Blood and Fibre Forensics

Teaching science in a forensic context

Presented by Peter J Ball, Southern Biological. For further information, please contact the author by phone (03) 9877-4597 or by email peterjball@southernbiological.com.

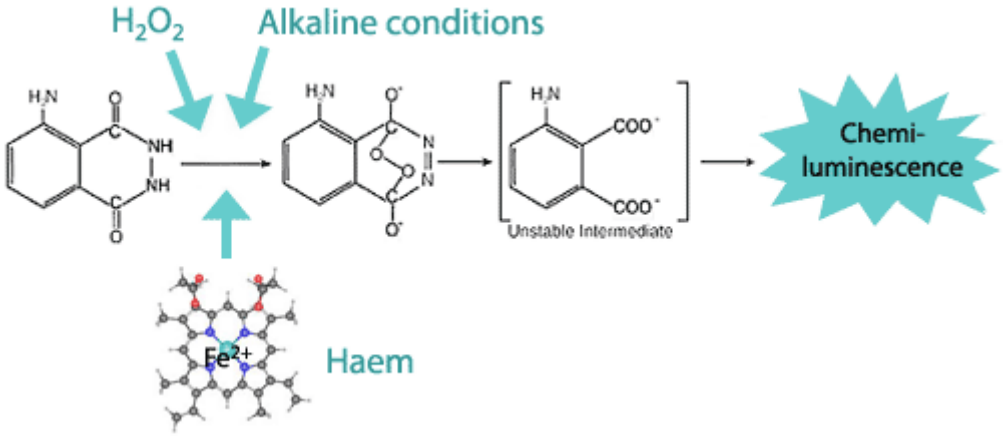
Introduction

Teaching science in a forensic context has been gaining in popularity right around the world for well over a decade. The idea is that topics that might seem dry and uninteresting can be presented in a more exciting way to help engage students and get them involved.

Blood and fibres are often collected at a crime scene and used as evidence to track down the perpetrator, so forensic science makes an ideal context to present lessons on these topics. Whilst solving a mystery, students can gain experience with microscopes, understand the need for experimental controls and learn about the composition of blood, and the structure and properties of fibres.

Detecting Traces of Blood

In alkaline conditions, luminol reacts with hydrogen peroxide to produce an unstable intermediate that sheds its excess energy as light. This reaction is greatly accelerated in the presence of haem, an organic iron complex found in haemoglobin. Haem is such a stable and effective catalyst that even very dilute and aged blood residues can be detected.



A convenient way to observe this effect is to apply the “Bluestar” forensic reagent system. This is supplied as two tablets which contain the necessary ingredients in the correct proportions to prepare 125mL of liquid spray.

The suggested approach is to apply dilute animal blood (MED25.10 or from meat) to pieces of fabric, paper or an absorbent surface such as natural wood. Allow the blood to dry then lightly spray with the mixed reagent system in dim light. For best results, allow your eyes to become accustomed to the low light conditions in advance. Compare the results to similar stains made with food dyes.

This reagent system will give a chemiluminescent result on mammalian blood regardless of whether it had a human or animal origin. Residues of other materials such as some household bleaches and chemicals containing copper can also cause a chemiluminescent reaction, but experienced crime scene investigators can usually distinguish between such "false positive" results and real blood residues. They take into account factors such as spatter pattern and the intensity of the luminescence when making an assessment.

Blood Typing

Early in the 20th century, the ABO blood typing system was discovered by an Austrian scientist called Karl Landsteiner. He was also involved in the later discovery of the Rh factor blood grouping system.

The main use of blood typing tests is to ensure safe transfusions, but it can also be used as a quick test in forensics to screen certain suspects and rule them out. For example, let us suppose that a forensic examiner tested blood that had been collected from a crime scene and found it to be type O+. A short time later, the police arrested a suspect found in the area with a cut on his arm. The examiner tested the blood type of the suspect and found it to be A-. Since the blood types do not match, the examiner can conclude that the suspect did not leave his blood at the scene.

ABO typing is based on the presence or absence of antigens on the surface of red blood cells, and the presence or absence of antibodies in the blood plasma. Red blood cells may contain type A antigens, or type B antigens, or both together (type AB), or neither (type O). As a corollary, blood plasma contains particular antibodies to complement the antigens on the red blood cells. The purpose of the antibodies is to mount an immunological response to foreign antigens if they should appear in the blood. Type A blood has anti-B antibodies, type B blood has anti-A antibodies, type AB blood has neither anti-A nor anti-B antibodies, and type O blood has both anti-A and anti-B antibodies.

As well as the A and B antigens, red blood cells may or may not have Rh factor antigens on the surface. Blood that has Rh factor antigens is described as Rh+. Blood that does not have the Rh factor antigen is Rh-. People with Rh- blood can develop anti-Rh antibodies if they are exposed to Rh+ blood.

The four ABO possibilities and the two Rh possibilities give a total of eight possible blood types under these systems:

O-	no antigens
O+	Rh antigen only
A-	A antigen only
A+	A and Rh antigens
B-	B antigen only
B+	B and Rh antigens
AB-	A and B antigens
AB+	A, B and Rh antigens

Blood typing involves placing three drops of blood on a white plate and adding one drop of anti-serum to each as follows:

To the first drop, add one drop of serum containing anti-A antibodies. If the droplets mix without clumping, the blood contains no A antigens. If clumping occurs, the blood contains A antigens.

To the second drop, add one drop of serum containing anti-B antibodies. If the droplets mix without clumping, the blood contains no B antigens. If clumping occurs, the blood contains B antigens.

To the third drop, add one drop of serum containing anti-Rh antibodies (also called anti-D antibodies). If the droplets mix without clumping, the blood contains no Rh antigens. If clumping occurs, the blood contains Rh antigens.

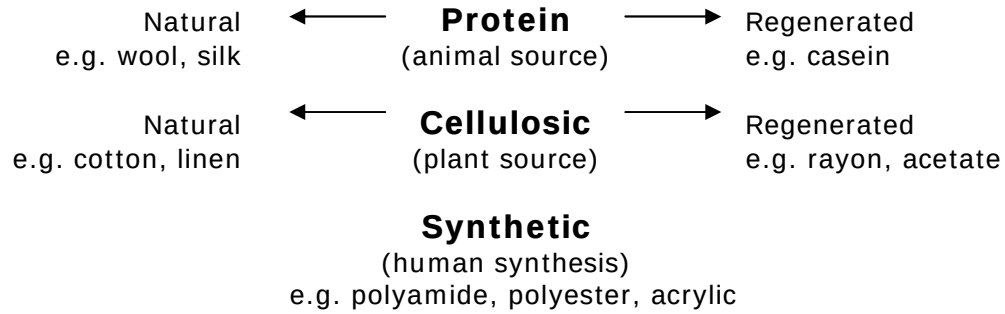
The ready availability of simulated blood and anti sera has now made realistic but totally safe blood typing experiments easy to perform in school laboratories.

Fibre Identification

Fibre identification is always a popular laboratory activity and ideal for presenting in a forensic context. Provide students with samples that have been gathered as "evidence" and have them link the samples to suspects in order to identify the guilty party.

The important key to a successful fibre identification exercise is to use samples that have not been dyed and are free from resin finishes that can mask the essential characteristics of the fibres being examined. For introductory activities, it is also a good idea to use pure samples rather than mixtures or blends.

Fibres can be classified according to their composition as follows:



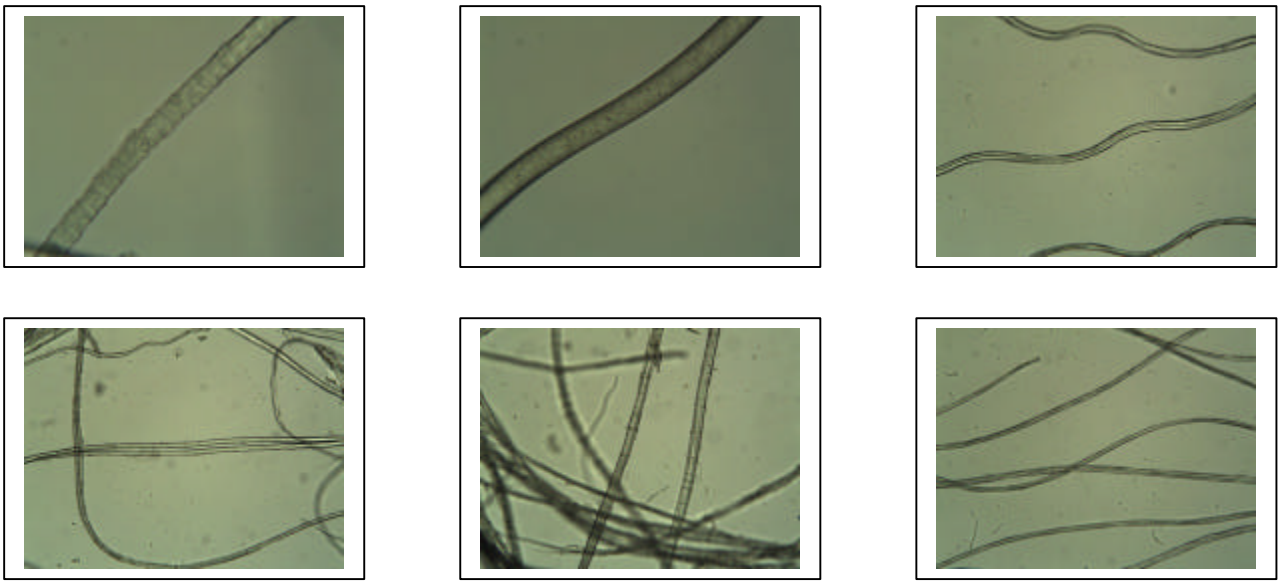
A burn test is the easiest way to make the initial classification. Fibres composed of proteins smell like burning hair and tend to blister and char. Cellulosic fibres smell like burning paper and leave a slight residue of fine grey ash. Synthetics tend to have a smell like burning plastic and usually (but not always!) melt as they burn.

As well as honing skills in experimental design, fibre identification is a great way to have students learn how to prepare slides and gain skills in microscopy. To identify unique visual characteristics , they will need to examine fibres at 400x magnification. This will lead to improved sample preparation, the ability to focus with a shallow depth of field, and the ability to recognize artefacts such as air bubbles.

Unique visual characteristics of common fibres include:

Cotton	lumen and ribbon-like convolutions
Linen	bamboo-like markings across the width
Rayon	striations along the length
Wool	overlapping scales on the fibre surface

Silk	rod-like filaments
Synthetics	rod-like filaments that may contain specks due to the presence of delustrant (TiO_2 particles)



More Resources for Forensics in Education

Many publishers and equipment manufacturers supply products that are designed to help teachers present forensic science lessons. For example:

The Crime Fighter

Written and published in Australia, this 24-page book is ideally suited to 5-10 week units for years 7-10. It describes activities such as finger printing, making footprint plaster casts, and using chemistry to identify colours in black ink. A Teacher's Guide is included. Southern Biological product code = BK70.20

Forensic Science Teacher's Collection

Topics ranging from osmosis to the polymerase chain reaction are presented in the context of a crime or mystery for students to solve. Investigative teams are responsible for finding background information in their laboratory guides, designing their experimental set-up, interpreting data and preparing results for presentation as would be done by a forensic scientist. This item consists of

- a Teacher's Manual containing case descriptions, selected answers, material lists and tips
- a Student Guide (black line master) with information in textbook format for students to understand and complete the exercises.

Southern Biological product code = BK70.60

Detective Science

This 114-age book contains 40 activities for years 7-10 involving searching for evidence, gathering clues and discovering how science helps solve mysteries. Southern Biological product code = BK70.35

Crime Solving Science Projects

This 128-page book describes experiments on fingerprint analysis, document counterfeiting and forgery, and evaluating trace evidence. Southern Biological product code = BK71.40

Electrophoresis Kit

This is a reliable self-contained experimental kit that simulates the use of DNA in forensic investigations. Students cast agarose gels, load pre-digested DNA and perform electrophoresis. The banding patterns of the DNA in the gel are used to compare the DNA profiles of two suspects with the evidence DNA. The power supply is not included, but 9V batteries may be used. Southern Biological products codes = G3.00 (Demo kit), G3.00CK (Classroom kit) and G3.00CKRK (Classroom kit refill).

Web sites

There are also many web based resources available to teachers. For example,

Texas Instruments: www.tiforensics.com

National Institute of Forensic Science: www.nifs.com.au

Use a search engine to track down more sites that can help give you ideas.

Conclusion

Whether you are presenting a one-off practical exercise, or planning a multi-week program of activities such as described in the appendix, framing the activity in the context of a forensic investigation is guaranteed to spark excitement and interest amongst your students. What seemed like a dull and uninteresting lecture can be transformed into an engaging topic that can involve everyone in the class. Forensic science is also a context that can be adapted for all ages, from primary to senior secondary.

Appendix

At the NSTA conference in April 2006, I was able to hear an account of a very successful forensic science program run by teacher Eric Rude at Pocatello High School in Idaho USA. He developed a 9 week course for middle school students who would not have been able to complete a traditional science course. His aim was to give them a "science credit" by having them learn a range of methods and techniques, as well as understand the science behind each activity.

He stressed that it is important to vary the details of the "crime" each year to add to the interest and anticipation of students who are about to start the program. He also compounds the depth of the mystery by setting two objectives - identify the criminal ***and*** the victim.

Examples of tests:

Fingerprints

Metal objects (e.g. a butter knife) collected at the crime scene can be tested by exposing to super glue fumes under a plastic cover in a fume cupboard.

Finger prints on the sticky side of adhesive tape can be "developed" by immersing in a solution of crystal violet.

A commercial finger printing kit can be used if resources permit, but sometimes there are more learning outcomes with "home made" tests.

Suspects' prints can be obtained with an ink pad.

In each case, the finger prints can be scanned and enlarged to make examination easier.

Soil

Soil can have various additives included to help narrow down the range of suspects. For example:

- Add $NaHCO_3$ powder to increase the pH
- Add fluorescent GlitterBug powder that will show up under UV light
- Add iron filings that will respond to a magnet
- Add objects such as shell grit, coloured sand, pine needles, seeds etc that can be associated with a particular place or activity that might be linked with the victim or the criminal.

Students carry out tests such as sieving to provide qualitative and quantitative data. Test with a few drops of HCl solution to see if there is a reaction due to $NaHCO_3$ or metal fragments. Measure the pH of an aqueous extract. Measure the settling rate by using a spectrophotometer or colorimeter and determining the time for light transmittance to drop. Measure the density gradient in a home-made densitometer consisting of a small cylinder containing 1-2mL of five different liquids such as corn syrup, water, glycerine, corn oil and iso-propanol.

Blood Typing

Carry out ABO blood typing on synthetic blood "found" at the scene. Does it belong to the victim or the criminal, or could it be either? Also carry out typing on synthetic blood samples "taken" from suspects. Does blood typing allow any suspects to be eliminated?

Fibre Identification

Use microscopic analysis to identify fibres found at the scene and then link them with the victim and suspects. Compare the fibres to descriptions of clothing in missing persons reports to assist in the victim identification process. Use fibre results to confirm or eliminate some suspects. Perhaps include animal hair to link the victim or a suspect to an animal such as a dog or cat.

It is also possible to use a laser pointer to estimate fibre diameter from an interference pattern.

Bone Analysis

Use diagrams and cardboard cutouts of bones to estimate the height and gender of the victim. Use the results with other data to identify the victim conclusively.

Records

The students must keep an accurate record at each stage of the investigation. This can include lists, descriptions, diagrams, pictures and photographs, tables of results, graphs, calculations, and deductive reasoning leading to conclusions. It should also include information about the methods used.

Some practicalities

Suspects are always teachers or other staff at the school. The program concludes with an "arrest" of the guilty party by the students. Before they can arrest their suspect, students must obtain an "arrest warrant" from their coordinator by justifying their case. This is a form of oral exam which includes the written details of their test results and conclusions. If necessary, the coordinator will guide the students to check their data before issuing the warrant. In other words, they have to arrest the right staff member!

Students collect evidence from the crime scene at the start of the program, but, to minimize downtime, evidence gathered from suspects is provided in sealed bags.

Ideally, the crime scene should be an area that can be locked up for the period of the investigation to conserve the evidence, e.g. shed or storage room. Even for outdoor crime scenes, it is useful to have a secure room where evidence can be safely stored after it has been collected, bagged and labeled.

For more information, visit Eric's forensic web site at:

http://web1.d25.k12.id.us/home/staff/rudeer/forensics.html