University of Dundee

The Curse of the Burial Dagger Teacher Materials

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The Curse of the Burial Dagger

Teacher/ Group leader workbook

When everyone is a suspect, and a killer is on the loose, is anybody safe?

A mansion near Dundee, 1923. Susie Sato finds herself investigating a murder when her great-uncle and host Lord Hamilton is found dead in his private museum, an ancient Egyptian burial dagger protruding from his back. Could it be the curse of the dagger, an object Lord Hamilton was warned not to remove from the tomb? Or could something else have caused his death?

The Curse of the Burial Dagger is an interactive graphic novel murder mystery, created by the Leverhulme Research Centre for Forensic Science and digital story studio Fast Familiar. Players use maths, logic and critical reasoning skills to assist Susie uncover different types of forensic evidence and weigh up contrasting hypotheses. Can they uncover the events leading up to Lord Hamilton's death and deduce how he died... before the curse strikes again ?

Materials

1. Teacher walk through
2. Factsheet – What is Forensic Science?
3. Factsheet – What is a hypothesis?
4. Marzipan Calculation
5. Factsheet and activity – Fingerprint Analysis
6. Activity – Chromatography investigation

Also available – career profiles, printable completion certificates and workbook with the importance of notetaking (available as separate files)

The Curse of the Burial Dagger was created by Fast Familiar for the Leverhulme Research Centre for Forensic Science at the University of Dundee.

Leverhulme Research Centre
for Forensic Science
University of Dundee

LEVERHULME
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Teacher/ Group leader Information

The game supports several areas of the Curriculum for Excellence and support for the four capacities including:

- ❖ An interdisciplinary experience for players
- ❖ Use of literacy, communication, and numeracy skills
- ❖ Making informed choices and decisions
- ❖ Working in partnerships and teams
- ❖ Applying critical thinking
- ❖ Use of technology for learning
- ❖ Applying learning in different situations
- ❖ Problem solving
- ❖ Communication
- ❖ Solving numerical calculations with fractions and percentages and using answers to make informed choices

The game was created for players aged 13 +

The game is played in groups of up to 6 in one game (multiple games can be played in a class setting). Each link generated can have up to 6 players.

The game takes approximately 60/90 minutes to play. It can be stopped and restarted.

There are instructions built in the game and players move through these at their own pace. As the game is played the likely hypothesis are highlighted. At the end the hypothesis results indicate the likely scenario.

Factsheet:

What is Forensic Science?

Science is all about understanding the world around us. Forensic scientists use scientific methods as well as observations and experience, to support the investigation of suspected crimes.

Forensic scientists work on the principle developed by Edmond Locard in the 1900s that 'any action of an individual...cannot occur without leaving a trace'. Different types of evidence can have different value in an investigation and the same type of evidence can also have different value based on the circumstances of the case (for example finding the DNA of a suspect in a car that they own has little value). The value of forensic evidence in a case is based on;

- ❖ whether the evidence type provides information to identify an individual (such as DNA, fingerprints or knuckle creases) or whether the evidence type provides information that can identify an object (such as fibres or ink which might be in mass produced items such as jumpers and pens or a well-worn shoe which might link to an individual item),
- ❖ the type of analysis and whether it is based on data from scientific methods (for example DNA or drug analysis) – called objective analysis – or based only on the observations of features (for example fingerprints or wear patterns) – called subjective analysis,
- ❖ how well the movement of evidence between people or between people and objects is understood (for example leaving DNA or fingerprints on an item you touch) and how long these deposited traces will remain.

Factsheet: What is Forensic Science?

What do Forensic Scientists do?

When an alleged crime occurs, the forensic scientist's job is to find the evidence, recover the evidence, analyse the evidence and present and communicate the value of the evidence to the investigation. Forensic scientists work as part of a team to provide support to an investigation rather than lead an investigation. Forensic Scientists use lots of different areas of science including physics, chemistry, biology, computer science and maths to answer questions and solve problems. They can be responsible for collecting and analysing materials such as DNA, fingerprints, footwear marks, fibres, and drugs. Digital forensic scientists work with technology such as CCTV, mobile phones and computers, finding information to support investigations.

Forensic scientists also provide written reports and present their evidence in Court including to the public who make up the jury. It is very important that the Forensic Scientists can explain what their evidence means in the context of the alleged events so that the jury can understand the value of the forensic scientist's findings when they make their decision.

Factsheet:

What is a hypothesis?

The definition of a hypothesis is 'an idea or explanation for something that may be true but has not yet been completely proved' (*Definition of hypothesis from the Cambridge Academic Content Dictionary © Cambridge University Press*)

A scientific hypothesis (sometimes called a proposition) is the first step in the scientific method and it has to be able to be tested through the acquisition and analysis of data.

When a hypothesis is created, the scientist puts forward a Null hypothesis and an Alternative (or research) hypothesis and the data that the scientist gathers through their analysis is used to test which of these hypotheses is more likely to be correct.

The Null hypothesis refers to a 'no change' situation and is assumed to be true until there is good evidence from the scientist's analysis, tests or experiments to suggest otherwise. For example,

'The slices of Hywel's cake eaten by Lord Hamilton did not contain a lethal dose of marzipan' is the Null hypothesis

The Alternative hypothesis is the one that is being tested – it usually states something else is happening. For example

'The slices of Hywel's cake eaten by Lord Hamilton contained a lethal dose of marzipan'

The calculation of marzipan in the cake can be carried out and produces the data to test the alternative hypothesis.

Factsheet:

What is a hypothesis?

We always assume the Null hypothesis is true, it is only rejected if there is evidence to support the alternative hypothesis eg if the calculation shows there was a lethal dose of marzipan in the cake that Lord Hamilton ate then the Null hypothesis can be rejected. If the calculation shows that there isn't a lethal amount of marzipan in the cake eaten by Lord Hamilton we fail to reject the Null hypothesis as it still stands to be correct.

Hypothesis testing always occurs in pairs – where the Null hypothesis is tested against an alternative hypothesis and the test is based on the data generated by analysis and experiments.

Hypotheses that have been tested, can be refined and tested again and scientists can create explanations and scientific theories based on the hypothesis testing process. In the Curse of The Burial Dagger the hypotheses have already been created and as you gather information and data, you can decide whether the Null or the Alternative hypothesis is more likely based on the outcome of the puzzle or information you have gathered.

Forensic scientists are responsible for creating the Null hypothesis and a number of different alternative hypotheses in their casework based on the alleged crime that may have been committed. These hypotheses are tested using the results of the analysis that the forensic scientist carries out on the evidence recovered relating to the case. They then make decisions as to which hypothesis is more likely given the results of their analysis. This information forms part of the investigation relating to the crime.

We can never be 100% sure if an outcome is true but the process of testing using Null and alternative hypothesis can enable us to decide which hypothesis is more likely.

Marzipan Calculation

To calculate the amount of marzipan you know you have 1.5kg of sugar which is the same as 1500g

To work out how much flour you use

$$1500 \times 1.5 = 2250 \text{ g of flour}$$

To work out how much butter (ratio of 3:5)

$$2250 \text{ g flour} / 5 = 450$$

$$450 \times 3 = 1350 \text{ g butter}$$

To work out the currants

$$1350 \times 0.20 = 270 \text{ g}$$

To work out the marzipan

$$270 \text{ g} / 5 = 54 \text{ g}$$

$$54 \text{ g} \times 14 = 756 \text{ g of marzipan in the whole cake.}$$

Only 4 slices of cake were eaten.

$$756 \text{ g} / 12 = 63 \text{ g in one slice of cake.}$$

$$63 \times 4 = 252 \text{ g of marzipan in 4 slices.}$$

Chromatography Investigation

Time for activity: 1 hour

Chromatography separates mixtures of substances into their components. This happens because of the way in which the individual components in the mixture interact with a solvent and a surface that they pass over.

A solvent is used to dissolve the components of the mixture. Spots of the solvent are then placed onto a solid surface - most commonly paper (paper chromatography), or a thin metal or plastic plate with silica coated onto the surface (Thin Layer Chromatography or TLC). The solid surface is then placed into a small amount of a different solvent which moves up the paper or thin plate by capillary action. The individual components of the mixture move up the paper or the plate at different rates and as a consequence separate from each other.

The task:

We are going to determine what type of pen was used to write a note by analysing the inks using thin layer chromatography, also known as TLC.

The first step is to make some marks using the different pens on paper. Next, we use a solvent to dissolve the pen ink separating it from the paper surface and do this for the writing on the note and for the writing we have made for each pen suspected of writing the note. The ink contains the mixture of chemicals we are interested in.

The components of the inks are separated by applying a spot of the ink onto the TLC plate (called a stationary phase) and then placing the plate standing in a solvent or solvent mixture (called the mobile phase – because it moves up the plate by capillary action).

The different inks of interest from different pens and from the text on the note are all prepared the same way and are all analysed beside each other on the same TLC plate so that they can be directly compared.

There are further resources available on TLC from The Royal Society of Chemistry
<https://edu.rsc.org/resources/thin-layer-chromatography/1074.article>

Adapted from an activity created by Caitlyn Norman at the Leverhulme Research Centre for Forensic Science, University of Dundee

Chromatography Investigation

Equipment:

- (a) Thin Layer Chromatography plates
- (b) Ethanol (for dissolving the ink and as a mobile phase)
- (c) Glass spotting capillary tubes (pulled to a fine point)
- (d) Note paper
- (d) Handwritten note
- (e) 6 black pens of different brands
- (f) Small vials for extracting the ink from the paper
- (g) TLC developing tanks or substitute (such as a glass beaker) and lids for the tanks
- (h) Filter paper
- (i) Graduated cylinder
- (j) Pipettes
- (k) Pencils

Please carry out a local risk assessment for this activity as it involves the use of ethanol.

Chromatography Investigation

Method:

1. Take each of the pens and write on the notepaper (keep the writing separate so you can cut out the paper with the writing on for each pen). Remember to take note of which pen wrote which piece of text.
2. Cut out a small piece of the paper bearing the ink and place it into a vial. Make sure you label the vial so that it corresponds to the ink.
3. Add a small volume of ethanol to dissolve the ink. This should result in a coloured solution. If you want to increase the concentration of ink in the solution just add some more paper with the relevant ink present.
4. You should have 7 coloured solutions – one for each pen and one for the writing on the note.
5. On the TLC plate use the pencil to draw a line across the plate about 1 cm above the bottom.
6. Mark 7 small 'x's in pencil on the line evenly spaced apart. Do not put the 'x' too near the edge of the plate. Mark the 'x's 1-7 lightly in pencil.

Chromatography Investigation

Method:

7. Take the pulled glass capillaries and very carefully and lightly spot the extract from each ink from each pen (1-6) onto the relevant 'x' 1-6 and from the note onto spot 7. Use a separate pulled capillary for each ink and each ink should be spotted onto the same 'x' three times, allowing the spot to dry before applying the next one.
8. Develop your plates by placing them in a shallow layer of the developing solvent (mobile phase).
9. Make sure the solvent isn't higher than your pencil line.
10. Take the TLC plate out of the developing tank when the solvent gets to about 1cm from the top of the plate and mark how high the solvent went with a pencil line.
11. It can take between 5 and 10 minutes for the inks to separate.

Chromatography Investigation

Analysis

When you look at the TLC plate, you will see that the inks have moved up the plate with the solvent.

You can see visually how many different dyes make up the ink as these will have separated as the solvent has moved up the plate. We can also take measurements to help identify the compounds present – the distance travelled by the solvent and by the compounds.

Dividing the distance the compound travelled (measured from the original pencil line to the middle of a spot which has travelled up the plate) by the distance the solvent travelled (the distance from the original pencil line to the line at the top of the plate representing how far the solvent travelled).

This value is called the retention factor or R_f value and is often reported for the different spots in mixtures so that they can be compared with other inks separated on the same TLC plate.

$$R_f = \frac{\text{Distance travelled by the sample component}}{\text{Distance travelled by the solvent}}$$

Questions:

Describe the results of your analysis of the inks from the pens and from the note, what did you find?

What conclusions can you make given that inks are mass produced items?

Would inks from the same brand of pen produce the same results on TLC? – if you said yes then what does that mean for your conclusions about whether you can tell if a specific individual pen wrote the note?

Does anyone know why we extracted them rather than using the pens to draw directly on the plate? (ANSWER: It is possible to do this for ink in a pen, but it can also damage the TLC plate so the chromatography doesn't work so well. You can't do this for the ink on the note which is why you are doing the extraction – to compare the pen ink with the ink on the note – and so you have to treat all the samples the same way and extract them all).

Fingerprint Investigation

Introduction: The marks on our fingers are thought to be different for every person including identical twins and are also different between all 10 fingers and thumbs of the same person. We can leave traces of these marks on the objects we touch, and they can be used as a tool to possibly identify people if a link is made between these marks and fingerprints when the two are compared together. The collection and comparison of fingerprints and marks has been used by the police for over 110 years and the comparison is still undertaken in broadly the same way today. This comparison follows a process rather than a scientific analysis and there is still very little understood about repeatability, reproducibility and the error rates in fingerprint comparison.

Terminology: A fingerprint is the term used when the source is known, for example, if you were arrested by the police, they would take your fingerprints. Fingermarks are used to describe the ridge pattern found on surfaces where the source is unknown for example, fingermarks left at crime scenes.

There can be a difference in the quality of fingerprints and fingermarks because of how they are collected. Fingerprints are taken by the police from a known person where the detail of the ridges within the image will be of a good quality.

Fingermarks collected at a crime scene are generally of poorer quality as they could be incomplete and smudged. Fingerprints and fingermarks can be stored on, and retrieved from, databases.

Fingermarks are frequently found at crime scenes or on objects associated with a crime such as a knife in an assault case, which facilitates ongoing and future investigations.

In this set of exercises you will collect and compare fingerprints and explore how fingerprint examiners look at differences and similarities in this type of evidence.

Fingerprint Investigation

Background: The skin over most of the body is relatively smooth and composed of 3 layers; the epidermis or outer layer, the dermis or inner layer and a fat layer below the dermis. Friction ridges are raised portion of the epidermis (figure 1), which form recognisable patterns and are found on the fingers, palms and soles of the feet.

Figure 1

(source: <http://www.crime-scene-investigator.net/fingerprintsoucebookchp2.pdf>)

Friction ridges on our hands (figure 2) allow us to grip items more strongly. Humans share this feature with some primates such as gorillas and apes. These features are formed as a baby is developing during pregnancy and do not change across a person's lifetime although they can become less pronounced as people get older. Only injury will change the friction ridge pattern.

Figure 2

(Source: [gfairchild](#) licensed under [CC BY 2.0](#))

Fingerprint Investigation

Fingerprint Classification: Fingerprints are produced when there is contact between the ridges present on our fingers and a surface. The transfer is achieved by the deposition of the secretions from our glands associated with the ridges on our skin, or by contaminants present on the finger surface.

Fingerprints are used to help to establish an individual's identity and to tell if someone has touched or handled an object or if their fingerprints are found, that they may have been in a certain location.

Friction ridges can be classified into three levels of detail and have been categorised this way for over 110 years (since 1901).

First level detail refers to the overall pattern occurring at the core and a delta which is at the edge of the print (figure 3).

Figure 3. (Source: <https://imgur.com/gallery/Qt3jS>)

Fingerprint Investigation

This includes common patterns known as loops, arches and whorls.

Loops: Here the ridges of the print enter from one side going across the finger and curve back around exiting on the same side of the finger as they entered. 65% of fingerprints contain loops (figure 4).

A plain loop points away from the delta

Converging loops: ridges at the core come together

Nutant loops point towards the delta

Figure 4 (Source: SQA)

Arches: Here the ridges enter from one side point upwards and then downwards exiting from the other side of the finger (figure 5). About 5% of fingerprints contain arches.

Plain arch

Tented arch

Figure 5

(source: http://www.indiangaming.com/istore/Nov09_Pender.pdf)

Whorls: Here the fingerprint contains ridges that complete a full circle between two deltas (figure 6). About 30% of fingerprints contain whorls.

Plain Whorl

Central Pocket loop

Double loop

Accidental

Figure 6

(source: http://www.indiangaming.com/istore/Nov09_Pender.pdf)

Fingerprint Investigation

Second level detail refers to the major characteristics called minutiae. These levels of detail are used in identifying individuals from their fingerprints. There may be dozens of such minutiae present in fingerprints (figure 7).

Figure 7
(source: leeecomputersociety.org)

Third level detail refers to the specific ridges themselves and in particular the positioning of sweat pores and details of the shapes of the edges of particular ridges as well as scars and other features (figure 8). This level of detail is not always present.

Figure 8
(source: leeecomputersociety.org)

Fingerprint Investigation

1st, 2nd and 3rd level details on a fingerprint are shown in figure 9.

Figure 9

(source: <http://perso.orange.fr/fingerchip/biometrics/types/fingerprint.htm>)

Fingerprint Investigation

Fingermarks can either be **visible** or **latent**.

Visible fingermarks can be seen on surfaces where as latent fingermarks are not visible to the naked eye.

The formation and visualisation of fingermarks are dependent on a variety of factors;

- ❖ The type of surface - Fingermarks on smooth surface such as paper or glass will enable ridge detail of good quality to be observed. Rough surfaces such as wood or some plastics can interrupt the ridge detail.
- ❖ The porosity of the surface - Surfaces can also be non-porous, semi-porous or porous. The fingermark sits on top of non-porous surfaces such as glass and can be removed by polishing the surface. Semiporous surfaces such as varnished wood can absorb the water-soluble part of the fingermark deposit over time and the surface acts as non-porous and the mark could be rubbed away. Fingermarks deposited on porous surfaces, such as paper, absorb the water-soluble part of the fingermark deposit very quickly.
- ❖ The time of contact – This can influence fingermark quality where the longer the finger is in contact with the surface the resultant quality of the mark increases.
- ❖ The Pressure of contact - Generally, a harder contact pressure of the contact results in a better quality fingermark.
- ❖ Finally, a persons diet and whether they have washed their hands recently can also influence the quality.

Visible fingermarks are generally recorded using photography.

Latent fingermarks are enhanced using a wide variety of chemicals which interact with the component within the fingermark residue deposited and can be imaged in various ways and photographed.

Fingerprint Investigation

Examining fingerprints and fingermarks: After a fingerprint is collected or a fingermark from a crime scene is enhanced, both are photographed and the digital image loaded onto a database.

This allows for an initial determination of 'candidate' fingerprints, to be selected from the database which may contain the same features as the fingermark recovered from a crime scene. Each 'candidate' fingerprint is then examined by eye by a fingerprint examiner.

Fingerprint examiners follow a methodology which involves four steps which, combined together, are known as ACE-V.

- ❖ **Analysis** – The three levels of detail are determined. The fingermark is first examined and the various features at each level of detail are marked and recorded. An assessment of the quality of the fingermark is made to determine whether a comparison can be made. Next the fingerprint(s) of different individuals suspected as being the source of the fingermark are examined and the various features at each level marked and recorded.
- ❖ **Comparison** – A direct comparison of two friction ridge impressions are made and similarities and differences are determined. The most likely 'candidate fingerprint(s)' which look most like the recovered fingermark are chosen. The fingermark and fingerprint are then placed beside each other and a direct comparison made looking for differences and similarities.
- ❖ **Evaluation** – Conclusions relating to the presence or absence of friction ridge detail is made to decide whether two friction ridge impressions (the fingerprint and the fingermark) could have been made by the same person, or by different people or whether there is insufficient detail to make a conclusion.
- ❖ **Verification** – This is where a second fingerprint examiner re-examines the impressions and reaches a conclusion independently.

Fingerprint Investigation

Below are examples of how fingerprints and fingermarks are charted to show the various features and how they are compared side by side to look at similarities and differences in the detail.

Figure 10
A charted fingerprint
(source Fingerprint inquiry
report, Scottish Government)

Figure 11 A charted fingerprint (right) and fingermark (left)
(source Fingerprint inquiry report, Scottish Government)

Fingerprint Investigation: Activity

TASK 1 - Taking your own fingerprints: This can be done in 5 easy steps.

Equipment

You will need:

- (a) a roll of sellotape
- (b) a sheet of A4 paper
- (c) a HB pencil

Step 1 – make a mark on the paper using the pencil.

Step 2 – rub your fingertip across the pencil mark so that the graphite covers your finger

Step 3 – press your finger onto the sellotape sticky side up.

Step 4– stick the sellotape onto the clean recording sheet.

Step 5 – repeat this for all of your fingers and record your name, and the date you took the fingerprints on.

Fingerprint Investigation: Activity

Fingerprint Recording Sheet

Your name:

LEFT HAND

--	--	--	--	--

Little finger

Ring finger

Middle finger

Index finger

Thumb

RIGHT HAND

--	--	--	--	--

Little finger

Ring finger

Middle finger

Index finger

Thumb

Fingerprint Investigation: Activity

TASK 2 - Recovering latent fingerprints: This can be done in 4 easy steps.

Equipment:

You will need;

- (a) a HP pencil
- (b) a metal nail file
- (c) a small dish
- (d) a small brush (small fine paint brush)
- (e) some Sellotape, and
- (f) white A4 Paper.

Step 1 – Pick up a clear glass jar - this will leave a fingerprint.

Step 2 – Using the nail file, grate the top of a HB pencil carefully into the dish to make a fine powdered graphite.

Step 3 - Using a small brush, carefully dust the fingerprint with the powdered graphite.

Step 4 – Once you see the fingerprint clearly, use a piece of sellotape to lift off the fingerprint and transfer it to the sheet of white paper. Record your name, where you recovered the fingerprint from and the date.

Fingerprint Investigation: Activity

TASK 3 – Comparing fingerprints

1. Recover your own fingerprints and examine each one in turn to determine whether it contains loops, whorls or arches. You may wish to use a magnifying glass and/or enlarge your fingerprint using a scan or photocopy so that you can see the detail.
2. Determine the 2nd level detail and mark these on a photocopy of your fingerprints. You may wish to enlarge your fingerprint using a scan or photocopy so that you can see the details. Mark these details with numbers and try and identify the features.
3. Determine the 3rd level detail and mark these on a photocopy of your fingerprints. You may wish to enlarge your fingerprint using a scan or photocopy so that you can see the details. Mark these details with numbers and try and identify the features.
4. In Task 2 you recovered your fingerprints from an object. Examine it for 1st, 2nd and 3rd level detail – mark these on a photocopy of the fingerprint. You may wish to enlarge fingerprint using a scan or photocopy so that you can see the details. Mark these details with numbers and try and identify the features.
5. Compare the marked details of your fingerprints from Task 1 with the marked details of your recovered fingerprints from Task 2 looking for similarities and differences. You may wish to enlarge your fingerprints using a scan or photocopy so that you can see the details. Mark the details you see in each with numbers and try and identify the features.

Fingerprint Investigation: Activity

Questions to consider:

How different are the fingerprints from your different fingers and from the fingers of others in your family or others in your class?

Have other people examine your fingerprints and mark them up for 1st, 2nd and 3rd level detail. Did they get the same results as you did? What do you think it means if they get different results?

Is there much difference between your fingerprint recovered from the object in Task 2 and the clear set of fingerprints you made in Task 1?

Did other people see the differences and similarities that you did in comparing the fingerprints in Task 1 and the fingerprints recovered in Task 2? What does this mean if you want to use the results to identify a person?

Fingerprint Investigation: Activity

Tutor's notes:

Timings:

Task 1 should be relatively quick to undertake for all 10 fingers – approx. 30 mins once all of the materials are set up.

Task 2 can be expanded to include many different types of surfaces. It works best on glass. – approx. 30 mins to 1 hour.

Task 3 can be short or long depending on how many fingerprints you want to chart and how many people you want to chart the same fingerprint to look at inter observer differences.

Key issues:

(1) to learn about fingerprints and how they are recovered and analysed,
(2) to demonstrate the fingerprint comparison process which involves identifying differences and similarities in fine detail within the marks,
(3) to demonstrate the importance of attention to detail and recording in forensic analysis,
(4) to illustrate the difference between a observational process and a scientific analysis (which requires repetitive analysis to demonstrate precision by the same person (repeatability) and by different people (reproducibility) as well as to understand error rates and accuracy). Current fingerprint comparison does not follow a scientific analytical process but does follow a subjective observational process. This could open up topics for debate across the students around the difference between objective measurements and subjective observations.

For more information, questions or feedback please contact:

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