Crime Scene Investigation Lab
IS 9011
Student Guide

INTRODUCTION

Scenario

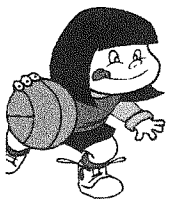
The biology teacher entered the lab one morning to prepare for the upcoming frog dissection lab scheduled for that day. Upon unlocking the door and entering the lab, the biology teacher immediately realized that something was suspicious. A window was open and he was sure he did not leave the window open the evening before. Upon further examination, the biology teacher noticed that the frogs for the dissection lab were missing. He looked around the room further and found a note that appeared to have been written in marker on the front lab bench. The note read:

"I have liberated these frogs in the name of the Frog Liberation Front. Any attempt to obtain more frogs will only have the same results!"

Authorities were immediately called in and the lab was sealed off and investigated. All apparent evidence was recovered. Among the evidence found was a few fingerprints on the open window, several hairs on the lab bench of unknown origin, and the note itself.

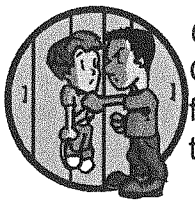
Upon interviewing the teachers in the science department and students in the biology class to see if anyone had displayed suspicious behavior or might have a reason to commit such an act, police were able to narrow the list down to four students that might have a motive to release the frogs. After searching the lockers of all four suspects, investigators were able to recover black markers from all four students, possibly used to write the note itself.

The Suspects



Annie "Athletic Scholarship" Archer
Annie is more concerned with athletics than science. Annie had also revealed recently to a teammate that she had become involved in an animal protection group and threatened action if the class had to perform a dissection lab.

Freddie "4.0 GPA" Franklin
Freddie excels in all academics. Freddie had been home practicing for the dissection lab with a kitchen knife and a pork chop and realized he was rather clumsy with sharp objects. Worried that a low grade on the dissection lab would affect his chances at getting into an ivy-league school, Freddie had recently been overheard telling his lab partner that he didn't know what he would do if he had to go through with the dissection lab.



Gary "Give Me Your Lunch Money" Garson
Gary just enjoys making trouble. After having recently received detention from the biology teacher, Gary bragged to several classmates that the teacher would "get what is coming to him".

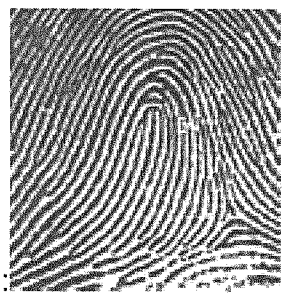
Priscilla "Prom Queen" Parker
Priscilla didn't care much for science and made no secret about it. Concerned more about make-up than mitosis, Priscilla had told friends that she would refuse to do a dissection lab because the frogs were "just gross".

BACKGROUND

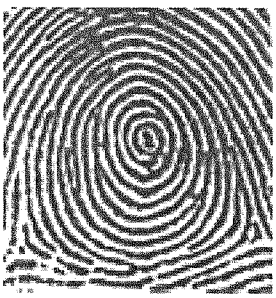
Fingerprints

Fingerprints, the unique pattern found between the last joint and the end of the finger, have long been a useful tool in the classification and identification of individuals. Everyone is born with fingerprints yet no two people have the same fingerprints. It is the distinctiveness of fingerprints that makes them such an invaluable tool.

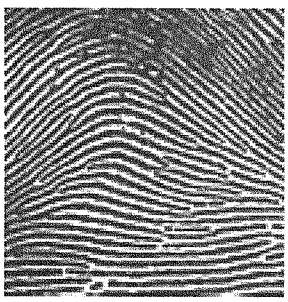
In order to identify and match a fingerprint to an individual, several characteristics must be compared and contrasted. Like most methods of identification, you start with very general properties and continue to work toward more specific characteristics. When first examining a fingerprint, the three major categories of classification are loop, whorl, and arch, examples of which are pictured below:



Loop



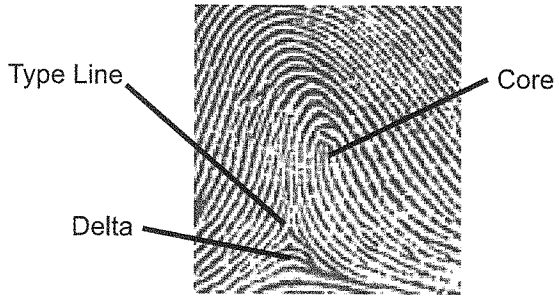
Whorl



Arch

However, considering approximately 60% of the population has loops, 35% has whorls, and 5% has arches, this is hardly a reliable means of identifying an individual. These three major categories have been further sub-classified based on further differences among each type. Before examining these differences, there are three terms used in classification that must be defined: type lines, delta, and core.

Type lines are two ridges that diverge, usually splitting around another object in the fingerprint, such as a loop. Deltas are ridge points found nearest the point at which type lines diverge. The core is used to refer to the approximate center of the pattern in question.



Arches

Arches are the simplest form of fingerprint and are broken into two groups: plain arch and tented arch. In a plain arch, ridges enter from one side of the print and exit on the opposite side. These ridges tend to gently rise and lower as they cross the fingerprint. Tented arches contain ridges that enter from one side and exit at the other side as well but instead of gently rising and lowering as they cross the fingerprint, they contain a sharp rise and fall that forms a point, or ridge.


Plain arch


Tented arch

Loops

The two major classification of the loop fingerprint are the radial and ulnar loop:

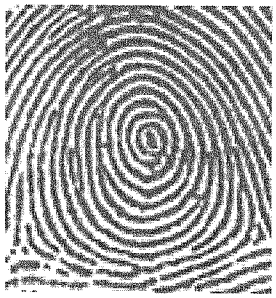
Radial Loop (right hand)

Ulnar Loop (right hand)

In the loop pattern, ridges enter from one side of the print, curve around, and exit toward the same side. A loop pattern that opens toward the thumb is called a radial loop and a loop pattern that opens toward the little finger is called an ulnar loop. Loops have type lines, a core, and only contain one delta.

Whorls

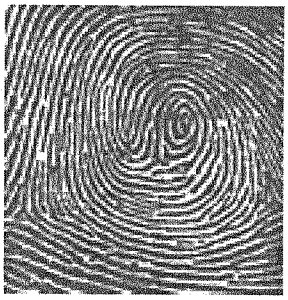
Whorls can be further defined as the following: plain whorl, central pocket whorl, double-loop whorl, and accidental whorl.



Plain Whorl

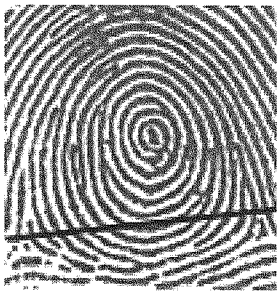
Central Pocket Whorl

Double Loop Whorl

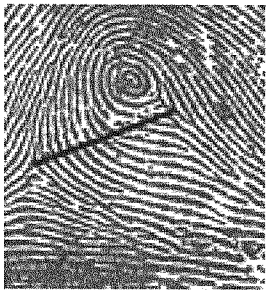


Accidental Whorl

In both the plain and central pocket whorls, at least one ridge on the fingerprint must form a complete circuit. All whorl patterns have type lines and at least two deltas. In order to differentiate between a plain and central pocket whorl, a line may be drawn between two deltas. If the line touches any part of the complete circuit, it is a plain whorl. If the line does not touch any part of the complete circuit, it is a central pocket whorl.



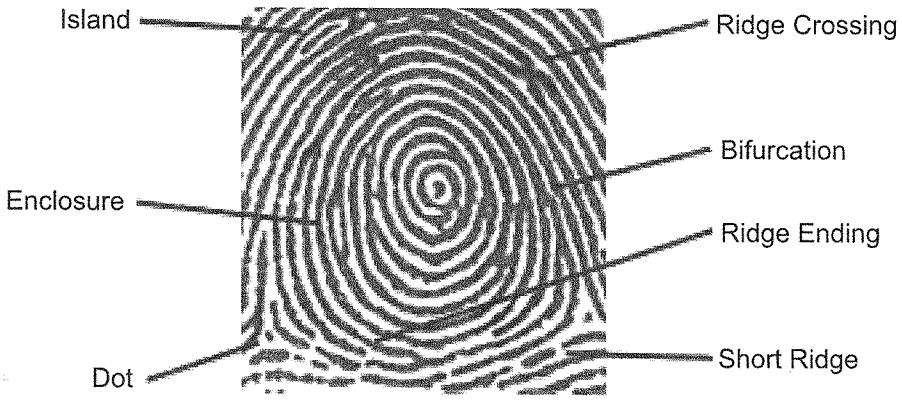
Plain Whorl



Central Pocket Whorl

Sometimes a fingerprint contains more than one loop pattern. This is referred to as a double-loop. Sometimes a fingerprint may not fall into any of the classifications, or contain a combination of types (with the exception of plain arch), such as a loop and tented arch. These fingerprints are referred to as accidental. (See above examples).

These more specific characteristics, while further refined, still do not offer nearly enough differentiation to identify a specific individual. Though useful for gross identification of fingerprints, it is really specific ridge characteristics within each fingerprint that creates the uniqueness of the print. Below is an example of some characteristics examined when comparing fingerprints.



These characteristics, often referred to as minutiae, are the real factor in defining a fingerprint as unique to an individual. It is estimated that the average fingerprint contains over 150 unique ridge details however usually only 10 or 15 of these must be identified to assume a fingerprint is a match.

In the case of a criminal investigation, there are three types of fingerprints a crime scene investigator would examine the scene for:

Patent prints – these are visible prints. They are caused by a finger that has come in contact with a visible substance, such as blood, paint, ink, or other material, that are then transferred to a surface upon contact between the finger and the surface.

Plastic prints – these are sometimes referred to as molded prints. They are impressions of a finger left behind when the finger comes in contact with a soft material such as wax or a soft plastic.

Latent prints – the word latent is derived from the Latin latens, which means to lie hidden

or concealed. Exactly as the name implies, these prints are hidden, or not visible to the naked eye. Latent prints can be caused by a variety of factors. Human skin naturally secretes substances, including oils, amino acids, and proteins, that may be left on a surface upon contact. The finger may have also come in contact with a non-visible foreign substance that is placed on a surface upon contact. Because there is such a wide variety of ways a latent print can form, this is the most complicated type of print to detect.

Patent prints are the most obvious and easy to collect and examine. Special tape, called lifting tape is used to capture the print. After an investigator photographically documents the print at a crime scene, the lifting tape is carefully placed over the print and material causing the print, such as blood, is transferred to the tape. The evidence may then be brought back to a lab for further investigation.

Plastic prints are a little more complicated. Because of the material that plastic prints formed in are physical impressions, it may not be possible to transfer to the print to lifting tape. These prints are often captured through casting. Suppose a criminal, whose fingers are stained with blood, attempts to clean up after committing a crime. The individual may inadvertently leave behind a fingerprint on a bar of soap used to wash his/her hands. The soap is collected, again after photographic documentation, and brought to a lab. A casting substance is applied, which varies depending upon the material in question, which seeps into the impression and eventually solidifies. The material may then be removed, containing a physical copy of the print.

Latent prints are the most complicated. Firstly, because they are invisible, a crime scene investigator must examine the entire crime scene, not knowing where a print may be present. Secondly, because of the wide range of substances that may cause a latent print, a variety of methods have been developed to detect these prints, depending on what may have caused them. One of the most common methods employed is dusting.

In the process of dusting, a very fine powder is placed in the end of soft bristled brush. The brush must contain very fine bristles so as not to destroy the print. The material is gently brushed over a surface, causing the powder to adhere to the material from which the print was formed.

Hair

What do we think of when we think of hair? Often, gross examination of hair yields very general characteristics such as color (red, blond, brown, etc.) or style (curly, wavy, straight, etc.). Such common descriptions are hardly specific enough to be of use when hair is being used as evidence when collected from a crime scene. Can hair reveal more? Could a hair sample have come from a possible suspect? Is the hair even of human origin? In order to make these types of determinations, investigators must look deeper into the sample, at a microscopic level, to present the sample as a piece of viable evidence.

Though even at a microscopic level, hair does not offer the specificity of evidence such as fingerprints, a single hair may yield valuable insight into characteristics such as race, sex, or possibly age of the source of the sample. To understand how hair may be used

as evidence, it is necessary to understand how hair is formed and the general structure of hair.

Hair is composed of a protein called keratin. Keratin is the same protein that forms fingernails, toenails, and the outer layer of skin. Hair grows from follicles within the skin and emerges to the surface. Hair is generally composed of three layers: the cuticle, the cortex, and the medulla.

The outermost layer, the cuticle, is composed of hard scales that overlap each other and point toward the tip (end furthest from the follicle) of the hair. The next layer, the cortex, has pigment-containing granules that are responsible for hair color. The innermost layer, the medulla, is a hollow tube that runs along the hair. In some samples, the medulla is not present, and in some samples, even when it is, it runs the entire length of the hair or may run a short length, stop, begin again, stop, etc.

Since hair is not only found on humans but is a general characteristic of mammals, oftentimes, investigators must first determine if a hair is even of human origin. Fortunately, years of observation and research have noted distinguishing characteristics among hairs of different mammalian sources. Each of the hair-forming layers can contain distinguishing characteristics aiding the investigator in the identification of the hair type.

Cuticle

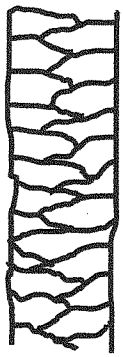
The cuticle forms overlapping scales. The pattern these scales form helps classify them. Scale patterns are classified into three basic types: imbricate, coronal, and spinous.

Imbricate (flattened) – very narrow, flattened, overlapping scales. Imbricate scales do not completely encircle the hair shaft. Imbricate scales are very common to human hair.

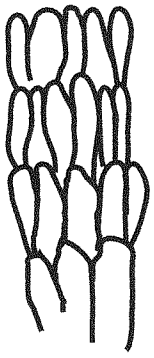
Coronal (crown-like) – these scales completely encircle the hair shaft. These overlapping, encircling scales have a "stacked" appearance. Found primarily in small rodents such as mice and rats, this type of scale pattern is rarely found in human hair.

Spinous (petal-like) – generally triangular in shape and protruding outward from the hair shaft, this scale pattern is never found in human hair.

Coronal



Imbricate



Spinous

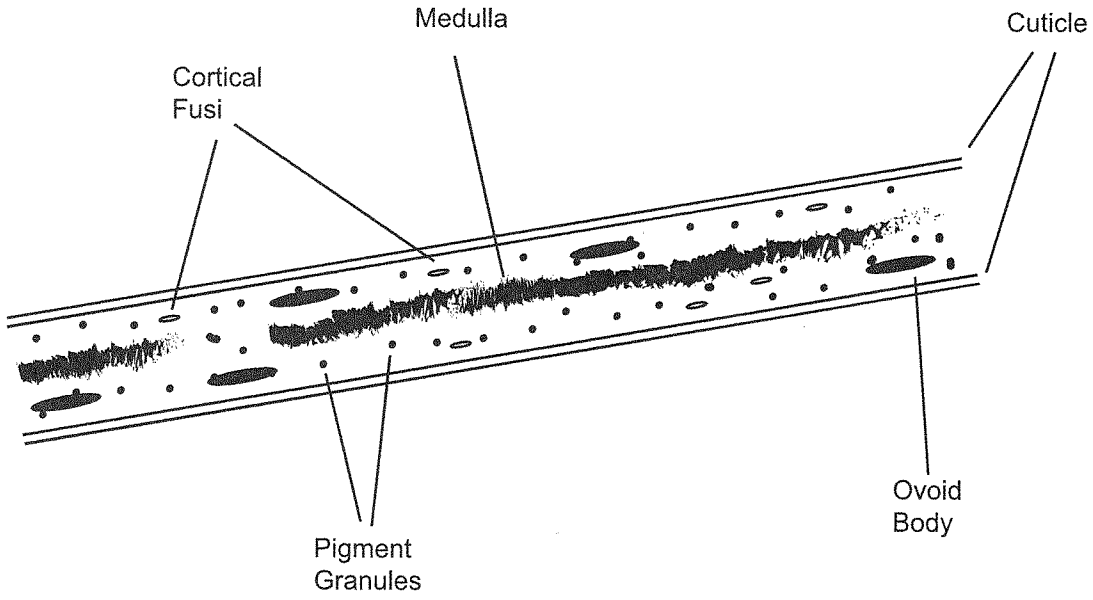
Cortex

The cortex, the layer between the cuticle and medulla (when present), also contain distinguishing characteristics, the most notable being pigment granules, which give hair its color. Two other features often examined are cortical fusi and ovoid bodies.

Pigment granules – these small, solid, structures vary in both color and distribution throughout the cortex. It is this variation in both color and distribution that is responsible not only for the color of the hair, but for the depth of color. Non-human hairs generally contain the majority of pigment granules toward the inside of the cortex whereas human hairs generally contain the majority of pigment granules toward the outside of the cortex, closer to the cuticle layer.

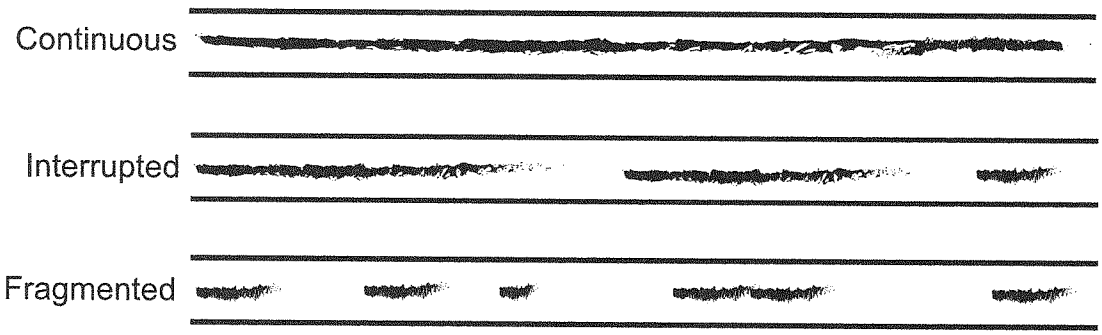
Cortical fusi – cortical fusi are actually air spaces within the cortex layer. Though under a light microscope, cortical fusi may be confused with dark pigment granules, cortical fusi are generally more irregular than pigment granules in both shape and size.

Ovoid bodies – these large, oval shaped structures are much larger than pigment granules. Unlike cortical fusi, which are actually air spaces, ovoid bodies are solid. Ovoid bodies are also more consistent in size that cortical fusi.



Medulla

As mentioned above, the medulla may or may not even be present in hair. When it is present, it can also reveal information as to the source of the hair. The three primary classifications of the medulla are continuous, interrupted, and fragmented.



Continuous – the medulla runs the entire length of the hair shaft. It is unbroken through the entire hair.

Interrupted – the medulla generally runs the entire length of the hair shaft. However, the medulla may stop occasionally before continuing again.

Fragmented – much like the interrupted medulla, the fragmented medulla is also a discontinuous pattern. Unlike the interrupted pattern, however, the points at which the medulla starts and stops are far more varied in both length and distribution.

In the laboratory, investigators most often examine hair through the use of light microscopy. By examining hair evidence, investigators are able to make several likely conclusions. Analysis may first be used to determine the source of the hair (e.g. human or animal). If it is recognized as animal hair, then the most probable species might be able to then be determined. If the source of the sample is shown to be human, it may then be possible to further refine the evidence. For example: the probable race of the person the hair originated from, if the hair was dyed or otherwise chemically-treated, if the hair was shed or if it was perhaps pulled out in a struggle (determined by the presence or absence of root material on the end of the hair), or which part of the body the sample may have come from.

Ideally, once a list of possible suspects is determined by investigators, the unknown hair sample will then be able to be compared to known hair samples (taken from the suspects), further solidifying the validity of the evidence.

Ink Analysis and Chromatography

Chromatography is a method for separating and analyzing mixtures of molecules. From the Greek words *chroma*, meaning color, and *graphein*, meaning writing, chromatography is literally "color writing." In the process of chromatography, a mixture of molecules, termed the analyte, is placed on a solid support and carried across the support by a gas or liquid, called the solvent. As the mixture travels along the support, the molecules in the mixture travel at different speeds and are separated based on several factors, including size, structure, and affinity for the solvent.

Chromatography can be performed on ink. The note in this case has been written in black ink. To the naked eye, all black ink looks generally the same. However, different ink manufacturers use different formulations and black ink is actually a mixture of different color dyes. By chromatographically separating the ink on the note and ink found in a

pen or marker tied to a suspect, it may be possible to demonstrate whether or not the ransom note could have been written with that particular pen or marker.

Though there are many forms of chromatography, such as electrophoresis, column chromatography, size-exclusion chromatography, and gas chromatography, to name a few, two of the most common and simplest chromatography techniques are paper and thin-layer chromatography.

In both of these methods, the mixture to be separated is placed in a solvent, which varies depending on the types of molecules in the mixture, and then placed on a solid support. In the case of paper chromatography, the support is paper. In the case of thin-layer chromatography, the support varies but involves a thin layer of a substance such as silica or cellulose against a support such as glass or plastic.

A small amount of solvent, the same or similar to that used to suspend the mixture, is placed in the bottom of a vessel, called the chromatography chamber. The chamber is covered, allowing the fumes from the solvent to permeate the air in the chamber. Meanwhile, a small sample of the mixture to be separated is applied near the bottom of the support, be it paper or a thin-layer chromatography plate. The support containing the mixture is placed in the solvent-containing chromatography chamber and the chamber is covered again.

The support containing the mixture is now in the solvent, though the level of solvent is not enough to touch the point where the mixture was placed. The support then acts as a wick, drawing solvent up. As the solvent passes the point where the mixture was placed, it begins to carry the molecules in the mixture across it. These molecules will travel at different rates, depending on a number of factors such as size of the molecule, charge of the molecule, or its affinity for either the solvent or the support. Once the solvent has traveled far enough up the support, the support is removed and the finished product, called a chromatograph, is examined. The result is separation of the molecules in the mixture, spread across the surface of the support.

Though several factors, such as solvent or support, can affect how the molecules separate, the reason they separate is because they behave in different ways when exposed to two different phases, called the mobile phase and the stationary phase. The mobile phase, as the name implies, is a moving phase and refers to the solvent that travels along the support. The interaction between molecules and solvent dictate how the molecule will move in the chromatography apparatus. For example, if a type of molecule in the mixture is very soluble in the solvent being used, it will travel faster and, therefore, farther, than a molecule that is not as soluble in the solvent.

The stationary phase refers to the support material, be it paper, silica, gel, cellulose, etc. The solvent travels the length of the support but the support remains stationary. Molecules in the mixture that have a high affinity for the stationary phase will not travel as easily in the solvent and spend more time in the stationary phase. Conversely, molecules with a low affinity for the stationary phase will travel more easily with the solvent (mobile phase).

Procedure

Part I: Fingerprinting

Materials Needed per Group

1 Acetate sheet with fingerprints
1 Fingerprinting brush
Fingerprint powder
Suspect fingerprint identification sheets
Hand magnifier
Adhesive tape

1. Obtain a piece of acetate. This represents the window glass of the biology lab.

2. Place a small amount of fingerprinting powder on the end of a dusting brush. Remember, fingerprinting is about examining detail so more is not always better. A small amount of fingerprint dust is enough to reveal detail without obscuring the print.

3. Gently brush the surface of the acetate. Notice how the dust adheres to the detail of the fingerprint, due to the presence of oils and sweat from the surface of the skin.

4. Once you have developed the prints, lift the prints with adhesive tape: Place the pieces of tape gently on each sample, being sure not to smudge the prints. Apply gentle, even pressure to the tape and carefully lift the tape from the surface of the acetate.

5. Place the lifted prints on the sheet labeled "Crime Scene Fingerprints".

6. Using a magnifier, examine both the crime scene prints and the prints on the suspect fingerprint identification sheets. Make observations and determine which of the suspects is the most likely match to the crime scene prints.

7. Record your conclusion in the fingerprint section of the "Evidence Analysis" sheet.

Part II: Hair Analysis

Materials Needed per Group

Suspect hair samples
Crime scene hair sample
Light microscope
Dropping bottle w/ distilled water
5 microscope slides and coverslips
Forceps

1. Using a wax pencil or permanent marker, label four microscope slides with each of the suspects' initials. Label a fifth microscope slide "Crime Scene".

2. Using the dropper bottle and dropper, place a single drop of water in the center of the microscope slide labeled "Crime Scene".

3. Using forceps, remove one or two hairs from the envelope labeled "Crime Scene".

4. Place the hairs in the water drop in the center of the slide. Once the hair samples are in the drop of water, gently place a coverslip on the drop of water.

5. Place the prepared wet mount under a microscope and observe the sample at low power. Note the overall appearance and characteristics of the hair.

6. Switch the microscope to higher power. Observe the sample and record your observations in the hair section of the "Evidence Analysis" sheet. Be sure to note all structural characteristics and make notes regarding the scale patterns, pigment granules, structure of the medulla, as well as any further observations with regards to the sample.

7. Repeat the procedure for each of the four suspect samples, being sure to use the properly labeled microscope slide for each of the suspects and recording your observations for each suspect.

8. Determine which of the suspect samples is the most likely match and state your findings in the hair section of the "Evidence Analysis" sheet. Be sure to provide as much detail as possible.

Part III: Ink Chromatography

Materials Needed per Group

1 chromatography chamber (500 ml beaker)
1 test tube
1 silica gel chromatography sheet
1 capillary tube
1 piece aluminum foil large enough to cover the chromatography chamber
Suspect markers
1 piece of ransom note containing ink
1 btl Chromatography solvent

1. Add the entire bottle of the chromatography solvent to the chromatography chamber.

2. Cover the chromatography chamber with a piece of aluminum foil. This will allow the chamber to equilibrate prior to performing the chromatography procedure.

3. Obtain a small piece of the ransom note containing some of the ink used in the writing. Using scissors, cut a piece of the note containing as much ink and as little paper as possible.

4. Place the piece of the note in a test tube.

5. Add about 1 ml of chromatography solvent from the chamber to the test tube. You will be extracting the ink from the paper. For good chromatography results, you will want the ink as concentrated as possible so do not use too much solvent. Immediately recover the chamber.

6. Allow the piece of the ransom note to soak in the solvent for approximately five minutes. You may want to gently swirl the tube every now and then to help extract the ink.

7. While the ink is being extracted from the ransom note, obtain a silica gel chromatography sheet.

8. Using a pencil, create a faint line across the chromatography sheet ½ inch from the bottom.

Note: *The silica gel on the chromatography sheet is very delicate. Use very gentle pressure and create a faint line with the pencil. DO NOT press hard with the pencil.*

9. Evenly mark five small spaces along the bottom of the chromatography sheet, below the line, as follows: "Note", "AA", "FF", "GG", and "PP".

10. Place the end of capillary tube in the solvent containing the extracted ink in the test tube. Notice how the extract is drawn up into the capillary tube.

11. **Gently** touch the end of the capillary tube to the line above the word "Note" on your chromatography sheet. Only touch the tube to the sheet briefly and remove it.

12. Allow the solvent to dry and repeat the spotting procedure. Continue spotting the plate until you have a good, dark sample of the ransom note on the chromatography sheet. Be sure to allow the solvent to evaporate between spottings.

13. Create spots on the sheet for the four suspect's markers. Quickly touch the tip of each marker to the line above each of the suspect's initials. Be sure to note in the ink analysis section of the "Evidence Analysis" sheet which brand of marker was used for each marking.

14. Remove the cover on your chromatography chamber and place the sheet in it with the spotted sample at the bottom. Quickly replace the cover on the chamber.

15. Observe as solvent begins to migrate up the chromatography sheet. Notice what happens as the solvent front passes the ink samples.

16. Continue to observe your chromatography run. Once the solvent front is approximately ½ inch from the top of the chromatography sheet, remove the sheet from the chamber.

17. Place the sheet on a flat surface and quickly trace the solvent front with a pencil, before the solvent evaporates.

18. Roughly sketch your finished chromatograph in the ink analysis section of the "Evidence Analysis" sheet. Be sure to include the solvent front, any bands you see in each ink sample, and note the colors of the bands.

19. Based on your finished chromatograph, document which marker you believe most likely was used in the writing of the note. Explain your reasons.

Innovating Science® by Aldon Corporation

Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Fingerprinting

Crime Scene Fingerprints

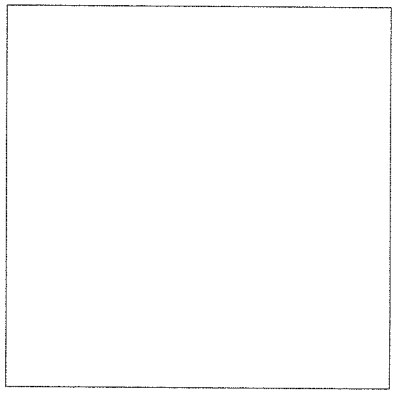
Conclusion

Innovating Science® by Aldon Corporation

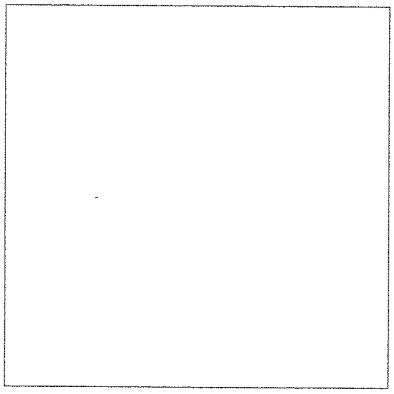
Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

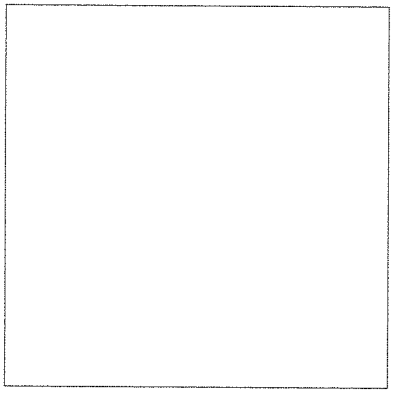
Hair Analysis



AA

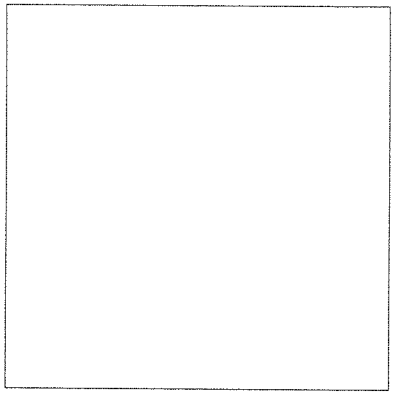


FF

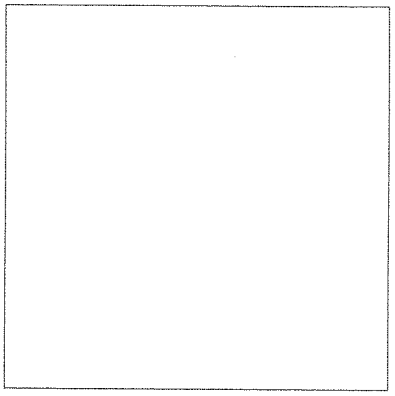


GG

Notes:



PP



CS

Notes:

Innovating Science® by Aldon Corporation

Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Hair Analysis

Conclusion: _____

_____

_____

_____

_____

_____

Ink Analysis

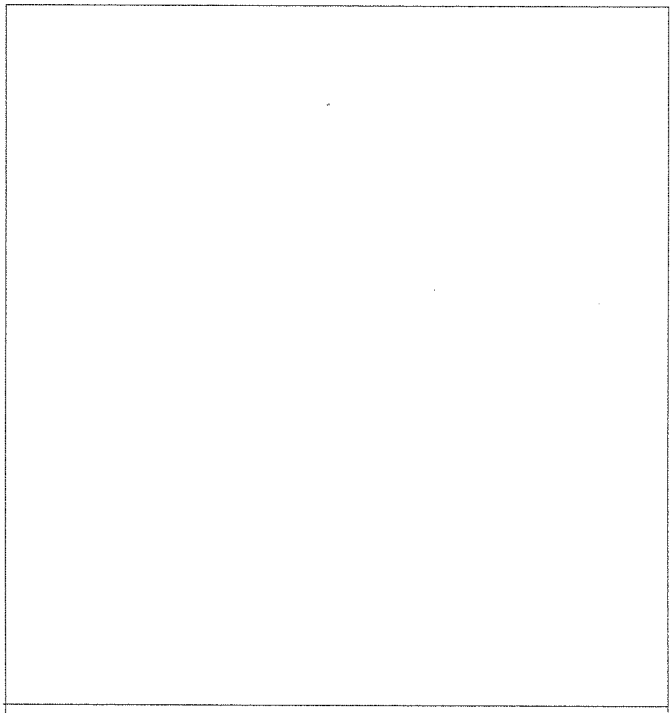
Suspect	Marker type
AA	
FF	
GG	
PP	

Innovating Science® by Aldon Corporation

Name:	Instructor:
Date:	Class/Lab Section:

DATA ANALYSIS

Chromatography Sketch



Note	AA	FF	GG	PP

Conclusion: _____

_____

_____

_____