A Field Guide For

CSI: LIN-WOOD

A Forensic Laboratory Experience

Lab # 1: OBSERVING LOCARD’S EXCHANGE PRINCIPLE
Lab # 2: CRIME SCENE SKETCHING & DIGITAL PHOTOGRAPHY
Lab # 3: TRACE EVIDENCE (Hairs and Fibers)
Lab # 4: FINGERPRINT IDENTIFICATION
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Lab # 11: BLOOD GROUPS, BLOOD TYPING
Lab # 12: BLOOD SPLATTER LAB
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Lab # 15: FACIAL RECOGNITION
Lab # 16: HANDWRITING COMPARISON & INK ANALYSIS LAB
Lab # 17: FORENSIC ENTOMOLGY
Lab # 18: FIRE ARM IDENTIFICATION
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APPENDIX:A
Lab # 1: Observing Locard's Exchange Principle

Locard's Exchange Principle states that with contact between two items, there will always be an exchange. This is the basis of trace evidence collection at a crime scene.

Trace evidence is material found at a crime scene or accident scene in small (maybe almost invisible) but measurable amounts. Trace evidence is critically important as it can definitively link an individual or object to the crime or accident scene.

Trace Evidence Can Help Solve the Case

No matter how much someone tries to clean up a crime scene, something is generally left behind. It may not always be detected, or even be visible to the human eye, but it's almost impossible to take any kind of violent action without shedding something. This principle, called Locard’s Exchange Principle, has become one of the motivating factors in the development of forensic science.

Although trace evidence on its own is often not enough to make a case, it could very well corroborate other evidence or even prompt a confession which could help to solve the case.

What is Locard’s Exchange Principle?

Trace evidence is based on Locard’s Exchange Principle which contends that every contact, no matter how slight, will leave a trace. The trace is normally caused by objects or substances contacting one another, and leaving a minute sample on the contact surfaces.

The main point is that some apparently foreign object or piece of material has been brought to a crime scene and tracing its origin can assist in an arrest and conviction. Similarly, finding some trace from the victim or crime scene on a suspect can also have a strong impact on a case.

Who was Edmond Locard?

Edmond Locard was the director of the very first crime laboratory in existence, located in Lyon, France. Locard’s techniques proved useful to the French Secret Service during World War I (1914–1918), when he was able to determine where soldiers and prisoners had died by examining the stains on their uniforms.

The Locard’s Exchange Principle, also known as Locard’s Theory simply says that every contact leaves a trace. In his own words: “Physical evidence cannot be wrong, it cannot perjure itself, it cannot be wholly absent. Only human failure to find it, study and understand it, can diminish its value.”

Collection of Trace Evidence from a Crime Scene

Trace evidence is any type of material left at – or taken from – a crime scene, or the result of contact between two surfaces, like shoes and the carpet, or fibers from where someone sat on a sofa.

After a crime has been committed the crime scene must be carefully preserved so that the police or the people first on the crime scene don’t contaminate it, because they also leave trace evidence. They need to keep any contact with the crime scene to a minimum.

Once the crime scene is sealed, the trace evidence needs to be collected. Each item is put into a sterilized container (contrary to popular belief, plastic bag are almost never used - actually a paper bag or envelope is used which will prevent further decomposition). This is labeled for later analysis at the laboratory.

Examples of Trace Evidence

Examples of typical trace evidence in criminal cases include:

- fingerprints, hairs, fibers, paper
- glass, paint chips, soils, metal
- botanical materials, gunshot residue
For such trace evidence to be useful, it must be compared to similar items from suspects, but particular care is necessary to ensure a thorough analysis.

Every time you make contact with a person or object there is an exchange of materials. This could mean the transfer of fibers, hairs, wood shavings, metal filings, tidbits of paper, or any small, lightweight item adherent to the donor object. This exchange enables forensic scientists to determine where someone has been based on trace evidence. It is even possible to track a person’s daily movements by examining his or her clothing.

Pre-lab Procedure
1. The day before the lab, choose a clean shirt, and wear it throughout the day.
2. Record your movements during the day. Describe the type of location and the people, animals, and activities you encounter.
3. At the end of the day, seal the shirt in a zip-top bag and bring it into school.

Lab Day Procedure
4. Clean the laboratory bench top with soap and water to inhibit contamination.
5. Carefully, remove the shirt from the bag and lay it flat on the bench top.
6. Using a hand lens and forceps, scan the shirt for any hairs or fibers and remove them using the forceps. Place the hairs and fibers you find inside small envelopes or use a clean sheet of paper to make druggist folds. Take special care around the collar area.
7. Note any stains or discoloration on the fabric.
8. Turn the shirt over and repeat this process.
9. Examine your hair and fibers under the microscope.
10. Group together hairs or fibers that look the same.
11. Try to identify each group based on your movements while wearing the shirt.

Questions
1. Make a chart relating each sample you found on your shirt to one of your activities while wearing the shirt. (If there are some samples that don’t seem to relate to any of your activities, list them with a? beside them.)

2. Make a hypothesis about how hairs or fibers that don’t seem to relate to your activities could have gotten onto your shirt.

Druggist Fold
Lab # 2: CRIME SCENE SKETCHING & DIGITAL PHOTOGRAPHY

How to Properly Investigate a Violent Crime Scene

Each crime scene is different, and there are hundreds of different types of crimes. For example, a crime of burglary will be investigated much differently from a crime of murder. If you're going to properly investigate a violent crime scene, however, you should know that a wide variety of personnel work together to ensure all evidence is gathered and that the crime is reconstructed to the best of their ability.

Secure the Crime Scene
Before you can properly investigate a violent crime scene, the area must be secured. This is to keep people, such as the media, away from the immediate vicinity, and to avoid contaminating evidence with substances that don't belong there. For example, a fiber that makes its way from an onlooker to the victim could distort the investigators’ understanding of the crime. Usually, it is secured with crime scene tape and uniformed officers around the perimeter.

Take Photographs
Crime scene technicians will start by taking photographs because anyone else is allowed to investigate a violent crime scene. This means that the area will be photographed *in situ*, or exactly the way in which it was discovered. Nothing is moved, and the photographers will capture every object, person and place from as many angles as possible so that the pictures can be reviewed by detectives at a later date. This is the only opportunity to preserve the scene.

Collect Evidence
The next step to properly investigate a crime scene is to collect physical evidence that might be destroyed once anything at the scene is moved. For example, with a murder, the medical examiner will collect trace evidence that might not survive the drive to the morgue, including hairs and fibers that might be clinging to the body. A gross physical examination of the victim will also help the M.E. to determine things like time of death.

Take Notes

It is important for investigators to record their every thought and observance when looking at a violent crime scene. For example, detectives will look for signs of forced entry if the crime occurred inside a home or office; they will also talk to people who live in surrounding areas to see if anyone might have been a witness. Taking notes will help police officers to track down leads at a later date.

Identify, Treat & Questions Victims
The victims are undeniably the most important piece of the puzzle when you investigate a violent crime scene. Just because someone was hurt does not mean that you're dealing with a murder case, and live victims must be interviewed quickly to get the most detail from their memories. Murder victims should be identified because their lives prior to the crime are often the best clues to solving it.

Log Evidence
Some evidence will find its way to the medical examiner's office for lab work, while some will go to the police evidence room, and still more will be receipted to various experts for examination. It is important for all investigators at a violent crime scene to know how to package, store and transport evidence because the chain of custody must remain in-tact. If authorities cannot say with certainty who handled a piece of evidence, it might be thrown out in court.
Examining the scene

There are several search patterns available for a CSI to choose from to assure complete coverage and the most efficient use of resources. These patterns may include:

The **inward spiral** search: The CSI starts at the perimeter of the scene and works toward the center. Spiral patterns are a good method to use when there is only one CSI at the scene.

The **outward spiral** search: The CSI starts at the center of scene (or at the body) and works outward.

The **parallel** search: All of the members of the CSI team form a line. They walk in a straight line, at the same speed, from one end of crime scene to the other.
The **grid** search: A grid search is simply two parallel searches, offset by 90 degrees, performed one after the other.

The **zone search**: In a zone search, the CSI in charge divides the crime scene into sectors, and each team member takes one sector. Team members may then switch sectors and search again to ensure complete coverage.

**While searching the scene, a CSI is looking for details including:**

Are the doors and windows locked or unlocked? Open or shut? Are there signs of forced entry, such as tool marks or broken locks?

Is the house in good order? If not, does it look like there was a struggle or was the victim just messy?

Is there mail lying around? Has it been opened?

Is the kitchen in good order? Is there any partially eaten food? Is the table set? If so, for how many people?

Are there signs of a party, such as empty glasses or bottles or full ashtrays?

If there are full ashtrays, what brands of **cigarettes** are present? Are there any lipstick or teeth marks on the butts?

Is there anything that seems out of place? A glass with lipstick marks in a man's apartment, or the **toilet** seat up in a woman's apartment? Is there a couch blocking a doorway?

Is there trash in the trash cans? Is there anything out of the ordinary in the trash? Is the trash in the right chronological order according to dates on mail and other papers? If not, someone might have been looking for something in the victim's trash.

Do the clocks show the right time?

Are the bathroom towels wet? Are the bathroom towels missing? Are there any signs of a cleanup?

If the crime is a shooting, how many shots were fired? The CSI will try to locate the gun, each bullet, each shell casing and each bullet hole.

If the crime is a stabbing, is a knife obviously missing from victim's kitchen? If so, the crime may not have been premeditated.

Are there any shoe prints on tile, wood or linoleum floors or in the area immediately outside the building? Are there any tire marks in the driveway or in the area around the building? Is there any blood splatter on floors, walls or ceilings?

The actual collection of physical evidence is a slow process. Each time the CSI collects an item, he must immediately preserve it, tag it and log it for the **crime scene record**. Different types of evidence may be collected either at the scene or in lab depending on conditions and resources.
SKETCHING THE SCENE

General:
The Photograph is ordinarily a two-dimensional representation of the scene of the crime and, as such, does not provide accurate information concerning the distance between various points in the scene. The relationship existing between objects present in the scene cannot be clearly understood unless the measured distances are known. Certain objects, moreover, are not visible in a photograph or cannot be clearly identified. A drawing or crime scene sketch is the simplest and most effective way of showing actual measurements and of identifying significant items of evidence in their locations at the scene. Sketches are divided generally into rough sketches and finished drawings.

Rough Sketch. The rough sketch is made by the investigator on the scene. It need not be drawn to scale, but the proportions should be approximated and the appropriate measurements or dimensions shown. The rough sketch may be used as a basis for the finished drawing. No Changes should be made on the original sketch after the investigator has left the scene.

Finished Drawing. The finished drawing is made primarily for courtroom presentation. It is generally based on the rough and drawn to scale by a person skilled in either mechanical or architectural drawing.

Materials. A sketch of a crime may be accomplished with little more than a pencil, a sheet of paper and a straight edge. On the other hand a finished drawing will require more advanced equipment. If the investigator wishes to draw an outdoor crime scene together with the surrounding terrain and achieve a reasonable degree of accuracy, he must possess an elementary knowledge of geometry. The following materials will be found useful although they should not be considered an absolute necessity.

For Rough Sketching. For a rough sketch it is generally desirable to use a soft pencil. Graph paper is excellent for sketching as it provides a guide for lines and proportions. A clipboard or similar board of a size that will fit in the investigator's briefcase will serve as a sketching surface. The investigator should have a compass so that he/she may accurately indicate directions and also a steel tape to insure correct measurements.

For Finished Drawing. When the finished drawing is to be made in the office and based on the rough sketch, the draftsman will require a drawing set a drafting board with accessories India ink, and a good grade of drawing paper. Since the drawing is made to scale, these materials are necessary to insure accuracy. If the finished drawing is to be made at the scene, the equipment of the draftsman should include a compass and steel tape.

Elements of Sketching:
The following considerations apply generally to all sketches:

Measurements. Measurements must be accurate. In portraying a large area a sufficient degree of accuracy is obtained by measurements of yards or tenths of a mile; for small areas measurements accurate to the sixteenth of an inch may be required.

Measurements should be accomplished by the sketcher himself making the actual measurement while his assistant verifies all readings. Measurements establishing the location of a movable object must be based on an immovable object. While measurements may be indicated between movable objects to establish a correlation at least one set of dimensions must reach an immovable object.

Compass Direction” Compass direction must always be indicated to facilitate proper orientation of the sketch. The compass is used to determine "North." A standard arrow of orientation will indicate this direction on the sketch.

Essential Items: The sketch should portray all items that have a bearing on the investigation being conducted. The inclusion of unnecessary detail will result in a cluttered or
crowded sketch and tends to hide or obscure the essential items. Simplicity is essential and sketches should be limited to the inclusion of only relevant material. For example, the sketch will include an outline of the room together with the doors, windows, chimney, and other large fixed objects. The furniture will then be indicated. The dead body or other significant object will be shown in relation to the furniture and other objects. Measurements will be made of the room, fireplace, sink, doorways, etc. The distances of the various parts of, for example, the body from these objects will be measured and recorded.

**Scale or proportion:** The scale of a drawing will normally be dependent upon the area to be portrayed, the amount of detail to be shown, and the size of drawing paper available. It is normally advisable to use the smallest scale practicable. The actual or approximate scale of a sketch should always be shown by words and figures, graphically. If a rough sketch is made, the size of an object may be approximated as correlated to other objects. For example, if one dimension of a room is thirty feet and the other ten feet, the first line would be approximately three times the length of the second.

**Legend:** The legend is an explanation of symbols used to identify objects in the sketch. In sketches portraying a large area, conventional signs or symbols may be used. These should be explained in the legend. If it is necessary to show considerable detail in a sketch covering a small area, the various objects may be lettered and an explanation included in the legend. Excessive lettering in the sketch generally will result in a crowded Sketch and obscure essential items.

**Title:** The title of a sketch should contain the case identification (case-file number and offense); identification of victim or scene portrayed; location; date and hour made; and the sketcher. These data authenticate the sketch.

**Projection:** The normal sketch will show the scene in two dimensions of one plane. When it becomes desirable to portray three dimensions to allow better correlation of the evidential facts of the scene, a projection sketch must be used. This projection sketch of the scene of a room is like a drawing of a cardboard box whose edges have been cut and the sides flattened.

**Surveying Methods:** When portraying large areas, some of the basic surveying methods may be used to facilitate the work of the sketcher and to help insure the accuracy and clarity of the sketch. If the investigator does not have knowledge of surveying, he should enlist the services of a competent surveyor. The coordinate method, of which there are many simple variations, can be used to meet most of the problems in field sketching.

**Rectangular Coordinates.** The simplest way to locate points on sketch is to give the distances from two mutually Perpendicular lines. If the crime scene is a room, the objects can be mapped by using two mutually perpendicular walls as the reference lines. A chair, for example, can then be located by measuring its distance from each wall, e.g., 82 inches from the west wall and 43 inches from the south wall. If a graph paper is used for sketching and each unit of the graph paper represents 5 inches (for example) in the room, the chair is located on the graph paper by a point located 16.4 units from the vertical axis and 8.6 units from the horizontal axis, where the two axes are the left hand margin and the lower margin.

**Polar Coordinates** A point can also be mapped by giving its distance from some chosen origin and the direction angle which the distance line makes with a chosen axis of reference. The system is particularly useful for outdoor scenes, being commonly used in daily life. Using a door of a house as the origin, a tree can be located by saying that it is 324 yards away in a direction 42° west of south. The angle is determined by compass using the side of the house as a reference line and the distance is measured from the door to the house.

(http://www.moval.edu/faculty/simmermanj/homicide/crime_scene_s ketch.htm)
LAB # 3: TRACE EVIDENCE (HAIRS AND FIBERS)

Part 1:
Go here and use this learning tool.

Trace Evidence Game
Solve the puzzles to unlock clues to a fictional crime. Be warned -- this game is addictive!

http://investigation.discovery.com/interactives(trace-evidence/game.html

Part 2:
Objectives:
- Gain and refine skills with microscopes and preparing wet mounts
- Establish skills in making scale casts and hair mounts
- Be able to identify the main characteristics of human hair and compare difference between individuals with respect to hair morphology
- Recognize basic differences between human hair and animal hairs and textiles
- Case study: make a tape lift of hairs from a garment (evidence). Make scale casts and wet mounts of the hairs and compare the hairs from the victim to whom the clothing belonged and 3 suspects.

Recall Locard’s principle that every contact leaves a trace. Hairs and fibers are used in forensics to link a suspect to a victim or to establish that a suspect was present at the scene of a crime. Hairs and fibers are therefore vital pieces of trace evidence. In this lab you will learn how to lift, mount and identify hairs. Because the hairs of other animals differ in morphology from human hairs, and because textiles vary so widely in their morphology, learning to distinguish different types of animal hairs and artificial fibers is largely beyond the scope of this lab. However, if this interests you, you can find more information here: http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm

Hairs may be used in forensics to link a suspect to the scene of a crime, indicate contact of the suspect with the victim, link clothes or shoes to a suspect and link a victim of a hit and run accident to the car of the suspect. However, human hairs vary widely both between individuals as well as within an individual from different parts of the body. Even hairs on the human head in a single individual will vary in their morphology, color and texture. Typically, dozens of hairs are collected from a suspect and used in comparison to account for the natural variation that exists.

In human hair, there are 3 main areas visible with a light microscope; the medulla, the cortex and the cuticle (see Fig. 1). Many animal hairs are discernable from human hairs by the size and shape of their medullae and the patterns of their cuticle and scale structure. Synthetic fibers lack a medulla and scale pattern. Therefore, it is important for a forensic scientist to collect information on all 3 of these areas both to rule out animal hairs and synthetic fibers as well as to compare to suspect hair. In this lab you will prepare a scale mount which separates the cuticle from the rest of the hair and prepare a wet mount of your hair to identify the main features of human hair.
**Figure 1.** Physical features of hair showing the three morphological regions—the cuticle, medulla, and cortex. From: [http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm](http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm)

**Hair Vocabulary:**

**Cuticle:** The cuticle is the outermost protective covering of the hair. It is usually thicker in animal hair and often contains overlapping scales that are unique to the species. These scales overlap and point upwards toward the tip of the hair.

**Cortex:** The cortex is located beneath the cuticle of the hair. This part of the hair contains pigment granules. These granules differ in their size, color, and pattern. The cortex of the hair is viewed most clearly using slides with a permanent mounting fluid.

**Medulla:** The medulla is a canal located inside of the cortex. Although it is the most visible structure of animal hair, it is usually very thin or absent in human hair.

**Root:** The root is the part of the hair in the follicle that is below the surface of the skin. The condition of the root is sometimes examined in forensics to determine whether or not the hair was pulled out in a struggle.

**Follicle:** The hair follicle is a pocket located beneath the surface of the skin from which the hair grows.

**Shaft:** The shaft is the part of the hair that is visible above the skin’s surface.

**Medullary Pattern:** The pattern of the medulla varies among species and can be used to distinguish animal hair from human hair. The following diagrams show different medulla patterns:

- **Fragmented**
- **Interrupted**
- **Continuous**
**Medullary Index:** The medullary index is the diameter of the medulla relative to the diameter of the hair. This index is often less than 1/3 in humans and may be over 1/2 in animals. From: [http://www.courttv.com/forensics_curriculum/msunit1.pdf](http://www.courttv.com/forensics_curriculum/msunit1.pdf)

**PROCEDURE**

- Work in groups of 2.

**Materials:**
- 10 glass slides and coverslips
- Prepared slides of animal hair, human hair and textiles
- Samples of your hair and your lab partner’s
- Sample of animal hair
- Clear fingernail polish
- Glycerine or Permount
- Samples of hair (envelopes A, B and C) for Part 3.

**Observations of prepared slides**

The objective here is to compare and contrast human hairs to animal hairs and textiles and fabrics. Obtain the slide titled “Hair, human, cat and sheep” – this slide obviously contains slides for a human, cat and sheep. Observe these hairs under 400X magnification. Use the picture below to identify cat and human hair. The sheep hair is the process of elimination (anything that doesn’t look like the hairs below = sheep).

![Human Hair vs Cat Hair](image.png)

Sketch each of the hairs – pay attention to detail. The goal here is to compare and contrast the hairs. *Answer the question comparing the hairs at the end of the lab.*

Repeat the procedure for one of the textile fibers from the slide titled “Textile fibers, synthetic”.

**Preparing a Wet Mount**

- You will be preparing a wet mount of your hair.
- Single out the hair to be wet mounted and place it on a piece of paper.
- Place 2-3 drops of Permount on a microscope slide.
- Place the hair on top of the Permount.
- Gently lower a coverslip over the Permount and hair.
- Using the eraser on a pencil, *gently* smooth out any bubbles that exit.
- Place the slide on the microscope slide and examine the hair at 100x magnification.
- Observe the general morphology of the hair.
- Answer the questions at the end of this lab handout (to be turned in).

**Preparing a Scale Cast**

- It is not possible to see scale patterns attached to the hair with a light microscope. This procedure will allow you to separate the scales from the hair so they can be observed under the microscope.
- You will only need to make a scale cast of 2 human hairs for this exercise.
- Select a human hair, and carefully clean it with a KhemWipe to remove grease and oil from the hair surface.
- Smear a glass slide with clear nail polish.
- Quickly, before the nail polish dries, place the hair on the nail polish. As the nail polish dries, the hair will be removed while the scale pattern remains intact.
- After about 20 seconds (before the nail polish dries completely), lift the strand of hair off the slide. You should see an imprint of the hair on the slide.
- Place the cast under the microscope and observe at 100x magnification.
- Answer the questions at the end of this lab handout (to be turned in).
- Repeat this procedure for the other sample of human hair.

**Case Study:**
The victim of an assault has identified a suspect. The suspect claims that they were never at the crime scene and has never met or even interacted with the victim before. As a forensic scientist specializing in trace evidence, you are given a coat belonging to the victim. During the assault, the assailant struggled with the victim and it is possible that the assailant left hair on the victim’s coat. In reality, you would dab the entire surface of the coat with a piece of clear tape to pick up as many hairs and fibers as possible. For the sake of time, you will be provided with 4 envelopes of hair – one containing hair from the victim and one with hair from the assailant (positive controls) and 2 envelopes containing 2 different hairs lifted from the coat. Using a wet mount, prepare 3 slides (one from each envelope) using the technique you just learned. Compare the hairs, fill in the forms at the end of the lab and answer the questions.

When you are done, place the scale cast slides in the broken glass container since they can not be reused. For wet mount slides, remove the coverslip, rinse the slides off with soap and water and place them on a paper towel to dry. All other materials should be replaced to the cart at the front of the room.

**Questions (to be turned in):**

The following links will help you answer the questions in this lab:

**Part 1.**
1. Sketch the 3 hairs and one fiber from the prepared slides you observed in 4 separate circles (about 3” in diameter). Make the drawings to scale so that differences can be observed. For example, if one hair has a proportionately larger medulla, this should be obvious from your illustrations. Label the structures of the hair, indicate the magnification and identify the source of the hair.
2. Describe any differences or similarities you see in the structure, color or texture of the 3 hairs and 1 fiber. Pay particular attention to length, width, color, ends (tapered, cut, etc), and the medulla length and type (fragmented, interrupted, continuous, absent). You may present your observations in a table if you like. The goal here is to summarize information that would be helpful in distinguishing between hair types and fibers. You may use information from the links above to help supplement your answer is you like.

**Part 2.**
1. Sketch the hair from the wetmount you observed in a circle (about 3” in diameter). Make the drawings to scale so that differences can be observed. For example, if one hair has a proportionately larger medulla, this should be obvious from your illustrations. Label the structures of the hair, indicate the magnification and identify the source of the hair.
Part 3.
1. Sketch the 2 hairs you observed in 2 separate circles (about 3” in diameter). Make the drawings to scale so that differences can be observed. Indicate the magnification and identify the source of the hair.
2. Research question (use texts, journal articles or sources from the web to answer this question). If you were presented with hair and fibers from sources other than human, how would you distinguish human hair from other sources such as animal hair or synthetic fibers with respect to morphology, color, shape, structure and possibly scale casts?

Part 4.
1. Fill in the form. Characteristics of Human Hair, for each of the 4 hairs you examined.
2. Write a brief report imagining that you are the forensic scientist in charge of the case summarizing your results. What are the major conclusions? Did the positive control hairs match any of the hairs lifted from the coat? What would you conclude about whether the suspect had made some contact with the victim? Is this conclusive evidence of guilt or innocence? How confident are you in your findings? How admissible do you think this evidence is? That is, if you were a judge, would you allow this fiber evidence as admissible? Why or why not (you should likely refer to the Daubert standards in making your ruling here).


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<th>Characteristics of Human Hair</th>
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<tr>
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<td>☐ Colorless  ☐ Blonde  ☐ Red  ☐ Brown  ☐ Black  ☐ Other</td>
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<tr>
<td><strong>Texture:</strong></td>
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<td>☐ Fine  ☐ Coarse</td>
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<tr>
<td><strong>Cuticle:</strong></td>
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<tr>
<td>☐ Present  ☐ Absent</td>
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<tr>
<td><strong>Medulla: (check all that apply)</strong></td>
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<tr>
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<tr>
<td><strong>Proximal End:</strong></td>
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<tr>
<td>☐ No Root  ☐ Root</td>
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<tr>
<td><strong>Distal End: (check all that apply)</strong></td>
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<tr>
<td>☐ Tapered  ☐ Abraded  ☐ Square cut  ☐ Angular cut  ☐ Frayed  ☐ Spilt  ☐ Burned  ☐ Other</td>
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Characteristics of Human Hair

Sample ID: ____________________________

Color:
☐ Colorless ☐ Blonde ☐ Red ☐ Brown ☐ Black ☐ Other

Texture:
☐ Fine ☐ Coarse

Cuticle:
☐ Present ☐ Absent

Medulla: (check all that apply)
☐ Present ☐ Absent ☐ Continuous ☐ Discontinuous ☐ Fragmented ☐ Opaque
☐ Translucent ☐ Other

Proximal End:
☐ No Root ☐ Root

Distal End: (check all that apply)
☐ Tapered ☐ Abraded ☐ Square cut ☐ Angular cut ☐ Frayed ☐ Spilt
☐ Burned ☐ Other

Sample ID: ____________________________

Color:
☐ Colorless ☐ Blonde ☐ Red ☐ Brown ☐ Black ☐ Other

Texture:
☐ Fine ☐ Coarse

Cuticle:
☐ Present ☐ Absent

Medulla: (check all that apply)
☐ Present ☐ Absent ☐ Continuous ☐ Discontinuous ☐ Fragmented ☐ Opaque
☐ Translucent ☐ Other

Proximal End:
☐ No Root ☐ Root

Distal End: (check all that apply)
☐ Tapered ☐ Abraded ☐ Square cut ☐ Angular cut ☐ Frayed ☐ Spilt
☐ Burned ☐ Other
OPTIONAL: FORENSICS FIBERS LAB

Not long ago, most fabrics were made of wool, cotton, linen or silk. It was easy to identify them just by feeling and looking. Today a wide variety of synthetic fibers has appeared on the market, and manufacturers have learned how to combine many fibers in making a single fabric, making it difficult to analyze completely or identify all fabrics. However, there are some simple tests which help greatly in distinguishing fabrics, the most common being the burning test and chemical tests. Physical tests such as strength and appearance are also useful in identifying fibers.

The Burn Test
Apparatus: Bunsen burner, heatproof mat, tongs, crucible and lid, fiber samples of wool, nylon, polyester, cotton, linen, acrylic, silk, and unknown fiber samples (Note: this experiment is best done in a fume hood.)
You are going to conduct a series of burn tests on different fiber samples and then try to determine what an unknown sample is by testing.

A. Set up a Bunsen burner with a crucible near by. Light the burner and adjust it for a blue flame.

B. Hold one of the fiber samples in a pair of tongs and ignite the other end in the flame.

C. Place in crucible and allow sample to burn. If the fiber goes out attempt to light again.

D. Observe the sample and answer the following questions, recording your answers in a table like that shown below.
   1. Burn Rate/Type - Does the fiber catch fire easily? Does the fiber continue to burn when it is out of the flame? How does the fiber burn? – (flame, smolders, sparks, brightly, etc.)
   2. Smell - Is there any smell? If so describe it? (Using your hand, wave smoke into your face to smell)
   4. Product - Describe what is left in the crucible; is it solid, does it crumble?

E. Ensure sample is fully burnt and/or extinguished. Clean out crucible, it may be necessary to rinse the crucible between samples to eliminate smell.

F. Repeat these observations for each sample.

G. Finally, test the unknown sample and record your observations. Use these to try to identify the sample. Check your results with your teacher.
NAME____________________

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Turn Rate/Type</th>
<th>Smell</th>
<th>Smoke</th>
<th>Product left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nylon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions:**
1. Summarize your conclusions for your unknown. What fiber do you think this is? Based on what evidence? Are there other tests (you may need to do some research on the web for this) that could be used to more definitely identify the fiber?
2. What are limitations to this lab? Explain how the methods of this lab may be useful in examining evidence from a crime scene. What are some of the limitations of these tests – and how might this affect the admissibility of this evidence in court?

*Lab developed from the National Institute of Forensic Science*
<table>
<thead>
<tr>
<th>Fiber</th>
<th>Burn Rate/Type</th>
<th>Smell</th>
<th>Smoke</th>
<th>Product left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>Will not burn on its own</td>
<td>Smells like burnt hair</td>
<td>Little smoke</td>
<td>Black ash that crumbles when poked</td>
</tr>
<tr>
<td>Cotton</td>
<td>Flares into bright flame and burns rapidly</td>
<td>Smells like burnt paper</td>
<td>Little smoke</td>
<td>Black ash that crumbles when poked</td>
</tr>
<tr>
<td>Nylon</td>
<td>Burns out shortly after removing from flame</td>
<td>Smells like celery</td>
<td>Gray smoke</td>
<td>Melts and beads into ball</td>
</tr>
<tr>
<td>Polyester</td>
<td>Burns out shortly after removing from flame</td>
<td>Mild burnt plastic smell</td>
<td>Black smoke</td>
<td>Melts and beads into black mass</td>
</tr>
<tr>
<td>Linen</td>
<td>Flares into bright flame and burns rapidly</td>
<td>Smells like burnt paper</td>
<td>Little smoke</td>
<td>Black ash that crumbles when poked</td>
</tr>
<tr>
<td>Silk</td>
<td>Doesn’t burn on own for extended</td>
<td>Mild smell</td>
<td>Little smoke</td>
<td>Black ash that crumbles when poked</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lab developed from the National Institute of Forensic Science
LAB # 4: FINGERPRINT IDENTIFICATION

Introduction
Fingerprint Identification is the method of identification using the impressions made by the minute ridge formations or patterns found on the fingertips. No two persons have exactly the same arrangement of ridge patterns, and the patterns of any one individual remain unchanged throughout life. Fingerprints offer an infallible means of personal identification. Other personal characteristics may change, but fingerprints do not.

Fingerprints can be recorded on a standard fingerprint card or can be recorded digitally and transmitted electronically to the FBI for comparison. By comparing fingerprints at the scene of a crime with the fingerprint record of suspected persons, officials can establish absolute proof of the presence or identity of a person.

History
The first year for the first known systematic use of fingerprint identification began in the United States is 1902. The New York Civil Service Commission established the practice of fingerprinting applicants to pre-vent them from having better qualified persons take their tests for them. The New York state prison system began to use fingerprints for the identification of criminals in 1903. In 1904 the fingerprint system accelerated when the United States Penitentiary at Leavenworth, Kansas, and the St. Louis, Missouri, Police Department both established fingerprint bureaus. During the first quarter of the 20th century, more and more local police identification bureaus established fingerprint systems. The growing need and demand by police officials for a national repository and clearinghouse for fingerprint records led to an Act of Congress on July 1, 1921, establishing the Identification Division of the FBI.

In 1924 the Identification Division of the Federal Bureau of Investigation (FBI) was established to provide one central repository of fingerprints. When the Identification Division was established its purpose was to provide a central repository of criminal identification data for law enforcement agencies throughout the Nation. However, in 1933 the United States Civil Service Commission (now known as the Office of Personnel Management) turned the fingerprints of more that 140,000 Government employees and applicants over to the FBI. Therefore, a Civil Identification Section was established. These innovations marked the initiation of the FBI’s Civil File which was destined to dwarf the criminal files in size. In 1992 the Identification Division was re-established as the Criminal Justice Information Services Division (CJIS).

The CJIS Division - Identification and Investigative Services Section

• Maintains the National Repository of Criminal History Records and Criminal History Data (expungements, dispositions/notices, and wants)
  - 41 million subjects in the Criminal fingerprint file
  - 40 million subjects in the Civil fingerprint file

• Provides Ten-Print Identification Services to All Federal, state, local criminal justices agencies and authorized employment and licensing agencies.

• Ensures quality of these services to All Federal, state, local criminal justices agencies and authorized employment and licensing agencies.

Each day approximately 7,000 new individual records are added to the files.
The New Age of Electronic Fingerprint Identification

Fingerprints are now processed through the Integrated Automated Fingerprint Identification System. The fingerprints are submitted electronically or by mail, processed on IAFIS, and a response is returned to the contributing agency within two hours or less for electronic criminal fingerprint submissions and twenty-four hours or less for electronic civil fingerprint submissions. Fingerprint processing has been reduced from weeks and months to hours and minutes with IAFIS.

Fingerprint Pattern Type

<table>
<thead>
<tr>
<th>Plain Arch</th>
<th>Tented Arch</th>
<th>Ulnar Loop</th>
<th>Radial Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Whorl</td>
<td>Central Pocket Loop</td>
<td>Double Loop Whorl</td>
<td>Accidental Whorl</td>
</tr>
</tbody>
</table>

Go here and Practice before we do this in the lab.

Here is a game for you to use to identify fingerprints.
http://investigation.discovery.com/interactives/fingerprint-memory/easy.html
**Ridgeology Basics**

Name ____________________________

1. Ridgeology: The study of the uniqueness of friction _____________________ structures and their use for personal ____________________.

2. Who coined the term “Ridgeology”? ____________________________

3. As we have learned in our first lesson, a fingerprint is made of a series of ______________ and ______________, on the surface of the finger. The uniqueness of a fingerprint can be determined by the ______________ of ridges and valleys as well as the location, shape, and position of ______________ points, which are points where the ridge structure changes.

4. Ridge Characteristics - Draw the different ridge characteristics listed below.

5. Take a look at the sample fingerprint on the screen to see several ridge characteristics that you might find during a fingerprint examination.

<table>
<thead>
<tr>
<th>Core</th>
<th>Ending Ridge</th>
<th>Short Ridge</th>
<th>Fork or Bifurcation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td>Hook</td>
<td>Eye</td>
<td>Dot or Island</td>
</tr>
<tr>
<td>Crossover</td>
<td>Bridge</td>
<td>Enclosures</td>
<td>Specialty</td>
</tr>
</tbody>
</table>
6. How many ridge characteristics can you identify in this fingerprint? Use a hand lens and highlighter to help you identify the characteristics and label each one.

7. AFIS stands for _______________ _______________ _______________ _____________. When minutiae on two different prints match, these are called points of _______________ or points of _______________.

8. For almost a hundred years, the primary method used to examine prints was the __________ system. An examiner would compare the ridges in two prints, and if enough of the ridge points _______________, anywhere from _______ to _______, then there was said to be an identification.

9. In the past _______ years, there has been a shift away from the points system to the system known as “Ridgeology”. An examiner must determine if there are enough _______________ (not just _______________) in common to determine if two fingerprints are matches.

Try It! - Which three ridge characteristics were most common in your fingerprints?

1._______________________
2._______________________
3._______________________
Step 1: Classify your fingerprints and record the number of each pattern below. Your total should equal 10!
Arches = ______ Loops = _______ Whorls = _______

Step 2: Complete the chart below by recording the total number of each pattern for the class. The expected averages are 60% for loops, 35% for whorls, and 5% for arches.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>#</th>
<th>Total Prints</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whorls</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How do our prints compare to the expected averages?

Step 3: Complete the chart below by recording the total number of each pattern for the males and females in the class.

<table>
<thead>
<tr>
<th>Pattern</th>
<th># Males</th>
<th># Females</th>
<th>Total Prints</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whorls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which pattern is most common pattern among the males in this class?

Which is most common pattern among the females?

How do the averages for each sex compare to the expected averages?

T. Trimpe 2007 http://sciencespot.net/
Lab Day Procedure

1. ____________ ____________ are impressions left by friction ridge skin on a surface, such as a tool handle, glass, door, etc.

2. Prints may be collected by revealing them with a dusting of ____________ ____________ and then lifted with a piece of ____________ ____________.

3. What is the most common type of animal hair that is used to make brushes? ______________

4. Some investigators use ____________ powder and UV lights to help them find latent prints on multicolored or dark surfaces.

5. ____________ powder can also be used to reveal latent prints. This type of powder works better on ____________ surfaces or ____________ baggies and containers.

6. The ____________ fuming method (often called the super glue method) is a procedure that is used to develop latent fingerprints on a variety of objects.

Directions:
1 - Cover your table with white butcher paper. You must dust everything on the white paper – not on your table or near the edge of the paper!
2 - Get a lifting kit from your teacher.
3 - Press the pad of your right thumb on a glass slide to make a print.
4 – Dip a brush lightly into the container of black powder and then tap off the extra on the lid. You only need a very small amount of powder to dust the print.
5 – Hold the brush over the print and rotate it between your thumb and fingers.
6 - Use a small piece of clear tape to lift the print and place it in the box below.

My Latent Print (Use the Finger Printing Cards from your evidence kit and turn this in with your...
LAB # 5: FINGERPRINT RECOVERY

Preparation of the "Evidence"

NOTE: Since it is important that only one fingerprint be placed on the material to be analyzed, students should use gloves to transfer the evidence from one place to another.

Exhibit A

1. Wash a beaker or glass and rinse it with distilled water. Wipe it dry, making sure no finger prints appear on the glass surface.

2. Hold the glass or beaker in a paper towel or cloth and place three distinct RIGHT thumb prints on the surface of the glass. If the print is smudged, is not clear, or is barely visible, wipe off the glass and try again. This time, rub your thumb over the oily portion of your face, blot the thumb, and place a good print on the glass.

3. Label glass with "Exhibit A" and your student I.D. number.

Exhibit B & C

1. Using a pencil, label a piece of filter paper with "Exhibit B" (or "Exhibit C") and your student I.D. number at the top of the paper.

   Ex:

   Exhibit B  12754

2. Place a good, RIGHT thumb print in the middle of the paper.

Exhibit D

1. Using a pencil, label a piece of bond paper with “Exhibit D” and your student I.D. number at the top of the paper.

2. Place a good, RIGHT thumb print in the middle of the paper.

Exhibit E

1. Using a pencil, label a piece of bond paper with “Exhibit E” and your student I.D. number at the top of the paper.

2. Ink your finger and place a good, RIGHT thumb print in the middle of the paper.
**Procedure A. Dusting For and Lifting Prints from a Smooth, Non-Porous Surface**

Dust adheres to the sweat and oil on the print.

**Materials needed**
- Exhibit A
- Dusting Brush
- Newspaper
- Dusting Powders (aluminum and carbon black)
- Cellophane Tape
- Index Card
- Magnifying Glass
- MO Sheets

**Procedure**

**CAUTION:** Metallic dust can be harmful to the lungs if inhaled!

1. Dip the brushes in the powder and lightly dust the area of Exhibit A containing the print.

2. Distribute the powder evenly over the surface that contains the print. If possible, pick up the object that carries the print and tap the edge of the object to uniformly distribute the dusting powder.

3. After all of the print is developed, remove the excess powder by blowing the dust from the surface or by gently brushing it away. Blowing the dust off the surface usually works better than using the brushes supplied in this kit. When blowing dust off, be careful not to inhale any of the dust between attempts. During the use of a brush to remove excess powder, be careful not to destroy the print with too hard a brush stroke.

4. To lift the print form the beaker to the index card, use about 5” to 6” of tape and place the end to the right of the thumb print on the beaker and allow the tape to cover the whole print. Slide a thumb over the tape and smooth it down over the print to force out all air bubbles.

5. The print can be removed by pulling up on the roll end of the tape and then placing it on the fingerprint card in the same manner as the tape was placed over the latent print. Make sure the tape is secure.

6. Observe the print under the magnifying glass and compare it to the right thumb prints on the MO's. Identify the owner of the print and record.
**Procedure B. Using Ninhydrin to Develop a Print on Paper**

Ninhydrin reacts with the amino acids in the perspiration on the print to form a pink or purple compound.

**Materials needed**
- Exhibit B
- Magnifying Glass
- Ninhydrin Soln
- Plastic Gloves
- Brush or Cotton Swabs

**Procedure**

**CAUTION:** Ninhydrin soln is volatile and flammable. Keep this solution away from open flames.

*NOTE:* Wear plastic gloves when working with the ninhydrin soln as it will react with the amino acids on your hands and turn them blue!

1. Tape the top of Exhibit B to a paper towel.

2. Dip the tip of the brush into the ninhydrin solution and carefully dab this liquid over the fingerprint area. Do not use too much pressure since that will destroy the print.

3. Allow the paper to dry. It may take 24 hours to develop. Observe the print under the magnifying glass and determine the identity of the person who left the print. Record the data.

*NOTE:* If the print does not develop, expose the paper to the fumes from ammonia, i.e. by opening a bottle of concentrated ammonia in the fume hood and holding the paper with the print over the opening of the bottle.
C. Using Silver Nitrate Solution to Develop a Print on Paper

Silver Nitrate reacts with the salt in the perspiration on the print to form silver chloride.

Materials needed
Exhibit C Magnifying Glass Silver Nitrate Soln
Plastic Gloves

Procedure

CAUTION: Exposure to silver nitrate soln will turn skin black.

NOTE: Wear plastic gloves when working with the ninhydrin soln as it will react with the amino acids on your hands and turn them blue!

1. Hold the undeveloped print in front of and over a tray. Spray the print with silver nitrate soln. The print should be soaked, but not runny.

2. Place the wet print under the U-V light until the print develops. Observe the print under the magnifying glass and determine the identity of the person who left the print. Record the data.

D. Using Iodine Crystals to Develop a Print on Paper

The dusting process used in Part A cannot be used to develop a print on porous paper because the water from the perspiration spreads out and the print appears smeared. Exposing the print to iodine crystals will develop the print. The oily material on the print absorbs the iodine vapor and produces a violet to purple-brown fingerprint.

Materials needed
Exhibit D Iodine Crystals Screw-top Jar
MO sheets Roll of Cellophane Tape Plastic Gloves

Procedure

1. Cut a piece of tape about 1" long and place half of it on top of Exhibit D. Open the jar containing the iodine crystals and quickly tape the paper to the lid so that the paper hangs down in the jar. Replace the lid and allow the print to come in contact with the iodine vapor for about 3 to 5 minutes or until the print is visible.

2. Once the print is developed, remove the paper from the jar. Be sure to quickly replace the lid on the jar.

3. Observe the print under the magnifying glass. Determine the identity of the person who left the print and record the data.

4. The developed print may disappear since the iodine will continue to sublime. To "save" the print, completely enclose the paper in plastic tape. (This could also be accomplished by completely immersing the paper in a solution containing 12.5 grams of calcium chloride and 43.9 grams of potassium bromide in 100 ml of water. This will "fix" the print for a few weeks.)
E. Identifying a Direct Print

Occasionally a criminal will leave behind a print that is clearly visible. Prints like these can be made by colored material that was on the person's fingers. Substances that leave usable direct prints include soot, inks, blood, paints, facial make-up, and dyes. Usable direct prints can also be left on materials like window putty or clay that are soft enough to take the impression of the print but firm enough to retain the image after the impression is made.

Materials needed
Exhibit E  Magnifying Glass  MO Sheets

Procedure
1. Use a magnifying glass to observe the inked print on Exhibit E. Compare this print to one on the MO sheets.

2. Determine the identity of the print and record the data.

Case Study 1: You are a forensic scientist investigating a homicide. You are given an aluminum baseball bat used in the beating death of a gang member. You manage to lift a partial latent print from the bat. Your job is to compare the partial print to the fingerprints of 3 rival gang members suspected in the beating death. Below is the partial print as well as the prints of the suspects. Write a report summarizing the results of your investigation. In it, you should include information on the latent print (basic fingerprint type and any distinguishing characteristics) as well as the fingerprint of the suspect you believe matches it (if any). You should describe the process by which you found your match – for example, you may rule out some suspect prints because they are not the same basic pattern as your latent print. You may cut and paste the prints into your report if you wish and use them to indicate what features you have identified. To get better resolution, you can view the prints in Word and view them at 150%. You should also indicate how confident you are in your results. Recall that most courts require 12 points to match for it to be considered a match.

Partial print from crime scene.

3. Case Study 2: the next page, there are prints from 4 suspects and a latent print from a crime scene. As you did with question 2, try to establish a link between the latent print and suspect prints. Use visuals to
show the matching minutiae, and write a brief report explaining how you made the match, and how confident you are in your findings.

4. As stated earlier in the lab handout, there is some controversy over the veracity of fingerprint evidence, particularly in light of the Daubert standards. Imagine you are a trial judge faced with defense attorneys arguing that fingerprint evidence should not be introduced in a trial because no systematic study or studies have been conducted to determine the accuracy with which a partial print can be matched to a fingerprint, and that no uniform standards for determining whether a match exist. Briefly explain your position on the admissibility of fingerprint evidence and explain whether you feel the field of fingerprint analysis is a reliable science under the Daubert guidelines. See links at the end of this lab handout as well as the course website to help you answer the questions in this lab.

Curriculum:
Most of this lab was created by CourtTV and was used by permission. The lab in its original form is available from CourtTV:
www.courttv.com/forensics_curriculum

Other links:
For an excellent tutorial on superglue fingerprinting, check out this link:
http://onin.com/fp/cyanoho.html
Excellent site maintained by Kasey Wertheim:
Complete Latent Print Examination
Crimes and Clues magazine – articles and links to fingerprints:
http://www.crimeandclues.com/fingerprints.htm
Another article on superglue fuming:
http://www.detectoprint.com/article.htm
A technique for lifting prints from adhesive surfaces:
http://www.redwop.com/minutiae.asp?action=showArticle&ID=84
Digital fingerprints:
http://www.eneate.freeserve.co.uk/

The Daubert standard and fingerprints (scroll down):
http://www.onin.com/fp/

Two links on fingerprint characteristics to help answer questions in this write-up:

Images from
<table>
<thead>
<tr>
<th><strong>Fingerprints</strong></th>
<th><strong>Date</strong></th>
<th><strong>Height</strong></th>
<th><strong>Weight</strong></th>
<th><strong>Hair</strong></th>
<th><strong>Eye</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>L. R. Thumb</td>
<td>BLE-410</td>
<td>09-09-1945</td>
<td>6'2*</td>
<td>245</td>
<td>Br</td>
</tr>
<tr>
<td>R. L. Index</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>S. R. Middle</td>
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<tr>
<td>R. R. Ring</td>
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<tr>
<td>S. R. Little</td>
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<tr>
<td>L. L. Thumb</td>
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<tr>
<td>L. L. Index</td>
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<tr>
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<tr>
<td>R. L. Ring</td>
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</tr>
<tr>
<td>10. L. Little</td>
<td></td>
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</table>

**SUSPECT 1**
**SUSPECT 2**

<table>
<thead>
<tr>
<th>LEAVE BLANK</th>
<th>CHIMINAL</th>
<th>(STAPLE HERE)</th>
<th>LEAVE BLANK</th>
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<tbody>
<tr>
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STATE USAGE

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SPECIAL EDUCATION

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SIGNATURE OF PERSONS IDENTIFIED

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SOCIAL SECURITY NO.

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MADAME MEDUSA

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ID NO.

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STATE IDENTIFICATION NO.

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DATE OF BIRTH

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<tr>
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HEIGHT

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<td>5'5&quot;</td>
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WEIGHT

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<td>160</td>
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STEPS

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<tr>
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<tbody>
<tr>
<td>Rd</td>
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</table>

1. R. THUMB

2. R. INDEX

3. R. MIDDLE

4. R. RING

5. R. LITTLE

6. L. THUMB

7. L. INDEX

8. L. MIDDLE

9. L. RING

10. L. LITTLE
**SUSPECT 3**

<table>
<thead>
<tr>
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<th>CRIMINAL</th>
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**STATE USAGE**

<table>
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**SIGNATURE OF PERSON REPRESENTED**

**STOMBOLI, IVAN**

**SOCIAL SECURITY NO.**

771-03-6115

**CRAYF IVAN**

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<th>DD</th>
<th>YY</th>
<th>SM</th>
<th>NAS</th>
<th>DEER</th>
<th>WEIGHT</th>
<th>EYES</th>
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<tr>
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**FINGERPRINTS**

1. R. THUMB
2. R. INDEX
3. R. MIDDLE
4. R. RING
5. R. LITTLE
6. L. THUMB
7. L. INDEX
8. L. MIDDLE
9. L. RING
10. L. LITTLE

**FINGERPRINTS**

1. R. THUMB
2. R. INDEX
3. R. MIDDLE
4. R. RING
5. R. LITTLE
6. L. THUMB
7. L. INDEX
8. L. MIDDLE
9. L. RING
10. L. LITTLE
Suspect 4

<table>
<thead>
<tr>
<th>LEAVE BLANK</th>
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<th>(STAPLE HERE)</th>
<th>LEAVE BLANK</th>
</tr>
</thead>
</table>

**Signature of Person Imprisoned:**

**Social Security No.:** 622-91-4795

**Governor Ratcliffe**

<table>
<thead>
<tr>
<th>HEAD</th>
<th>STATE IDENTIFICATION NO.</th>
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<th>NN</th>
<th>RR</th>
<th>YY</th>
<th>RACE</th>
<th>HEIGHT</th>
<th>WEIGHT</th>
<th>EYES</th>
<th>HAIR</th>
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<tr>
<td>STI - 7012</td>
<td>12-07-1960</td>
<td>8</td>
<td>A.I. 6'0&quot;</td>
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</tbody>
</table>
LAB # 6: FORENSIC GLASS ANALYSIS

Glass Fragment Notes

A physical property describes a substance without reference to any other substance.

- weight
- volume
- color
- boiling point
- melting point

A chemical property describes the behavior of a substance when it reacts or combines with another substance.

Why is glass important to a crime scene?

- It can be lodged in a suspect's shoes or clothes.
- Headlight glass can help identify a suspect's vehicle

What is glass made of and how is it made?

- Glass is made of silicon oxide and metal oxides
- Sand and metal oxides are melted and then cooled

Types of Glass

- Window and bottle glass are made of soda-lime, sand, and the following metal oxides: sodium, calcium, magnesium, and aluminum.
- Auto headlights and heat-resistant glass also have boron oxide.
- Tempered glass is stressed glass that is rapidly heated and cooled.
- Laminated glass is used as windshields and is made by sandwiching a piece of plastic between two pieces of window glass

How is a glass fragment analyzed?

- pieces are put together like a puzzle
- refractive index: velocity of light in a vacuum divided by the velocity of light in the medium
- density: the mass divided by the volume
Forensic Glass Analysis

Purpose: To observe the properties of glass fractures and to apply Refraction index and Density to the identification of different glass samples.

Procedure: In this laboratory you will move through 4 stations set up with the different application of glass analysis. At each station you are to read the procedure, perform the activity and record your observations on the data tables below. Make sure you have gloves and goggles as you move about room.

STATION ONE: Examination of Glass and Glass Fractures

1. **Examine** the “bullet” hole in the pane of glass. How can you tell the difference between the entrance and the exit? ________________________________

Draw a diagram of the hole below

<table>
<thead>
<tr>
<th>Entrance</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Carefully remove the marked glass fragment from the 5 X 5 picture frame glass.
- **What type of fragment is this?** Radial or concentric?_____________________
- Using the strongest magnification (smallest lens) on the hand lens, look at the edge of the fractures glass.
- **Draw a diagram** of the edge of the fractures glass.

Indicate the Direction of the Force and the type of fracture

<table>
<thead>
<tr>
<th>Fracture</th>
</tr>
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<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

- **Relate** your observations to the 3-R rule

3. Observe the glass pane with multiple impacts. **Draw** the fractures below. Number each in the order that they occurred.

4. Observe the four type of glass. Record their similarities and differences.
<table>
<thead>
<tr>
<th>Glass Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td></td>
</tr>
<tr>
<td>Pyrex</td>
<td></td>
</tr>
<tr>
<td>Tempered</td>
<td></td>
</tr>
<tr>
<td>Lead Crystal</td>
<td></td>
</tr>
</tbody>
</table>

**STATION TWO: Determining the Density of Glass Types**
Because glass is not very dense, determine the volume first. It will take several pieces of glass to see a change in volume in the graduated cylinder. Be sure to determine the mass of ALL the glass pieces you used to find the volume. Also be careful to use pieces that will not get stuck!
1. Calculate the volume of several pieces of glass. Record in data chart.
2. Remove glass from the cylinder and determine the mass of all of them together.
3. Record the mass and calculate the density of the glass.
4. Repeat for the other three types of glass.

<table>
<thead>
<tr>
<th>Density of Glass</th>
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</thead>
<tbody>
<tr>
<td>Glass Type</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

**STATION THREE: Determining the Refractive Index of Liquids**
There are three different liquids that you will be working with. They are in marked beakers at the station. DO NOT POINT THE LASER DIRECTLY INTO EYES!!
1. Half fill the plastic containers with the liquid you are testing. (Hint: This may have already been done for you!)
2. Line up the container between the two marks on the horizontal line of the refractive index sheet. (See diagram to guide you)
3. Line up laser pen with the incident ray line as shown in the diagram. Turn on the laser and follow the incident line through the liquid in the dish until a distinct refracted line appears. Make sure it intersects the dot in the center of the paper.
4. Using the protractor, measure the angle of refraction and record in data table below.
5. Calculate the refractive index for each liquid using Snell’s Law.

**SNELL’S LAW Formula:**
\[(n_1)(\sin \angle_1) = (n_2)(\sin \angle_2)\]
Where \(n_1\) = the index of refraction of the first medium (unknown)
\(n_2\) = the index of refraction of the second medium (air)
Angle 1 = the angle of incidence between the incoming ray and the normal line
Angle 2 = the angle of refraction between the outgoing ray and the normal line

Refractive Index of Liquids

<table>
<thead>
<tr>
<th>Substance Being Tested</th>
<th>Angle of Incidence (1)</th>
<th>Angle of Refraction (2)</th>
<th>Index of Refraction of Air (n₂)</th>
<th>Index of Refraction of Liquid (n₁)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30º</td>
<td>1.0003</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30º</td>
<td>1.0003</td>
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<td></td>
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<td>1.0003</td>
<td></td>
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<tr>
<td></td>
<td>30º</td>
<td>1.0003</td>
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<td></td>
</tr>
</tbody>
</table>

STATION FOUR: Refractive Index Comparison of Glass Types

At each set up, you will observe 4 types of glass and a liquid on a paper towel.
1. Using forceps, dip one of the pieces of glass into the liquid.
2. Observe the appearance of Becke lines for each glass sample. Using a hand lens, rate the appearance of the line using a scale of 0-5. (0 = no visible Becke line; 5 being very visible).
3. Record your categories in the data chart below.
4. Please return each glass sample to its marked area/container on the paper towel.
5. Using the refraction indices of the liquids from Station 3, determine the possible refractive index for each sample.

Refractive Index Comparison of Glass Types

<table>
<thead>
<tr>
<th>Glass Fragment</th>
<th>Water</th>
<th>Vegetable Oil</th>
<th>Clove Oil</th>
<th>Estimated Refractive Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Lab Questions:

1. How can glass analysis help to determine a sequence of events?
2. List and describe three other types of trace evidence that could be found at the crime scene on or near glass fragments?
3. As a lab technician, you have been asked to prepare a summary of the glass evidence for the court. What kind of information would you prepare and present to them?
4. How is windshield glass manufactured and how is it designed for safety?
5. Research two other types of glass? (that were not tested in this lab) Describe their characteristics.
6. How would a window pane fracture differently if it were impacted with a .22 caliber bullet vs. a small thrown rock?
LAB # 7: PAINT CHIP IDENTIFICATION

Introduction:

Paint is ubiquitous, it is useful, and it looks nice. It is also a frequently overlooked part of many forensic curriculums. But this doesn’t have to be; paint chips are easier to make and analyze than many people believe. Your students will be engaged, your supervisors will be impressed (should they stop by), and you’ll wonder why you didn’t do this earlier.

Paint is a heterogeneous mixture of organic and inorganic components found on many common items. The organic component is usually the pigment contained in the paint which gives it its color. The binder holds the substances together and to the wall. A solvent is added to paint to give its liquid form so that it can be spread upon the surface to be painted. This solvent evaporates in air and allows the paint to convert to the solid that we commonly see.

Paint is a form of trace evidence that may come into a forensic science laboratory from hit and run accidents, vehicles involved in automobile accidents, or on the tools used during a burglary. Paint evidence can most often be used to associate a particular suspect with a crime scene. This form of class evidence, while not enough to convict a suspect all by itself, can be an integral part of the evidence presented in a court case to convince a jury that the suspect is guilty beyond a reasonable doubt.

To make the paint chips, I borrowed 5 colors of tempera paint and some brushes from the school art department. Any type of paint would probably work. After that it was easy; directions will be in the download specified below.

The scenario: A teacher from River Hill High School walks to the parking lot after school to find that their brand new BMW Z3 convertible has been hit while they were in school. The security officer, Mr. Gonzalez, saw an older model brown sedan driving erratically through the parking lot but was unable to get the license plate number. The police examine the BMW, photograph it from every angle and take paint samples from the scrape on the side. A check of parking permits issued by the school shows that 5 students drive a brown sedan. Police take samples from each of their cars for comparison purposes.

This article features case background for students, data sheets, content links for teachers, and instructions on making your own paint chips. Unfortunately, it is too long to print here. However, a complete copy is available at www.theforensicteacher.com/articles.

Believe me, it’s so much fun you can’t have just one!

Materials List:
This lab activity will take about 50 minutes to complete with students working in groups of two students.

- modeling clay or playdoh to hold paint chips on their edge for viewing
- dissecting microscope or hand lens to view edges of paint chips; a magnification of 20-30 is recommended
- 5 different teacher created paint chips
- colored pencils for sketching paint chips
- reproducible student lab sheet
A teacher from River Hill High School walks to the parking lot after school to find that their brand new BMW Z3 convertible has been hit while they were in school. The security officer, Mr. Gonzalez, saw an older model brown sedan driving erratically through the parking lot but was unable to get the license plate number. The police examine the BMW, photograph it from every angle and take paint samples from the scrape on the side. A check of parking permits issued by the school shows that 5 students drive a brown sedan. Police take samples from each of their cars for comparison purposes.

**Procedure:**
1. Place the paint sample from student A’s car into a piece of clay so that the chip is on its’ thin edge can be seen when looking through the objective. Place the sample under the microscope.
2. Record the order of the paint layers colors that you see using words in your data table under Student A.
3. Count and record the number of layers that you see in the sample as you look from edge to edge.
4. Sketch the paint chip layers in order using colored pencils in your data table.
5. Remove this sample and put it in the proper container.
6. Repeat steps 1-5 with the remaining student suspects paint samples.
7. When you’ve observed all of the student samples, get an unknown crime scene sample from your instructor. Be sure to note the evidence identifier (crime scene number) in your data table.

**Data:**

<table>
<thead>
<tr>
<th>Suspects</th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
<th>Student D</th>
<th>Student E</th>
<th>Crime Scene #____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color Layer Sequence (in words)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Layers in Paint Chip</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sketch of Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colors Found in This Sample?</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Conclusion:**
1. From your experimental results, which suspect’s paint sample was consistent with the paint chips found at the scene of the hit and run accident? Be sure to include evidence identifier (crime scene number) in your answer!
2. Does the evidence from this experiment positively prove that this student hit the teacher’s car? What argument might a good defense attorney use in court? Explain your answer.
3. Would you be able to complete this comparison if there was only one coat color on the car? What additional testing, if any, should be done? Explain your answer.
Appendix: Tooth Charts

Tooth numbering – universal system.

**Please note:** When you look at the tooth chart, you are looking into a person’s mouth with the jaws open. You're facing the person, so their upper right jaw will be on the left of this image.

1. 3rd Molar (wisdom tooth)
2. 2nd Molar (12-yr molar)
3. 1st Molar (6-yr molar)
4. 2nd Bicuspid (2nd premolar)
5. 1st Bicuspid (1st premolar)
6. Cuspid (canine/eye tooth)
7. Lateral incisor
8. Central incisor
9. Central incisor
10. Lateral incisor
11. Cuspid (canine/eye tooth)
12. 1st Bicuspid (1st premolar)
13. 2nd Bicuspid (2nd premolar)
14. 1st Molar (6-yr molar)
15. 2nd Molar (12-yr molar)
16. 3rd Molar (wisdom tooth)
17. 3rd Molar (wisdom tooth)
18. 2nd Molar (12-yr molar)
19. 1st Molar (6-yr molar)
20. 2nd Bicuspid (2nd premolar)
21. 1st Bicuspid (1st premolar)
22. Cuspid (canine/eye tooth)
23. Lateral incisor
24. Central incisor
25. Central incisor
26. Lateral incisor
27. Cuspid (canine/eye tooth)
28. 1st Bicuspid (1st premolar)
29. 2nd Bicuspid (2nd premolar)
30. 1st Molar (6-yr molar)
31. 2nd Molar (12-yr molar)
32. 3rd Molar (wisdom tooth)
### RECORD OF IDENTIFICATION PROCESSING

**DENTAL CHART**

<table>
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<th>LAST NAME</th>
<th>FIRST NAME</th>
<th>MIDDLE INITIAL</th>
<th>GRADE</th>
<th>SERVICE NO./SOCIAL SECURITY ACCT. NO.</th>
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<tbody>
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</table>

**NAME OF CEMETERY, EVACUATION NUMBER, OR SEARCH AND RECOVERY NUMBER**

<table>
<thead>
<tr>
<th>PLOT</th>
<th>ROW</th>
<th>GRAVE</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

**MARKING ABBREVIATIONS:**

- F: Facial
- O: Occlusal
- D: Distal
- AM: Amalgam
- Fill: Filling
- Por: Porcelain
- Bac: Backing
- L: Lingual
- M: Mesial
- I: Incisal
- CR: Crown
- Plas: Plastic
- Sil: Silicate
- Fac: Facing

### TEETH

#### UPPER LEFT

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<th>12</th>
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#### LOWER LEFT

<table>
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<tr>
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<th>19</th>
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<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
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<th>27</th>
<th>28</th>
<th>29</th>
<th>30</th>
<th>31</th>
<th>32</th>
</tr>
</thead>
</table>

### RESTORATIONS

#### UPPER RIGHT

#### LOWER RIGHT

### CAVITIES

### CARIES

### THE FOLLOWING CONDITIONS WILL BE INDICATED IF PRESENT (Describe in detail in Remarks section)

- **MOTTLED ENAMEL**
- **ENAMAL HYPOPLASIA**
- **EROSION**
- **ABRASION**

- **ROTATION**
- **UNERUPTED TEETH**
- **MALOCCLUSION**
- **SUPERNUMERARY TEETH**

- **MOTTED ENAMEL**
- **ENAMAL HYPOPLASIA**
- **EROSION**
- **ABRASION**

- **FRACTURED ENAMEL**
- **FRACTURES OF TEETH**
- **RETAIRES DECIDUOUS TEETH**
- **ABNORMAL INTERDENTAL SPACES**

- **IRRREGULARITY OF ALIGNMENT**
- **UNUSUAL RESTORATIONS**
- **UNUSUAL APPLIANCES**
- **MALPOSED TEETH***

**PREPARED BY (Typed Name and Signature)***

**VERIFIED BY (Typed Name and Signature)***

---

DD FORM 891, FEB 56 (EG) REPLACES DD FORM 869, 1 SEP 51, WHICH IS OBSCOLETE (for Army use only).
Impression Data Report

Individual Filing Report: ________________________________

Impression ID#: ___________ Date: _________________________

Part I. Arch Width (distance from the center of 1st bicuspid across to center of 1st bicuspid)

Maxillary Arch (upper teeth): _______________ (mm)

Mandibular Arch (lower teeth): _______________ (mm)

Part II. Labiolingual Position (tooth out of alignment):
Circle all teeth out of alignment in the chart below and indicate the degree of misalignment (slight, moderate, and severe):
Part III. Rotational Position (twisted):
Circle all teeth that have rotated in the chart below and indicate the degree of rotation (slight, moderate, and severe):
**Part IV: Tooth Width and Thickness:**
For teeth 5-12 and 21-28, provide measurement data for width and length

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**CSI: Lin-Wood A Field Guide and Laboratory Experience**

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Lab #9: FORENSIC ANTHROPOLOGY

BACKGROUND

Imagine that you are hiking in the woods when suddenly you stumble upon what appears to be a human skull. Upon closer inspection, you notice some other bones in the area. The authorities are called and immediately begin to investigate the scene. You may wonder whose job it is to identify the remains you have just found and how they even go about doing just that.

In this case, a forensic anthropologist would be called on to assess the bones and make that determination. Through careful observations and measurements of key bones, these experts are able to suggest the sex, race, height, and age of the skeleton at the time of death. They may also learn about the deceased's medical history and sometimes even the cause of death! They are able to accomplish all of this by taking advantage of their knowledge of the many bone changes that occur throughout a person's lifetime, including growth, repair, and maturation.

Forensic anthropologists use both metric and non-metric data to assess bones. Most commonly however, they rely on metric data when studying a skeleton. Usually, these experts use costly precision instruments such as sliding calipers, spreading calipers, and osteometric boards to make measurements of the skull and long bones. Nonmetric traits are those that are purely observational in nature. These traits are examined and compared on the basis of frequency of occurrence within certain populations. Due to its inherent subjectivity, the data collection of non-metric traits is not as definitive as metric data collection. However, it is still considered to be a very useful tool in the assessment of skeletal remains.

The job of identifying skeletal remains is, of course, made much easier if the entire skeleton is present. However, many times this is not the case and the scientists must make their assessment based on only a few bones. This will be the case with today's lab activity. You, "Sherlock Bones", will be given only a few bones; all obtained from the same individual. You are the forensic anthropologist assigned to the case and it's up to you to determine as much information as possible about these bones to help identify this individual.

Sex Determination

A number of skeletal indicators are used to determine sex. The more indicators used, the more accurate the results will be. However, it is important to note that there is very little sexual dimorphism in preadolescent skeletons, which makes sex determination in them nearly impossible.

The pelvis is considered to be the best bone with which to estimate sex. This is mainly due to the fact that the female's pelvis is designed to allow for the passage of a child. Consequently, the pelvis of a female is generally larger and wider than that of a male. These differences can be observed in Figures 2-5.

The skull is the second most commonly used bone to determine sex. Many of the skull traits related to sexing are most easily observed when directly compared to a skull of the opposite sex. This is why one's ability to sex a skull, and a skeleton for that matter, improves with experience. Observe the differences between a male and a female skull in Figures 9-12.

Normally, the long bones alone are not used alone to estimate gender. However, if these bones are the only ones present, there are characteristics that can be used for sex determination.
Race Determination

It can be extremely difficult to determine the true race of a skeleton. This is due to several factors: First, forensic anthropologists generally use a three-race model to categorize skeletal traits: Caucasoid (European), Asian (Asian/Amerindian), and African (African/West Indian). Although there are certainly some common physical characteristics among these groups, not all individuals have skeletal traits that are completely consistent with their geographic origin. Additionally, there is the issue of racial mixing to consider. Often times, a skeleton exhibits characteristics of more than one racial group and does not fit neatly into the three-race model. Also, the vast majority of the skeletal indicators used to determine race are non-metric traits, which, as stated earlier, can be highly subjective. Despite these drawbacks, race determination is viewed as a critical part of the overall identification of an individual's remains.

The skull is considered to be the most important bone for race determination because without it, the origin of race cannot accurately be determined. Forensic anthropologists use lengths, widths, and shapes of skull features along with population-specific dental traits to aid them in reaching a conclusion. Compare the skulls in Figures 16-21 to assess the racial variation between them. The femur bone can also be used to aid in the race determination of a skeleton but is only used to eliminate either the Caucasoid or African race.

Height Determination

The height, or stature, of a skeleton is most commonly determined by examining the long bones of that individual (femur, tibia, fibula, humerus, ulna, and radius). If a complete set of these bones is not available, the accuracy in height determination is improved if two or more bones are used. The femur and the humerus bones are excellent skeletal indicators for height when used together.

Age Determination

The best bone to use in determining a person's age at the time of death is the pelvis. Many changes can be observed on the face of the pubic symphysis and the auricular surface of the ilium over time that are good indicators of a person's age. The extent of suture closure on the skull can also be used as an indicator. However, these changes are best viewed on a natural skeleton rather than on a plastic one.

For this lab we will look at another indicator of age, the process known as epiphyseal union. At birth, humans have about 450 bones. These bones will eventually fuse together to form just 206 adult bones. During the course of development, the ends of each bone are separated from the shaft by a layer of cartilage (as
seen in the example below). This layer remains throughout the bone's development and forms a very distinct line of fusion in the bone. This line becomes increasingly faint until the bone is fully formed (ossified) and then completely disappears. Because the lines created by epiphyseal unions remain for a definite amount of time, they are a useful trait in aging individuals, especially juveniles.

Development of Coxal (Hip) Bone

Juvenile

Adult

OBJECTIVES

Become familiar with tools and key skeletal features used by forensic anthropologists

Utilize qualitative observations and quantitative measurements to determine the sex, race, height, and approximate age of an individual at the time of death

MATERIALS NEEDED PER GROUP

1 Venire caliper 1 Protractor 1 Metric ruler 1 Calculator

SHARED MATERIALS

skull, humerus, pelvis, and femur large caliper

PRE-LAB EXERCISE

1. In the Analysis section, write a list of skeletal traits that you believe could be used to help identify an individual.

PROCEDURE

Scenario

Your local police department has been searching for three individuals who have been reported missing within the last two years. Recent news of the discovery of human bones in the area has given rise to new
hope of identifying one of these individuals. As Sherlock Bones, the lead forensic anthropologist on the case, it is your job to provide the authorities with a physical description of the individual. Good luck!

Key Directional Terms
Anterior (ventral) - Situated in front of; the front of the body
Posterior (dorsal) - Situated in back of; the back of the body
Superior - Toward the head; relatively higher in position
Inferior - Away from the head; relatively lower in position
Medial- Toward the midline of the body
Lateral - A way from the midline of the body
Proximal - Closer to any point of reference on the body Distal- Farther from any point of reference on the body

PELVIS
Refer to Figures 2-8 when assessing the pelvis.

Sex Determination
1. Determine the sub-pubic angle (Figure 6, no. 1) by using the method described below and the sidebar photo:
Situate your protractor so that the black dot located at the base of the protractor, is positioned at the midline of the pubic symphysis (Figure 6, no. 2) where the rami of each ischium (Figure 6, no. 4) would meet if the bones continued onward. Align the "0" baseline with the ramus of the left ischium and determine the degree of the angle formed by the two rami of the ischium bones. Record your result in Table 1 in the Analysis section.

2. Use the Vernier caliper to measure the pubis body width (Figure 6, no. 10). Start at the middle of the lateral edge of the pubic symphysis and measure across to the medial edge of the obturator foramen (Figure 6, no. 6). Record your result in Table 1.

3. Locate the greater sciatic notch (Figure 8, no. 11) and use the following method to measure its angle: Place the pelvis posterior side down on the desk and turn it in such a way that the greater sciatic notch is closest to the paper. Trace the angle of the sciatic notch onto the piece of paper. Use a straight edge to go over the lines you have just made and extend those lines until they meet to form an angle. Use your protractor to measure the angle you have just drawn by following the same technique listed in Step 1. Record your result in Table 1.
4. Locate the sacrum and the coccyx (Figures 7 and 8, nos. 8 and 9 respectively). Hold the pelvis in such a way that the pubic symphysis (Figure 6, no. 2) is facing down and parallel to the tabletop (as shown in Figure 7). Hold the pelvic cavity (Figure 7, no. 12) at eye level in order to observe its shape properly. Is the opening circular and wide, showing mainly the coccyx (as shown in Figure 5), or is it more heart-shaped, showing a large portion of the sacrum and the coccyx (as shown in Fig. 3)? Record your result in Table 1.

**Age Determination**

1. Refer to Table 8 in the analysis section to determine the approximate age when each bone will have fused and/or completely ossified (i.e., there is no evidence of an epiphysis or cartilaginous line).

2. Inspect the entire pelvis carefully. Pay close attention to any evidence of epiphyseal unions. In Table 8, draw a circle around each age or age group in which the specified developmental occurrence has already taken place.

**SKULL**

Refer to Figures 9-24 when assessing the skull.

When viewing from the front or the side, always have the skull oriented so that it is anatomically correct (i.e., the eye sockets should be parallel to the tabletop as shown in Figures 10 and 12, and not directed upwards). This is known as the Frankfort Horizontal Plane. To keep the skull in this position, a textbook, or the like, may be used to prop the skull up.

**Sex Determination**

1. Run your finger over the upper edge of the eye orbit (Figure 13, no. 13). Is it rounded or sharp? Record your result in Table 2 in the Analysis section.

2. Observe the shape of the eye orbit. Is it closer to being square or round? Record your result in Table 2.

3. Locate the zygomatic process (Figure 14, no. 15). Is this ridge expressed beyond the external auditory meatus (Figure 14, no. 16)? Record your results in Table 2.

4. Observe the occipital region of the skull (Figure 14, no. 17). The nuchal crest is a ridge that runs along the base of the occipital bone (Figure 15, no. 18). Is this area smooth (similar to the rest of the skull) or rough and bumpy? Record your result in Table 2.

5. Is there a single bump, known as the external occipital protuberance, present in this region? (Figure 15, no. 19). Record your result in Table 2.

6. Observe the frontal bone from the side (Figure 14, no. 20). Is it low and slanting (as in Figure 10) or rounded and globular (as in Figure 12)? Record your result Table 2.

7. Observe the mandible from the inferior view (as shown in Figure 15, no. 21). Does it look squared and V-shaped or rounded and V-shaped? Record your result in Table 2.

8. Observe the ramus of the mandible (Figure 14, no. 22). Draw an imaginary vertical line down from the external auditory meatus (Figure 14, no. 16) to the floor (being sure to keep the skull in the Frankfort Horizontal Plane). Is this line fairly parallel with the ramus, indicating that it is straight, or does the ramus
slant away from the imaginary line as your eye moves down it? Record your result in Table 2.

**Race Determination**

1. Using your Vernier caliper or a ruler, determine the nasal width by taking an inside measurement of the widest portion of the nasal cavity (Figure 13, no. 23). Determine the nasal height by placing one end of your caliper on the nasion (Figure 13, no. 24) and the other end on the nasal spine (Figure 13, no. 25). Determine the nasal index by dividing the nasal width by the nasal height and record your result in Table 5.

2. To demonstrate racial differences among skulls, use your metric ruler to determine the nasal width and height of each of the skulls in Figures 22, 23, and 24. Record this information in the space provided below Table 5. Determine the nasal index of each skull and record your results in the space provided. Answer the question that follows these results.

3. The nasal spine is located medially at the base of the nasal cavity (Figure 14, no. 25). To assess the prominence of this protrusion, rest your pencil, sideways, across the maxilla (Figure 13, no. 27). Try to run the pencil gently onto the nasal cavity. Is the nasal spine so prominent that it completely blocks your pencil from reaching the nasal cavity, or does your pencil run over a small protrusion in order to reach the cavity, or is the spine so small that your pencil can easily glide into the opening? Record your result in Table 5.

4. Feel the base of the nasal cavity, on either side of the nasal spine (Figure 13, no. 26). Do you feel sharp ridges (nasal sillling), rounded ridges, or no ridges at all (nasal guttering)?

5. A jaw is considered to be prognathic if it juts out away from the face. To assess prognathism, hold your pencil in a vertical position against the nasal spine (Figure 14, no. 25) and lower the pencil towards the face and attempt to touch the chin. Does the pencil touch, or come close to touching, both the anterior nasal spine and the chin at the same time or does the pencil angle out too far due to a protruding jaw? Record your result in Table 5. See Figures 17, 19, and 21 to compare prognathism between races.

6. Observe the shape of the eye orbits (Figure 13, no. 13). Are they rounded and somewhat square, rounded and circular, or fairly rectangular? Record your result in Table 5.

**Sex Determination**

1. Using your Vernier caliper, determine the maximum epiphyseal breadth of the proximal tibia by measuring the maximum distance between the lateral condyle (Figure 25, no. 28) and medial condyle (Figure 25, no. 29). Record your result in Table 3 in the Analysis section.

2. Using your Vernier caliper, determine the maximum epiphyseal breadth of the distal tibia by measuring the maximum distance between the tibiofibular joint (Figure 25, no. 30) and the medial malleolus (Figure 25, no.31). Record your result in Table 3 in the Analysis section.

3. Using your large caliper, obtain the maximum length of the tibia by measuring from the most superior surface of the lateral condyle to the most distal tip of the medial malleolus. Record your result in the space provided above Table 6.

**Age Determination**
I. Refer to Table 9 to determine the approximate age when each bone initially appears or joins the shaft of the tibia.

2. Inspect the tibia bone carefully. In Table 9, draw a circle around each age or age group in which the specified developmental occurrence has already taken place.

**HUMERUS**
Refer to Figures 26-28 when assessing the humerus.

**Sex Determination**

1. With your Vernier caliper, measure the transverse diameter of the humeral head (Figure 27, no. 39) and record your result in Table 4 in the Analysis section.

2. With your Vernier caliper, measure the vertical diameter of the humeral head (Figure 28, no. 40) and record your result in Table 4.

3. Using your large caliper, obtain the maximum length of the humerus by measuring from the most superior portion of the humeral head (Figure 26, no. 32) to the most inferior portion of the trochees (Figure 26, no. 36). Record your result in Table 4 and in the space provided above Table 7.

4. Using your Vernier caliper, obtain the epicondylar width by measuring from the most lateral portion of the internal condyle (Figure 26, no. 35) to the most lateral portion of the external condyle (Figure 26, no. 38). Record your result in Table 4.

**Age Determination**

1. Refer to Table 1 in the Analysis section to determine the approximate age when each bone joins or unites with the shaft of the humerus.

2. Inspect the humerus bone carefully. In Table 10, draw a circle around each age or age group in which the specified developmental occurrence has already taken place.

**ANALYSIS**

**Pre-Lab Exercise**

1. List skeletal traits that you believe could be used to help identify an individual.

**Final Determinations**

*Remember that all of the bones used to assess any given trait should be looked at as a whole. For example, if the majority of the bones used to determine the sex indicate that the individual was male, then your final determination of sex should be male.*

1. Based on your results entered in Tables 1-4, make a final determination as to the sex of this individual. Write this answer in the space provided below Table 4.

2. Based on your results entered in Table 5, make a final determination as to the race of this individual. Write this answer in the space provided at the bottom of that page.
3. Now that you have determined the sex and race of this individual, you can now determine the height by following the steps below:

a. In the space provided just above Table 6, convert the data for the maximum length of the tibia (MLT) from millimeters to centimeters. In Table 6, locate the regression formula that corresponds to the sex and race of the skeleton as you have determined them to be. Insert the converted (MLT) into this formula and calculate. Record the height in centimeters to the right of this formula. Use the corresponding confidence interval to calculate the height range.

b. Repeat the above step for the maximum length of the humerus (MLH) in order to complete Table 7.

c. To determine the probable height range of this individual, refer to Tables 6 and 7 and record the minimum value and the maximum value of the calculated height ranges in the space provided below Table 7. Convert each value to feet and inches by following the instructions provided below Table 7.

4. Based on the ages circled in Tables 8, 9, and 10, determine the minimum age of this individual at the time of death. Write this answer in the space provided below Table 10.
### Table 1. Pelvis

<table>
<thead>
<tr>
<th>Trait</th>
<th>Result</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Pubic Angle</td>
<td>&gt;90°</td>
<td>&lt;90°</td>
<td></td>
</tr>
<tr>
<td>Pubis Body Width</td>
<td>~40 mm</td>
<td>25-30 mm</td>
<td></td>
</tr>
<tr>
<td>Greater Sciatic Notch</td>
<td>&gt;68°</td>
<td>&lt;68°</td>
<td></td>
</tr>
<tr>
<td>Pelvic Cavity Shape</td>
<td>Circular and wide, showing mainly coccyx</td>
<td>Heart-shaped, showing sacrum and coccyx</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Skull

<table>
<thead>
<tr>
<th>Trait</th>
<th>Result</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Edge of Eye Orbit</td>
<td>Sharp</td>
<td></td>
<td>Blunt</td>
</tr>
<tr>
<td>Shape of Eye Orbit</td>
<td>Round</td>
<td></td>
<td>Square</td>
</tr>
<tr>
<td>Zygomatic Process</td>
<td>Not expressed beyond external auditory meatus</td>
<td></td>
<td>Pressed beyond external auditory meatus</td>
</tr>
<tr>
<td>Nuchal Crest (Occipital Bone)</td>
<td>Smooth</td>
<td></td>
<td>Rough and bumpy</td>
</tr>
<tr>
<td>External Occipital Protuberance</td>
<td>Generally Absent</td>
<td></td>
<td>Generally present</td>
</tr>
<tr>
<td>Frontal Bone</td>
<td>Round, globular</td>
<td></td>
<td>Low, slanting</td>
</tr>
<tr>
<td>Mandible shape</td>
<td>Rounded, V-shaped</td>
<td></td>
<td>Square, U-shaped</td>
</tr>
<tr>
<td>Ramus of mandible</td>
<td>Slanting</td>
<td></td>
<td>Straight</td>
</tr>
</tbody>
</table>
Table 3. Tibia

<table>
<thead>
<tr>
<th>Trait</th>
<th>Result</th>
<th>Average Female</th>
<th>Average Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Epiphyseal Breadth of Proximal Tibia (mm)</td>
<td></td>
<td>70.26</td>
<td>79.40</td>
</tr>
<tr>
<td>Maximum Epiphyseal Breadth of Distal Tibia (mm)</td>
<td>46.31</td>
<td></td>
<td>52.48</td>
</tr>
</tbody>
</table>

Table 4. Humerus

<table>
<thead>
<tr>
<th>Trait</th>
<th>Result</th>
<th>Average Female</th>
<th>Average Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse Diameter of Humeral Head (mm)</td>
<td>37.0-39.0</td>
<td>42.7-44.7</td>
<td></td>
</tr>
<tr>
<td>Vertical Diameter of Humeral Head (mm)</td>
<td>42.7</td>
<td>48.8</td>
<td></td>
</tr>
<tr>
<td>Maximum Length (mm)</td>
<td>305.9</td>
<td>339.0</td>
<td></td>
</tr>
<tr>
<td>Epicondylar Width (mm)</td>
<td>56.8</td>
<td>63.9</td>
<td></td>
</tr>
</tbody>
</table>

Final Sex Determination

Race Determination

Nasal width: __________ mm  Nasal height: __________ mm

Table 5

<table>
<thead>
<tr>
<th>Trait</th>
<th>Result</th>
<th>Caucasoid</th>
<th>Asian</th>
<th>African</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal Index</td>
<td>&lt;.48</td>
<td>.48-.53</td>
<td>&gt;.53</td>
<td></td>
</tr>
<tr>
<td>Nasal Spine</td>
<td>Prominent spine</td>
<td>Somewhat prominent spine</td>
<td>Very small spine</td>
<td></td>
</tr>
<tr>
<td>Nasal Sillng / Guttering</td>
<td>Sharp ridge (silling)</td>
<td>Rounded ridge</td>
<td>No ridge (guttering)</td>
<td></td>
</tr>
<tr>
<td>Prognathism</td>
<td>Straight</td>
<td>Variable</td>
<td>Prognathic</td>
<td></td>
</tr>
<tr>
<td>Shape of Orbital Openings</td>
<td>Rounded, somewhat square</td>
<td>Rounded, somewhat circular</td>
<td>Rectangular or square</td>
<td></td>
</tr>
</tbody>
</table>

Final race determination _________________________
## Height Determination

### Tibia

Maximum Length of Tibia (MLT) \( \text{_____ mm} = \text{_______ cm} \)

**Table 6**

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
<th>Female</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression Formula</td>
<td>Height (cm)</td>
<td>Confidence Interval</td>
<td>Regression Formula</td>
</tr>
<tr>
<td>Caucasian</td>
<td>2.42 (MLT) + 81.93</td>
<td>± 4.00</td>
<td></td>
<td>2.90 (MLT) + 61.53</td>
</tr>
<tr>
<td>Asian</td>
<td>2.39 (MLT) + 81.45</td>
<td>± 3.27</td>
<td></td>
<td>2.68 (MLT) + 67.05**</td>
</tr>
<tr>
<td>African</td>
<td>2.19 (MLT) + 85.36</td>
<td>± 3.91</td>
<td></td>
<td>2.45 (MLT) + 72.56</td>
</tr>
</tbody>
</table>

**To convert to feet and inches:** assign the “feet” value to the chart, then subtract the appropriate whole number (in inches) from your answer to calculate the inches portion of the number (e.g. 63.78 in. >60 in. therefore, the person is at least 5 ft. tall; 63.78 – 60 = 3.78 in. to give a final answer of 5’ 3.78” tall).

** Table 7**

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
<th>Female</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression Formula</td>
<td>Height (cm)</td>
<td>Confidence Interval</td>
<td>Regression Formula</td>
</tr>
<tr>
<td>Caucasian</td>
<td>2.89 (MLH) + 78.10</td>
<td>± 4.57</td>
<td></td>
<td>3.36 (MLH) + 57.97</td>
</tr>
<tr>
<td>Asian</td>
<td>2.68 (MLH) + 83.19</td>
<td>± 4.16</td>
<td></td>
<td>3.22 (MLH) + 51.32**</td>
</tr>
<tr>
<td>African</td>
<td>2.88 (MLH) + 75.48</td>
<td>± 4.23</td>
<td></td>
<td>3.08 (MLH) + 64.67</td>
</tr>
</tbody>
</table>

Maximum Value = \( \text{_______ cm} ÷ 2.54 = \text{_______ inches} = \text{____ feet} \text{____ inches} \)

Minimum Value = \( \text{_______ cm} ÷ 2.54 = \text{_______ inches} = \text{____ feet} \text{____ inches} \)

**To convert to feet and inches:** assign the “feet” value to the chart, then subtract the appropriate whole number (in inches) from your answer to calculate the inches portion of the number (e.g. 63.78 in. >60 in. therefore, the person is at least 5 ft. tall; 63.78 – 60 = 3.78 in. to give a final answer of 5’ 3.78” tall).
## Age Determination

### Pelvis

<table>
<thead>
<tr>
<th>Developmental Occurrence</th>
<th>Approximate Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>The pubis bone and ischium are almost completely united by bone (Figure 6)</td>
<td>7-8</td>
</tr>
<tr>
<td>The ilium, ischium, and pubis bones are joined together (Figure 6)</td>
<td>13-14</td>
</tr>
<tr>
<td>The two lowest segments of the sacral vertebrae become joined together (Figure 8)</td>
<td>18</td>
</tr>
<tr>
<td>The ilium, ischium, and pubis bones become fully ossified with no evidence of epiphyseal unions (indicated by cartilaginous lines)</td>
<td>20-25</td>
</tr>
<tr>
<td>All segments of the sacrum are united with no evidence of epiphyseal unions</td>
<td>25-30</td>
</tr>
</tbody>
</table>

### Femur

<table>
<thead>
<tr>
<th>Developmental Occurrence</th>
<th>Approximate Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>The greater trochanter first appears</td>
<td>4</td>
</tr>
<tr>
<td>The lesser trochanter first appears</td>
<td>13-14</td>
</tr>
<tr>
<td>The head, greater trochanter, and lesser trochanter first join the shaft</td>
<td>18</td>
</tr>
<tr>
<td>The condyles first join the shaft</td>
<td>20</td>
</tr>
</tbody>
</table>

### Humerus

<table>
<thead>
<tr>
<th>Developmental Occurrence</th>
<th>Approximate Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>The head and tuberosities join to become a single large epiphysis</td>
<td>6</td>
</tr>
<tr>
<td>The radial head, trochlea, and external condyle blend and unite with the shaft</td>
<td>16-17</td>
</tr>
<tr>
<td>The internal condyle unites with the shaft</td>
<td>18</td>
</tr>
<tr>
<td>The upper epiphysys unites with the shaft</td>
<td>20</td>
</tr>
</tbody>
</table>

Final minimum age determination (range) __________ years
FINAL ASSESSMENT

1. The police have narrowed the pool of candidates who were reported missing about the same time and in the same general area that the remains of your victim were found. These individuals were:

**Kim Lee - A 25 year old, Asian female, standing 5'1'' tall.**

**Theresa Woods - A 45 year old, African American female, standing 5'3'' tall.**

**Jonathan Parker - A 24 year old, Caucasian male, standing 5'5'' tall.**

Write a forensic report summarizing the results of your analyses. In it you should make a conclusion about the conclusions you reached as to the likely age, height, gender and race of the victim and how you reached these conclusions. You should present your results clearly and concisely – I am looking for organization, clarity of presentation (e.g. tables presented clearly with relevant results and conclusions – perhaps organized into subsections), a brief but relevant introduction to your report, and an overall conclusion. In the conclusion you should also make a reference to the 3 missing people the police have provided to you, a statement about whether you feel the remains you examined belonged to any of them certainty of this conclusion (i.e. are you absolutely certain? Why, or why not?) and what, if any, additional information should be used in positively identifying the remains. If you cite a source of forensic evidence we have discussed elsewhere in this course, be as specific as possible in explaining what evidence should be collected and what you would be looking for. I will send you a copy of this lab handout in case you wish to use any of the tables in it for your report.

*This lab report is the Final Assessment Section for your lab write-up.*
Key to Anatomical Photos
1 Sub-Pubic Angle
2 Pubic Symphysis
3 Ischium
4 Ramus of Ischium
5 Ilium
6 Obturator Foramen
7 Iliac Spine (Crest)
8 Sacrum (Sacral vertebrae)
9 Coccyx
10 Pubis
11 Greater Sciatic Notch
12 Pelvic Cavity
Key to Anatomical Photos
13 Eye Orbit
14 Zygomatic Bone
15 Zygomatic Process
16 External Auditory Meatus
17 Occipital Crest
18 Nuchal Crest
19 External Occipital Protuberance
20 Frontal Bone
21 Mandible
22 Ramus of Mandible
23 Nasal Cavity
24 Nasion
25 Nasal Spine
26 Nasal Sill or Dam
27 Maxilla
Figure 18

Figure 19

AFRICAN

Figure 20

Figure 21

CAUCASOID
Figure 22
Figure 23
AFRICAN

Figure 24
Key to Anatomical Photos
28 Lateral Condyle of Tibia
29 Medial Condyle of Tibia
30 Tibiofibular Joint
31 Medial Malleolus
Forensic footwear evidence can be used in legal proceedings to help prove the identities of persons at the crime scene. Footwear evidence is often the most abundant form of evidence at a crime scene and in some cases can prove to be as specific as a fingerprint. Initially investigators will look to identify the make and model of the shoe or trainer which made an impression. This can be done visually or by comparison with evidence in a database both methods focus heavily on pattern recognition and brand or logo marks. Information about the owner of any footwear can be gained from the analysis of wear patterns which are dependent on angle of footfall and weight distribution. Detailed examination of footwear impressions can help to link a specific piece of footwear to a footwear imprint as each shoe will have unique wear characteristics.

Types of footwear evidence

Footwear evidence can come in at least three forms, footwear outsole impressions, footwear insole impressions and footwear trace evidence.

Footwear outsole impressions

Footwear outsole impressions are impressions left on an object that was caused by contact with a piece of footwear. These can left on the ground or raised surface by persons treading over it, left on doors or walls by persons attempting to kick or climb over a wall or even left on other persons after being kicked or stomped on.

There can also be latent impressions not easily visible to the naked eye, on many different surfaces such as floor tiles, concrete or even carpet. Detection may require the use of additional specialized light sources such as portable ultraviolet lighting. Recovery typically includes photography as well as lifting with "gel" or "electrostatic" dust lifters.

Footwear insole imprints

Footwear insole imprints are imprints left in the inside of footwear caused by contact from the person’s foot. Analysis of the insole imprints can be used to link a person(s) to a piece of footwear.
Footwear trace evidence

Footwear trace evidence is trace evidence that is recovered from footwear. Types of trace evidence that could be recovered include skin, glass fragments, body hair, fibers from clothing or carpets, soil particles, dust and bodily fluids. The study of this trace evidence could be used to link a piece of footwear to a location or owner.

Casting

Evidence left via impressions can generally be recovered utilizing a plaster cast. Initially the impression is isolated by framing the area with a solid boundary. Following this a plaster mix can be gently poured inside the frame, it is generally considered not best practice to pour directly onto the impression. In some cases where the surface is not ideal for casting prior techniques can be utilised to gain a better cast of the impression. Sand can often be fixed in place by applying an aerosol resin or glue although hair spray is often used. Wet mud impressions can be dried using a combination of pipetting water from the surface and applying hot air, often in the form of a hair dryer.

Examination of footwear impressions evidence:

Footwear impression can be used by examiners to obtain information the following information:

![Image 1](image1)

Fig. 1 Comparison of shoeprints left at crime scene and test prints made by recovered shoe.

![Image 2](image2)

Fig. 2 Comparison of "Class characteristics" and "Identifying characteristics" between impression and recovered shoe.
Footwear manufacturer, model and size: Examination of footwear impression for "Class Characteristics" such as general outsole patterns and shapes, footwear design features and feature markings can help examiners identify the manufacturer, model and size of the footwear. This Information can be used to help profile the suspect and provide leads on who may have bought or worn the footwear which created the impression. Approximate height and wearer: Measurements of footwear impression dimensions can be used to provide the approximate height of a suspect. With shoeprint size information, investigators can refer to statistical data to approximate the height of the person since shoeprint vs. height relationship follows a normal distribution. Height can also be approximate by stride length which could be measured from a set of footwear impressions.

Activity of wearer when imprint was made: Analysis of a plastic footwear impression can also be used help determine the activity of the wearing when the imprint was made. The footwear imprint left by person is different when they are walking, running or carry heavy loads. A footwear impression left by running person will typically deeper in the heel and toe sections of the shoeprint. A person carrying a heavy load such as a body will cause deeper prints than a person not carrying anything.

Establish link between footwear impression and specific piece of footwear: A specific piece of footwear can be linked to a specific footwear impression with careful analysis. Every piece of footwear will show different amounts of tread wear, different amounts of damage in the form of tiny cuts and nicks. These unique characteristics will also show on the impression left by the footwear.

Limitations of footwear evidence

The Unabomber, Theodore Kaczynski, was known to keep shoes with smaller soles attached to the base in order to confuse investigators about the size of the suspect's feet. [1]

Footwear databases

Forensic investigators can use computerized footwear databases to quickly compare the class characteristics between footwear impression and outsole profile of footwear outsoles stored in the database. This greatly reduced the time required to match shoemarks found at crime scenes and those from criminals in custody or those stored on the database.

By far the best system available is TreadMark, marketed by Crime Scene Investigation Equipment Ltd, Northampton, England and currently used by Police departments in the UK, Europe, USA and Taiwan. Others are available such as the Footwear Intelligence Technology (FIT) launched by the Forensic Science Service (FSS) in February 2007 and SICAR but TreadMark is more versatile and has many powerful tools to help the shoemark examiner.

The Lab: Part I:
Students will measure each others’ heights, foot lengths and shoe lengths and share the data with the class. Using the data students will determine the average difference between shoe length and foot length. Students will examine the data for patterns, allowing for discussion of data that seems out of place. Measurement skills will likely have to be reviewed to ensure accuracy. Calculator skills may also need to be reviewed. Alternately, students can use a spreadsheet to store their data and formulas to find the averages etc. If using a spreadsheet it is important that students focus on the patterns being observed to ensure understanding of the concepts. Students will need to hear of the “average” relationship of foot length being 15% of total height. Discussion of possible implications will also be necessary.

Part II:
Students will proceed to the crime scene and use meter sticks and digital cameras to record accurate evidence of footprint length. Discussion of shoe type may also follow. Students will have ideas about the footprints that may or may not help in solving the mystery. Using the suspect data sheets students will try to narrow down the field of suspects.

Plaster of Paris sets very quickly mix it quickly and pour straight away - It should be the consistency of thick cream. It give off a lot of heat when setting - leave it to cure a while before taking it out of the mould. Measure out the amount of Plaster of Paris needed to make a mold. The general use for most brands of Plaster of Paris is one part water to two parts of plaster with a yield of approximately 1 ½ cups of the finished product.

Determine the amount of mixed Plaster of Paris needed to complete your project by pouring water into the mold to the level you want the plaster and measuring it out in cups. For instance, if you want to make a mold of your hand print in a pie plate, you would pour water in to the depth you want. If you used 4 ½ cups of water, you will then need to use 6 cups of Plaster of Paris and 3 cups of water.

Measure out the dry plaster into a plastic bowl and make a well in the middle. Pour in the water all at once and stir until the mixture is smooth.

Pour the liquid plaster into your mold slowly, starting with the lowest areas and filling in all the spaces. Use all the plaster you prepare as it doesn’t save well.

Allow your Plaster of Paris mold to sit, undisturbed until it hardens. Carefully, loosen the edges and allow the plaster to fall out. Make sure you catch it.
Experiments with blood transfusions, the transfer of blood or blood components into a person's blood stream, have been carried out for hundreds of years. Many patients have died and it was not until 1901, when the Austrian Karl Landsteiner discovered human blood groups, that blood transfusions became safer.

Mixing blood from two individuals can lead to blood clumping or agglutination. The clumped red cells can crack and cause toxic reactions. This can have fatal consequences. Karl Landsteiner discovered that blood clumping was an immunological reaction which occurs when the receiver of a blood transfusion has antibodies against the donor blood cells.

Karl Landsteiner's work made it possible to determine blood types and thus paved the way for blood transfusions to be carried out safely. For this discovery he was awarded the Nobel Prize in Physiology or Medicine in 1930.

What is blood made up of?

An adult human has about 4–6 liters of blood circulating in the body. Among other things, blood transports oxygen to various parts of the body. Blood consists of several types of cells floating around in a fluid called plasma.

The red blood cells contain hemoglobin, a protein that binds oxygen. Red blood cells transport oxygen to, and remove carbon dioxide from, the body tissues.

The white blood cells fight infection.

The platelets help the blood to clot, if you get a wound for example.

The plasma contains salts and various kinds of proteins.

What are the different blood groups?

The differences in human blood are due to the presence or absence of certain protein molecules called antigens and antibodies. The antigens are located on the surface of the red blood cells and the antibodies are in the blood plasma. Individuals have different types and combinations of these molecules. The blood group you belong to depends on what you have inherited from your parents.

There are more than 20 genetically determined blood group systems known today, but the AB0 and Rh systems are the most important ones used for blood transfusions. Not all blood groups are
compatible with each other. Mixing incompatible blood groups leads to blood clumping or agglutination, which is dangerous for individuals.

Nobel Laureate Karl Landsteiner was involved in the discovery of both the AB0 and Rh blood groups.

**AB0 blood grouping system**

According to the AB0 blood typing system there are four different kinds of blood types: A, B, AB or 0 (null).

### Blood group A

If you belong to the blood group A, you have A antigens on the surface of your red blood cells and B antibodies in your blood plasma.

### Blood group B

If you belong to the blood group B, you have B antigens on the surface of your red blood cells and A antibodies in your blood plasma.

### Blood group AB

If you belong to the blood group AB, you have both A and B antigens on the surface of your red blood cells and no A or B antibodies at all in your blood plasma.

### Blood group 0

If you belong to the blood group 0 (null), you have neither A or B antigens on the surface of your red blood cells but you have both A and B antibodies in your blood plasma.

**Rh factor blood grouping system**

Many people also have a so called Rh factor on the red blood cell's surface. This is also an antigen and those who have it are called Rh+. Those who haven't are called Rh-. A person with Rh- blood does not have Rh antibodies naturally in the blood plasma (as one can have A or B antibodies, for instance). But a person with Rh- blood can develop Rh antibodies in the blood plasma if he or she receives blood from a person with Rh+ blood, whose Rh antigens can trigger the production of Rh antibodies. A person with Rh+ blood can receive blood from a person with Rh- blood without any problems.
Blood group notation

According to above blood grouping systems, you can belong to either of following 8 blood groups:

<table>
<thead>
<tr>
<th>A Rh+</th>
<th>B Rh+</th>
<th>AB Rh+</th>
<th>0 Rh+</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Rh-</td>
<td>B Rh-</td>
<td>AB Rh-</td>
<td>0 Rh-</td>
</tr>
</tbody>
</table>

Do you know which blood group you belong to?

Blood typing – how do you find out to which blood group someone belongs?

A person with A+ blood receives B+ blood. The B antibodies (yellow) in the A+ blood attack the foreign red blood cells by binding to them. The B antibodies in the A+ blood bind the antigens in the B+ blood and agglutination occurs. This is dangerous because the agglutinated red blood cells break after a while and their contents leak out and become toxic.

1. You mix the blood with three different reagents including either of the three different antibodies, A, B or Rh antibodies.

2. Then you take a look at what has happened. In which mixtures has agglutination occurred? The agglutination indicates that the blood has reacted with a certain antibody and therefore is not compatible with blood containing that kind of antibody. If the blood does not agglutinate, it indicates that the blood does not have the antigens binding the special antibody in the reagent.

3. If you know which antigens are in the person’s blood, it's easy to figure out which blood group he or she belongs to!

What is happening when the blood clumps or agglutinates?

For a blood transfusion to be successful, AB0 and Rh blood groups must be compatible between the donor blood and the patient blood. If they are not, the red blood cells from the donated blood will clump or agglutinate. The agglutinated red cells can clog blood vessels and stop the circulation of the blood to various parts of the body. The agglutinated red blood cells also crack and its contents leak out in the body. The red blood cells contain hemoglobin which becomes toxic when outside the cell. This can have fatal consequences for the patient.

The A antigen and the A antibodies can bind to each other in the same way that the B antigens can bind to the B antibodies. This is what would happen if, for instance, a B blood person receives blood from an A blood person. The red blood cells will be linked together, like bunches of grapes, by the antibodies. As mentioned earlier, this clumping could lead to death.

Fake Blood…A Halloween Essential

What you need

- Stir stick or toothpick
- Cup
- Measuring spoons
- White corn syrup
- Water
- Red food coloring
- Cornstarch
- Cocoa powder

What to do
1. Place 2 tbsp of corn syrup into a cup. 2. Add 1 tbsp water and stir with a toothpick. 3. Add 4 drops of red food coloring and stir with the toothpick. 4. Add 1 tbsp cornstarch and 1/2 tsp cocoa. 5. Mix the cornstarch and cocoa into the mixture. You might need to add a bit more cocoa or food coloring to get a ‘rusty blood’ red. If the blood is too red, add more cocoa and if it is too brown, add more food coloring. 6. This blood is non-toxic, which means you can put it in your mouth and then let it drip out and say “I want to suck your blood!”

**A crime:** Ollie Tabooger has been mugged, but he managed to slash his attacker with a paring knife. Fresh blood is collected at the scene. The police round up several suspects, but Tabooger cannot positively identify any of them. Blood samples are collected from the crime scene and suspects are delivered to you with the request for immediate typing because the police can’t hold the suspects for very long. Tabooger’s blood type has been taken from his blood donor card and is an A-.

**Materials**
- Simulated blood from a crime scene
- Simulated blood from 4 suspects
- Simulated anti-A
- Simulated anti-B
- Spot Plates
- Magnifying glasses
- Pipettes

**Procedure**
1. Add three drops of Suspect #1’s blood side by side to the spot plate.
2. Add one drop of serum with A antibodies (labeled anti-A) to the first blood drop.
3. Add one drop of serum with B antibodies (anti-B) to the second blood drop.
4. Add one drop of the anti-Rh serum to the third blood drop.
5. Mix the cells and the sera with a toothpick, watching to see whether agglutination takes place. Be sure to clean the toothpick between drops or use a clean toothpick to avoid contamination. Observe the drop a blood to see if cloudiness develops. Sometimes the reaction takes a few minutes; have patience!

**Table 1: Agglutination Reactions**

<table>
<thead>
<tr>
<th>If Anti-A...</th>
<th>And Anti-B...</th>
<th>Then blood type is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>B</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>AB</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>O</td>
</tr>
</tbody>
</table>

* + Means agglutination occurred
* - Means no agglutination

6. Use Table 4 to determine the blood type and Rh factor of Suspect #1.

7. Repeat the procedure for Suspects #2, #3, and #4 and the sample from the crime scene. The Rh factor is either present or not present; agglutination indicates its presence, and no reaction indicates its absence.
Fill out the Table below:

**Results of Blood Typing Tests, Ollie Tabooger Case:**

<table>
<thead>
<tr>
<th>Suspect #</th>
<th>Anti-A</th>
<th>Anti-B</th>
<th>Anti-Rh</th>
<th>Blood Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crime Scene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions (to be turned in with Lab):**

1. According to your results, which suspect(s) should the police to consider as suspects? Which ones, if any can be vindicated based on your tests results?

2. On the way to the police department for questioning, Suspect #4 was in a severe car accident and needed a blood transfusion. Which of the other suspects could be donors for Suspect #4? Explain.

3. How many people in the general population would have the same blood type as Suspect #4?


5. Which blood type is known as the universal donor? Why can this blood type be transfused to all others?

6. If you were allowed to perform additional tests using this blood stain from the crime scene, what would you recommend?
LAB #12: BLOOD SPLATTER LAB

The objective of this lab is to use a little math (basic trigonometry) to analyze patterns of blood stains. At the scene of violent crimes, forensic scientists often find large volumes of blood – usually the victim’s. Blood is a liquid (obviously) and as such, it follows well known and well studied patterns conforming to the laws of physics and fluid dynamics. A forensic scientist can use patterns of blood stains left by the victim or from a weapon to recreate a crime scene, determine where an altercation took place, and even to determine how many times a victim was bludgeoned or stabbed. When blood is traumatically lost from a victim by force (e.g. being stabbed or hit with an object), drops of blood are thrown or dropped onto hard surfaces such as walls or the floor forming blood “spatter”. In this lab, you will use some basic trigonometry to analyze patterns of blood spatter.

The surface of most liquids acts like a membrane under tension, this phenomenon is known as surface tension. Surface tension arises from the molecules of the liquid being attracted to each other molecules in the fluid experience a zero net force on them, however, fluid molecules on the surface experience a small net force that draws them into the liquid this small force will tend to minimize the surface area of a liquid. If a liquid is falling in air, the surface tension will cause the liquid to minimize its surface area and form a spherical drop, because a sphere has the lowest surface to volume ratio of all the geometric shapes. This is why we assume air-borne blood drops are spherical.

When blood is spattered, we assume that the blood drops are spherical, based on the effects of surface tension. When an in flight blood drop collides with a flat surface, such as a wall or floor, the flight path of the blood drop will form an angle with the flat surface (note: analysis of spatters on irregular shaped surfaces are very complex and beyond the scope of this course), this angle \( \theta \) is called the "impact angle." The impact angle \( \theta \) of a blood droplet can be determined by measuring the major and semi-major axis of the elliptical blood spatter that is produced when a moving droplet of blood hits a flat surface. The major axis, designated as "L" also provides the "direction" needed to determine the trajectory the droplet followed before impact. The semi major-axis of the blood spatter designated as "D" is the width of the blood spatter and is equal to the diameter of the original droplet (dependent on the surface tension of the original liquid), the diameter of the droplet does not change appreciably when it impacts a flat surface. The impact angle \( \theta \) can therefore be determined from \( \sin \theta = \frac{D}{L} \) (Figure 1).

Note in above Figure 1 that the "secondary splashes", these splashes result from small amounts of liquid (in this case blood) splashing from the larger droplet during impact, these small secondary splashes will continue to move in the same direction of the original droplet and provide a good indicator of the direction that the larger "primary" droplet was traveling prior to impacting with the surface. The secondary splashes will always point towards the original direction of travel of the larger primary spatter.
Figure 1. Relationship of angle a blood droplet is traveling to the shape of the spatter formed.

PROCEDURE:

Work in groups of 2

PART I. – The effects of angle on blood spatter.

Materials:
- Several sheets of blank, white paper
- Simulated blood (about 50-100 ml)
- 1 disposable pipettor
- Protractor
- Roll of packing tape
- Meter stick (yardstick)
- One set of calipers

You will be making measurements of the diameter $D$ and length $L$ for five individual spatters created at the following impact angles: 15°, 30°, 45°, 60°, 75°, 90°. Then from these data you will generate two graphs, one graph will let you determine if $\sin \theta = \frac{D}{L}$ (confirming your results), and the second graph will allow you to determine any impact angle from measurements of $D/L$.

Set up the target board. Your first drop will be at 90 degrees – dropping vertically onto a board on the floor. For all other angles, use the following procedure: Place your clipboard or piece of cardboard against a wall, using a protractor at the top of the board where it meets the wall set the angle formed to 15° and securely tape it to the wall (see Figure 2). Note the angle formed by the board and wall is identical to the angle formed by the board and the trajectory of a blood drop, because the blood drops
trajectory is parallel to the wall. Now tape a clean white sheet of paper to the target board and label the bottom right corner with the angle that the board is set at.

Use the pipettor to suck up some of the blood. Hold the stick 1 meter above the target sheet and gently drop some blood onto the paper, one drop at a time. Do not flick the pipettor, or move it rapidly in any way to make the drop release, this could impart a different velocity and direction to the drop (we only want gravity acting on the drop). Repeat making individual spatters on the sheet until you have at least 8 or more good spatters that have not run much, or overlap any other spatters. Note, you only need to measure 5 spatters but it is good to have a few spares just in case.

**Figure 2.** Method of setting up the board using a protractor.

![Protractor Setup](image)

After completing the spatters on the sheet carefully remove it from the target board and lay it flat some where safe to dry (drying times will vary, but usually the sheets are dry after one hour).

Repeat the steps above for: 30°, 45°, 60°, 75°, and 90°. When finished you should have blood spatter sheets made at 7 different angles. When the sheets are dry label 5 spatters on each sheet 1 through 5. Using calipers, carefully measure the width of each spatter (\(D\)) and the length of each spatter (\(L\)) (to the nearest 10\(^{th}\) of a mm) and write the values down beside the spatter. Next, record your values in an Excel data sheet for the appropriate angles. Your spatters should resemble those seen in Figure 3.
Figure 3. Sample blood spatters from different angles (from: http://www.ccc.commnet.edu/MWP/book1/section1/abstract05.pdf)

Calculate the ratio D/L for each spatter and record the results in the provided table. Then calculate the average D/L ratio for each impact angle, and record these results in the appropriate column in the same
table. Calculate the sin of each angle and record the results in the provided table. Using Microsoft Excel plot a graph of the average of D/L versus the impact angle \( \theta \), this graph should yield a straight line.

For this part of the lab, turn in your Excel graph with axes labeled, graphs numbered and a clear and descriptive title for each graph.

**PART II: Blood spatter analysis**

**Materials:**
- Simulated blood (about 10 ml)
- 2 ml syringe
- Several pieces of blank white paper or 1 large piece of butcher’s paper
- Calipers
- Calculator
- Meter Stick

In this exercise, you will use some blood spatter to determine where a victim was standing when they were assaulted and the distance each blood drop is from the victim. This requires you to use some basic blood spatter trigonometry from Part I of this lab, as well as some extensions of these principles.

In this exercise, you will simulate a crime scene and determine how accurate your calculations are in determining the height of the “victim”. Start by placing several sheets of paper on the floor. Use a lot of paper and cover a large area (about the size of a desk). Next, fill a syringe with blood. Stand exactly 2 meters back of the front line of your sheets. At exactly 1m in height, gently project the blood to create some spatter on your paper. A few things to keep in mind – first, make sure your syringe is level and as close to 1 meter above the ground as you can get it since this is the height you are trying to calculate from your analyses. Second, create a gentle and constant pressure in the syringe; too much and you’ll overshoot, too little and you’ll fall short. You want to create some sizeable blood drops. Finally, make sure that you clean up all blood on yourself, the floor, walls, etc before moving onto the next part of the lab. Ensure that blood drops are dry before moving onto the calculations.

Now for the calculations. Pick about 5 good sized drops. If you can get them all on one piece of paper all the better since you’ll be passing in your blood spatter with your calculations. First put your names on the paper(s) you will be using for analysis. Next, label the 5 drops you will be using in your calculations A-E. Next, draw the axes lines and take measurements of W and L for each of the drops. Create a labeled table similar to one used in part I of this lab to summarize the data for your drops. Finally, now that you know W and L for each drop, use \( \theta = \sin^{-1}(W/L) \) to calculate the angle for each drop. This corresponds to the angle each drop was traveling from your hand when it struck the ground. Show your calculations for the angles on a separate piece of paper.

Next, use the major axes for each blood drop to estimate where the victim was standing when they were attacked. Using a meter stick, extend each axis line for each drop. The point where these axes lines converge will be the point where the person should have been standing when they were struck. See how well this corresponds to the actual position of your hand. On your paper with the blood drops, write the distance each drop is from the point where the lines converge in meters (to the nearest 0.1 m). You’ll be using these numbers in your final round of calculations,
Finally, determine the vertical distance of the “victim” (your hand). To do this, you’ll need to use a little more trig, and refer to Box 5.3 in your textbook. A 3 dimensional triangle is formed by each blood drop – from the centre of the drop horizontally to the point where the victim’s feet were on the floor (line DF in Figure 5), from the victim’s feet vertically to the point of impact (line DE in Figure 5) and the line from the point of impact to the center of the blood drop (line EF in Figure 5). You are interested in calculating the height, line DE. To do this, use the formula derived in the textbook; \( DE = \tan \theta \times DF \).

For your calculations, measure the distance each drop is to the front edge of the paper, and add 2 meters (the distance you were standing from the paper). For example, if one blood drop was 30 cm to the front edge of the paper, it would be 230 cm from where you were standing.

For each blood drop, you have measured the distance to the victim’s feet (DF) and you have calculated \( \theta \). Therefore, on a separate piece of paper, calculate the height of the victim, line DE. Show your calculations for each blood drop. Finally, take an average of the calculations to get an approximate height. Ideally, they would all give you exactly 1 m which is the height your hand was at. However, in reality they likely vary a little.

**Figure 5.** Blood spatter calculations; from Jackson and Jackson.

**Analysis Questions:**

1. Did your blood spatter calculations give you a height of 1 m? If not, why not. Discuss all possible sources of error that may have caused you to get the wrong height. Try to avoid obvious ones like “we may have measured incorrectly”. Think about all the possible sources of error that may exist at a crime scene – from irregularities in how the victim was struck, the surfaces on which blood drops may fall (absorbent, hard, soft, irregular shapes like carpets), and possibly how small errors in measurement and/or calculations may compound to give the wrong answer. Based on all of these sources of error, how reliable do you think these techniques are, and do you feel they should be admissible as evidence in a court of law? This latter question should be supported by references to the literature. You have your own opinion based on your experiences with blood spatter analysis, but do a little research and see what the legal experts think; what are challenges to blood spatter analysis? Can you find any rulings on whether it has been ruled admissible or not? Your grade on this analysis question will be based on the
depth of research and analysis, and how well supported your opinion is. You could try Google, Lexus Nexus or EBSCO to find relevant research.

**Lab Report:**
The following items should be passed in with your lab report:
- A Labeled graph from the data in the spreadsheets for Part I of the lab
- Calculations from Part II
- Answer to analysis questions
- Report from the case study

**Links:**
A blood spatter tutorial:
http://www.bloodspatter.com/BPATutorial.htm

A primer on blood types:

A recent story on CNN on how blood spatter may clear a teen accused of killing her parents:
http://www.cnn.com/2005/LAW/03/03/johnson/

Another blood spatter story about a forensic scientist in Washington State:
http://www.truthinjustice.org/charles-vaughn.htm

A story from CourtTV about blood spatter:
http://www.crimelibrary.com/criminal_mind/forensics/serology/1.html

The website of a forensic scientist specializing in blood spatter:
http://www.bloodspatter.com/

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**Glossary of Key Bloodstain Pattern Analysis Terms**

*Angle of Impact:* the angle at which a blood droplet strikes a surface

*Arterial Gushing:* the large pattern of blood that is created when blood escapes an artery under pressure; the increase and decrease in blood pressure is apparent

*Arterial Spurs:* large patterns created under pressure, but with less volume and usually more distinctive evidence of blood pressure rising and falling

*Clot:* a mass of blood and other contaminants caused through clotting mechanisms

*Cast-Off Stains:* blood that has been thrown from a secondary object (weapon or hand) onto a target other than the impact site

*Drop Patterns:* characteristic patterns present when blood drips into standing, wet blood

*Expiratory Blood:* blood which is spattered onto a target, as a result of breathing; typically, this occurs when an injury is sustained to the throat, mouth, or airway

*Impact Site:* usually the point on the body that received the blow or applied force, from which the blood was shed

*Origin:* the point in space where the blood spatter came from

*Parent Drop:* the droplet from which satellite spatter originated

*Projected Blood:* blood under pressure that strikes a target
**Satellite Spatters**: small drops of blood that break off from the parent spatter when the parent droplet strikes a target surface.

**Shadowing/Ghosting/Void**: a pattern that helps to place an object or body in the scene; normally, the area in question lacks blood even though areas surrounding it show blood.

**Skeletonized Stain**: the pattern left when an object moves through a partially dried stain, removing part of the blood, but leaving the outline of the stain intact.

**Spatter**: bloodstains created from the application of force or energy to the area where the blood is.

**Spines**: the pointed edges of a stain that radiate out to form the spatter.

**Splash**: pattern created when a volume of blood in excess of 1 mL strikes a surface at a low to medium velocity.

**Swipe**: the transfer of blood onto a target surface by a bloody object that is usually moving laterally.

**Transfer Pattern**: the pattern created when a wet, bloody object comes in contact with a target surface, leaving a pattern that has the features of the object making it useful for identifying the object.

**Target**: the surface where the blood ends up.

**Wipe**: pattern created when a secondary target moves through an existing wet blood stain on some other object.

Glossary from: [http://www.bergen.org/EST/Year5/EA/Serology2_1.htm](http://www.bergen.org/EST/Year5/EA/Serology2_1.htm)
Image from: [http://www.assassinrecords.net/images/splash_04.jpg](http://www.assassinrecords.net/images/splash_04.jpg)

Much of the procedure for this lab is from the following site which also has videos of some of the protocol: [http://www.ap.stmarys.ca/~smitchel/for201labs/blood_angle/ang_procedure.html](http://www.ap.stmarys.ca/~smitchel/for201labs/blood_angle/ang_procedure.html)
<table>
<thead>
<tr>
<th>Angle (°)</th>
<th>Spatter #1</th>
<th>Spatter #2</th>
<th>Spatter #3</th>
<th>Spatter #4</th>
<th>Spatter #5</th>
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<th>D/L Spatter #2</th>
<th>D/L Spatter #3</th>
<th>D/L Spatter #4</th>
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<table>
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<tbody>
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<tr>
<td>90°</td>
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</tbody>
</table>

Relationship of the Impact
Angle to Blood Spatter Shape
Observations
Comparision of $\sin \theta$ and the ratio of D/L for blood drops made at different Impact Angles

![Graph showing comparison of $\sin \theta$ and ratio of D/L.](image-url)
Blood Pattern Analysis Lab – Part 2

The Scenario: Police have responded to a missing persons call. Co-workers of Anita Huginkiss have reported that she has not shown up for work in three days, and uncharacteristically, she has not called in to explain why. The police, getting no response by knocking on her apartment door, have asked the landlord to give them access. Upon entering the apartment, they discover a crime scene; blood spatter has been found in several locations in her study, and there is evidence that a body has been dragged from the study to the main hall. The trail goes cold from there. However, police are working under the assumption this is evidence of foul play involving Ms. Huginkiss. Police are looking for a body, but in the meantime, you have been called in to analyze the blood spatter evidence, and to use the evidence to recreate what happened in Huginkiss residence.

Besides the marks from pooled blood that indicate the victim was dragged from one room to another, there are 5 principle areas of interest to you; three areas that contain blood spatter of similar size (1-3), a series of small drops found near the door (4), and several drops of blood on the ceiling (5). You are to analyze the blood spatter evidence, and write a report that clearly and concisely summarizes your findings. You should use analyses to support you results, and your report should be clear, logically organized, and should use tables, figures and calculations to support your claims. How you organize this is up to you, but I would suggest organizing your report into sections in which you discuss individual blood spatter evidence, and then a conclusion section in which you put it all together to explain the relevance of each analysis and how it fits together in your crime scene reconstruction.

The Evidence:

You start by testing various blood stains to determine blood type. You find that most of the blood is O– (the blood type of the purported victim). One other blood type was found at the crime scene. Use the table below to deduce the blood type found at the crime scene and that of 4 suspects, and incorporate this information into your report.

<table>
<thead>
<tr>
<th>Suspect #</th>
<th>Anti-A</th>
<th>Anti-B</th>
<th>Anti-Rh</th>
<th>Blood Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Crime scene</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Next you discover areas that contain blood drops that are consistent with medium-velocity impact spatter (areas 1 – 3 on the map of the room). You find an area of convergence for each of the blood spatter areas; X₁, X₂ and X₃ respectively. You wish to find the height at which the blood fell, so you measure from 3 blood drops in each area back to the point of convergence. You then measure a blood drop from each area (a representative blood drop from each area is shown in the table below. Using what you know about blood spatter analysis, fill in the table below to determine the height at which the fell at each point, X₁, X₂ and X₃. You may wish to do 3 calculations for each blood drop in each area, and then determine the average height. You may also wish to bear in mind that factors
such as gravity and air resistance may affect your calculations, and possibly to adjust for these factors.

<table>
<thead>
<tr>
<th>Area</th>
<th>Distance to point of convergence</th>
<th>Representative blood drop</th>
<th>Height from which blood fell</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Drop 1 = 0.3 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 2 = 0.27 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 3 = 0.25 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_2$</td>
<td>Drop 1 = 0.51 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 2 = 0.46 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 3 = 0.52 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_3$</td>
<td>Drop 1 = 0.66 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 2 = 0.61 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drop 3 = 0.64 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally, you find the following blood stains (figures 4 and 5). Explain what the blood stains are, how they are formed, and how they are relevant to your reconstruction of the crime scene.

**Figure 4.** Blood stain found on the wall behind the door leading to the hallway.
Figure 5. Blood stains found on the ceiling on the eastern side of the room.

Figure 6. Map of Anita Huginkiss’ study in which blood spatter was found. Blood spatter used in this case were found in areas marked 1 – 6, and areas marked $X_1$ to $X_3$ indicate areas of convergence for blood spatter found in areas 1, 2 and 3 respectively.
LAB # 13: CREATE A DNA FINGERPRINT

Go to this site and complete the lab.

http://www.pbs.org/wgbh/nova/sheppard/analyze.html

Go here and complete the mystery.

http://learn.genetics.utah.edu/archive/mystery/
LAB 14 ANALYSIS OF DRUGS AND POISONS

Objectives:
1.) use chemical tests to identify some common over-the-counter drugs
2.) use chemical analyses to test for some "controlled drugs" by using simulated narcotics and toxins (things that act the same way for a test but really aren't that substance).
3.) detect heavy metal poisoning (lead and mercury) by analyzing various materials left at the scene of the crime and the amino acids in body fluids (simulated).

**Note** – this is one of the first labs where you will need to be attentive to chemical safety protocols.

- Many substances used in this lab are volatile and flammable. Keep them away from an open flame, and avoid inhaling the vapors. Work with hexanes under the fume hood.
- There is to be NO eating or drinking in this lab.
- Do not touch unknown powders – use spatulas.
- Rinse spatulas between uses to avoid cross contamination.
- Wash your hands before and after the lab.

Background Information

A DRUG is considered to be any substance used as a medicine internally or externally. It can have an effect on the function or structure of living tissue through various chemical reactions. Some drugs are habit-forming and are classified as NARCOTICS. These drugs usually relieve pain, induce sleep and can cause death when taken in excess. Consequently, they are regulated by Federal law. Other narcotics, such as LSD, have no known or studied medicinal effects, but are behavior altering, affect the central nervous system and may cause hallucinations. All drugs that are covered by law and are restricted in some manner are called "controlled drugs." Whenever a drug of any type is taken in excessive amounts and causes illness or death, it exhibits toxic properties and is then classified as a POISON. Poisons may also include substances that are not controlled but that have toxic and lethal effects if ingested.

An apparent deliberate poisoning, a homicide, an accidental death or suicide can all involve drug consumption. If a victim is found unconscious at the scene of an incident, it is important to determine as fast as possible if a drug or poison was administered to the victim and what that substance was. Thus, the crime scene needs to be carefully searched for the presence of evidence that may contain the substance or residues of the substance that was ingested such as empty glasses, milk or wine bottles, or medicine containers; traces of powder or liquids on the victim's body, clothes or possessions or on the carpet or floor nearby; suspicious material in the trash.

It is easier to determine what poisoned a victim by examining an empty container than to have to examine the victim's blood, tissues or stomach contents.

When a person is arrested for possession or sale of illegal drugs, analysis is needed to determine if the confiscated material is a controlled drug, not just an over-the-counter drug. Forensic chemists must continuously develop new methods for analyzing drugs and poisons to keep up with the modern drug industry and with the hideous criminals who make and sell their own drugs. As soon as a pharmaceutical company produces a new drug, it sends a sample to the FBI Crime Lab. Tests are developed to identify both large and minute quantities of the substance and results are placed on file for use as a reference when unknown samples are analyzed. Many techniques are used to test drugs and poisons including
chromatography (gas paper and thin layer) spectrophotometer (ultraviolet and infrared) mass spectrometry and spot tests using certain chemical reagents. A spot test may be carried out using a glass slide, a porcelain plate, or a piece of laboratory filter paper. A drop or two of a sample in solution is mixed with a chemical preparation, or reagent, that reacts in a specific way—typically by changing color or precipitating a solid—if the suspected element is present. It is this method that we will use in this lab.

An unknown sample may be one of over a thousand or more common over-the-counter drugs or it may be nothing at all. It may also be a powerful illegal narcotic. The first step of the investigation must be one of screening these possibilities in order to gain a small and manageable number of possibilities to confirm.

If a drug is a tablet capsule or caplet the identification process begins with the use of the Physicians Desk Reference. A powder might necessitate spot test or implementation of the microscope for observation of plant bits or crystalline precipitates. Once limiting procedures have approximated the drug type specific analysis techniques often involving thin layer chromatography (TLC) or other sophisticated laboratory apparatus are undertaken.

Often drugs sold illicitly are not pure. They are often "cut" with other inert materials known as additives—e.g. sugar, starch or quinine. At times other poisonous substitutes are incorporated within these illicit drug samples. This "filler" material must also be identified in that it is used to dilute the drug's potency and stretch its value when sold on the illicit market.

1. Over-the-Counter Drugs

Many legal, over-the-counter drugs can cause accidental poisoning or even death, especially to children. These drugs include alcohol (found in substances like cough syrup), antacids, nicotine, aspirin, and other pain relievers. It is important to identify these substances as soon as possible so measures can be taken to help save the victim's life.

One of the first synthetic pain relievers was salicylic acid. Although it was a good pain reliever and fever reducer, it had a sour and irritating taste. One of its derivatives, acetylsalicylic acid, has replaced it and is now the most widely used drug in the world: aspirin! In the powder form, the 2 drugs look identical. You will use a spot test to determine which is which.

How do we know it is Aspirin?

An acidified solution of ferric nitrate can be used to detect the presence of aspirin in an unknown powder. The aspirin hydrolyzes to form salicylic acid and acetic acid, and the ferric ion reacts with the salicylic acid to form a compound with a specific purple color.
How do we know it is Tylenol?

Acetaminophen, available as Tylenol, is also a good pain reliever. It is not acidic and can be used by those who are allergic to aspirin. It reacts in a similar way as aspirin to ferric nitrate, but is far less acidic.

How do we know it is an Antacid?

Antacids are slightly basic compounds that are used to treat a condition of hyperacidity; too much hydrochloric acid (HCl) in the stomach. Many of these products contain carbonates (CO$_3^{2-}$) which react with or neutralize the acid in the stomach to produce salt water and carbon dioxide gas. Bicarbonate of Soda (NaHCO$_3$), also known as sodium bicarbonate or sodium hydrogen carbonate, reacts in the following manner:

Alka-Seltzer, which contains sodium bicarbonate, citric acid and a very small amount of aspirin, reacts with water to produce carbon dioxide gas and a buffer.

The citric acid-sodium citrate buffer reacts with the excess stomach acid to relieve hyperacidity. If too great an amount of antacid is taken, severe stomach disorders may result.

You will use the universal indicator to qualitatively measure pH in this lab. Universal indicator changes color in acids and alkalis. Its color shows the strength of an acid or alkali.

<table>
<thead>
<tr>
<th>pH</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>deep blue / purple</td>
</tr>
<tr>
<td>10</td>
<td>turquoise / blue</td>
</tr>
<tr>
<td>9</td>
<td>green</td>
</tr>
<tr>
<td>7</td>
<td>orange / yellow</td>
</tr>
<tr>
<td>1</td>
<td>red</td>
</tr>
</tbody>
</table>
Experiment 1: Test for over-the-counter drugs versus narcotics

Materials (work in pairs)

1. Unknown powders A and B
2. Alka-Seltzer®
3. Tylenol®
4. 0.5 M HCl
5. Ferric nitrate solution
6. Universal indicator and chart
7. Depression plate
8. Aspirin
9. Sodium bicarbonate
10. Distilled water
11. Toothpicks
12. Data sheet (1 per lab group)

Procedure

1. Carefully sprinkle a few granules of aspirin into 3 depressions along a row of the depression plate. Use a pencil to label this row.
2. Repeat this procedure for Tylenol, alka-seltzer, sodium bicarbonate and your unknown powder. If possible, use every other row of the depression plate to avoid cross contamination.
3. Observe the powders and make some general descriptions about their consistency and color.
4. Add 5 drops of distilled water to each of the powders. Describe any reactions that occur on your data sheet.
5. Add 1 drop of universal indicator to each of the depressions containing the powder and water from step #4. Use a clean toothpick to gently stir each one. Record your results and explain whether each substance was acidic, alkaline (basic) or neutral.
6. Add one or two drops of 0.5M HCl to each of the powders in the next vertical column of depressions. Record your observations (which, if any, of the powders fizzes and produces CO$_2$).
7. Add one or two drops of the ferric nitrate solution to each of the powders in the last column of depressions. Use a clean toothpick to stir each of the solutions. Record your observations (which turns purple) on your data sheet.
8. Carefully clean up the depression plate by washing the solutions down the drain. If any powders remain in the depression plate, carefully scrub them with a bottle brush.
9. Turn in your data sheet along your answer to the following question:
   a. What is the likely identity of your unknown substance? Explain your answer by comparing the results of the spot test for the known samples to your unknown sample. Can you say definitively that your unknown is what you say it is? What factors may lead you to inconclusive results or false positives (i.e. a positive test result for a narcotic when the substance is not a narcotic)?
2. Controlled Drugs

Some of the drugs that have been making headlines in the news over the last decade include "hallucinogenic" drugs: LSD, marijuana, heroin, cocaine, etc. With the exception of marijuana these are classified as alkaloids: basic nitrogen containing plant products having marked physiological action when given to animals. Most are white powders.

Cocaine is the main alkaloid in the leaves of the coca bush and stimulates action on the central nervous system. Most alkaloids can be identified by the colored precipitates they form with specific reagents. Observation under various types of lighting and the results of chromatography can also be used to identify an unknown drug.

LSD - lysergic acid diethylamide - is the alkaloid from ergot, a fungus on rye and cereals. Only 50 micrograms taken orally produces psychosis resembling schizophrenia. Besides changes in visual perception, depersonalization and brain disturbances, LSD can also damage the chromosomes. This dangerous drug has been found in candies, aspirin tablets, sugar cubes and blotting paper.

The first step in screening a suspicious hallucinogenic sample is to examine it under ultraviolet light. Most hallucinogens show up as fluorescent areas. If this test is positive, the substance can then be dissolved in an appropriate solvent and tested further with the appropriate chemical reagent. Thin layer chromatography can be used to detect micrograms of the material.

Marijuana - is the only hallucinogen that does not contain nitrogen! It is the most widely used illegal drug. It actually is made from the dried parts of the hemp plant, Cannabis sativa.

One of the first steps in the examination of suspected marijuana is the visual identification under a microscope. At the base of the leaf hairs, you should be able to observe small crystals of calcium carbonate. If a drop of hydrochloric acid is added to the material, bubbles of carbon dioxide gas will be produced.

\[
\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2
\]

A chemical test that is positive for marijuana is the Duquenois Test. When one or two milliliters of Duquenois reagent (0.5 mL fresh acetaldehyde, 1.0 g vanillin and 50 mL ethanol) is added to a sample in a test tube and shaken for a minute, the solution turns pink, then violet and then blue upon standing. When the material is extracted with 2 mL of chloroform, a purple or dark blue color in the chloroform layer is a positive test.

Testing for marijuana

Presumptive, or screening, tests for illicit drugs are based on spot tests that produce specific colors for specific drugs. The most commonly used test for marijuana is the Duquenois-Levine test, developed in 1941, which creates a purple color when the active ingredients of marijuana are present in a sample.
A police officer pulls a car over for a minor traffic violation. The officer thinks she smells marijuana in the car. A search uncovers a plastic bag containing plantlike material stuffed under the front seat. The occupants of the car insist it is “stuff used to make incense, like oregano and cloves” and is strictly innocent. A sample has been submitted to your laboratory for preliminary analysis. Does it contain marijuana?

**Materials**
- Test tubes
- Hexane
- Oregano
- Cloves
- Alleged marijuana
- Marijuana standard
- Duquenois reagent

**Procedure**
1. Place about 2-3 mm of the suspect material in a 10 X 75 mm test tube. Add just enough Duquenois reagent to cover the material then add about 2-3 mm more. Note the color.
2. Add a volume of hexane equal to one half the volume of the Duquenois reagent in the test tube and shake it for one minute. A red-purple color in the aqueous phase as well as in the immiscible (hexane) layer at the top of the test tube indicates the presence of THC, the active ingredient of marijuana. You should also test a control sample of known marijuana (simulated), exactly the same way, as well as each of the alleged ingredients of the “incense”, oregano and cloves.
3. Prepare a brief report of your results and justify your conclusion.

Spot tests like this are used for screening. Negative results mean that the drug you are testing for is not present. There are, however, substances that can cause a false positive, so you should do another test to confirm to be conclusive as evidence. The presence of marijuana can be confirmed with a microscopic examination or thin layer chromatography.

**Experiment 3. Drug Tests that use Color**

As with the Duquenois-Levine test for marijuana, you can use a number of spot tests to determine the presence of a particular drug. A positive result implies the presence of a particular drug or type of drug, but these tests are not conclusive, and they must be confirmed by a more specific test to rule out false positives.

The table below summarizes the more common spot tests used by law enforcement agencies.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Reagent</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td>Duquenois-Levine (D-L)</td>
<td>Blue-violet</td>
</tr>
<tr>
<td>LSD</td>
<td>Erlich / Van Urk (ERL)</td>
<td>Blue violet</td>
</tr>
<tr>
<td>Amphetamines</td>
<td>Marquis (MARQ)</td>
<td>Red-orange → brown</td>
</tr>
<tr>
<td>Cocaine</td>
<td>Cobalt thiocyanate (CO)</td>
<td>Blue flaky precipitate</td>
</tr>
</tbody>
</table>
**Materials**
Spot plate  
Spatula  
Test reagents  
Drug standards  
Unknown drug  
Toothpicks  
Safety goggles

**Procedure**
1. Put a small amount (the size of a grain of rice – no more!) of each simulated drug in the cavity of a spot plate, according to the diagram below. The LSD sample is the only one impregnated on paper, so some of the tests are not required as indicated by the “X”.

2. Add one drop from the labeled bottle of reagent to the edge of each sample. Mix if necessary. Note and record any changes, initially and over a period of 15 minutes.

<table>
<thead>
<tr>
<th>Test / Drug</th>
<th>ERL</th>
<th>MARQ</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSD</td>
<td>○</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Amphetamines</td>
<td>X</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Cocaine</td>
<td>X</td>
<td>○</td>
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<td>Heroin</td>
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<tr>
<td>Unknown A</td>
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<td>Unknown B</td>
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</tbody>
</table>

Labs taken from Forensic Science for High School: Barbara Deslich and John Funkhouser
LAB # 15: FACIAL RECOGNITION

Part 1. The Art of Crime Detection

Learning Outcomes:

1. Player will understand differences between the right brain and the left brain: right brain processes visual information (size, shape, shade, hue, etc.), left brain processes language and symbols.
2. Understand that visual images can be more effective than words to describe something.
3. Understand that visual vocabulary helps one draw things realistically, and a model helps one draw someone accurately.
4. Understand that to draw realistically, you must use the right brain. To draw accurately, you must study someone or something before you draw it.
5. Understand that although people look dramatically different from others, there are a few "rules" of portraiture drawing that apply to everyone.
6. Begin to apply rules of portraiture drawing (e.g., eyes are halfway between chin and top of head).

Go to this Link: http://www.alifetimeofcolor.com/play/crimedetection/index.html

Part 2

Go to the Faces program and work on the Observation Exercises. Follow my directions.
LAB#16: HANDWRITING COMPARISON & INK ANALYSIS LAB

There are three known pens available. These samples will be compared with the unknowns.

Procedure:

1. Measure 0.5 cm from the top and bottom of the chromatography paper. Lightly draw a line across the paper at these points IN PENCIL.

2. Determine where you will place your seven samples by marking, under your pencil line, where the ink samples will go.

3. For the three known samples, the principal's pen, and the two suspects pens, place a small amount of ink above your labeled paper. Firmly press down on the paper with the pen. You want to make a small dot.

4. For the crime scene sample, you will need to extract the ink from the check. To do this, cut a small square from the check that includes the pen mark. Add the alcohol/water solution to this sample. This will dissolve the ink. Using a micropipette, place a drop of this extracted liquid to the chromatography paper where you marked "Crime Scene."

5. Staple the ends of the chromatography paper together with the ink marks on the outside. DO NOT overlap the paper! Place this inside the plastic cup. DO NOT let the chromatography paper touch the side of the cup.

6. Add 2:1 propanol/water to the Petri dish. Place the chromatography paper and plastic cup in the solution.

7. It will take 20-25 minutes for the mobile phase to end. You want to remove your chromatography paper from the Petri dish when the liquid is at the upper pencil line.

8. Remove chromatography paper from solution. Using a pencil, circle the points where the ink has traveled and separated. Dispose of solution as instructed. Hang your chromatography paper up to dry.

Lab Questions

1. What does "polar" mean? Give an example of a polar substance.

2. What does "non-polar" mean? Give an example of a non-polar substance.

3. What does the phrase "like dissolves like" mean?
4. Why is thin layer chromatography an important lab tool?

5. List two components of ink.

6. What is the stationary phase? The mobile phase? Explain your answer.

7. Which known matches Suspect #1?

8. Which known matches Suspect #2?

9. Which known matches the principal's pen?

10. Which known matches the check?

11. Who stole the check from the principal's office? Why?
Lab 17 Forensic Entomology

Objectives:

• To become familiar with the basic concepts of forensic entomology.

• To be able to employ the concepts described to accurately predict time of death (aka Post Mortem Interval- PMI) using attached insect tables.

Aspects of Forensic Entomology

Basic definition
Forensic Entomology is the use of insects and their arthropod relatives to aid legal investigations. The field of forensic entomology is commonly broken down into three general areas: Urban, Stored Product Pests, and Medicolegal.

Urban
This aspect deals with the arthropods that affect man and his immediate environment. This area has both criminal and civil components and mostly includes litigations and civil law actions involving insects in dwellings or as garden pests or a loss of revenue due to insect damage. It also involves lawsuits dealing with the misuse of pesticides. For example, an argument between a landlord and tenant over whom is responsible for infesting a house with bedbugs.

Stored product
This aspect deals with arthropod infestation or contamination of a variety of commercial products. The forensic entomologist may serve as an expert witness during both criminal and civil proceedings involving food contamination. For example, if a fly is in someone's ketchup bottle, the entomologist can try to determine if it got into the bottle at the factory or at the buyer’s home.

Medicolegal
This aspect is what is commonly thought of when forensic entomology is mentioned. It focuses on arthropod involvement in felony criminal cases. The most widely known aspect is the use of necrophagous insects (those that eat dead flesh) to help police detectives and investigators determine time of death and various other aspects of homicide (for instance, if the body was moved after death). However, it also can involve physical abuse and drug trafficking. This aspect is the only one we will cover in lab. 2

Basic Concepts of Medicolegal Forensic Entomology

Death
There are two types of death: somatic and cellular. Somatic death occurs when the individual is irreversibly unconscious- what we consider “dead.” This does not mean all functions immediately cease. In fact, after somatic death, the body’s cellular processes continue. The time frame for this continuance varies according to many things like type of cell (blood, tissue, organ, etc), trauma to the cells (like a stab wound or drowning), activity level before death, and environmental factors (like rain or temperature). These factors affect when rigor mortis occurs and when the body begins to decay.

Rigor mortis
Rigor mortis is a stiffening of the muscles due to lactic acid build up after somatic death occurs. Because the muscle cells are still alive, they contract, producing the stiffening effect. Rigor mortis usually occurs about 2-3 hours after death. Around 36 hours after the onset of rigor mortis, the body again relaxes and is pliable.

Stages of Decay
There are five stages of decay and each stage attracts its own set of insects. This succession is what aides the forensic entomologist in determining the time of death; also known as Post Mortem Interval or PMI.
**Initial Decay**

This is the first stage. The body appears normal on the outside, but is beginning to decay on the inside due to cellular death and microbial and nematodal activity. The first insects on the scene are the Diptera, specifically Calliphorids. Depending on weather conditions, these flies can lay eggs within minutes of death. They lay their eggs in all orifices—natural (nose, mouth, etc) and mechanical (open wounds) and use the body as a rearing facility. It is important to note, these flies are only active during the day.

![Initial Decay Image](http://deathonline.net/decomposition)

Diptera: Calliphoridae
Blow fly or Bottle fly larvae
Initial decay cont.

*Phaenicia sericata*- Green bottle fly (4-16 mm)

*Calliphora vomitoria*- Blue bottle fly (4-16 mm)

*Cochliomyia macellaria*- Secondary screw worm (4-16 mm)
In this second stage, the abdomen is swollen due to internal gases formed by bacteria and the odor of decay is produced. The next insects to arrive are more Diptera, namely Sarcophagids or Flesh flies (though Blow flies are still attracted) followed closely by Coleoptera (Staphylinids and Silphids). Like the blow flies, Flesh flies also use the body as a breeding ground, but they are larviparous, meaning they lay larvae, not eggs. The big difference in this stage is the feeding material. All of these insects (Flesh fly larvae and both adult beetles) are predaceous and feed on the eggs and larvae of other insects.

Diptera: Sarcophagidae
Flesh fly
(10-17 mm)

http://deathonline.net/decomposition

Comparison of fly maggots.

Hairy blow fly
House fly
Flesh fly

http://www.policensw.com
Putrefaction cont

Coleoptera: Silphidae
Sexton beetle (25-35 mm)

Coleoptera: Siphidae
American Carrion Beetle (13-18 mm)

Coleoptera: Staphylinidae
Rove beetle
(0.01-8 mm, usually 1-4 mm)

Larval Coleoptera
Black Putrefaction

The name says it all in this third stage. Due to the breakdown of flesh, the gases have escaped thus making the odor of decay very strong. The majority of necrophagous (eaters of the dead) insects are found in this stage. These include Diptera (Calliphorids, Sarcophagids, *Phorids, Muscids, and Sepsids*) and Coleoptera (Staphylinids, Silphids, and *Histerids*)

Diptera: Phoridae
Coffin fly (3-4 mm)

http://deathonline.net/decomposition 7

Coleoptera: Histeridae
Hister beetle
(3.5-4 mm)
Black Putrefaction cont.

http://www.gwydir.demon.co.uk/insects/acalyptatae.htm

Diptera: Muscidae
House fly (8-12 mm)

http://deathonline.net/decomposition 8

Butyrie
This fourth stage is the drying out stage. The exposed skin may start to mould and a cheesy odor develops. As the body becomes drier, conditions are less conducive to rearing young insects. Therefore, this is the stage where insect activity and presence declines. The egg layers are gone and most predaceous insects are as well.
Dry Decay
This fifth and final stage has a very slow rate of decay. The body is pretty much dry and the odor is very minor to nonexistent; bones are exposed. There are a few insects that take advantage of this stage—mostly Coleoptera (Dermestids), Lepidoptera (Tineids), Blattaria (Periplaneta) and Acari (mites). Dermestid beetles, or Hide beetles, eat hair, skin, tendon, and bone. Tineids, or clothes moths, feed on rotting clothes and hair, and Cockroaches eat hair and fingernails. Mites eat varying parts, depending on the mite.

Coleoptera: Derestidae
Hide beetle

Lepidoptera: Tineidae
Clothes moth

Acari: Haplozetidae mite 9
How PMI is determined

Knowing the above stages of decay and the insects found during each stage gives you a rough estimate of PMI. However, since the rate of decay varies due to environment, more information is needed to make a true estimate. Knowing insect life cycles and growth rates help in this matter. For instance, if you find 3rd stage larvae of a Blow fly and you know it takes approximately 7-11 days to reach that stage, you can count backward to oviposition (remember the first in- Calliphorids will find the body within minutes if the conditions are right). When using this method, a 2 day error factor is usually included. An even more accurate way to determine growth rate is by collecting some larvae and rearing them out in a lab environment with the same approximate conditions as the field (same humidity, same temperature). When the reared adults mate and lay eggs, you can accurately gage the time it takes for that larvae to reach the same stage you saw (ie you will know it was EXACTLY 9 days).

When using this method, one of the things you must consider is the presence of drugs. Some narcotics and poisons affect the growth rate of insects. For instance, high doses of cocaine greatly increases the size of while amitriptyline (an antidepressant) delays the development of Flesh fly larvae. Luckily, insect larvae contain traceable amounts of drugs and poisons long after it is impossible to recover them from the body. Therefore, if you know to look for this, you can still accurately predict PMI while providing invaluable information for the police.
SCENARIO 1

A ferry skipper is serving a life sentence in prison for the murder of a Postmaster. After eight years, he still maintains his innocence and has gotten a lawyer to reopen his case.

**Background:**
The ferry in question crosses the Long Island Sound from Connecticut to New York and back. There are three shifts: 6 AM - 2 PM, 2 PM - 10 PM, and 10 PM - 8 AM. On September 18th, the Skipper reported for work for the 2 pm shift. He spends his entire shift on the water. On September 19th at about 7 am, a cleaning man found body of a male stuffed in one of the ferry’s cleaning closets. Apparent cause of death was multiple stab wounds. The body was removed and taken to the morgue. Although all employees were questioned, more emphasis was placed on the 2nd shift because of when the body was found. Due to circumstantial evidence, such as height and dexterity, the Skipper was arrested and found guilty.

The reason the trial was reopened is that the autopsy report was not included in the original trial. You have been provided with a copy of the report. You must answer the question,

“Did the Skipper murder the Postmaster?”

**Note:** You must be able to support your answer.

**Autopsy Report**

**Morgue case number** 15684  **Date admitted** _Sep 19, 1996_  **Time admitted** 8:01 am

**Date of autopsy** _Sep 19, 1996_  **Time of autopsy** 1 pm

**DESCRIPTION:**
Victim is an adult male, Caucasian with sandy brown hair, height- 5 feet 11 inches, weight- 162 pounds. There are no distinguishing scars, tattoos, or birthmarks. Probable cause of death is multiple stab wounds to the upper torso. The first is 1 inch above the right nipple, 2 inches wide and 2.25 inches deep. Fly egg masses were affixed to wound. The second wound is to the lower right rib inline with the armpit. It is approximately 1.75 inches wide and 2 inches deep. Fly egg masses and small (1-2 mm) larvae were infesting the wound. The third is central approximately 3 inches above the navel. It is approximately 2 inches wide and 3 inches deep. Fly egg masses and small (1-2 mm) larvae were infesting the wound. Additionally, there is a defensive wound on the left hand that runs the length of the hand along the palm. Fly egg masses were affixed to wound. Angle of penetration of all wounds shows the attacker to be right-handed and 4-5 inches taller than the victim. The depth of penetration is that of a strong man, possibly very much outweighing the victim. "Y" incision showed all organs normal, stomach empty. Toxicology screen was negative.
SCENARIO 2
A man was found lying near the center of a forested area. The forest was 25 miles from any town. He was fully clothed, lying partially buried in dirt and oak litter, and had a gunshot wound to the head. It appears as if the body was partially uncovered by wild animals. He was found by hunters at 6 pm on Jul 3rd. At the time, the victim was in a shaded locale, but the area was partially sunny at other times of the day. You recovered live maggots and pupae.

What is the PMI (when did he die)?
Is there any information you can find that will be beneficial to the police?
NOTE: to answer the PMI question, you must figure out when oviposition occurred

Police Report
Police case number 2 Date found Jul 3, 2004 Time found 6 pm
Location found forested area ~25 mi from nearest city (Marlboro, Tn)
Weather conditions at collection time (rain and temp.) clear skies, 24.5 deg C
WEATHER HISTORY
Temperature Avg daily temp approximately 25 deg C for past 2 weeks
Rainfall slight showers on Jun 28th encompassing most of county equalling only 0.1 in

DEATH SCENE
Rural
forest ....√......., tillable field ..........., pasture ..........., brush ..........., roadside ..........., barren area ..........., beach ..........., gulley ..........., ditch ..........., (water present?, how much) .N/A.,

DESCRIPTION OF REMAINS
Clothing __ blue jeans, black polo style shirt, tube socks, sneakers, and a gold watch
Burial? __ partial__ How deep? __ upper half of body exposed__ what is covering? __ oak leaf litter
Wounds? __Yes__ type __ small caliber gunshot where? __ front of head above eyes
Body position __ In a sprawling fashion, face up.
Exposure
full sun partial sun __√__ shade __ how long/day? __ approximately half time in part sun, and half of the day in shade ________________
Stage of decomposition stage 2 (beginning) ___________
SCENARIO 3
A woman was found in an overgrown parking area in between an abandoned building and a low rent apartment complex. She was discovered on Jun 1st at 7 am by 2 boys cutting through the lot to go to school. She was partially hidden by grass and weeds, but otherwise fully exposed. Her underclothing was removed and there were signs of a struggle. Sexual violence is a probability. Apparent cause of death was strangulation as evidenced by the bruising around her neck. The body had maggots of two different sizes (~ 15 mm and ~ 9mm) in different locations. The crackerjack cops responding to the scene had seen many CSI episodes and knew exactly what to do: They collected the larger maggots and put them in vials of alcohol for later identification. The body was promptly worked and then taken to the morgue.

The lab received the vials of alcohol 2 days later. The larvae were Sarcophagids. Due to their size, it was inferred that they were fully grown (or really close) and since they were found on the body, it was assumed somewhere towards the end of feeding 3rd instar. That would make the maggots about 48 hours (~1200 ADH) old at 25 deg C. Therefore, the flesh flies larviposited first thing in the morning on May 30th. Since they come in no earlier than 2 days after death, it can be assumed the victim was murdered on or before the 27th. The problem is, the victim was seen the afternoon of the 28th in the corner store.

They come to the students for help. The student must answer:

“What did they miss? When did she really die?”

Police Report
Police case number 3 Date found June 1, 2004 Time found 7 am
Location found overgrown parking area in between an abandoned building and a low rent apartment complex, Sulphur Springs, Fl.
Weather conditions at collection time (rain and temp.) 25 deg C/ Clear skies
WEATHER HISTORY
Temperature Avg daily temp approximately 29 deg C for past 2 weeks
Rainfall Last rainfall was 19 May equaling 1.3 nches
DEATH SCENE
Urban
   closed building .........., open building .........., vacant lot ........, pavement ..........,
   trash container .........., closet .........., on carpet .........., on hard floor ..........,
Please describe Lot is nestled in between 2 buildings on backside of grocery. It is rundown with high grasses and weeds; Partially fenced. Victim was found near back side by grocery store, near a break in fence used as a pass through for neighborhood inhabitants. Maggots were recovered from scene, in vials of alcohol.
Ground body resting on
   on soil directly? ........, sandy ........, rocky ........, muddy ........, other ........,
   on vegetation? ........, describe type Grasses and various weeds height Approx 18 in
DESCRIPTION OF REMAINS
clothing Torn white top on body; red pants and underwear lying next to body, black pumps still on victim’s feet. No personal effects recovered.
burial? No How deep? N/A what is covering? Body in open, but not readily visible due to high grasses and weeds
wounds? Yes type severe bruising, cuts and scrapes where? bruising on neck and throat, inner thighs, shoulders. Scrapes on shoulders and back.
Body position Face up on the ground
Exposure full sun, partial sun shade how long/day? all day Stage of decomposition stage 2
THE EXPERIMENT

Flies and maggots also provide an approximate time of death, very useful for cases where the body has been long dead. Only certain insects will feed and lay eggs on a dead corpse and forensic entomologists study these insects, their larvae cycles and thereafter can determine whether a body has been dead for just one day or up to 3 or 4 weeks.

<table>
<thead>
<tr>
<th>Time</th>
<th>Physical Appearance of Body</th>
<th>Insects Present at that Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 days</td>
<td>3 days Proteins and carbohydrates in the deceased body begin to break down.</td>
<td>Blowflies e.g. Bluebottle flies, Syrphidae flies</td>
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<tr>
<td>4-7 days</td>
<td>Body is starting to decay and causes the abdomen to inflate because of the gases inside.</td>
<td>Fly larvae and beetle e.g. Rove Beetles</td>
</tr>
<tr>
<td>8-18 days</td>
<td>8-18 days Decay is well and truly setting in; the abdomen wall begins to break down.</td>
<td>Ants, cockroaches, beetles and flies</td>
</tr>
<tr>
<td>19-30 days</td>
<td>The decaying body enters a stage know as ‘post-decay’; in wet, humid conditions, the body is sticky and wet; in hot dry conditions, the body is dried out.</td>
<td>Beetles and mites e.g. Springtail beetle, Acari, Nematocera (present only during the winter months), Brachycera</td>
</tr>
<tr>
<td>31 and over days</td>
<td>The bones, skin and hair that remain no longer give off a powerful stench and smell just like the soil surrounding it.</td>
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</tbody>
</table>

It is important to note that the collection of insects and other arthropods from a death scene may disturb the remains. Therefore, the forensic entomologist (or the crime scene personnel charged with making the collection) should contact the primary investigator and make plans for the collection of entomological evidence. Once a course of action as been determined, utmost care should be taken during insect collection so that the remains are disturbed as little as possible. Before collections are made notes should be taken as to the general habitat, ambient weather conditions, and location of the body. Observations should also be made to describe the microhabitat immediately surrounding the body.

**Scene observations and weather data.**

Entomological investigation of the death scene can be broken down into the following steps:

1). Observations of the scene should note the general habitat and location of the body in reference to vegetation, sun or shade conditions, and its proximity to any open doors or windows if recovered within a structure. Locations of insect infestations on the body should be documented as well as noting what stages of insects are observed (such as eggs, larvae, pupae, or adults). It is also useful to document evidence of scavenging from vertebrate animals and predation of eggs and larvae by other insects such as fire ants. Observations such as these can be noted on the *Death Scene Form*.

2). **Collection of meteorological data at the scene. Such data should include:**

   a). Ambient air temperature at the scene taken approximately at chest height with the thermometer in the shade. **DO NOT EXPOSE THERMOMETER TO DIRECT SUNLIGHT!**

   b). Maggot mass temperature (obtained by placing the thermometer directly into the larval mass center).

   c). Ground surface temperature.
d). Temperature at the interface of the body and ground (simply place the thermometer between the two surfaces).

e). Temperature of the soil directly under the body (taken immediately after body removal).

f). Weather data that includes the maximum and minimum daily temperature and rainfall for a period spanning 1-2 weeks before the victims disappearance to 3-5 days after the body was discovered. Such information can be gathered by contacting the nearest national weather service office, or your state climatologist.

Collection of insects from the body at the scene

The first insects that should be collected are the adult flies and beetles. These insects are fast moving and can leave the crime scene rapidly once disturbed. The adult flies can be trapped with an insect net available from most biological supply houses. They are inexpensive and readily obtainable. Once the adult flies have been netted, the closed end of the net (with the insects inside) can be placed in the mouth of a "killing jar" (which is a glass container with cottonballs or plaster soaked with ethyl acetate, or common fingernail polish remover). The jar is then capped and the insects will be immobilized within a few minutes. Once they are immobile they can be easily transferred to a vial of 75% ethyl alcohol. Beetles can be collected with forceps or gloved fingers and placed directly into 75% ethyl alcohol.

It is extremely important that the collected specimens are properly labeled. Labels should be made with a dark graphite pencil, NOT IN INK. The label should be placed in the alcohol along with the specimens, and alcohol can dissolve the ink from the paper! However, pencil is not affected by alcohol and should be used for labeling purposes. The collection label should contain the following information:

1). Geographical Location
2). Date and hour of collection
3). Case number
4). Location on the body where removed
5). Name of collector

**A duplicate label should be made and affixed to the exterior of the vial.**

Once the adults have been collected the collection of larval specimens from the body can begin. First the investigator should search for the presence of eggs, which are easily overlooked. After this step, the larvae should be readily apparent on the body. Generally speaking, the largest larvae should be actively searched for and collected. Additionally, a representative sample of 50-60 larvae should be collected from the maggot mass. These insects can be placed directly into a killing solution or ethyl alcohol. However, the specimens are better preserved if they are placed in boiling water for about 30 seconds. Obtaining boiling water at a scene is difficult, so boiling of the larvae upon returning to the proper facility is satisfactory. If the larvae are boiled with about 48 hours of initial preservation, a good specimen should result. It is important to note that some forensic entomologists prefer not to have the submitted larvae boiled. Therefore, the investigator should discuss preservation techniques with their cooperating entomologist. In any case the exact preservation techniques should be documented and forwarded to the forensic entomologist. If the body has more than one area of colonization (more than one maggot mass) each site should be treated separately.
Once the preserved collections have been made, duplicate samples should be made for live shipment. Living specimens can be placed in specimen containers or Styrofoam cups with tight fitting lids along with some moist paper toweling, or most preferably a food substrate such as beef liver or pork meat. Tiny air holes should be poked in the lid using an ice pick or similar instrument. This cup should be placed into a slightly larger container that has about 1/2 inch of soil or vermiculite in the bottom to absorb any liquids that may accumulate and leak. This entire container should be enclosed in an appropriate shipping container and shipped overnight to a forensic entomologist.

**Collection of insects from scene after body removal**

Many of the insects that inhabit a corpse will remain on, or buried, in the ground after the body has been removed. The steps listed above should be followed when collecting insects from the soil (i.e. both a preserved and a living sample should be taken). Soil and litter samples should also be taken both immediately under where the body was positioned, and from the immediate surroundings. It is not necessary to dig deeply. A good technique is to collect the leaf litter and debris down to the exposed upper surface of the soil, and then make a separate collection from about the first two or three inches of topsoil. Each soil collection area should be about 4-6 inches square, and be taken from underneath the head, torso and extremities. All soil samples should be placed in a cardboard container for immediate shipment to a forensic entomologist. These collections should be labeled and forwarded to the forensic entomologist along with the insects collected from the body.
LAB 18 FORENSIC FIREARM IDENTIFICATION LAB

Forensic Firearm Identification Lab Exercise #1

Case Synopsis:
Police responded to a shoot out involving multiple shots fired. By the time the police arrived, all the suspects had fled the scene. Ten fired bullets were recovered from cars and trees in the area of the shooting. Ten cartridge cases were also found at the scene.

Detectives interviewed several people who were in the neighborhood at the time of the shooting. A few witnesses reported seeing Sammy Madison running from the scene.

The police got a search warrant for Mr. Madison’s residence and went to look for evidence. When they arrived, they found Mr. Madison in his workshop cutting a firearm into pieces. Among the parts recovered was a portion of a gun barrel.

Mr. Madison was taken to police headquarters for questioning. When asked about the night of the shooting, Mr. Madison stated that he was not in the area at the time of the shooting and his gun could not have been used.

Crime Lab Request:
The police have relayed Mr. Madison story to the crime lab and want to know if it’s possible if his firearm was used in the shooting.

Procedure:

1) Check the calipers to verify they read “Zero” when fully closed.
2) Measure the base of the bullets and record the diameter
3) Examine the lands and grooves and determine if the rifling is cut or polygonal
4) Count and record the number of lands
5) Determine the direction of twist and record
6) Using the calipers, measure the lands and grooves. The most accurate measurements will be at the base of the bullet.
7) Weigh the bullet in grams and record
8) Convert the weight from grams to grains and record
9) Determine the bullet type using the Bullet Reference Chart
10) Measure the class characteristics of the recovered portion of the gun barrel. Determine if any of these bullets could have come from the gun barrel. Explain your answer.
<table>
<thead>
<tr>
<th>Item Number</th>
<th>Diameter</th>
<th>Rifling Type</th>
<th>Number of Lands</th>
<th>Direction of Rifling Twist</th>
<th>Bullet Groove Width</th>
<th>Bullet Land Width</th>
<th>Weight in grams</th>
<th>Weight in grains</th>
<th>Bullet Type</th>
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Fired Bullet Worksheet

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<tr>
<td>Rifling Type___________________</td>
<td>Number of Lands_________</td>
</tr>
<tr>
<td>Direction of Rifling Twist______</td>
<td>Bullet Groove Width_____</td>
</tr>
<tr>
<td>Bullet Land Width_______________</td>
<td>Weight in grams_________</td>
</tr>
<tr>
<td>Weight in grains_______________</td>
<td>Bullet Type___________</td>
</tr>
</tbody>
</table>

| Item Number____________________ | Diameter________________ |
| Rifling Type___________________ | Number of Lands_________ |
| Direction of Rifling Twist______ | Bullet Groove Width_____ |
| Bullet Land Width_______________ | Weight in grams_________ |
| Weight in grains_______________ | Bullet Type___________ |

| Item Number____________________ | Diameter________________ |
| Rifling Type___________________ | Number of Lands_________ |
| Direction of Rifling Twist______ | Bullet Groove Width_____ |
| Bullet Land Width_______________ | Weight in grams_________ |
| Weight in grains_______________ | Bullet Type___________ |

| Item Number____________________ | Diameter________________ |
| Rifling Type___________________ | Number of Lands_________ |
| Direction of Rifling Twist______ | Bullet Groove Width_____ |
| Bullet Land Width_______________ | Weight in grams_________ |
| Weight in grains_______________ | Bullet Type___________ |
Which bullet(s) could have come from the barrel recovered from Mr. Madison’s house? Explain your answer.

_________________________________________________________________________________

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<table>
<thead>
<tr>
<th>Caliber</th>
<th>Diameter</th>
<th>Weight 1</th>
<th>Weight 2</th>
<th>Weight 3</th>
<th>Weight 4</th>
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<tbody>
<tr>
<td>.380 Auto</td>
<td>.355 in.</td>
<td>88 gr.</td>
<td>90 gr.</td>
<td>95 gr.</td>
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<tr>
<td>9mm</td>
<td>.355 in.</td>
<td>115 gr.</td>
<td>124 gr.</td>
<td>147 gr.</td>
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<tr>
<td>.38 Spl.</td>
<td>.357 in.</td>
<td>110 gr.</td>
<td>125 gr.</td>
<td>158 gr.</td>
<td>180 gr.</td>
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<tr>
<td>.357 Magnum</td>
<td>.357 in.</td>
<td>110 gr.</td>
<td>125 gr.</td>
<td>158 gr.</td>
<td>180 gr.</td>
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<td>.40 S&amp;W</td>
<td>.400 in.</td>
<td>155 gr.</td>
<td>165 gr.</td>
<td>180 gr.</td>
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<td>.45 Auto</td>
<td>.451 in.</td>
<td>185 gr.</td>
<td>200 gr.</td>
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Bullet Reference Chart

- Wadcutter
- Full Metal Jacket
- Jacketed Hollow Point
- Jacketed Soft Point
- Lead Round Nose
- Semi Wadcutter
**Lab 19 Tool Mark Analysis**

**Part 1 Drill Bit Examination**
Police were called to a restaurant at 2:00 a.m. on a report of a suspicious man loitering around the rear door. When police arrived they found a man entering his car. They stopped him and searched his vehicle. They found a cordless drill in the passenger seat. Upon examining the door of the restaurant, they found some suspicious marks. They labeled the marks “A”, “B”, and “C” and removed the section of the door frame. They also took the drill bit from the suspect’s drill and labeled it “Item 1”. The police are requesting that you examine the toolmarks and determine if the drill bit could have made any of the marks.

Using magnification, examine the marks on the door frame and describe their class characteristics. Determine if any of the drill marks could have come from the suspect drill bit and explain if they can be included or excluded.

Drill Bit Class Characteristics

---

Mark A

---

Mark B

---

Mark C

---

Results/Conclusion

---

**Part 2 Screwdriver Examination**

While conducting further investigation at the restaurant the police noticed more marks. They knew they weren’t made by a drill and suspect that they could have been made by one of the screwdrivers recovered from the suspect’s vehicle. They labeled the marks and removed the section of the door for submission to the crime laboratory. Examine the toolmarks and document the class characteristics of the...
toolmarks. Also, document the class characteristics of the screwdrivers and determine if they can be excluded or included as having made either of the marks.

Toolmark A sketch

Toolmark B sketch

Toolmark A class characteristics______________________________________
_________________________________________________________________

Toolmark B class characteristics______________________________________
_________________________________________________________________

Screwdriver 1 class characteristics ____________________________________
_________________________________________________________________

Screwdriver 2 class characteristics ____________________________________
_________________________________________________________________

Screwdriver 3 class characteristics ____________________________________
_________________________________________________________________

Screwdriver 4 class characteristics ____________________________________
_________________________________________________________________

Results/Conclusions___________________________________________________________________
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Part 3 Wire Examination

There have been multiple reports of car stereos being stolen from vehicles in the mall parking lot at night time. While on patrol, police caught two men running from a car with a broken window. Suspect “A” had a pair of wire cutters in his pocket. Suspect “B” had a pair of diagonal cutters in his pocket. Police removed the tools from the suspects and labeled them “A” and “B”. They have also included the wire from the car stereo and labeled it “Item 1”. The end cut by the police is covered by the label. The exposed end is the end cut by the suspect.

The police want you to determine if the wire cutters (A) or the diagonal cutters (B) were used to cut the wire labeled Item 1. They have included wire for you to make test marks with the suspect tools. Sketch the diagonal cutters and wire cutters in the boxes below. Also note the class characteristics and the type of cutting tool in the narrative. Use magnification to examine the wires and document your observations on the worksheet below. Determine if either of the wires could have cut the evidence wire and explain your answer.

---

**Item A overall sketch**  
**Item A blade sketch**

Type of cutting action:____________________________________

Marks made by tool on test cut wire:________________________ ________

---

**Item B overall sketch**  
**Item B blade sketch**
Type of cutting action: __________________________________________
Marks made by tool on test cut wire: ________________________________
________________________________________________________________
________________________________________________________________
Characteristics of evidence wire: _________________________________
________________________________________________________________
________________________________________________________________
Results/Conclusion: _____________________________________________
________________________________________________________________
________________________________________________________________

**Part 4 Impressed Mark Comparison**

Police have broken up a ring of car thieves. These thieves have been restamping the Vehicle Identification Numbers on stolen cars to make them impossible to trace. While executing a search warrant of the car shop, they found 4 sets of stamps possibly used in the restamping of VIN numbers. They made a sample of each #5 stamp and have labeled them “A”, “B”, “C”, and “D”. They made a sample of each #3 stamp and labeled them “F”, “G”, “H”, and “I”. They have one vehicle that they suspect may have been restamped by the suspects. They have included the stamped section of the VIN plate and request that you determine if any of the stamp sets made they “#5” which is marked “E” or the #3 marked “J”.

Using magnification, examine all of the test marks and unknown mark and sketch the individual characteristics within the stampings. Use the individual characteristics to determine if any of the stamps found in the shop made the unknown marks.

Stamp ________ Stamp__________
Based on the examinations of the impressions, report which (if any) of the stamp sets from the garage made the stamp impression on the VIN plate.

____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
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____________________________________________________________________________________

Stamp__________
Stamp__________
Stamp__________
LAB 20 SOIL LAB

I. Purpose:

The purpose of this lab is to compare soil samples in an attempt to differentiate or match them.

II. Materials:

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Equipment</th>
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<tbody>
<tr>
<td>Soil</td>
<td>UV light source</td>
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<td></td>
<td>Hammer or mallet</td>
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<tr>
<td></td>
<td>Micro-scope</td>
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<td></td>
<td>Weighing Dish</td>
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<td>Balance</td>
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<td>Slides</td>
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</table>

III. Procedure:

**Physical Observation**

First dry the soil samples; it is important that soil is observed dry. Now powder the soil, be sure to note any foreign objects as well as rocks, roots, or grass which are present. Also note the textures, shapes, and colors as compared to each other.

**U-V Observation**

Spread the soil out as thin as possible on a non-florescent surface. Now run over the soil with a U-V light source. *(CAUTION: U-V light is very harmful to eyes).* Note the shape, size, number, and identity (if possible) of any material that fluoresces in the sample.

**Microscopic Observation**

Place a small amount of each soil on separate slides. Try to spread the dirt in the same proportion on each slide. Observe the samples only at 10x, anything stronger would be useless for soil. Note the textures, shapes, and colors as compared to each other. Do this observation with three samples from each soil sample.

Methods for analyzing soil as evidence

**General Description**

1. Write a description of the soil sample. Note the color, texture, and general appearance. Record all observations on the data sheet.
2. Then, use a magnifying glass, and note the presence of any vegetation or any unusual materials. Record your observations on the data sheet.

**Ultraviolet Light**

1. Observe the soil sample with an ultraviolet light. It is best to have the soil in a dark area when doing this.

**pH**

1. Mix 2 grams of the soil sample in 50 mL of distilled water.
2. Stir the mixture for 1 minute then use a pH probe to read the pH of the solution.

**Soil Density Profile**

1. Before making the soil profile, dry the soil, then put through a 30-45 mesh seive.
2. Make a density gradient tube by carefully putting 1-2 mL of each of the following liquids in a small test tube: rubbing alcohol, corn oil, water, glycerin, and corn syrup. Allow to settle.
3. Drop a small amount of well-mixed soil into the tube and allowed to sit for 12 to 24 hours. Then sketch the sample profile and estimate the percentage of the total sample at each density.

**Reaction with Acid**

1. In a well-plate place a small sample of soil (about the size of an aspirin). Add 10 drops of HCl to the sample. Carefully look for the presence of any gas bubbles and record your observations in the data sheet.
2. If gas bubbles are produced it indicates presence of a carbonate or the presence of the metals, zinc, iron, or magnesium. In soil the most likely would be carbonate but at a crime scene you might find the metal fragments mixed in with the soil.

**Settling Rate**

1. Use a spectrophotometer to determine the settling rate of the soil particles. Make sure the Spec20 has been warmed up and calibrated.
2. Obtain 0.5 g of a well-mixed soil sample. Fill a clean cuvette about two-thirds full of water. Add the soil to the water and shake vigorously for about 1 minute.
3. Immediately insert the tube into the sample compartment, close the cover, and record the percent transmittance from the scale.
4. Continue to take readings every 30 seconds for the first few minutes, then at one-minute intervals until the transmittance reaches a stable value or until 10 minutes of recording has been completed.
5. Use a piece of graph paper to plot time versus percent transmittance. This graph can then be compared to graphs from other soil samples.

*Warning: Place only a small amount of sample on a slide at a time. Be sure the dirt is placed only in the center of the slide so as not to allow it to fall in the microscope.*
IV. Observations:

**Physical Observation**

<table>
<thead>
<tr>
<th>Sample A</th>
<th>Sample B</th>
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</table>

**U-V Observation**

<table>
<thead>
<tr>
<th>Sample A</th>
<th>Sample B</th>
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</table>

**Microscopic Observation**

<table>
<thead>
<tr>
<th>Sample A</th>
<th>Sample B</th>
</tr>
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</table>

1st Slides

2nd Slides

3rd Slides

VII. Conclusion:

What did you learn?
What would you do different if you had the chance to do this lab over?
What warnings would you give someone else who has to do this lab?
Where is this kind of lab, data, and/or experiment used in the real world?
Appendix A

FORMS You Will Need.

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<th>Offense</th>
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<tr>
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<tr>
<th>Day of Offense</th>
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<table>
<thead>
<tr>
<th>Investigation Team</th>
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Guide to Paper Work

Goal
The goal of these investigations is to obtain successful and accurate indictment(s). Evidence may only be included on an indictment if and only if it is obtained and documented legally. Appropriate completion of the following documents should assure accurate and legal documentation.
“If you don’t document it, then it didn’t happen and it doesn’t exist”

Daily Documentation
Man-Power Assignments-A planning sheet used to delegate responsibilities to the CSI’s Crime Scene Personnel Sheet-a running list of investigators who enter the crime scene Interrogated Witness Log Sheet-A running log of witnesses or suspects interrogating during the investigation Significant Evidence List-A running list of evidence the CSI’s believe to be significant to the case Event Schedule-a running list of each and every activity the CSI group initiates and participates

The Crime Scene (each of the following are to be completed as a set and correspond for a single crime scene)
General Crime Scene Information-must have one completed for each crime scene Crime Scene Sketch & Evidence Measurements/General Information-must have at least one sketch and general information completed for each crime scene Crime Scene Photo Log-a list of photographs taken at the crime scene; must have one completed for each crime scene Lab Work Request Form-this form must be completed in order to obtain lab work on evidence Additional Crime Scene Forms (Use only if applicable)
Vehicle/Crime Scene-to be completed if a vehicle is searched Body/Crime Scene & Wound Chart-to be completed upon the examination of a body Weapons Report-to be completed upon the discovery or confiscation of a weapon Coroner & Ambulance Information-to be completed by the Coroner or Ambulance service

Interrogation Documents
Miranda Rights Card-a list of rights which legally must be read to any one questioned and signed Individual Interrogation Request Form-must be completed in order to request an interrogation (this document will initiate officers acquisition of individuals for you to question) Interview Information-must complete one of these for each person interrogated Obtaining Evidence not at the Crime Scene (Any evidence obtained outside of the crime scene requires probable cause, a waiver, or a warrant) Sample Waiver-used to obtain evidence from an individual with adult permission Affidavit for Search Warrant-used to obtain evidence by bypassing consent; Must be submitted and approved by a judge. Control Requisition Form-used to request lab techs to obtain know samples from an individual or location for comparison purposes Other Generic Request Form-used to request action by a judge, lab tech, or psychologist, not covered in other documents Press Release-if a case becomes high profile, a certain amount of information must be released to the press; this form is to document such releases
### Man-Power Assignments

**Victim**

**Supervisor in Charge of Investigation**

### Scene Investigation

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### Medical Follow-up

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### Interview Assignments

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### Other

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# Crime Scene Personnel Sheet

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<table>
<thead>
<tr>
<th>Time In</th>
<th>Name/Rank</th>
<th>Time Out</th>
<th>Responsibility at Crime Scene</th>
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<tbody>
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## Interrogated Witness List

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<th>Name (Last, First, Middle)</th>
<th>Area of Testimony</th>
<th>Est. Time</th>
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<tbody>
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Remarks:
## Significant Evidence List

<table>
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<th>Submitted by</th>
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**Remarks:**
## Significant Evidence List

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**Remarks:**
## Event Schedule

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<tr>
<th>Date</th>
<th>Time</th>
<th>Activity</th>
<th>Officer In Charge</th>
<th>Comments</th>
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</table>
### General Crime Scene Information

Reminders:
- Photograph everything first
- Make detailed sketches
- Watch where you walk and what you touch-if possible wear gloves
- Plan to obtain control samples
- Plan to collect blood samples from different areas

<table>
<thead>
<tr>
<th>Address or Location</th>
<th>Telephone Number</th>
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<table>
<thead>
<tr>
<th>Name of Business/Apartment etc.</th>
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<tr>
<th>Type of Structure (Number of stories, color, brick, frame etc.)</th>
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<thead>
<tr>
<th>Bordering Streets</th>
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<th>Lighting Conditions</th>
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<thead>
<tr>
<th>Comments:</th>
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<tr>
<td>Offense</td>
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<tr>
<th>Date</th>
<th>Location</th>
<th>Photographer</th>
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<th>Camera</th>
<th>Lens</th>
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CSI: Lin-Wood A Field Guide and Laboratory Experience
Crime Scene Sketch

Area:

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<thead>
<tr>
<th>Symbol</th>
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<th>Symbol</th>
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Officers:

* Make different sketches for different areas
* Symbols & letters for stationary items
* Numbers for movable items
* Refer to scale as approximate
## Evidence Measurements/General Information

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Ht</th>
<th>Remarks</th>
<th>L*</th>
<th>E*</th>
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<tbody>
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</table>

**Officers**

**Date**

**Comments**

*Use different pages of this form for different areas of investigation

*L – LAB WORK NEEDED

*E – EVIDENCE RETAINED
## Lab Work Request Form

<table>
<thead>
<tr>
<th>Item</th>
<th>Date Submitted</th>
<th>Comments</th>
<th>Recovered From</th>
<th>Recovered By</th>
<th>Crime Scene Key</th>
<th>Submitted by</th>
<th>Analysis Requested</th>
<th>Compare to</th>
<th>Results of Tests</th>
<th>Comments</th>
</tr>
</thead>
</table>


# Vehicle/Crime Scene

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Year</th>
<th>Color</th>
<th>License No.</th>
<th>VIN</th>
<th>Location</th>
<th>Odometer Reading</th>
<th>Fuel Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position of Doors, Windows, Locks</td>
<td></td>
<td></td>
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<tr>
<td>Ignition Position</td>
<td>Gear Shift Position</td>
<td>Lights</td>
<td>Brakes</td>
<td></td>
<td></td>
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<tr>
<td>Damage (Exterior, Interior, Glass, etc)</td>
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<tr>
<td>Identifying Features (Bumper Stickers, Antenna, Parking Permit, Stereo, etc)</td>
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<tr>
<td>Contents-Interior</td>
<td>Contents-Trunk</td>
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<tr>
<td>Contents-Glove Box</td>
<td>Contents-Ashtrays</td>
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<tr>
<td>Registered Owner</td>
<td>Address</td>
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</tbody>
</table>

**Officers**

**Date**

**Comments**
* Obtain search warrant or waiver if applicable
* Photograph and Fingerprint
* Check to see if vehicle is operable
* Use body form for any victims
# Body/Crime Scene

<table>
<thead>
<tr>
<th>Name of Victim (Last, First, Middle)</th>
<th>Race</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Phone #</td>
<td>Age</td>
</tr>
<tr>
<td>Employer/School</td>
<td>Address</td>
<td>Phone #</td>
</tr>
<tr>
<td>Height</td>
<td>Weight</td>
<td>Hair</td>
</tr>
<tr>
<td>Next of Kin</td>
<td>Relationship</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td>Phone #</td>
<td></td>
</tr>
<tr>
<td>Deceased</td>
<td>How Determined</td>
<td>Method if Known</td>
</tr>
</tbody>
</table>

**Visible Injuries (Location/Type)**

**Scars, Marks, Tattoos**

**Clothing/Jewelry**

**Position of Body (Describe in Detail - Arms, Legs, etc)**

**Measurements (Related to the Body Only)**

<table>
<thead>
<tr>
<th>Odors</th>
<th>Body Temp</th>
<th>Room Temp</th>
<th>Hand Bag</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

*Photograph in detail prior to moving the body or obtaining ID
*Chalk or mark around body
*Bag hands
*Inspect the bottom of the shoes
*Fill out a wound chart
<table>
<thead>
<tr>
<th>Date</th>
<th>Offense</th>
<th>Victim</th>
<th>Officer</th>
</tr>
</thead>
</table>

Comments:
# Weapons

<table>
<thead>
<tr>
<th>Description</th>
<th>Location Found</th>
<th>Found By</th>
<th>Introduced Into Evidence By</th>
</tr>
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</table>

*IF KNIFE-list Brand, Type, Size, Color, Single/Double edged, Sharp/Dull  
*IF BLUDGEONS-list Type, Size, Length, Color, Diameter, Approximate Weight  
*IF GUN-list Make, Model, Type, Serial Number, Color, Caliber, Position of Hammer, Bullet Capacity, Barrel Length, Color of Grips/Stock, Ejection Path, number of Rounds in Chamber/Clip.  
*Determine if prints are needed  
*Handle weapon as little as possible  
*List all stains, hairs, fibers on the weapon
Works Cited

http://www.moval.edu/faculty/simmermanj/homicide/crime_scene_sketch.ht


5. A good link to comparisons of human and animal hairs http://www.fbi.gov/hq/lab/fsc/backissu/july2004/research/2004_03_research02.htm