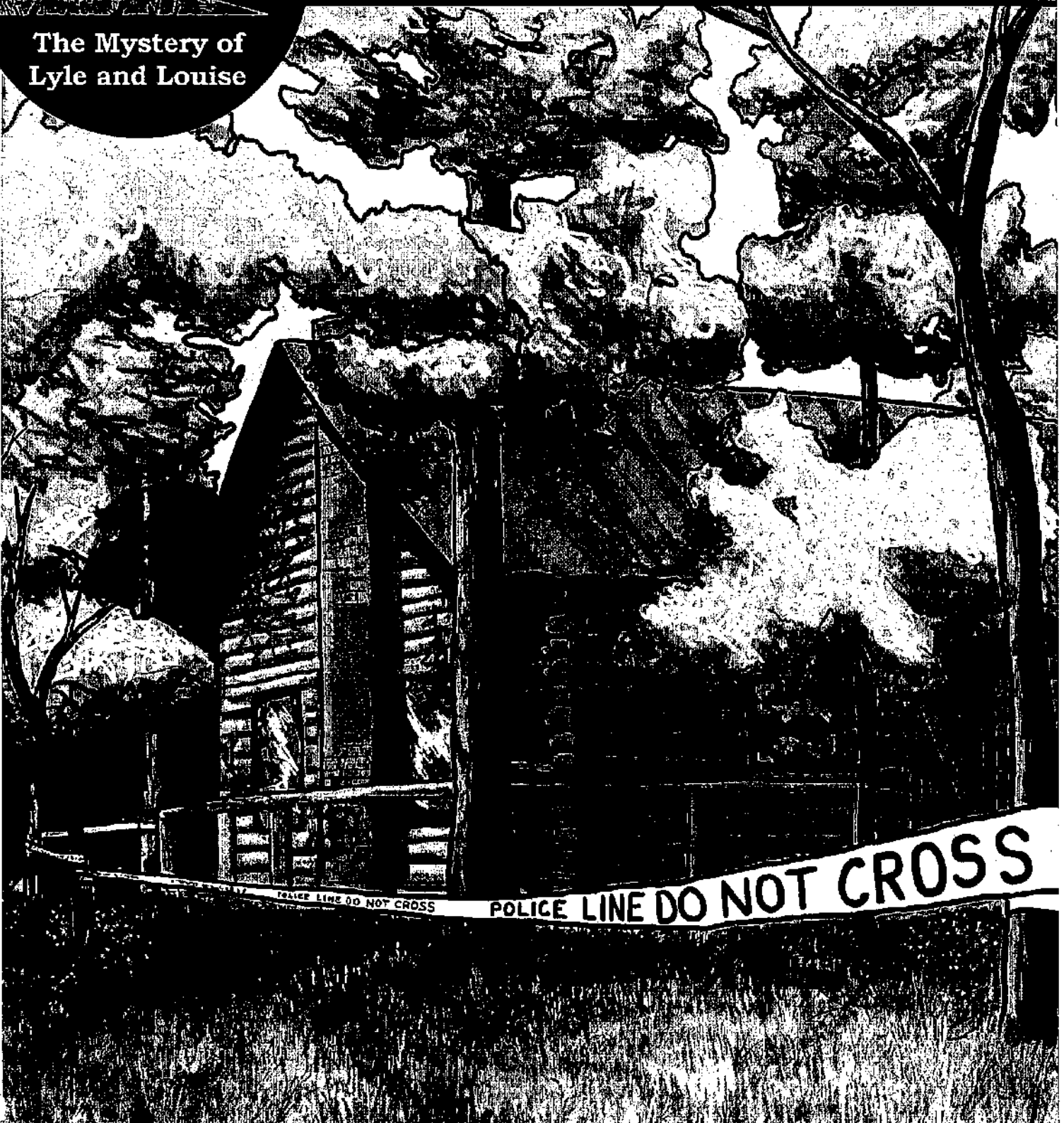


**The Mystery of
Lyle and Louise**

Patterns of Murder

A Lab on Blood Spatter



The Mystery of Lyle and Louise: Patterns of Murder A Lab on Blood Spatter

National Science Education Standards:

Unifying concepts and processes	Evidence, models, and explanation
	Change, constancy, and measurement
Science as inquiry	Abilities necessary to do scientific inquiry
	Understanding about scientific inquiry
Physical Science	Motions and Forces
Science and technology	Understanding about science and technology
Science in personal and social perspectives	Science and technology in local, national, and global challenges
History and nature of science	Science as a human endeavor
	Nature of scientific knowledge

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Introduction to Patterns of Murder

WELCOME to Patterns of Evidence, a Blood Spatter Analysis lab in the Mystery of Lyle and Louise. A brutal murder case is unfolding in a small Appalachian town. Already the case spans two crime scenes and five people are dead. In this lab activity, your students must analyze the blood spatter evidence left behind during the murder of two people in a remote fishing cabin and de-



termine the type of weapon used in the crime and develop a theoretical time line of how the crime unfolded.

In this lab, students will learn about types of blood spatter, how blood spatter patterns are formed, and how to interpret their presence at a crime scene. Additionally, students will conduct an experiment to determine properties of blood spatter, and then use a spreadsheet program to create a mathematical model of blood properties.

In addition to this experiment, students will examine blood drop and spatter photographs from the investiga-

tion and string a crime scene to determine points of origin of blood spray. Once the lab results have been analyzed, students may host a mock trial to hold a chosen suspect accountable for their actions.

Teacher's notes can be found at the beginning of the manual, and copies may be freely made of all materials for your students.



THESE notes are provided to assist in the preparation and execution of the laboratory experiment. A solutions key for the pre- and post-lab questions can be found on page 9.

Supplies

- Cardboard Blood Drop Angle Support (6)
- 11x17" Paper (50 sheets)
- Synthetic Blood, 1 oz. bottle (6)
- Pasteur Pipettes (12)
- Pasteur Pipette Bulb, 1 mL (6)
- Cardboard Cabin Model (6)
- Crime Scene Blood Spatter Images (6 sets of 4)
- String, 18" (6 bundles of 18)
- Push Pins (1 box)
- Tape Measure (6)
- Protractors (6)

Other Supplies and Equipment Required

- Clear Tape
- Lab Gloves
- Computer with MS Excel

Assemblies

An assembly sheet for the Blood Drop Angle Support and the Cabin Model is included. To save class time, you may wish to assemble these prior to the lab session. However, when assembling the cabin model, do not attach the blood spatter images until directed in Lab Procedure 3.

Safety Precautions

- Imitation blood will stain clothing.
- Exercise caution with push pins, as they stick through the cardboard mock-ups.
- While dropping blood from the highest height, do not stand on unstable supports.

Spreadsheets

- This lab requires that you download the Excel spreadsheet from www.LyleAndLouise.com. Go to <http://www.vandaliascienced.com/lyleandlouise/modules/blood/details.html> to download the spreadsheet.

Equations

By analyzing their data, students should come up with equations similar to the ones shown below.

- Angle vs. Arc Sin is $y = 55.743x - 4.9547$
- Height vs. Width is $y = 610x - 410$

Note that students' equations will vary, but if a group is having trouble with Lab 2, the equations above will allow them to complete Lab 3.

Dropping Blood

Dropping the blood from the pipettes needs to be done consistently between individuals and groups for the best data. Here are some tips:

- Instruct students to always hold pipette vertically.
- Before dropping blood, shake the bottle vigorously. Recap and shake often during the lab.
- When making blood drops, hold constant pressure on the pipette and make 4-5 separate blood drops in succession. The first drop will usually not be useful as it will have air in it. The remaining drops should be measured and used for data analysis.
- Measure drops after they have dried.
- Do not allow the paper to be tilted while drying.

Suggested Teaching Timeline

Groundwork

Before performing any of the lab exercises in the Lyle and Louise suite, cover the investigation and background story to give students a framework for the work they are about to do. This only needs to be covered once for all of the modules.

Day 1:

Cover the background material on Blood Spatter Pattern Analysis. Emphasize the areas on determining blood height and spatter origin.

Distribute lab procedures.

Assign Pre Lab questions as homework.

Day 2:

Perform Lab Procedure 1.

Day 3:

Perform Lab Procedure 2. As this lab is entirely computer-based, it may be assigned as homework if desired.

Day 4:

Perform Lab Procedure 3.

Day 5:

Data synthesis and evaluation, and post-lab questions.

Pre-Lab Questions

1. The investigator must take a macroscopic look at everything in the scene.
2. Medium velocity stains are characterized by small, but still easily identifiable, droplets.
3. Answers will vary:
Low: knife stab, garrote, foot in blood pool
Medium: knife slash, baseball bat, punch
High: gunshot, machinery
4. An object or person was present that blocked the spray of blood.
5. Circle & ellipse. A circle indicates that the blood impacted perpendicular to the surface; an ellipse indicates an impact at some angle other than 90°.
6. Angles: 90°, 80°, 60°, and 40°.
Heights: 30 cm, 60 cm, 120 cm, 150 cm.
8 Sheets
7. The length will always be longer.
8. The strings will intersect at or around the origin on the blood spray.
9. When constructing the model, the scale of the photos is needed to know where to position the crime scene photos. When measuring the width/length ratio of blood drops, the scale is unimportant because you are interested in a ratio and not an absolute measure.

Post-Lab Questions

1. No. The length must always be greater than the width.
2. The sin of the impact angle is equal to the width/length ratio.
3. The diameter of a drop is logarithmically proportional to the height from which it fell.
4. Answers will vary. Some examples include holding the pipette at a constant angle and dropping a constant volume of blood. Answer should also include a possible solution to these problems.
5. The drops at the crime scene were created from a height of approximately 3 feet (91 cm).
6. Answers will vary. Possible statements may involve the attacker's height or gate.
7. There are two points of convergence. They are found at: XYZ and: XYZ
8. A low point of convergence might indicate that the attack continued even after the victim had fallen prone, negating any claims of self-defense.
9. A knife made the spatter in the corner. Other types of weapons that might make multiple medium-velocity blood spatter stains are also possible.

Blood Spatter Pattern Analysis

PHYSICAL evidence is a strong and often convincing voice. Through the investigation of a crime, and the systematic processing of a crime scene, the facts surrounding the case must be defined. Some of these questions may have obvious answers which can be backed by scientific evidence. For example, eye-witness testimony in combination with fingerprint comparison and DNA analysis can definitively answer 'who'. Answers to "what" and "how", on the other hand, are often harder to determine. In most cases, the only individuals with firsthand knowledge of an event are the perpetrator and victim. One way to help answer these questions is to analyze bloodstains present at a crime scene in the hope that these silent witnesses will shed light on the events.

Blood Spatter Pattern Analysis (BSPA) can be defined as an all-inclusive, structured approach to evaluate the origin and mechanics involved in the creation of a bloodstain. This investigative tool should not be confused by referring to it as an "interpretation" of the spatter or stain, since interpretation implies a subjective bias by the analyst. BSPA requires answering a standard set of questions and determining their relationship to the surrounding scene. These include determining the type of impact, the direction the blood traveled after impact, the minimum number of blows or shots, the distance between target and origin, the stain's area of origin, the possible handedness of the perpetrator, the position of the victim or an associated object, and any movement of the victim or object after bloodshed.

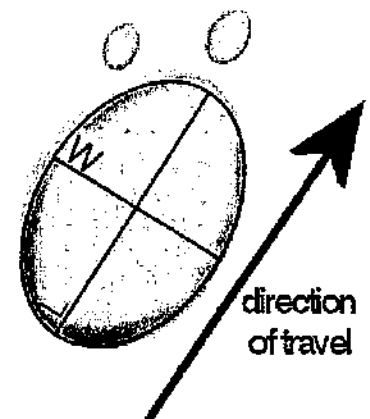
In order to characterize a bloodstain pattern, it is first necessary to macroscopically (with the unaided eye) review the crime scene. Typically the point where the violence started will be close to the location where the least amount of blood is observed at the scene. Bleeding is likely to increase as greater damage and breach of the circulatory system occurs; victims are also less likely to be able to flee as an attack progresses. Once a scene has been examined and a general assessment of events is determined, blood patterns should be placed into general stain

groupings. Stains can be first grouped into passive stains, projected stains, or transfer stains. Each of these general categories can provide information to an expert which may aid in or dictate subsequent analysis steps.

To further define bloodstains, it is important to understand some physical and biological characteristics of blood as a liquid that affect pattern characteristics. Surface character plays a fundamental role in altering the surface tension that holds a droplet of liquid (blood) together during impact. When blood strikes a surface, it will leave a pattern based on the material it strikes. Droplets hitting smooth surfaces will remain relatively intact, while those hitting rough surfaces will tend to fragment.

In studying patterns formed on flat surfaces, two main stain shapes are observed; round and elliptical. Round stains indicate the droplet struck the surface at a 90° angle; either falling straight down or traveling in a perpendicular direction when striking walls. Elliptical stains are formed when a droplet strikes the surface at a steeper angle; generally longer stains indicate more acute angles of impact. "Scalloped" edges may also occur in a stain, which point away from the origin. Impacts occurring at sharp angles create smaller droplets, called satellite stains, which can originate from the parent stain with a fine straight line connecting the two. As a general rule, impact spatter has a radiating effect; the center of the radiation pattern is the point of origin, and as droplets trail away from origin, they become more diffuse.

Categorizing bloodstains requires describing pattern characteristics. The most basic of BSPA descriptions is direction of travel. As a droplet impacts a surface, inertia keeps the mass of the droplet moving along the same path it



Blood Spatter Pattern Analysis

was traveling prior to impact. The major (or long) axis of the circle/ellipse begins to define a droplet's direction of travel. To further define which direction the droplet is traveling in reference to its long axis, satellite stains, scallops, or spines are used. At an impact angle of 90°, satellite stains and spines may be evident around the entire stain. As the impact angle decreases, stains become more elliptic and travel forward along the leading edge of the droplet. Stains formed at these acute angles are also likely to create a smaller number of satellite droplets. Using these general characteristics, the direction of travel of a droplet can be identified by drawing a line down the long axis of the parent stain and aligning it with the tail, scallops, or satellite droplet. However, these are general guidelines and don't always result in a definitive directional determination because of human influences at a scene.

Projected spatter stains are categorized based on the volume of blood present in the flying droplet. This volume is correlated to the amount of force that generated the droplets from the blood source, since no spontaneous subdivisions of droplets occur in the flight of the blood droplet. Projected

stains are split into three categories: low, medium, and high-velocity spatter. Low-velocity spatter result from low energy at the point of origin. Examples include blood dripping or being splashed onto a flat surface or a stain formed when a pool of blood is stepped in. This type of pattern could also originate from a large volume bleed such as major

arterial laceration. Medium-velocity spatter results from an impact that was sufficient to overcome the surface tension of blood. To generate this type of stain, an object must strike the blood source at a velocity of 5-25 feet per second. Most of these spatter patterns result from blunt-force trauma and often result in hundreds of blood droplets. The blood can be deposited on the perpetrator's clothing during such an event. Even the fastest of swings in these instances aren't strong enough to produce high-velocity spatter. High-velocity spatter is caused by aerosolizing liquid blood, and generally requires an impact of greater than 100 feet per second. These stains are often caused by a gunshot wound, but may be associated with explosions or other machinery wounds where revolving parts are present, like helicopter blades. Normally blood in this form doesn't travel a significant distance; therefore, high-velocity stains occur in close proximity to the point of origin. These types of stains often occur in combination with medium-velocity spatter due to insufficient force necessary to aerosolize the entire volume of blood.

In real crime scenes, stains often fall into multiple categories. In order to adequately and systematically characterize these stains with multiple velocity characteristics, analysts may use a "preponderant stain sizing technique". The number of droplet stains are counted and placed into the three spatter velocity categories based on size. The highest percentage of droplets in a particular category dictates the overall classification. For example, high-velocity impact stains are generally associated with gunshot wounds and produce a very fine mist and small droplet stains. However, in addition to these small droplet stains, some droplets characteristic of medium-velocity impacts may be produced and therefore the overall stain would have been created by a combination of small and medium sized droplets. In order to effectively categorize the stain, a sufficient sampling of droplet stains must be selected and placed into one of the categories. The category having the highest percentage of droplets is listed as the stain's type.



Blood Spatter Pattern Analysis

Some additional characteristic patterns occurring as a result of bloodshed are cast-off, pattern transfers, and stain ghosting or voiding. Cast-off stains involve the projection of blood from an object and can occur by two actions, both associated with centrifugal force. When a blood covered object is swung in an arc, blood is flung off this object during the swing or by inertia at the end of the swing. Generally these patterns are linked groups of blood drops in a straight line, which makes them easily recognized. Cast-off stains also travel away from the victim or point of origin. The nature of the arc, the width of item, and the volume of blood all play a part in cast-off pattern formation. Analysis of these stains is very important in the identification of the minimum number of blows occurring during an event. Investigators count the arcs and add one to the number counted since the first blow may not have had enough blood pooled on a weapon to result in a cast-off pattern.

Cast-off stains may provide directionality of blows (e.g. right versus left-handedness). Blow patterns made by a strong hand are likely to be made in smooth, fluid arcs whereas weak-handed blow patterns may produce a less fluid and potentially "jerky" arc. These types of analyses tend to be subjective, however, and should be interpreted and reported with extreme caution as they could influence the next steps in an investigation. These stain patterns can also be used to orient an attacker swinging a weapon during an attack. Droplets striking adjacent walls hit at 90°, as do droplets striking the ceiling directly above the point of origin. Correlating the 90° impacts from both walls and ceiling allows the identification of the general pivot point during the event. In certain cases, cast-offs may be created by a victim swinging an arm in self defense, so it is important for analysts to critically interpret the stains in combination with other crime scene data to accurately portray the combination of events.

Another type of common stain is pattern transfer, owing to the adhesive nature of blood. By comparing a pattern transfer found at a crime scene to an

item believed as having created it, the item can potentially be placed at the crime scene. For example, a screwdriver, believed to be the murder weapon, could be matched with a bloody impression left on a suspect's pants pocket. Reporting this type of stain characteristic is limited to "consistent with" or "inconsistent with," but these can play a powerful role in supporting or refuting testimony. Missing portions of stains can also aid an investigation. Such voids in a stain pattern indicate that another object was located between the impact area and the spatter and was moved before the stain analysis. These voids can define specific moments during the incident in question.

After evaluating a stain and identifying the direction of a projected stain's creation, the area of origin must be established. To do so, the common converging point of several spatters should be determined. There are three ways to determine convergence/origin:

- 1) use an overhead view which identifies a point of convergence;
- 2) use a combination of overhead and side views which defines both convergence and height
- 3) view spatter using software or stringing techniques.

The overhead viewing technique is easiest, though this technique is limited to determining a two dimensional convergence point and no information on vertical height is available to form a true point of origin. In each instance in which a stain's path can be defined, a line is drawn in the exact opposite direction. By mapping the path of multiple droplets, an intersection point can be determined. If the droplets are caused by the same impact, the intersection point should be close to the origin of the blow. Multiple blows can be established by determining clusters of intersection points from multiple droplets.

To establish a specific location above the point of convergence, an investigator must use a side-view

Blood Spatter Pattern Analysis

approach; requiring the determination of a droplet's impact angle. Dr. Victor Balthazard was first to recognize a relationship between the length and width of a resulting stain and the angle of projected droplet's impact. This relationship was further refined by Dr. Herb MacDonell who applied sine functions. Because droplets in flight are spherical, when the droplet impacts the target, its dimensions can be used to define the angle of impact.

The inverse of this sine relationship provides an estimate of impact angle and is accurate to within 5°-7°. These techniques require the ability to define a well formed stain; one where length and width of the stain can be clearly and precisely measured. Satellite stains and spines must also be excluded; to do so, only the ellipse part of the stain is measured.

Building on these theoretical bases for determining points of origin, two three-dimensional techniques have been developed to aid analysts in evaluating bloodstains at a crime scene. Stringing a crime scene is simply a physical extension of the side and overhead approach described above. This involves placing a protractor along the stain and running a string at the determined impact angle in the direction opposite the trailing spatter, thus defining the potential flight of a droplet. Repeating this exercise using multiple stains will create a series of strings that converge in an area of impact. This can be cumbersome and may not permit others to simultaneously evaluate a crime scene. Therefore, in practice, this method is only useful as a visual aid for the education of both student and jury. The addition of laser tags to the analyst's toolbox in place of string has increased the ease of use of this technique at an active scene.

Recently, computers have been used to reconstruct the point of origin of blood spatter. Forensic BSPA software employs previous described variables and adds actual flight path calculations, estimates of blood droplet's volume, gravity, and air resistance factors to increase the accuracy of the model. However, while ease of use is greatly improved, the process may not necessarily increase precision. In ad-

dition to efficiency, this method provides a handy three dimensional graphic, including XYZ reference points, which can be used in court presentations. Caution should be taken to present these points as points of reference and not absolute points of origin. Using either of these techniques will identify an area of origin which can offer information such as the position of the victim (sitting/standing/lying down) and possibly confirm or rebut testimony of events from witnesses and suspects.

In summary, to identify the point of origin, first identify the general location at which the impact occurred. Next differentiate between multiple points of origin (if necessary) and move to determine the impact angle as well as convergence point measurements. These are used to construct a three dimensional model of the incident. Collectively, these data should finally be used to refute or confirm statements made by those involved in the crime scenario.

BSPA has its roots in science and in mathematics. Those using this process of recreating a blood shedding event at a crime scene must be diligent and thorough in their analysis for its true merits to be realized. When the victim can not speak and the suspect will not, the investigators must turn to the physical evidence to tell the story by recreating the events that occurred during the commission of a violent crime.

The American Academy of Forensic Sciences does not specifically accredit blood spatter analysts. However, AAFS does have a General Division, which requires a minimum of a bachelor's degree and supervised work experience. New investigators can become experts in blood spatter analysis by working in crime scene reconstruction under the supervision of an experienced investigator and through participation in training workshops.

ADDITIONAL READING:

Bevel, T. and Gardner, R.M. (1997) *Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction*. CRC Press, Boca Raton,

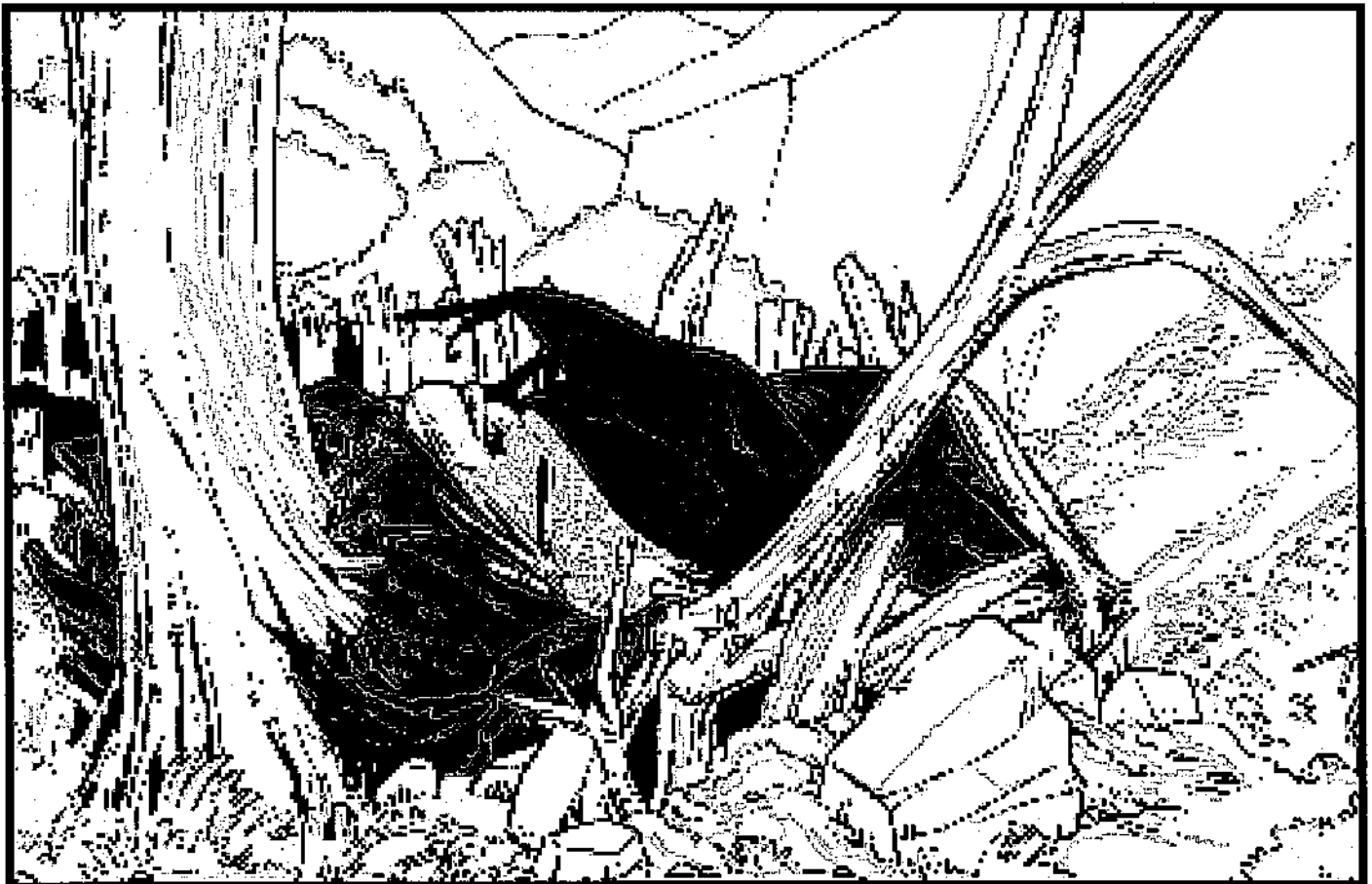
The Investigation

NINE days ago, during the night of a sudden summer thunderstorm, the Mondelo family car went over the side of Backbone Mountain and caught fire on impact. Three bodies were found in the wreckage; an adult woman, a teenage male, and a female child. All were burned beyond recognition. The three victims were identified as Louise Mondelo and her children Wally and Jan by personal effects that survived the fire.

Pictures of the scene were recorded, but, due to the rainstorm, the crash was initially believed to be simply a tragic accident and was not treated as a crime scene. When Lyle Mondelo could not be reached and was found to be missing, he became a possible suspect, and the wreckage was thoroughly processed. However, the scene was substantially disturbed, and some evidence was undoubtedly lost. The bodies, as part of an ongoing criminal investigation, were kept in the county morgue.

The small town of Highland Park was shocked, since nothing this terrible had ever happened in the area. Tips from neighbors and friends poured into the police department, but none of the tips were eyewitness accounts or provided specific information regarding the car accident. Lyle was the likely suspect, but was nowhere to be found. An all points bulletin was issued for everyone to be on the lookout for Lyle Mondelo. He was presumed armed and dangerous and to be driving a missing blue 1993 Ford Ranger with Tumbling Water Land Development Co. logos. Four days ago, Lyle Mondelo's credit card was used to purchase gasoline and food at a gas station in Texas.

When contacted, business associate John Wayne Gretzky told investigators that Lyle had been slipping into a deep depression because of trouble at their jointly owned business, Tumbling Water Land Development Company. Gretzky also hinted that there had been problems in the Mondelo family. At



The Investigation

this time, investigators noticed that John had a large bite mark on his upper arm. When asked about the wound, Gretzky claimed to have been bit during a bar fight the night before and allowed the bite to be photographed. He was not held or charged with any crime.

Background Investigation

With no additional leads, police launched a full investigation into the Mondelos. Louise Wilson and Lyle Mondelo had met at college while receiving Business Degrees in Management. They married in college and moved to Highland Park, Louise's hometown, after graduation. The town was still ailing at the time, suffering from the shut down of the mines a little over a decade ago. Although at first Lyle thought their business prospects in the small town were poor, he soon discovered that money could be made developing land for the private lodges and ski resorts that employed most of the residents.

After returning to Highland Park, Louise ran into her old High School sweet heart, John Wayne Gretzky. While talking to him, Louise learned that he was also a developer. Glad to see an old friend, and thinking that a favorable business relationship could develop, Louise asked John to meet with her and Lyle over dinner. Lyle and John soon became friends, and rather than compete for business against each other, the three decided to join together and start Tumbling Water Land Development Company.

About a year after Tumbling Water was founded, Louise conceived her first child, Wally. Friends of the Mondelos said that Lyle suspected Louise and John of having an affair at the time, and the two nearly divorced. The couple, however, worked out their relationship with the help of a marriage counselor.

Tumbling Water became prosperous and was able to buy several hundred acres of land adjacent to Blackrock River, a prime recreational waterway. Soon thereafter, Louise had another child, Jan, and took leave from the office to work from home while she raised the two children. Friends say that Lou-

ise never really went back to Tumbling Water, even after the children were older and in school. Their friends also suggested that Lyle and Louise's relationship was healthier with them not working together.

Tumbling Waters' lawyer told investigators that she began preparing bankruptcy papers for the company about a year ago; the ski resort was dragging out negotiations for a property purchase, and the company's other business deals weren't making enough profit to keep the business afloat. Soon after being asked to begin the bankruptcy filing, though, she said an unexpected deal was made to build a number of fishing cabins on the Blackrock River land. That was enough to keep the business going, and after that, Tumbling Water began making deals at a steady rate.

A potentially related case recently touched on the Mondelos' lives. Three weeks ago, a crystal methamphetamine lab was discovered in an abandoned camper on Tumbling Water land. Louise's nephew, Mitch Wilson, and John Wayne's brother, Larry Gretzky, were found in the lab and indicted for possession with intent to sell the 6 kilograms of meth found in the lab. Two days later they were both released on bond, posted by Lyle Mondelo and John Gretzky. Mitch and Larry gave no names of possible suppliers or dealers.

Two weeks before the crash, Louise Mondelo filed for divorce. Friends say she told them that she suspected Lyle of being involved with drugs, but that the friends believed she was involved with John Wayne Gretzky again. Two days later after filing for divorce, Louise requested a peace bond against Lyle, stating that Lyle had harassed her and the children. Louise also told police that she was afraid that Lyle might try to take the children away from her.

When attempting to contact Mitch Wilson and Larry Gretzky for questioning about the car accident, police discovered that they had both skipped town along with Larry's girlfriend Mary Bradey. Authorities believed that their disappearance could be related to the accident, and they were described as



possibly armed and dangerous in the warrant posted for their arrest.

Two days ago, an abandoned blue Ford Ranger with out-of-state plates was found on a strip of New Mexico highway. The pickup was dirty

and dusty, but investigators noticed a Tumbling Water Land Development Co. sign on the back tailgate. Forced entry was apparent. Upon access to the truck, investigators discovered several pieces of trace evidence and sent it to Highland Park for analysis.

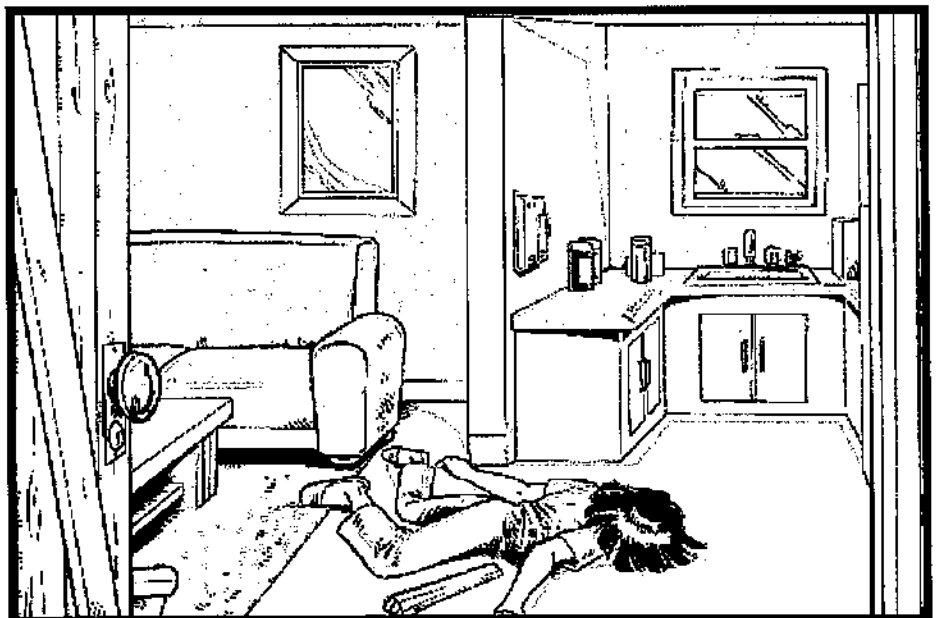
At the Scene

The forest gets thicker and buildings less frequent the farther you drive along old Route 52. You see the sign for Tumbling Water Land Development Company and make the turn onto the gravel road cutting into the forest. Before long you see the other police vehicles, and Detective Murray is motioning you over to the side of the road. A small cabin, now surrounded by police tape is sheltered by trees here, and you see several other similar cabins further down the road. You hear the Blackrock River roaring not too far off behind the cabin.

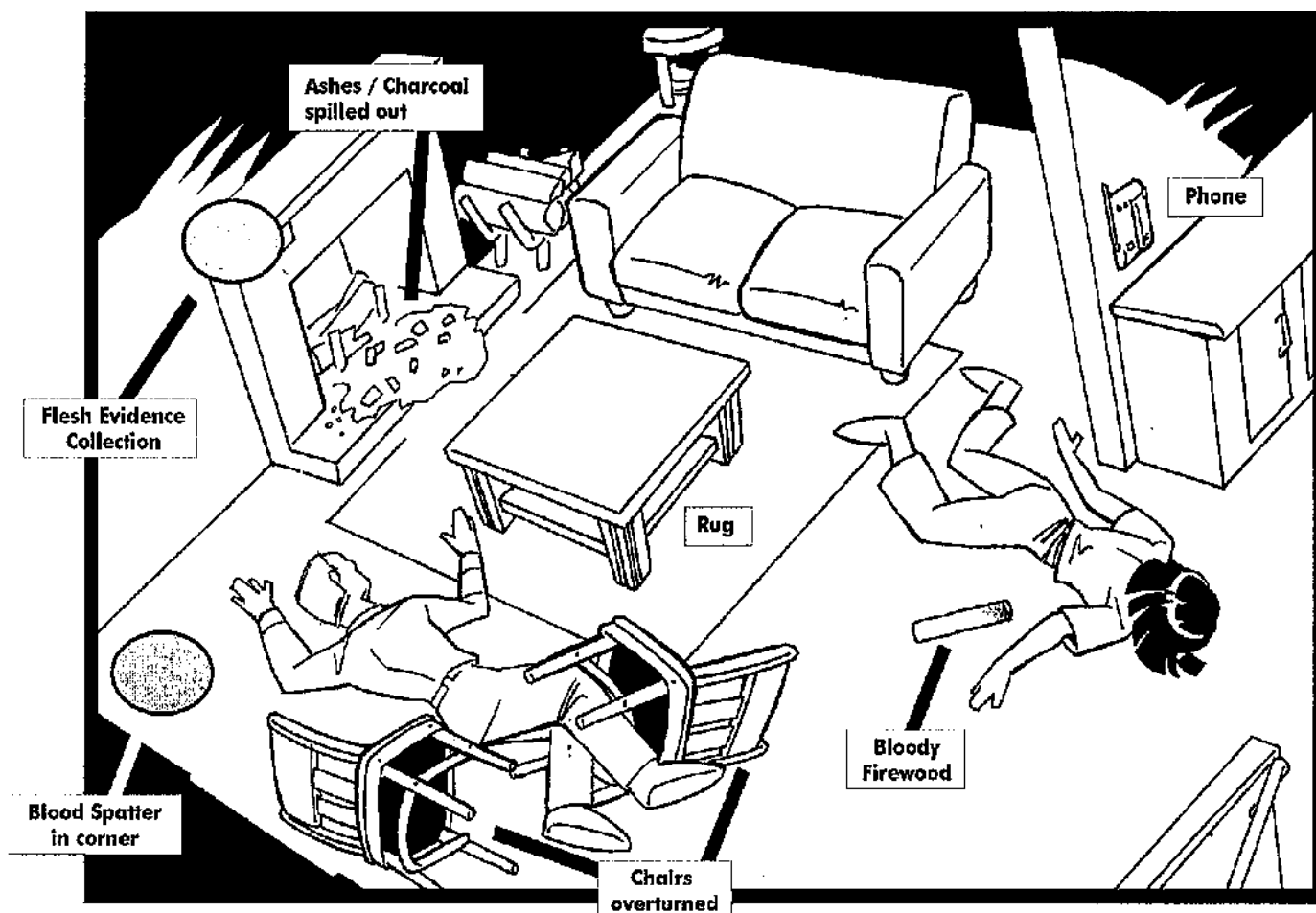
As you and your partner get out of the car, the hot July sun hits you. Detective Murray comes up, sweating in the heat. "Hey folks, welcome to the scene. Two bodies inside, both pretty bad off, and who knows how long they've been there. A Girl Scout found them about an hour and a half ago on a hiking trip. Gave her quite a fright; her troop leaders weren't much better off. Anyway, we've got a problem. We've

ID'd the woman inside as Louise Mondelo, the same woman identified last weekend in that car that ran off Backbone Mountain during the storm. Neither body's in good shape and nothing positive can be made until we get DNA, but we need to figure this one out."

The smell of human decay assaults your nose as you go inside. Overturned chairs and tables announce the struggle that took place here. The smaller body, dressed in a blouse and jeans, lays near the phone that now dangles from its line. The larger corpse is dressed in a man's polo shirt and slacks and lays in a corner to the left of a door; blood covers the walls and floor around him. Another investigator is already collecting maggots from the corpses to help establish a time of death. As you process the scene, you find flesh scraped on the stone of the fireplace, and you collect blood and skin from a piece of bloody firewood laying near the woman's body. The wounds on her head seem consistent with the firewood, but nothing is certain with her in this state of decay. Outside of the cabin, you notice a set of tire tracks deeply rutted in the mud and grass. None of the investigators had driven near that area, so you take plaster molds and pictures to preserve evidence.



The Evidence



Spatter

The bulk of the blood spatter was discovered in the corner of the fishing cabin near the male corpse. Spatter covers two walls in the corner and has a number of spatter-centers.

A piece of firewood near the female victim has a small amount of blood on it.

Pooled blood was discovered around the female victim that is consistent with a knife wound at her throat.

Low-velocity spatter was discovered near the female victim.

Blood Trails

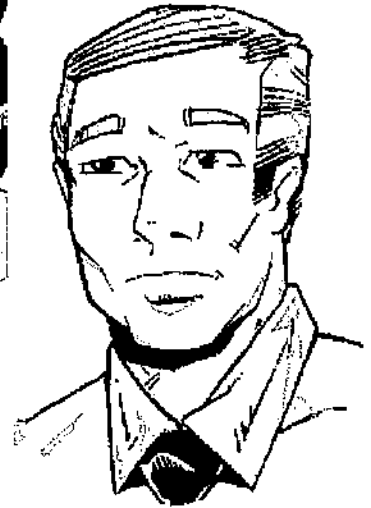
A trail of blood drops connects the male victim and the female victim. Another, similar trail, connects the female victim to a spot near the door, where the trail ends.

A trail of bloody footprints leads from the female victim to the door.

The Mondelos

Louise Ann Mondelo is the 42 year old mother and wife of the Mondelo family. She is also one of the owners of Tumbling Water Land Development Company. Friends say that Louise was in an unhappy marriage and had recently filed for divorce.

Lyle Christopher Mondelo is the 44 year old husband and father of the Mondelo family. He is a part owner of Tumbling Water Land Development Company and, along with his wife, a partner in L&L Mondelo.



John Wayne Gretzky

John Wayne Gretzky is 43 years old. He is a friend and business partner of the Mondelo's in the Tumbling Water Land Development Company. Rumors have it that John Wayne and Louise had a brief affair when Lyle and Louise first moved to Highland Park. He is known around town to be a greedy businessman, and has been suspected of shady deals in the past.



Larry Gretzky and Mitch Wilson

Larry Gretzky and Mitch Wilson were recently indicted on charges related to their apparent operation of a methamphetamine kitchen. Larry was bailed out by his brother, John Wayne, and Mitch was bailed out by his uncle, Lyle Mondelo. Larry and Mitch skipped bail and are currently missing. Police are interested in locating them for questioning.





Pre-Lab Questions

Background

1. What is the first step in characterizing a bloodstain pattern?

2. What does a medium-velocity blood stain look like?

3. What type of objects might cause wounds with low, medium, and high impact patterns?

4. In Blood Stain Pattern Analysis, what is indicated by a void?

5. If you were studying a bloodstain on a flat surface, what are the shapes of droplets you will observe? What do they indicate?

Procedure

6. At what angles and heights will you drop blood? How many sheets of drops will you have at the end?

7. When measuring the width and length of blood droplet, which will be longer?

8. When stringing a crime scene or crime scene model, what does the string's intersection indicate?

9. Why is it, or is it not, important to know the scale of the crime scene photos?

Lab Procedure 1: Blood Impact Properties

Assembling the Angle Support

1. Fold the wings of the cardboard angle support assembly up and turn the tabs so that they stand along the back.
2. Fold the back of the assembly up and over the tabs and tuck it into the holes at the base.
3. Fold the support tabs down and into the assembly. They will hold the rectangular piece of cardboard that supports your paper.

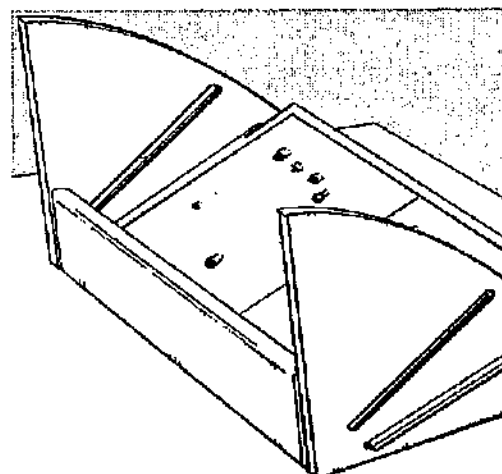
Creating Blood Drops

Each piece of paper is used for two tests, one test on each half. It is best to put different heights on the same page and keep the angle constant. This results in two sheets used for each of the four angles.

1. Choose a piece of paper. Draw a line down the center.
2. Label one half of the sheet as "30 cm, 90°" and the other as "60 cm, 90°".
3. Place the sheet into the support so that it rests flat against the bottom.
4. Draw some of the blood from the vial into your pipette. NOTE: Before every measurement, cap the bottle of blood and shake vigorously. Repeat often during the experiment.
5. Using your tape measure as a guide, hold the pipette above the half of the page at the height written on that half.
6. Drop 5 to 10 drops onto the half. Be sure that the volume of blood dropped is consistent and that there are no bubbles at the tip.
7. Now move to the other half of the page and repeat steps four through six.
8. Remove the sheet from the support, and set it

Student Note

The angle you write on your sheet is the angle of impact the blood drop will have with the page. For a sheet laying flat, the drop impacts at 90°, and a sheet that's nearly vertical will have an impact near 0°.



aside to dry. If you have several people in your lab group, some should begin processing the blood drop sheets as per the directions in the next section, Measuring Blood Drops.

9. Keeping the angle constant, repeat steps one through six for the additional heights of 120 cm and 150 cm.
10. Repeat this procedure for all of the remaining angles, so that you have samples for 90°, 80°, 60°, and 40°.

When finished, you should have 8 sheets of drops, with two angle-height combination on each.

Measuring Blood Drops

1. Choose a blood drop collection -- half of one of the sheets.
2. With your pencil, circle several drops on that half that are well formed.
3. Measure the width and length of these drops and record your measurements beside the drop measured. Be sure to measure according to the figure on page 11 (the length is the longest measurement).
4. Find the arithmetic mean (average) for both the widths and lengths of all drops measured on that half. Record these means on the "Blood Spatter Data Collection" worksheet.
5. Repeat these steps for each of the 16 blood drop collections.

Blood Spatter Data Collection

	90°	80°	60°	40°
30 cm	mean width:	mean width:	mean width:	mean width:
	mean length:	mean length:	mean length:	mean length:
60 cm	mean width:	mean width:	mean width:	mean width:
	mean length:	mean length:	mean length:	mean length:
120 cm	mean width:	mean width:	mean width:	mean width:
	mean length:	mean length:	mean length:	mean length:
150 cm	mean width:	mean width:	mean width:	mean width:
	mean length:	mean length:	mean length:	mean length:

Lab Procedure 2: Spreadsheet Calculations

The remaining portions of the laboratory procedure require a computer with MS Excel, and the "blood_spatter.xls" sheet downloaded from www.LyleAndLouise.com. Alternatively, the sheet can be printed and data hand-written in for later analysis.

the crime scene.

The trendline equation of height versus width will be used to determine the height from which a measured blood drop fell.

Generating Data Plots

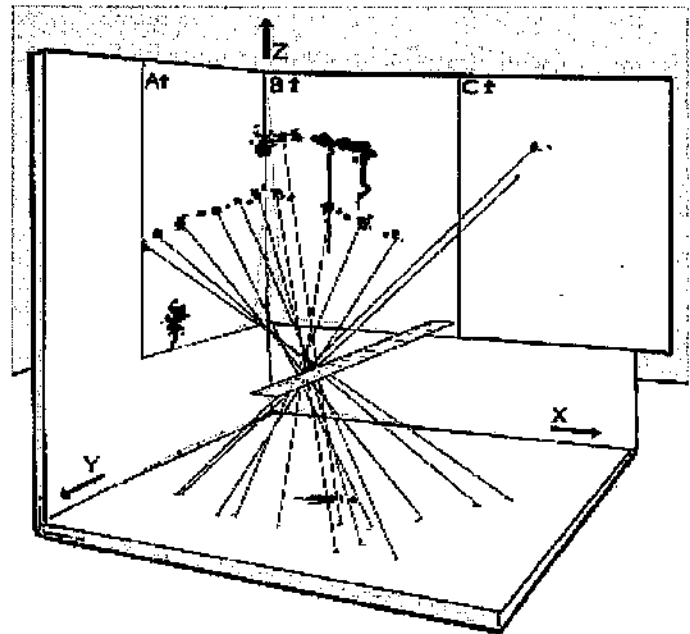
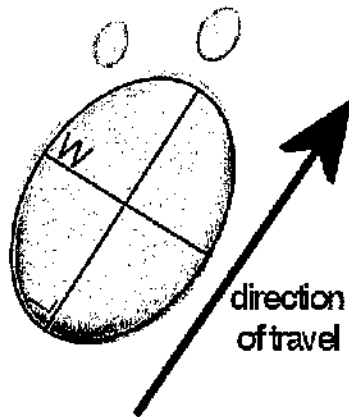
1. Open the MS Excel sheet "blood_spatter.xls" provided by the instructor.
2. Transfer the width and height data from the "Blood Spatter Data Collection" sheet to the "Lab2 Data" worksheet within the workbook.
3. After entering all of the data, switch to the "Angle vs. Arcsin" chart within the workbook.
4. This is an X-Y scatter plot from all of the observations of Angle versus Arcsin. The plot will contain data points 'stacked' at each of the four angles, along with a linear trendline.
5. In the top right-hand corner of the chart is shown an equation and R^2 value. The closer the R^2 value is to 1, the more statistically relevant the data. If the R^2 is close to 1, then the angle of blood spatter is directly proportional to the arcsin of the width-length ratio, or put another way, the width-length ratio is directly proportional to the sin of the angle.
6. If the R^2 is far away from 1 (less than 0.7), then the data is suspect, and the procedure should be re-done.
7. Now switch to the "Height vs. Width" chart within the workbook.
8. This is an X-Y scatter plot from all of the observations of Height versus Width when the angle is 90° .
9. Look at the resulting R^2 value. If it is far away from 1 (less than 0.7), then the data is suspect, and the procedure should be re-done.

In Lab Procedure 3, the trendline equation of angle versus arcsin will be used to approximate the relationship between the width and length of a drop and its angle of impact. This is used when stringing

Lab Procedure 3: Analyzing the Evidence

3a. Determining Area of Impact

1. Open the "Lab3a Data" worksheet in the "blood_spatter.xls" spreadsheet. Replace the formulas in column H with the equation derived in the "Angle vs. ArcSin" chart. Replace the "x" in the formula with the appropriate cell in column G. For example, in row 8, the formula in cell H8 should be " $=[\text{SLOPE}]*G8 + [\text{INTERCEPT}]$ ", where [SLOPE] and [INTERCEPT] are the values from your equation.
2. Choose up to 15 large, clear blood spots from blood spatter images A, B, and C, and measure their length and width. Note that the length will always be the longest part of the ellipse.
3. Circle and number each spot. Also note with a small arrow the direction of travel (see figure below).
4. Enter the length and width data into the "Lab3a Data" worksheet, in the gray shaded cells. NOTE: The cabin model is a 1/8 scale model. Measurements are corrected in the spreadsheet automatically accommodate this scale.
5. Assemble the cabin model of the interior corner of the cabin, using blood spatter images A, B, and C. The sheets should be mounted 5 cm from the floor to aid in measuring. Note that the base of the model has the largest area.
6. Use a pushpin to secure an end of string to the center of each blood spot.
7. Hold a protractor to the model wall so that it is centered on the end of the string.
8. Using the protractor, pull the string out so that it runs in the direction of travel, and at the appropriate angle as generated by the "Lab3a Data" worksheet.
9. Attach the free end of the string to the base of the model with a piece of tape - do not use the pushpins on the base.



10. Repeat these steps for each of the drops circled. If a drop is not able to be measured easily, or if the string is too short to mount to the base, choose a different blood drop.
11. After placing the strings, they should converge in one, two, or three areas. These areas are the locations of impact.
12. Measure to the center of each of the areas of impact, along the x, y, and z axes (as shown in the figure above). Record the measurements in the "Lab3a Data" worksheet.

3b. Determining Height of Drops

1. Open the "Lab3b Data" worksheet in the spreadsheet. Replace the formulas in column E with the equation derived in "Height vs. Width" chart. Replace the "x" in the formula with the appropriate cell in column B.
2. Now examine blood spatter image D. This is a 1:1 scale image of the trail of drops from the male victim to the female victim, so the measurements do not need to be adjusted.
3. Measure the length and width of drops in the photo. Record these values in the gray shaded cells in the "Lab3b Data" worksheet.
4. Now the spreadsheet will have generated the estimated height from which the blood drops fell.

Post-Lab Questions

Measuring Impact Properties

1. Can the width/length ratio of a bloodstain ever exceed a value of 1? Explain.

2. What kind of relationship does the width/length ratio have to impact angle.

3. Describe the relationship between the height of the fall and the diameter of the drop.

4. During this procedure, what possible sources of human error could have occurred? What could you suggest or what kind of adaptations could correct this type of error?

Analyzing Evidence

5. What was the estimated height of the fall of the drops at the crime scene?

6. Can you say anything about the attacker?

7. How many points of convergence did you find?

8. Legally, what might a low point of convergence suggest that a high point of convergence does not?

9. What kind of weapon could have made the spatter seen at the crime scene? Explain.

Using this Kit in the Mock Trial

Patterns of Evidence contains information regarding the attack on the two victims found at the fishing cabin. This evidence collected in this lab cannot prove conclusively that a specific person performed these acts. However, this lab does provide details about what occurred during the attack. If everything in the lab was run correctly, you should have the following information:

- The male victim was discovered near medium-velocity spatter, suggesting a hand-held weapon. Low-velocity spatter was found near the female victim, as was a piece of slightly bloodied firewood.
- A bloody object was carried across the room between the male and female victim at a height of approximately 100 cm (3 ft).
- The male victim was attacked at least once while standing, and at least once while lying on the ground.
- No blood spatter was found resulting from the firewood used as a cudgel, suggesting that only one blow was made.

If Blood Spatter is the only kit done in the Mystery of Lyle and Louise, a Mock Trial is unlikely to be useful, as prosecution has no evidence for a suspect. Instead, leave the results as an exercise in blood spatter analysis. However, if other kits were done, a mock trial can help students take all of the evidence presented in the investigation and available from other kits into account, not just blood spatter. Information on running a mock trial follows.

Before the trial

If you wish to involve more social studies, have students read through the procedures for trial of criminal cases and the simplified rules of evidence. Also conduct lessons designed to familiarize students with the court system and judicial procedure

Brainstorming

Using the story and module evidence, list the facts of the case on the board.

Determine, as a class, who should be charged for each murder.

Put students into brainstorming groups. Give all of the groups five to ten minutes to come up with ideas for each of the following:

1. Identify how each fact can support the prosecution's case.
2. Identify how each fact can support the defense.
3. Identify critical weaknesses in the reliability of each fact.

Review the brainstorming results as a class, and have students string facts together to make logical assumptions about the case.

Student Roles

Have students split up into roles.

A few of students may need to act as the Court, filling the roles of Judge, Bailiff, and Clerk. The Judge must research court proceedings and make determinations of law; the instructor may wish to take this role themselves. The Bailiff is responsible for swearing in witnesses and keeping order in the court. The Clerk is responsible for recording the trial proceedings. You may wish to omit these roles, or have these students work with the prosecution or defense during the planning stages. If you have a large class, some students may also play the role of jury. They must attend to the trial proceedings and also review the evidence and written

Mock Trial

documents prepared by the defense and prosecution to come to a conclusion about the case. They must then either meet outside of class and come to a unanimous decision, or each write a short paper justifying their own decision.

At least one student should act as the forensic scientist who processed all of the evidence; if you used multiple modules, several students should fill this role. This student must be very familiar with the laboratory procedures used to process the evidence and should also be aware of the ways the evidence can be mishandled and the precautions taken against evidence contamination and faulty methods, as these are likely to come up in court.

The remainder of students should split into the prosecution and defense. The student filling the role of the accused should work with the defense. Each side should assign their members as either lawyers or witnesses. The lawyers are responsible for building their case and developing the questions to ask their witnesses, and also to identify key witnesses called by the other side to exploit during cross examination. Each side should also identify critical weaknesses in their own case and prepare counter-arguments for them. Finally, since there are always surprises, each side should prepare strategies to deal with the unexpected.

The prosecution must provide a reasonable series of events that are consistent with the facts of the case, a motive for the events that occurred, and prove beyond a reasonable doubt that the accused is guilty. The defense may present their own account of the facts, or undermine the prosecution's case by showing that the prosecution's witnesses are unreliable, that the prosecution's version of the events make no sense or is seriously inconsistent, or by introducing reasonable doubt into the prosecution's case.

Unlike a real trial, witnesses may help the lawyers build their case; their primary duty, however, should be to become intimately familiar with their testimony. Expert witnesses are especially useful when dealing with forensic evidence, and each side

may wish to call their own, or use the other side's expert. The students playing the role of expert witness must become very familiar with that field and be able to field questions about the accuracy and limitations of the techniques.

Preparation

To make sure that students will be ready to argue your case, have the prosecution and defense answering these questions:

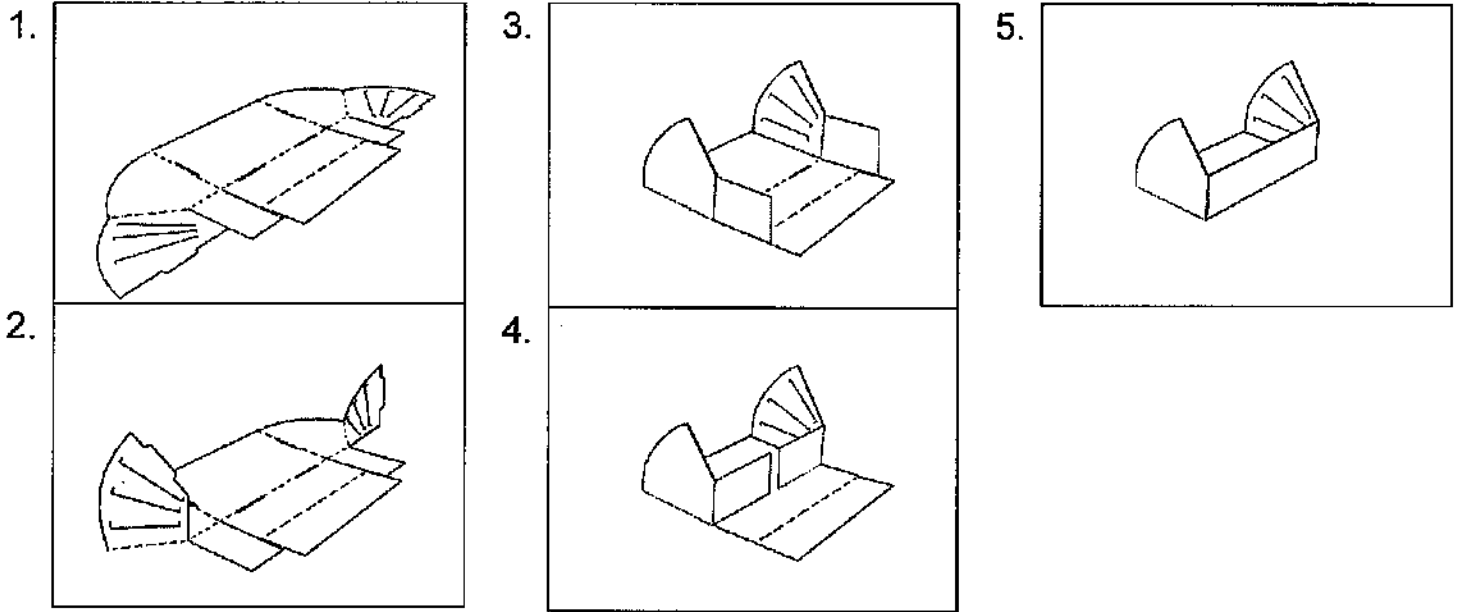
1. What are the facts of the case?
2. Why did these things happen?
3. Who was involved?
4. Will you have enough evidence necessary to participate in the courtroom?
5. What is key to you proving your point?

Have the witnesses answer the following:

1. To what are you testifying?
2. What are the most important parts of your testimony to the prosecution? The defense?
3. What holes are in your testimony? If you are an expert witness, what are the limitations of the evidence presented that is relevant to your field?

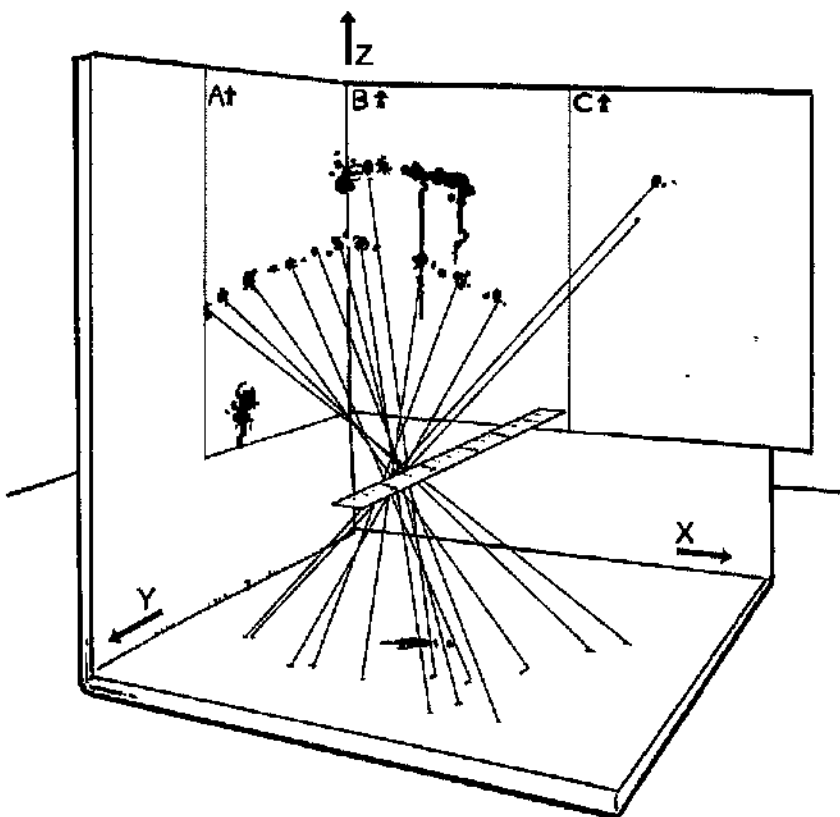
LYLE & LOUISE BLOOD SPATTER ASSEMBLY DIRECTIONS

Blood Drop Angle Holder – Fold angle template together as shown below. Use 11x17 sheets of cardboard as "shelves" to form the angle.

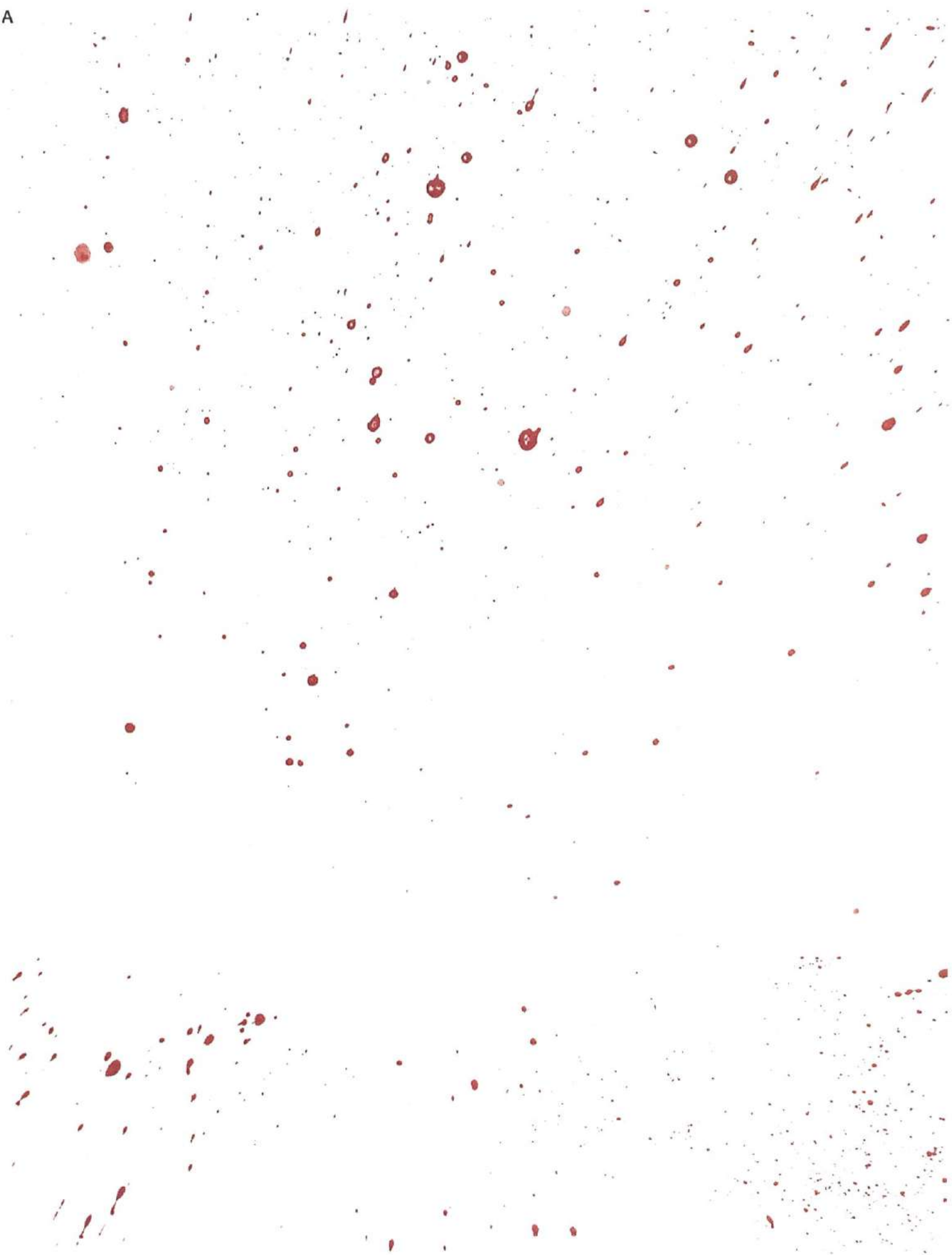


Cabin Corner Model – Do not assemble this model until directed by the lab procedure. Use tape to hold cardboard in a 3-D corner. The base should be the side with the greatest area.

Attach blood spatter images A through C with tape or push-pins. The bottom of the images should be 5cm from the base of the model to allow for easier measuring.



A



B



c

