this, a 23cm hair belonging to Sarah had first transferred onto the bag containing the sweatshirt and then onto the sweatshirt itself when it was taken out of the bag for the first examination. But this examination had been completed before the hairbrushes were taken out of the exhibits store and no orange adhesive was found in Sarah's hair when tested. While giving evidence in court a forensic scientist told the jury it was unlikely that contamination had occurred in the manner suggested.

- **Doing work on exhibits from both the victim and the suspect provided opportunities for cross-contamination**

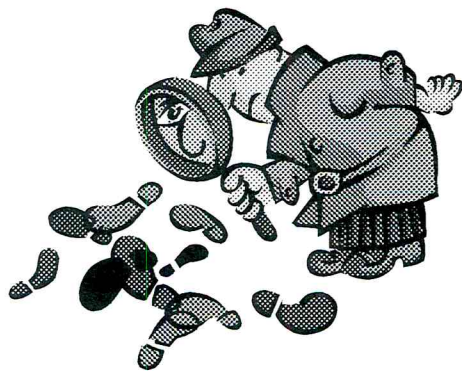
However, normal rigorous procedures had been followed and examinations relating to victim and suspect were carried out on different floors of the lab.

- **The fibres evidence wasn't important.**

The defence argued there were few fibres and that the tests aren't as discriminating as DNA tests. A forensic scientist pointed out that although each fibre type on its own may not be rare, taken together the combination of fibres could provide extremely strong evidence, in the same way that 20 common alleles combined to give a very rare DNA profile.

In December Roy Whiting was found guilty and sentenced to life imprisonment.

Unit Nine ~ Crack the Code



Unit Nine

LESSON 1 ~ Crack the Code

Forensic Science is all about solving mysteries. Is this a bloodstain? Who left these footprints? Is this the weapon used in the attack?

Imagine the following scenario.... Professor Looby, an all round nutty professor has made a scientific break through. He has developed a gas which when released into the atmosphere will turn the population of Ireland into mindless zombies, ready to take his orders.



The gas, he claims, is sealed in a container under lock and key in a safe location. This morning the police received a message from the professor giving the exact location of the gas. The professor has stated that he will release this gas in 24 hours unless the police can find it. So what's the problem? The message is in code!

The following is the message the police received:

6O 7O 2ψ 64ρδεν 5Hεδ.
 ρε2Oπε 4 βOOκ Oν 7Hε περ1Oδ13 74βλε φρO2
 7Hε βOOκ5Hελφ 4νδ ψOU ω1λλ βε πρε5εν7εδ ω17H 4 5ε3ρε7
 π45546ε.
 47 7Hε ενδ Oφ 7Hε 5ε3ρε7 π45546ε 7Hερε 15 4 54φε.
 1ν51δε 7Hε 54φε 15 4 7ε57 7Uβε Oφ 7Hε 645.

Impossible, huh? Maybe not!

The **PINK NUMBERS** in the message represent the first letter of the answers to the following clues given by the professor:

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

So, say the answer to clue number 1 was SILVER then you would put an S in for every **1** you see on the message.

The **BLUE LETTERS** have been given to us by the professor as a starting point and do not need to be changed.

Try to find the answers to each of the above clues then put the number of each clue below the first letter of its answer. Can you now try to read the message using the code below? You will need to find out what the symbols are for the missing letters.



A	B	C	D	E	F	G	H	I
							H	
J	K	L	M	N	O	P	Q	R
-					O		-	
S	T	U	V	W	X	Y	Z	
		U			-		-	

Congratulations! You have helped the police to find the safe! But...the safe is locked and the professor has left this little note saying:

Well done my friends!

You have found my safe, but you need the combination to open it. If you can complete the following experiment using the materials I have laid out, then you will be given what you desire. Be careful,

Professor Looby

The experiment was laid out on the laboratory bench across from the safe. The police have asked you once again to help them.



Finding the Combination

Materials needed

- 2 x 50 cm³ graduated cylinders
- 250 cm³ conical flasks
- burette
- plastic funnel for filling burette
- clamp and retort stand
- 100 cm³ beaker
- safety goggles
- 25 cm³ solution A-NaOH (0.04 mol/dm³)
- 25 cm³ solution D-NaOH (0.02 mol/dm³)
- 25 cm³ solution E-NaOH (0.08 mol/dm³)
- 25 cm³ solution L-NaOH (0.06 mol/dm³)
- 100 cm³ 1 mol dm³ hydrochloric acid (0.10 mol/dm³)
- phenolphthalein indicator solution

- phenolphthalein indicator solution

Note:

All P.P.E must be worn.

All the solutions A, D, E and L (especially E and L) are irritants and may be corrosive. Keep them off your skin and if spilled, wash at once with plenty of water. Phenolphthalein indicator solution is highly flammable.

Procedure:

1. Measure out 25cm³ of solution A using the graduated cylinder provided.
2. Pour this into a clean conical flask, and then wash the measuring cylinder with water.
3. Add 3 drops of phenolphthalein to solution A, it should turn pink.
4. Fill the burette with hydrochloric acid solution to the zero mark using the funnel, and then wash the beaker well with water.
5. Place the conical flask containing solution A under the burette. Carefully and slowly, let the acid out of the burette, about 1cm³ at a time. Swirl the flask gently after each addition.
6. Stop adding the acid when the liquid in the flask has JUST turned colourless.
7. Read off the level of the acid in the burette. Record this value in the table below. This is the amount of acid needed to neutralise 25cm³ of solution A.

Solution	Volume of acid needed to neutralise solution (cm ³)

Total volume of acid used =

8. Empty the conical flask by pouring the liquid down the sink. Wash the flask well with water.
9. Repeat the experiment with each of the other solutions in turn (D, E and L). Enter your results in the table.
10. In the first four boxes below, put the letters that correspond to the volume of acid used in increasing order. Start with the letter for the smallest volume.
11. Enter the value for the total amount of acid used (to the nearest cm³) in the fifth box. You should now have the combination of the safe.

--	--	--	--	--

For example, if you got the following results:

Solution	Volume of acid needed to neutralise solution (cm ³)
A	10
D	5
E	20
L	15

Total volume of acid used = 50cm³

The combination would be DALE50

**Discussion:**

Well done! The professor's evil plan has been destroyed and the people of Ireland are safe. But before you leave for a well-earned rest, can you explain the chemistry behind that experiment and answer the following questions:

1. Explain what is meant by the terms

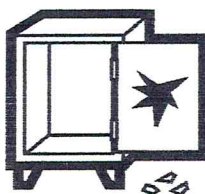
(i) Acid:

(ii) Base:

(iii) Alkali:

(iv) Indicator:

(v) pH



2. Name the acid and alkali used.

3. Name the products formed.

4. Write a balanced equation for this reaction.

5. If this salt was dissolved in water, would you expect the resulting solution to be acidic, basic or neutral?

Unit Ten ~ You be the Detective



Unit Ten

LESSON 1 ~ You be the detective

*****NEWS FLASH*****

Yesterday afternoon at approximately 2:45, as Little Bo Peep looked for her lost sheep, she came across a strange looking bundle at the bottom of Nursery hill. On closer inspection she found that it was the body of Jack Rhyme, a neighbour of hers. Jack had several broken bones and a broken crown.

As she reached for her mobile she noticed an upturned pail for carrying water halfway up the hill. At that moment, Jack's on-off girlfriend Jill came running over the hill shouting "What Happened? We weren't meant to fetch water until three o'clock!" When he arrived, Georgie Porgie, the local policeman, was immediately suspicious. On talking with locals, he established three suspects:

Suspect 1

Grettel Woods, who was seen with Jack earlier that morning. Old Mrs Hubbard claimed that Grettel had told her she would marry Jack some day. Jack however, had ended their affair the day before the accident.

Suspect 2

Hansel Woods, Grettel's overprotective older brother who was very angry with Jack.



Suspect 3

Jill, angry with Jack because of his romance with Grettel, could she have caused this 'accident'?

Georgie Porgie is a good policeman. He has collected a lot of evidence from the crime scene but needs your help to catch the culprit. The following is the evidence found at the crime scene:

- ✓ A hand-written note found in Jack's pocket. The note reads 'meet me at the top of the hill at 2 o'clock'. The notepaper used is sold in Mrs Hubbard's shop and is a very popular brand; all three suspects have some.
- ✓ Blue material fibres from Jack's hand that do not match anything Jack was wearing.
- ✓ A suspicious footprint found at the top of the hill.
- ✓ Fingerprints found on the pail.
- ✓ Dirt from the ground around the crime scene.



Georgie has also collected the following from the suspects:

Suspect 1

1. A handwriting sample
2. A pen of the same type used to write the note
3. A copy of her footprint
4. A copy of her fingerprints
5. Soil found on her shoes
6. Fibres from a blue dress she was wearing that day

Suspect 2

1. A handwriting sample
2. A pen of the same type used to write the note
3. A copy of his footprint
4. His fingerprints
5. Soil found on his work boots
6. Fibres from a blue jacket found at his home

Suspect 3

1. A handwriting sample
2. A pen of the same type used to write the note
3. A copy of her footprint
4. A copy of her fingerprints
5. Soil found on her shoes
6. Fibres from a blue jumper she was wearing that day

Your assignment:

1. Your assignment is to determine who pushed Jack.
2. Using the evidence collected and analysed, name the most likely suspect, provide scientific evidence to support your claim, and provide a reason, supported by the evidence, why the other suspects are innocent. Remember...a hunch is fine, but it's not scientific!
3. Use the skills and techniques you have gained from previous labs to analyse the evidence.
4. Make sure to label everything from the very start, as a mix-up, or contamination of the samples may cause a miscarriage of justice.
5. Keep a record of the results of all of your tests.
6. Write a report on the crime. In your report include the following: motive, a record of all of the evidence, how scientific analysis of the evidence was carried out and how it was beneficial, the results of your work and your conclusions.

