A

Level 3 Certificate/Extended Certificate

APPLIED SCIENCE

Unit 3 Science in the Modern World

January 2022

ASC3/PM

Pre-release Material

- **This pre-release material should be opened and issued to learners on or after 1 NOVEMBER 2021.**
- **A clean copy of the pre-release material will be provided at the start of the examination.**

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INFORMATION

This pre-release material is to be issued to learners for use during preparation for this examination. The pre-release material consists of four sources (A–D) on the subject of FORENSIC SCIENCE.

This material is being given to you in advance of this examination to enable you to study each source in preparation for questions based on the material in SECTION A of the examination.

A wider understanding of the topics and issues raised in the sources would be beneficial for the assessment. You are not required to understand any detailed scientific explanations beyond that outlined in SOURCES A–D and that in the Applied Science specification.

You may write notes on this copy of the pre-release material, but you will not be allowed to bring this copy, or any other notes you may have made, into the examination room. You will be provided with a clean copy of this pre-release material at the start of the examination.

It is suggested that a minimum of three hours detailed study is spent on this pre-release material.

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SOURCE A: Adapted journal article from 'New Scientist', 19 June 2017

FUTURE FORENSICS: Harnessing the spirit of Sherlock Holmes

The fictional Victorian detective prophesied several enduring forensic methods. But how much will today's big advances shape the future of this field?

Updated 19 June 2017

Tuck away the pipe, pull out the magnifying glass, and begin the hunt for clues. For Sherlock Holmes, it was elementary. The fictional Victorian detective prophesied some of the enduring crime-solving methods of forensic science – in particular, the way that traces of evidence can help uncover a suspect's identity.

But forensic science is evolving, and so is the search for clues. Researchers at the cutting edge are developing new detective tools. When a suspect's identity cannot be established, detectives may soon still be able to build a picture of what the person looks like, and even their habits and diet, from the traces they leave. And computer algorithms can go a step further, potentially identifying would-be criminals before they commit a crime from clues in their behaviour.

Even fingerprints – the detective's staple that Holmes was interrogating a decade before the technique was

adopted by London's real-life police force at Scotland Yard – are getting an upgrade. The intricate pattern of ridges across our fingertips is unique to each of us. By dusting a crime scene for prints, investigators can identify these patterns and match them to prints already recorded in a database.

"The first thing an analyst asks is: is it good enough quality?" says Annemieke van Dam at the University of Amsterdam's Academic Medical Centre in the Netherlands. A computer can do part of the job, but an analyst is required to make the final call on whether enough of the fingerprint matches the database search result.

TIPS FROM FINGERS

But what to do when there is no database match? Or when two analysts disagree on a fingerprint? Fingerprint evidence is far from infallible, and famously led to the wrongful imprisonment of US lawyer Brandon Mayfield, who was accused of the 2004 Madrid bombing.

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Van Dam is one of a group of research scientists who are looking for other clues in the marks we leave behind when we touch surfaces and objects. "The fingermark is comprised of all kinds of stuff," she says, using the term for marks left by our fingers in the real world. (Forensic scientists reserve the term fingerprint for prints collected from known individuals in controlled conditions.)

Part of this mark is made up of proteins and fats secreted from our skin. A more detailed inspection of these compounds could reveal a host of information about the person who left them, such as their diet.

When we digest food in our gut, the products – called metabolites – are absorbed into the bloodstream. Many of them also end up in our fingertip secretions, says van Dam. So far, research scientists have succeeded in identifying metabolites from foods and compounds such as green vegetables and caffeine in fingermarks. "Maybe one day we'll be able to tell if the person who left a fingermark was a meat eater or a vegetarian," says van Dam.

Other research scientists have also found evidence of drug use in fingermarks. This kind of fingermark analysis is not used by crime scene investigators at the moment, but van Dam reckons it is only a matter of time before it becomes routine. "We've only been looking at the ridge pattern of fingermarks, but there's so much more," she says.

DNA LEADS

Van Dam's team has even been able to find tiny amounts of DNA in some fingermarks – which might prove useful as DNA sequencing technology improves.

DNA evidence is, after all, seen as the 'gold standard' of crime scene evidence. Biological components such as saliva and blood contain a person's DNA. Standard testing involves isolating the DNA from samples of those and then screening the genetic code for pieces of DNA called 'short tandem repeats'. These chunks don't necessarily code for useful proteins but are known to differ between individuals – so they can be used to tell people apart.

A suspect's DNA profile can be searched against a database, and DNA can also be used to identify a single perpetrator among a set of suspects. But when the database comes up blank, investigators can find themselves stumped.

"If you have nothing to compare it to, DNA analysis can give you a beautiful genetic profile with no answers," says Susan Walsh, forensic geneticist at Indiana University-Purdue University, Indianapolis.

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Walsh and her colleagues are working on new ways to make use of such genetic profiles. By searching for genes known to influence a person's physical traits, they hope they might be able to use DNA analysis to build a picture of a suspect. "The idea is to look for pieces of DNA that tell us what the person looked like," says Walsh.

BUILDING A PICTURE

Geneticists have already started to identify genes for some traits. They have a good idea of which genes are responsible for eye and hair colour, for example, as well as skin colour and height. Some genetic variants are also known to put people at risk of obesity, so could go some way to predicting a person's weight.

Walsh thinks this knowledge could be applied to criminal cases. The first trait she investigated in relation to potential use in this area was eye colour. "We looked at all the fundamental research and found that we could use 22 markers on 11 genes to predict eye colour with 80 percent accuracy," she says.

Since then, she and her colleagues have developed similar tests for the colour of skin and hair. The technique, known as DNA phenotyping, is not yet used in investigations, although Walsh has convinced local crime investigators to apply it to old DNA evidence from a handful of cold cases. "They were excited that they had something to work on," she says. "We've asked for more cases."

THE BACTERIAL CLUES WE LEAVE BEHIND

A crime scene without blood, hair and the like can leave investigators with little trace evidence to go on. But Jarrad Marcell, microbial ecologist at the Argonne National Laboratory in Chicago, Illinois, thinks we may leave other, less human, clues.

Marcell is exploring the bacterial traces that people leave on every surface they touch and in the air they breathe. We are, after all, heaving masses of bacteria, with more bacterial than human cells in our bodies. Recent research suggests that these bacterial collections may be unique to each of us. Marcell and his colleagues are working on ways to obtain and interrogate bacterial traces for criminal investigations.

PRE-CRIME POLICING

Perhaps the most futuristic – and controversial – development in forensic science is the application of technology to spot clues to a crime before one has even occurred. Take PredPol, for example. This software, developed by mathematician George Mohler at Santa Clara University in California, is fed data on recorded crimes, such as local burglaries. It seeks to identify and use patterns in the timing and locations of crimes to predict where future ones might take place – suggesting a regular location for police officers to investigate.

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"It's a promising approach," says Kathryn Seigfried-Spellar at Purdue University in West Lafayette, Indiana. "We are, after all, creatures of habit." Even Sherlock Holmes would surely agree with that.

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SOURCE B: Adapted journal article from 'Engineering and Technology', 18 March 2020

NON-FICTION FORENSICS: weird ways in which real-world crimes have been solved

By Sarah Griffiths   Wednesday, March 18, 2020

Better than a delicious plot twist in a crime novel that is both shocking and satisfying, some real-life crimes have been solved in the strangest of ways. In fact, some are so bizarre that they may seem like the cunning concoctions by Arthur Conan Doyle.

In modern times, baffling crimes are seldom solved by an eccentric genius like Sherlock Holmes. More commonly the critical discoveries come from teams of specialists called upon by the police.

"A lot of cases involve multidisciplinary teams such as botanists, soil scientists, pollen experts, entomologists and others as and when required," says forensic anthropologist and archaeologist Dr Julie Roberts, who is a lecturer in forensic anthropology at Liverpool John Moores University and has helped solve many cases that are stranger than fiction. Here are some examples of confuddling crimes solved by some far-from-elementary methods.

MULLING OVER MAGGOTS

Maggots may be disgusting when they are found devouring decomposing remains, but they are incredibly helpful when solving some serious crimes. The grisly job of analysing wriggling larvae and other insects falls to entomologists, who can estimate the time since death or deposition of a body by looking at the different life cycles of minibeasts. An entomologist helped Dr Roberts solve a strange case in which someone had tried and failed to dispose of a body in a garden buried in concrete. They discovered a body and some maggots, wrapped in bin liners from which they were able to work out the sequence of events.

GRASPING THE NETTLE

In a similar way to DNA and fingerprinting, plant material is unique – to plant species and ecological areas – allowing forensic botanists to narrow down the possibilities of where and when a crime was committed, as well as who did it.

Experts sometimes study pollens, plants, trees, and aquatic environments – where the presence of microscopic algae like diatoms in the lungs can prove someone died from drowning in a particular body of water.

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Botanical evidence can be used to identify clandestine graves by looking at disturbances in the soil and plants. For example, the suspect who was convicted of the murders of two girls in 2003 was convicted in part due to evidence about nettle disturbance and pollen. At the hearing for the Soham Murders, Dr Patricia Wiltshire, forensic ecologist, botanist, palynologist (pollen specialist) and author of 'Traces', explained that while foliage around the ditch where the girls' bodies were concealed appeared untouched, some stinging nettles had sprouted side-shoots, which only happens when they have been trampled. The rate of new growth led her to believe that the plants had been disturbed thirteen-and-a-half days earlier, giving the police a better indication of when the girls had been killed. By comparing soil samples from the suspect's car and the ditch, Dr Wiltshire was also able to prove the suspect had been at the site.

ALL THAT GLITTERS IS... EVIDENCE

If you have ever been 'glitter bombed' you will know the sparkly stuff gets everywhere. And it's been used to solve crimes for decades – perhaps for the first time during the Cold War in Germany, when the US Army's crime lab used it to solve an assault case. But the investigator of that case realised the variety of glitter particles meant they could be useful for solving crimes.

More recently, glitter particles were the deciding factor in a hit-and-run incident. In 2004, an intoxicated woman denied colliding into a car, while driving her truck,

which resulted in the death of a mother and child. However, her glittery makeup was discovered on the car's airbag.

IM-PURR-FECT CRIMES

It was cat hair that led to the incarceration of a man in Canada. When a mother called Shirley Duguay disappeared in 1994, people suspected her estranged husband may have been involved, but it was her blood-stained jacket with cat hairs that proved to be Douglas Beamish's undoing. One of the investigators remembered a white cat in Beamish's home when he questioned him and DNA analysis confirmed the hairs on the jacket belonged to his cat, Snowball. He was sentenced to 18 years in prison.

THE VERDICT

It's hard to believe some of these cases are for real (or fur real, as the case may be) but when it comes to forensic techniques, there are a host of unusual ways to catch a thief or murderer and reality can put the plots of detective novels to shame.

As the famous fictional detective says, "When you have excluded the impossible whatever remains, however improbable, must be the truth."

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SOURCE C: Adapted journal article from 'Science Daily', 24 June 2020

Bringing burnt bones back to 'life' using 3D technology

University of Portsmouth June 24, 2020

Forensic scientists at the University of Portsmouth have discovered a new way of presenting fragile evidence, by reconstructing a 'jigsaw' of human bone fragments using 3D printing.

In the first known study of its kind, researchers took fragmented burnt human bones and tested the ability to make 3D models suitable to be shown to a jury in court.

Forensic investigation of crime scenes and other incidents requires the analysis of many different items as evidence, including human remains, some of which may be damaged or fragmented. To determine whether these pieces of evidence were originally one whole, they must undergo a process called 'physical fit analysis'.

One of the scientists involved in the research, Dr Katherine Brown, Senior Lecturer, Institute of Criminal Justice Studies, University of Portsmouth, says: "A positive physical fit indicates that two or more fragments have originated from the same object. Confirming physical fit at a crime scene is essential to

draw links between locations, place suspects at the scene, and allow for object reconstruction."

However, physical fit analysis relies on the manual handling and then placing back together of the human remains and is often challenging to conduct with bone fragments; particularly when fragile, sharp, or embedded in other materials.

Dr Brown says: "We wanted to find a way to circumvent the need to manually handle the delicate bones, so we looked to 3D technology. Whilst the use of 3D technology has become increasingly widespread within the field of forensics to our knowledge, this approach has not yet been applied explicitly to physical fit analysis."

The scientists compared two different 3D imaging techniques: micro-computed tomography, and structured light scanning. By generating virtual 3D models and prints of burned human bone fragments, they tested the suitability of these imaging techniques and subsequent 3D printing for physical fit analysis. The researchers ultimately found that 3D imaging and printing allowed for effective physical fit analysis without excessively handling the original fragments.

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Limiting the handling of fragile forensic evidence minimises damage and contamination. Additionally, the use of 3D prints opens up the possibility for physical fit demonstration, and the opportunity for a jury to explore the evidence replicas. Interaction with 3D virtual models and animations also provides 360-degree visualisation in an engaging, understandable, and potentially impactful way, improving a jury's understanding.

Dr Brown says: "The application of 3D imaging and printing for physical fit analysis has many advantages compared with traditional methods. Overall, the techniques demonstrated by the study add value in forensic investigation and evidence presentation within the courtroom."

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SOURCE D: Adapted journal article from ‘The Conversation’, 14 August 2020

Forensic breakthrough helps explain how innocent people’s clothing fibres could end up at crime scenes

August 14, 2020 1.20pm BST

by Kelly Sheridan and Matteo Gallidabino
Senior Lecturers in Forensic Science, Northumbria University, Newcastle

Every time you put on a coat, hug somebody or sit on a sofa, you leave behind tiny little fibres from your clothing. You also pick up fibres left behind by other people. This movement of fibres is known as fibre transfer and forensic scientists can use this to solve crimes.

Textile fibres are one of the most important types of evidence in forensic science. And have been pivotal in solving some of the UK’s most notorious crimes. But establishing textile fibre links is only half the battle for forensic scientists working on criminal cases. What is equally, if not more important, is to work out how the fibres actually got there in the first place.

To date, it has largely been assumed that fibre transfer only occurs when two surfaces touch. So, for example, when the front of your jumper touches the shirt of

someone you hug, or when the back of your trousers touches the sofa you sit on. But we now know this is not necessarily the case.

A NEW DISCOVERY

Our new research has found a new way that fibres can be transferred: 'contactless airborne transfer'. This is when fibres move from one garment to another without contact. So, for example, imagine there are two people in the same room, but they don't touch each other. It's possible that fibres from person A's clothing could transfer through the air, to person B's clothing (and vice versa).

From the perspective of an investigation, this means that, under certain conditions, fibres found on a person could have been passively transferred rather than through direct involvement in a crime.

In our experiment we used everyday garments – jumpers, long-sleeved tops and fleeces – that were fluorescently dyed. This allowed us to track the airborne transfer of their fibres between garments.

One participant wearing a fluorescent garment stood in one corner of an elevator and another wearing a non-fluorescent black top stood in the diagonally opposite corner. Both participants remained in the elevator

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(without touching each other) for 10 minutes. During this time the elevator operated as normal and non-participants of the study entered and exited as usual.

Following the experiment, the black top of the recipient was photographed using UV-imagery techniques to determine the number of fibres transferred. The results of the study proved that not only can textile fibres transfer between garments without physical contact, but they can do so in relatively high numbers.

Often in a criminal case the finding of just a few fibres can be considered significant. So, the fact that up to 66 fibres were transferred in a single experiment, was considerably higher than anticipated.

That said, not all garments we tested transferred fibres to the same extent. We found the type of fibres the donor garment was constructed from and its ability to shed those fibres was key in contactless fibre transfer. The type of clothing worn by the recipient also impacted transfer, as did the movement of people and the opening or closing of the elevator doors.

FIBRE EVIDENCE

When forensic evidence is presented in court, a forensic scientist is responsible for evaluating the significance of that evidence. And our new findings may be particularly relevant for those specific cases where a small number of fibres are found and the

circumstances are right for contactless fibre transfer to take place.

For example, imagine two people were in an elevator and one alleges to have been assaulted by the other. If hundreds of the victim's fibres are found on the suspects clothing, it's highly unlikely that contactless transfer alone is the reason for all the fibres. But if only a few fibres are found, contactless transfer is more viable.

And in this way, the results of our study can be used as a baseline in the evaluation of fibres found as part of a case – and will also help to increase the robustness and validity of forensic evidence being presented in court.

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