Developing Traditional Forensic Science Exploitation of Contaminated Exhibits Recovered from a Nuclear Security Event

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Introduction

- The investigation resulting from the malicious use of nuclear and other radiological material outside of regulatory control will require scientific support:

    1. Analyses of the recovered “unknown” nuclear / other radiological material

    2. Examination of associated material / items (packaging/documents etc) recovered from the contaminated crime scene

- The examination of the associated material / items will aim to recover fingerprints, DNA, hairs and fibre etc…
- Traditional forensic science examination on exhibits contaminated with nuclear and other radioactive material can be problematic…

Exercise photograph

Traditional Forensic Science Examinations on Exhibits Contaminated with Nuclear or other Radioactive Material

Traditional Forensic Science Laboratories

- ☒ Laboratories not licensed handle nuclear and other radioactive material
- ☒ Laboratories not designed for operations with nuclear and other radioactive material
- ☒ Staff not trained to handle nuclear and other radioactive material
- ☑ Expertise in traditional forensic science disciplines

Nuclear/Radiological Materials Laboratories

- ☒ Laboratories not equipped to undertake traditional forensic science
- ☒ Staff not trained to undertake traditional forensic science examinations
- ☑ Laboratories licensed to handle nuclear and other radioactive material
- ☑ Expertise in handling and characterising nuclear and other radioactive material

Enabling Traditional Forensic Science Examinations on Contaminated Items

- Solution…enable traditional forensic scientists to perform their examinations in a suitable controlled environment under appropriate radiological protection supervision

- Office for Security & Counter-Terrorism, Home Office (UK) funded the development of a specialist laboratory at AWE

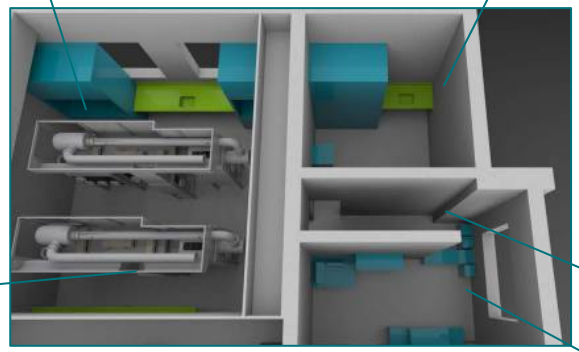
- The project utilised:
  - AWE expertise in nuclear materials
  - Traditional forensic science expertise from:
    - The Metropolitan Police Forensic Science Directorate
    - Dedicated Forensic science service provider
    - Forensic Explosive Laboratory
    - Home Office Centre for Applied Science & Technology

End-User Requirements

The CFAC Laboratory

- ☑ Laboratory licensed to handle radiological material
- ☑ Laboratory designed for operations with radiological materials
- ☑ Laboratory able to receive RN+E contaminated exhibits
- ☑ AWE providing technical advice on dealing with the radiological hazard
- ☑ Forensic practitioners from external organisations (e.g. the Police) trained to work within the laboratory
- ☑ Traditional forensic science examinations to a standard acceptable to UK Court of Law
- ☑ Broad range of traditional forensic science examinations possible:
  - ☑ Record photography
  - ☑ Swabbing for DNA
  - ☑ Trace evidence recovery
  - ☑ Digital data recovery
  - ☑ Fingerprints
  - ☑ Questioned Documents

The CFAC Laboratory



- 360º tour generated by Darren Jones (SCO4)

Glove Box Units for Exhibit Examinations

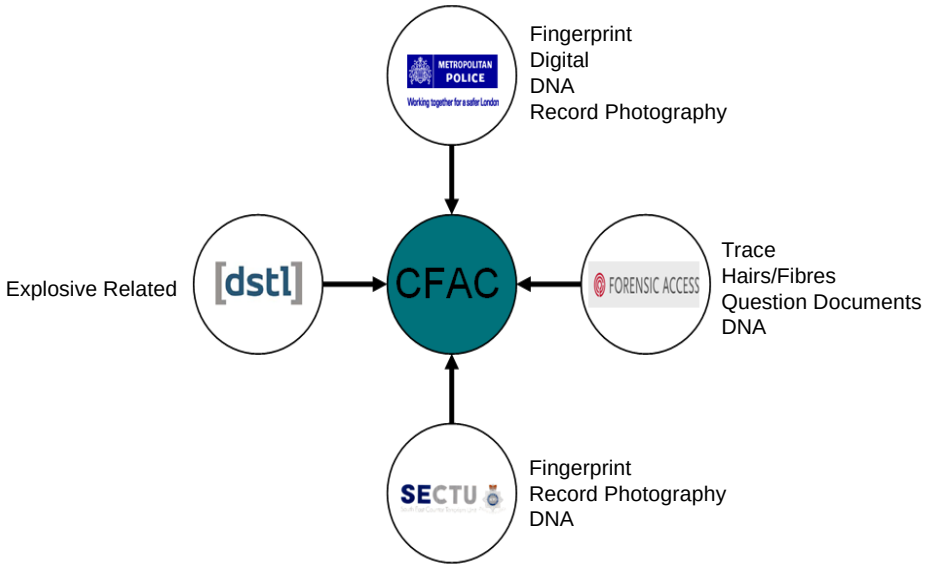
- Two dedicated glove box units designed to examine exhibits contaminated with nuclear or other radioactive material
  - CNA chamber for fingerprint development incorporated into the glove box

Forensic Examinations within the Lab

- Broad range of more detailed examinations can be performed around laboratory, including:
  - Questioned Document analysis
  - Trace evidence examinations, e.g. comparison microscopy
  - Digital data recovery from mobile phones

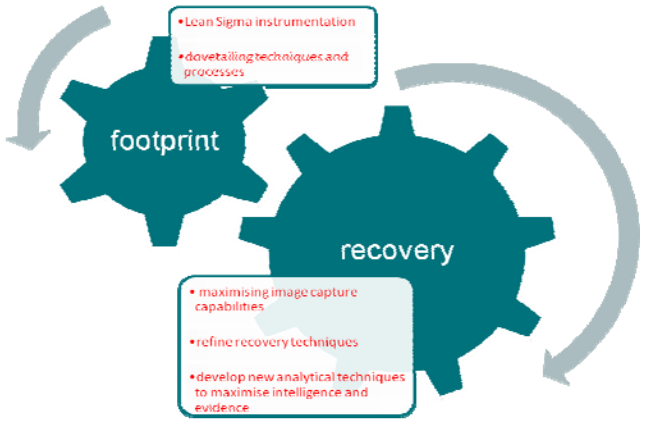
Operating Model for the CFAC Laboratory

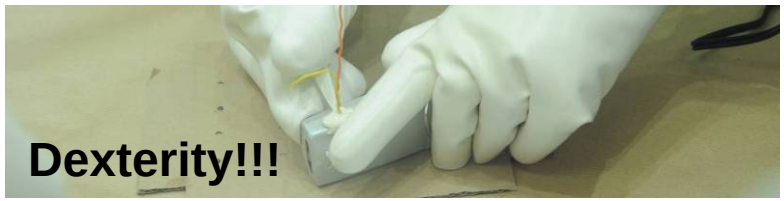
- External Forensic Scientists to undertake the casework examinations after training to operate in a glove-box with support from technical specialists from AWE (e.g. radiological protection advice)



Challenges of Operating in a Glove-Box

- Different environment to the “normal” forensic science laboratory…co-existing disciplines all in the same space
  - Requires a different approach to examinations yet still maintaining the standards expected for forensics!





Validation & Method Development

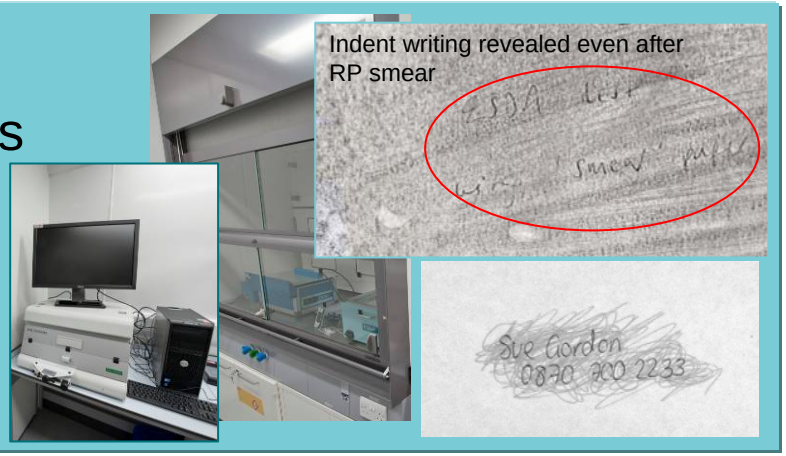
- Transferring methods and procedures from “home” laboratory to the CFAC
  - Fingerprints, QD, Trace, DNA, Digital etc
- Adapting methods for use in the CFAC
- Develop SOPs for accreditation and to comply with the Forensic Science Regulator’s Code of Practice

Biology

- Searching and ID of blood using KM
- ID of human blood with Hematrace
- Recovery of DNA
- Blood pattern analysis

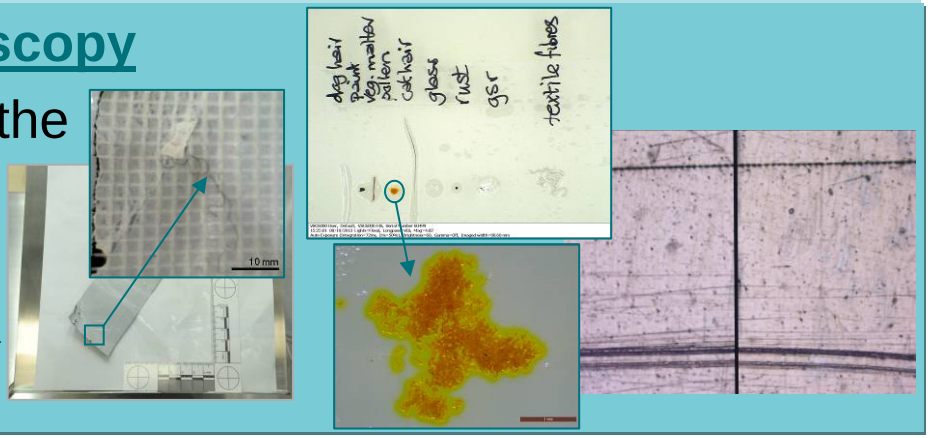
Question Document

- Validating ESDA and VSC instruments against know test samples
- Adapting operator procedures
- Testing impact of radiation protection monitoring processes



Trace Evidence & Optical Microscopy

- Recovery of “loose” material in the glove-box
- Development of procedures for instrumentation e.g. MSP, FTIR
- Evaluating tape-lift materials

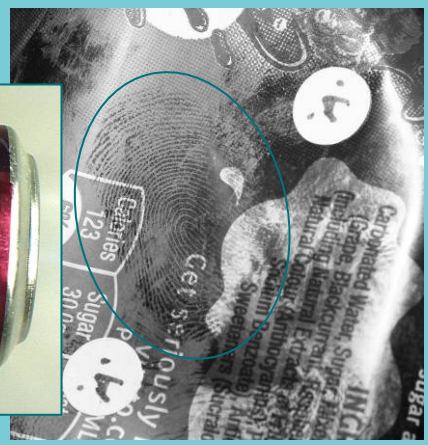


Fingerprint Development

- Validation of methods for:
  - CNA fuming
  - Alternative light source imaging

Foster + Freeman Crime-lite® CL-2 & CL-82S

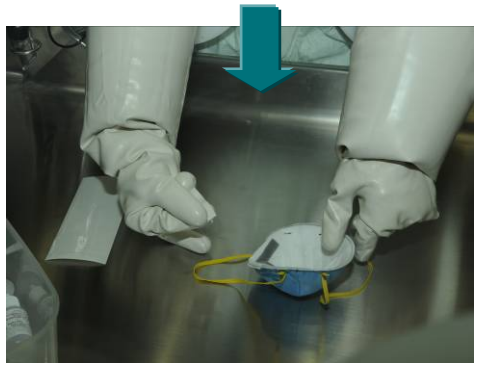
white, UV, violet, blue, blue-green, orange (82S)



Validation Drills

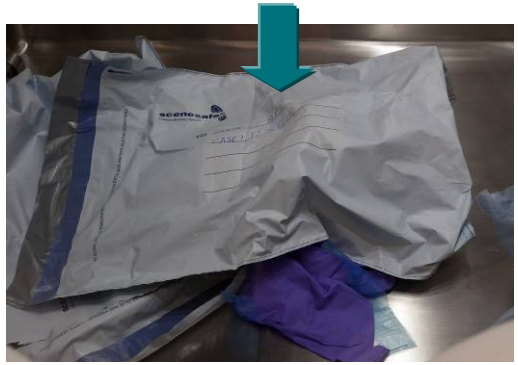
- To-date three (3) drills have been undertaken in the CFAC laboratory
  - Opportunity to test procedures, processes and adapted methods

Drill No.1



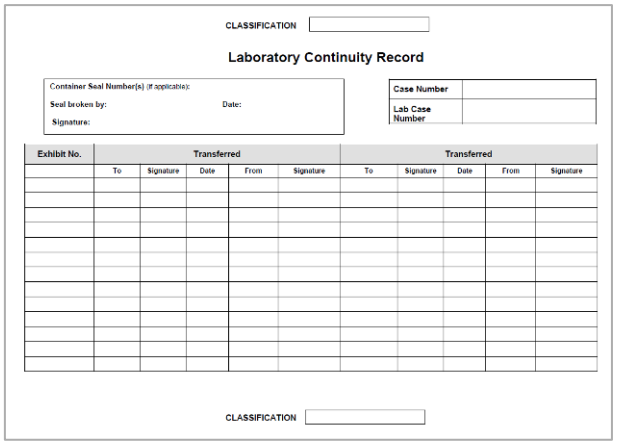
Drill No.2

Drill No.3



General Forensic Science Requirements to be Implemented at the CFAC laboratory

- In addition to the validation studies currently being undertaken the laboratory is implementing standard good practices in forensic science
- Compliance with the Home Office Forensic Science Regulator's Code of Practice and Conduct and accreditation body requirements
- Case Management procedures and processes, e.g.
  - Exhibit Submission form
  - Evidence Continuity form
  - Communication log


CLASSIFICATION

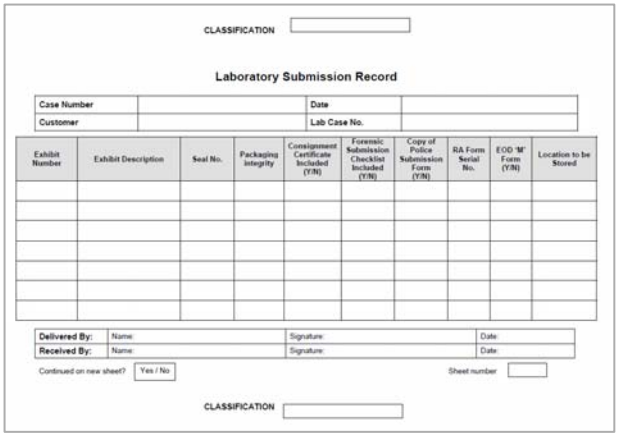
Laboratory Continuity Record

Container Seal Number(s) (if applicable):
Seal broken by: Date:
Signature:

Case Number
Lab Case Number

Exhibit No.	Transferred					Transferred				
	To	Signature	Date	From	Signature	To	Signature	Date	From	Signature

CLASSIFICATION


CLASSIFICATION

Laboratory Submission Record

Case Number		Date	
Customer		Lab Case No.	

Exhibit Number	Exhibit Description	Seal No.	Packaging Integrity	Consignment Certificate Included (Y/N)	Forensic Submission Checklist Included (Y/N)	Copy of Police Submission Form (Y/N)	RA Form Serial No.	EOD 'M' Form (Y/N)	Location to be Stored

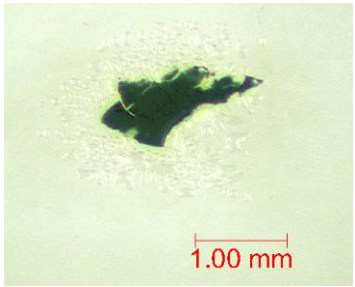
Delivered By:	Name:	Signature:	Date:
Received By:	Name:	Signature:	Date:

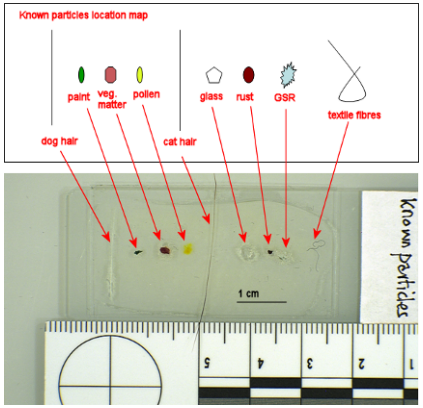
Continued on new sheet? Yes / No Sheet number

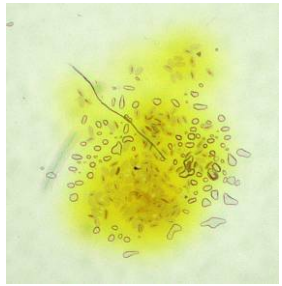
CLASSIFICATION

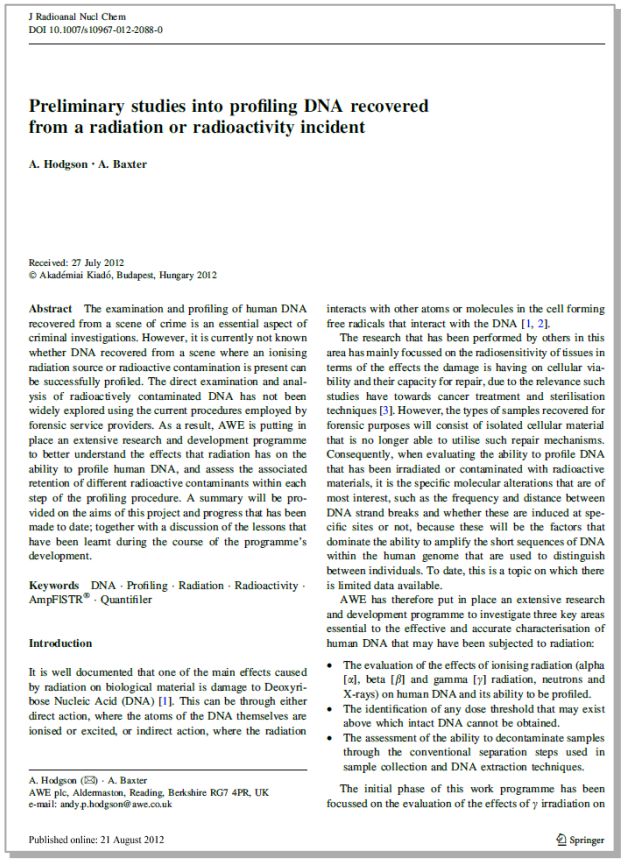
Method Development

- A need to understand the effects of radiation on hairs, fibres, DNA etc
- A need to understand the effects of decontamination on hairs, fibres, DNA etc
- Refine process to maximise recovery of all evidence types









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Preliminary studies into profiling DNA recovered from a radiation or radioactivity incident

A. Hodgson · A. Baxter

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Abstract The examination and profiling of human DNA recovered from a scene of crime is an essential aspect of criminal investigations. However, it is currently not known whether DNA recovered from a scene where an ionising radiation source or radioactive contamination is present can be successfully profiled. The direct examination and analysis of radioactively contaminated DNA has not been widely explored using the current procedures employed by forensic service providers. As a result, AWE is putting in place an extensive research and development programme to better understand the effects that radiation has on the ability to profile human DNA, and assess the associated retention of different radioactive contaminants within each step of the profiling procedure. A summary will be provided on the aims of this project and progress that has been made to date; together with a discussion of the lessons that have been learnt during the course of the programme's development.

Keywords DNA · Profiling · Radiation · Radioactivity · AmpFlSTR® · Quantifiler

Introduction

It is well documented that one of the main effects caused by radiation on biological material is damage to Deoxyribose Nucleic Acid (DNA) [1]. This can be through either direct action, where the atoms of the DNA themselves are ionised or excited, or indirect action, where the radiation interacts with other atoms or molecules in the cell forming free radicals that interact with the DNA [1, 2].

The research that has been performed by others in this area has mainly focussed on the radiosensitivity of tissues in terms of the effects the damage is having on cellular viability and their capacity for repair, due to the relevance such studies have towards cancer treatment and sterilisation techniques [3]. However, the types of samples recovered for forensic purposes will consist of isolated cellular material that is no longer able to utilise such repair mechanisms. Consequently, when evaluating the ability to profile DNA that has been irradiated or contaminated with radioactive materials, it is the specific molecular alterations that are of most interest, such as the frequency and distance between DNA strand breaks and whether these are induced at specific sites or not, because these will be the factors that dominate the ability to amplify the short sequences of DNA within the human genome that are used to distinguish between individuals. To date, this is a topic on which there is limited data available.

AWE has therefore put in place an extensive research and development programme to investigate three key areas essential to the effective and accurate characterisation of human DNA that may have been subjected to radiation:

- The evaluation of the effects of ionising radiation (alpha [α], beta [β] and gamma [γ] radiation, neutrons and X-rays) on human DNA and its ability to be profiled.
- The identification of any dose threshold that may exist above which intact DNA cannot be obtained.
- The assessment of the ability to decontaminate samples through the conventional separation steps used in sample collection and DNA extraction techniques.

The initial phase of this work programme has been focussed on the evaluation of the effects of γ irradiation on

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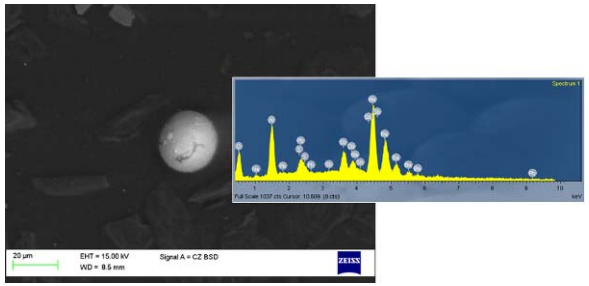
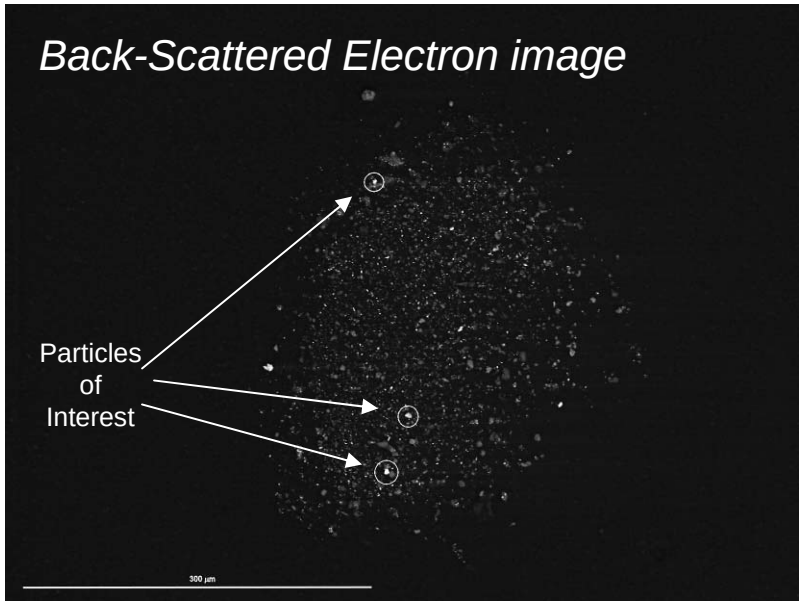
Applied Nuclear Forensic Analysis

- Classical “trace” forensics, e.g. GSR used to infer associative links



- Apply same philosophy to a Nuclear Forensic Investigation…
- Identification of particulate material on exhibits, e.g. clothing
- Simulated Nuclear Forensics crime-scene study

  - Disposable glove recovered from scene and sampled using adhesive SEM stub
  - Stub analysed using SEM/EDX



- Future work…need to developed an understand of:
  - Persistence
  - Transfer

Summary

- The CFAC laboratory provides the appropriate environment / facility for handling exhibits contaminated with nuclear and other radioactive material
- Experienced traditional forensic scientists are being trained to be able to operate within glove boxes with supervision
- Current efforts are focussing on method development and validation studies
- Gain ISO 17020/17025 accreditation for the various examination methods
- The forensic science procedures and examinations performed within the CFAC laboratory will be to a standard acceptable in a UK Court of Law