BLOODSTAIN PATTERN ANALYSIS (BPA)

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INTRODUCTION

- Bloodstain pattern analysis (BPA) **is the examination of the shapes, locations, and distribution patterns of bloodstains, in order to provide an interpretation of the physical events which gave rise to their origin.**

- Blood spatters according to some scientific principles. This enables trained analysts to carry out a forensic study on a crime scene and draw valid conclusions.

- Analysts examine the size, shape, distribution and location of the bloodstains to form opinions not just about what happened but also what could not have happened at the crime scene.

INTRODUCTION

- Analysts can categorize what may appear to be a random distribution of bloodstains at a crime scene by gathering information from spatter patterns, transfers, voids and other marks like smearing pattern and projection patterns.

- They can then recreate the sequence of events that had occurred which led to the bloodshed.

INTRODUCTION

Presentation was made taking help from the following resources:

- A Simplified Guide to Bloodstain Pattern Analysis; Available on http://www.forensicsciencesimplified.org/blood/faqs.html
- How Blood Stain Pattern Analysis Works; Shanna Freeman & Nicholas Gerbis; Available on https://science.howstuffworks.com/bloodstain-pattern-analysis2.htm
- Peschel, O., Kunz, S.N., Rothschild, M.A. and Mützel, E., 2011. Blood stain pattern analysis. *Forensic science, medicine, and pathology*, *7*(3), pp.257-270.

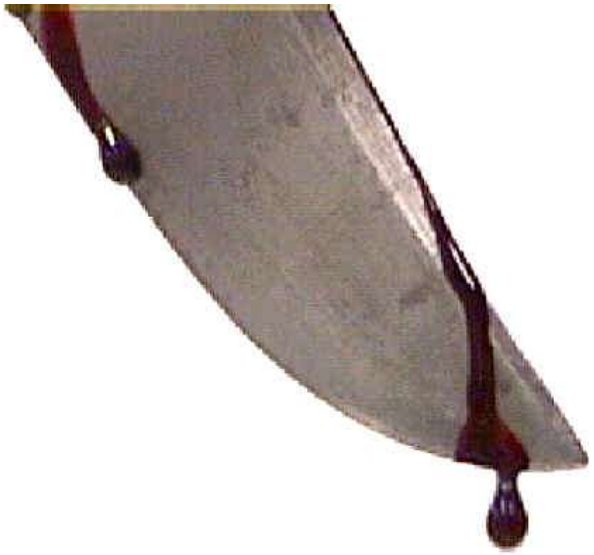
DISCIPLINES INVOLVED IN BLOODSTAIN PATTERN ANALYSIS

Bloodstain pattern analysis draws on the following scientific disciplines to assist investigators

- Biology
- Chemistry
- Physics
- Mathematics
- Law
- Psychology
- Sociology
- Biochemistry
- Biophysics
- Physical Chemistry
- Environmental Science
- Medicine

TYPES OF BLOOD STAINS: Passive Stains

- These are drops creates by the force of gravity acting alone. Examples are drops, flows and pools.



Passive bloodstain on a wooden floorboard. (Courtesy of John Black, Ron Smith & Associates)

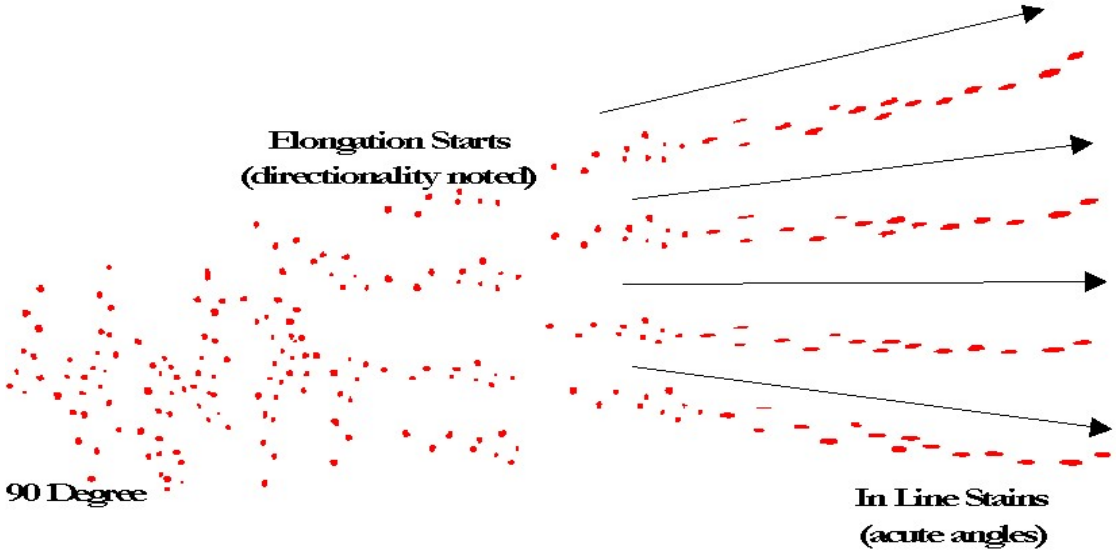
TYPES OF BLOOD STAINS: Transfer Stains

- This results from objects coming into contact with existing bloodstains and leaving wipes, swipes or pattern transfers behind. Examples include a bloody shoe print, hand print or a bloody body dragged against the floor.

TYPES OF BLOOD STAINS: Active (Projected) Bloodstains

Active stains result from blood projecting through the air and are usually seen as spatter. For example, gushes, splashes and arterial spurts.

Rule of Thumb: As impact angle goes down, bloodstain shape becomes more elongated.



TYPES OF BLOOD STAINS: Active (Projected) Bloodstains

- **Gunshot spatter** - includes both forward spatter from the exit wound and back spatter from the entrance wound.
- **Cast-off** - results when an object swung in an arc or a geometric curve flings blood onto nearby surfaces. This occurs when an assailant swings the bloodstained object back before inflicting another blow. Analysts can tell the direction of the impacting object by the shape of the spatter (tails point in the direction of motion).
- **Arterial spray** - Arterial patterns result from blood projected into the scene under pressure form the artery or heart. There are distinctive physical characteristic in the arterial patterns, marked with the typical bright red color of oxygenated blood, as well as the spiked appearance of the blood being released under pressure from the breached artery.

Arterial Spurts

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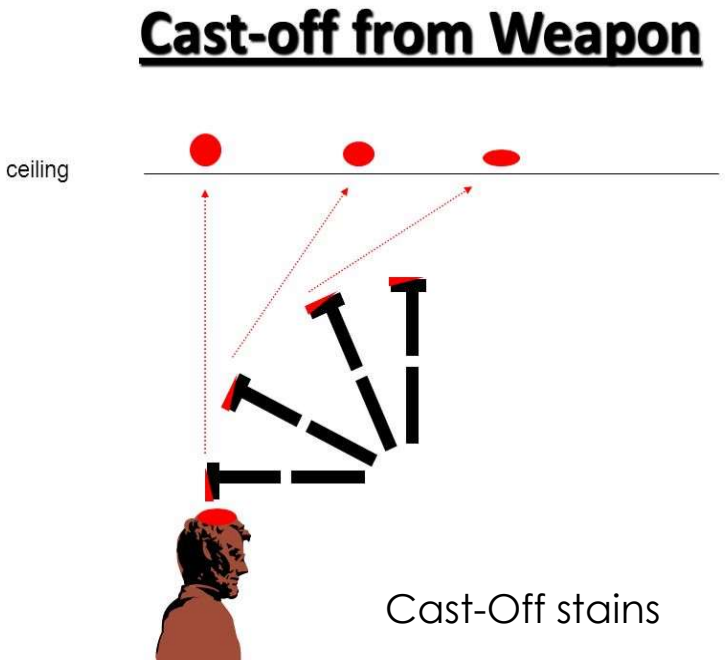
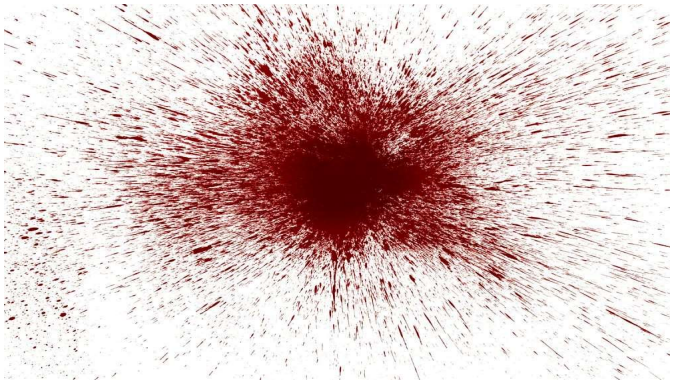


Cast-Off stains

TYPES OF BLOOD STAINS: Active (Projected) Bloodstains

- **Expirated spatter** - is usually caused by blood from an internal injury mixing with air from the lungs being expelled through the nose, mouth or an injury to the airways or lungs. Expirated spatter tends to form a very fine mist due to the pressure exerted by the lungs moving air out of the body.



Gun-shot wound spatter

Expirated Spatter

BLOOD STAINS CAN ALSO BE CLASSIFIED ACCORDING TO VELOCITY

TYPES OF BLOOD STAINS: Low Velocity

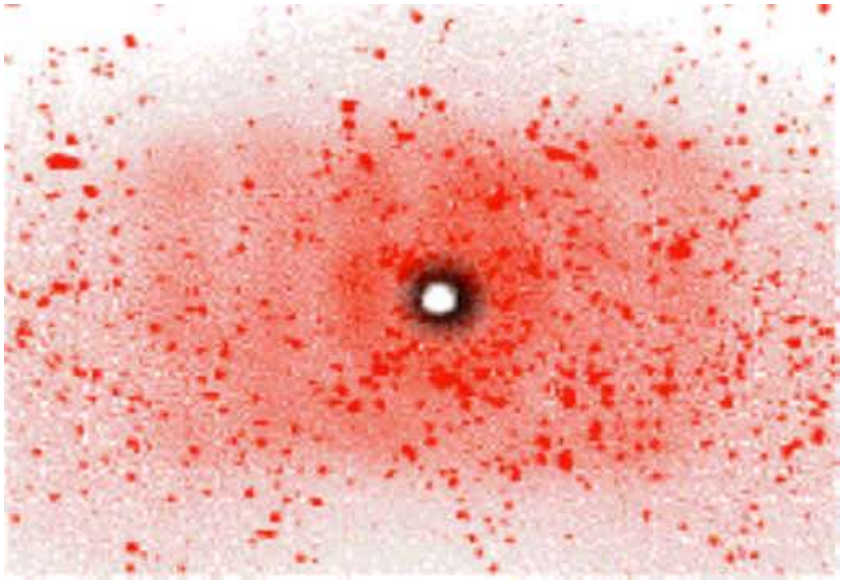
- velocity ≤ 5 ft/s
- stain size is (relatively) large: diameter ≥ 4mm
- Commonly typifies passive stains
- examples: blood drops into blood and footstep spatters

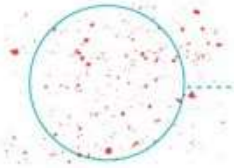
TYPES OF BLOOD STAINS: Medium Velocity

- 5 ft/s ≤ velocity ≤ 25 ft/s
- stain size : 1 mm ≤ diameter ≤ 4mm
- examples: blood flicked off finger and blunt object used on victim

TYPES OF BLOOD STAINS: High Velocity

- velocity ≥ 100 ft/s (≈ 68 mph)
- stain size (relatively small): diameter ≤ 1mm
- examples: gunshots and propellers





HIGH-VELOCITY

FORCE OF IMPACT: >100fps
DIAMETER: less than 1mm
POSSIBLE SOURCE: gunshot wounds

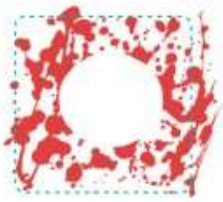
OTHER BLOODSTAIN PATTERNS

fig. 1

CAST-OFF STAINS

When blood on an object that is swung through space flies off onto a surface.

fig. 2



SHADOWING/ GHOSTING

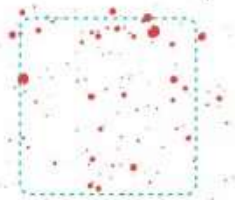
When there is an empty space, or "void" in spatter, indicating that an object blocked spray.

fig. 3

SWIPES AND WIPES

Swipes occur when blood on a surface is smeared, and wipes occur when a bloody object brushes against a surface.

fig. 4



EXPIRATORY BLOOD

Blood that is coughed up or breathed out. Misty pattern resembling high-velocity spatter results.

fig. 5

TRANSFER PATTERN

The bloodstain pattern left on a surface after a bloody object has been placed on it.

COMMON WOUNDS AND THE CLASSIFICATIONS INTO WHICH THEY FIT

TYPES OF WOUNDS

If no victim is present, forensic analysts can use the information gathered from BPA to assess what kinds of wounds may have been dealt:

fig. 1

INCISIONS

Thin wound caused by a sharp-edged object such as a knife.

Spatter: Low-velocity, wipe

fig. 2

LACERATIONS

Tear wounds caused by blunt trauma.

Spatter: Low- or medium-velocity

fig. 3

PENETRATION WOUNDS

Occur when a sharp object is inserted and pulled out of the skin.

Spatter: Low- and medium-velocity

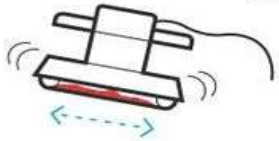
fig. 4

GUNSHOT WOUNDS

Caused by a bullet or other high-velocity projectile entering the skin. May result in two wounds (entry and exit).

Spatter: High-velocity

fig. 5



ABRASIONS

Scrapes caused by sliding against a rough surface.

Spatter: Wipes

fig. 6

PUNCTURE WOUNDS

Caused by a thin, pointy object puncturing the skin.

Spatter: Low-velocity, wipe

PRINCIPLES OF BPA: Basic properties of blood

- Blood contains both liquid (plasma and serum) and solids (red blood cells, white blood cells, platelets and proteins).
- Blood is in a liquid state when inside the body.
- When it exits the body, it starts to coagulate to form clots: Hence, the presence of blood clots in bloodstains can indicate that the attack was prolonged, or that the victim was bleeding for some time after the injury occurred.
- As blood exits the body, it can flow, drip, spray, spurt, gush or just ooze from wounds. All these ways of exit indicate different forms of injury.

PRINCIPLES OF BPA: Basic properties of blood

- On average, accounts for 8 % of total body weight *5 to 6 liters of blood for males*.
- *4 to 5 liters of blood for females.*
- A 40 percent blood volume loss, internally or/and externally, is required to produce irreversible shock (death).
- A blood loss of 1.5 liters, internally or externally, is required to cause incapacitation.

ANALYSIS OF A BLOOD STAIN

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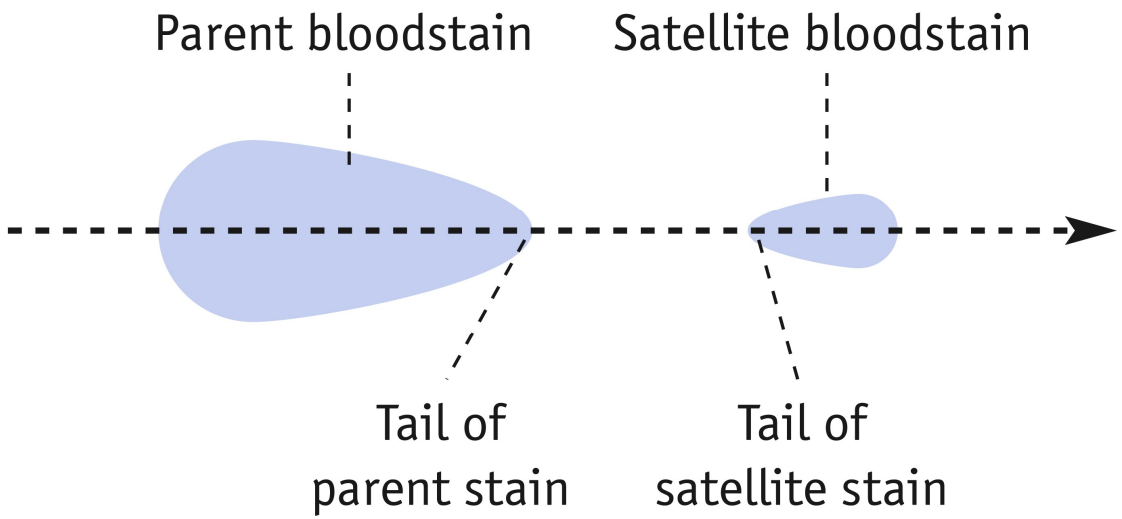


Figure 5.7 Parent and satellite bloodstains (arrow shows direction of travel)

Parent Drops & Satellite spatters

Parent Drop?

- A drop of blood from which a cast-off or satellite spatter originates.

Satellite Spatter?

- Small droplets that break off from the parent spatter upon impact with a target surface.

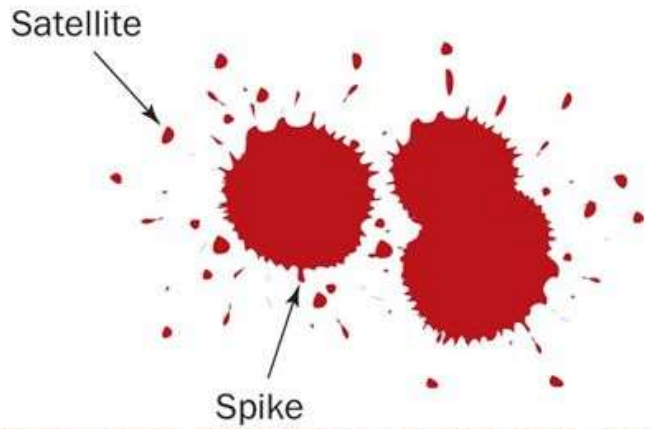
BLOOD SPLATTER ANALYSIS

Satellite droplets—

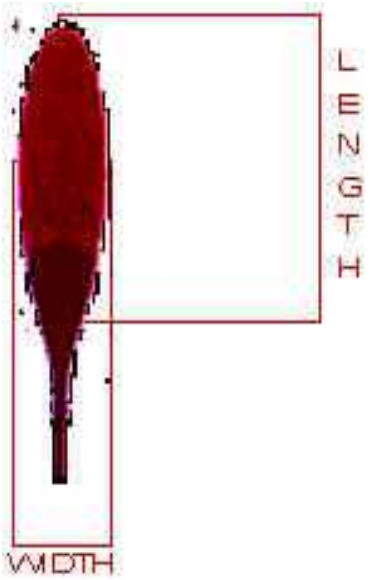
- When blood falls from a height, or at a high velocity,
- It overcomes its natural cohesiveness, and
- Separates from the main droplet

Spiking patterns—

- Form around the droplet edges when blood falls onto a less-than-smooth surface



ANALYSIS OF A BLOOD STAIN



- Work backwards from blood spatter to determine "launch position" of blood.

ANALYSIS OF A BLOOD STAIN

ANALYZING THE PATH OF A BLOOD DROPLET

After determining the type of spatter and weapon likely used, forensic analysts look at the shape of individual droplets to mathematically determine their point of origin.

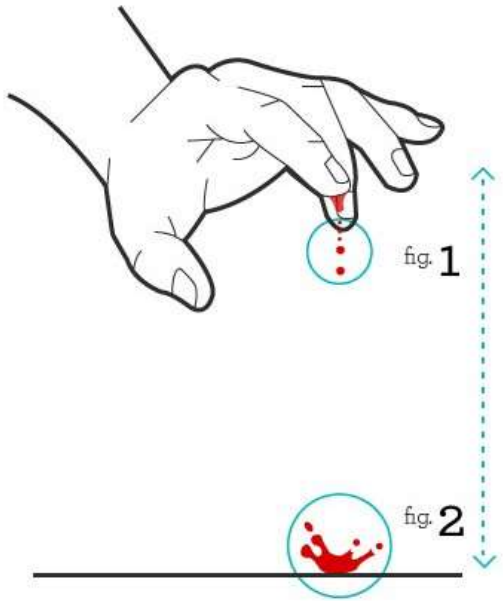
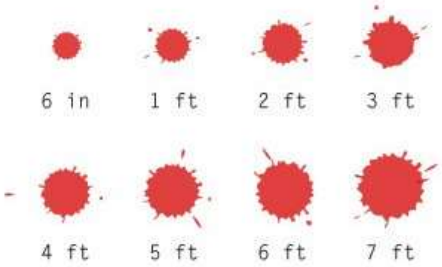


fig. 1

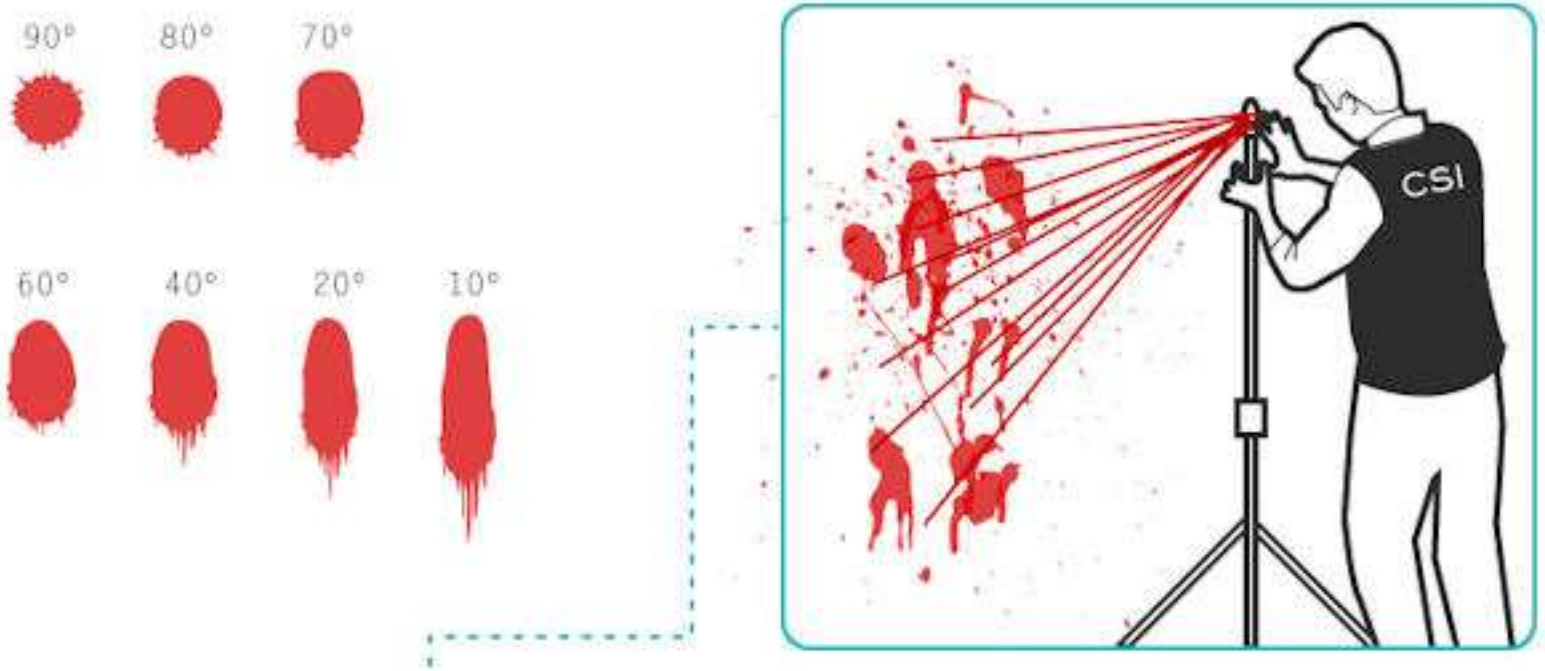
Though blood droplets form at the edge of a surface as teardrops, they travel as spheres.

fig. 2

The diameter of a blood stain increases with the height from which it was dropped.



ANALYSIS OF A BLOOD STAIN



ANALYSIS OF A BLOOD STAIN

- Bloodstain pattern analysis is performed in two phases: pattern analysis and reconstruction.

1. **Pattern Analysis** looks at the physical characteristics of the stain patterns including size, shape, distribution, overall appearance, location and surface texture where the stains are found. Analysts interpret what pattern types are present and what mechanisms may have caused them.

2. **Reconstruction** uses the analysis data to put contextual explanations to the stain patterns: What type of crime has occurred? Where is the person bleeding from? Did the stain patterns come from the victim or someone else? Are there other scene factors (e.g. emergency medical intervention, first responder activities) that affected the stain patterns?

- To help reconstruct events that caused bloodshed, analysts use the direction and angle of the spatter to establish the areas of convergence (the starting point of the bloodshed) and origin (the estimation of where the victim and suspect were in relation to each other when bloodshed occurred).

ANALYSIS OF A BLOOD STAIN

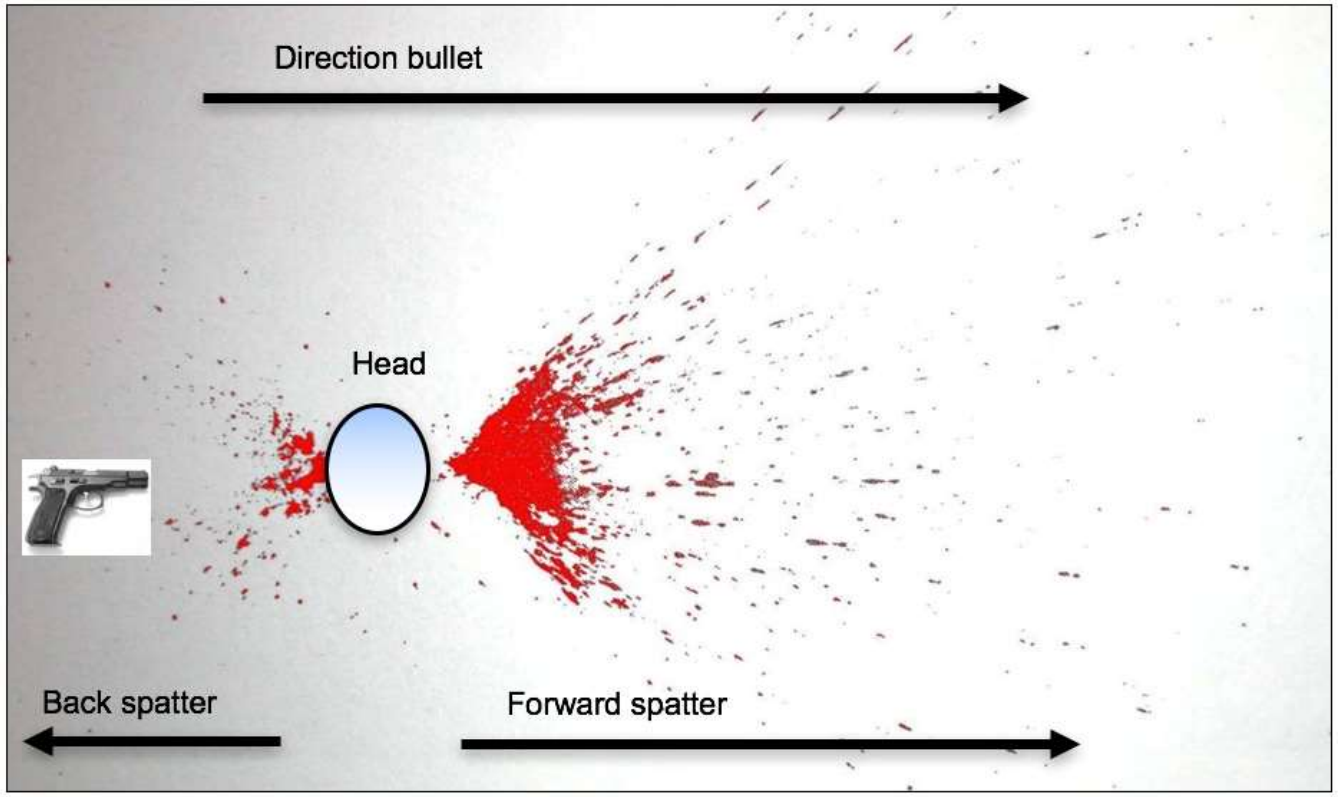
- To find the area of convergence, investigators typically use string to create straight lines through the long axis of individual drops, following the angle of impact along a flat plane, for instance the floor or wall where the drops are found. Following the lines to where they intersect shows investigators where the victim was located when the drops were created.
- To find the area of origin, investigators use a similar method but also include the height calculations. This creates a 3-D estimate of the victim's location when the drops occurred. For example, if the area of origin is determined to be only two feet above the area of convergence on the floor, the analyst may presume the victim was either lying or sitting on the floor. If it is five feet above the convergence, the victim may have been standing. This analysis can be done using strings and a protractor, mathematical calculations or computer models.

ANALYSIS OF A BLOODSTAIN

Tools used to determine area of convergence and area of origin include:

- Elastic strings and protractors
- Mathematical equations - (tangent trigonometric function) AOI=Sin -1 (W/L)
- Computer software programs such as BackTrack™ or Hemospat
- Limiting angles method, which examines the physical evidence to exclude angles from analysis (e.g. if blood is found on the underside of a desk or table, analysts know that at least a portion of the spatter-producing event took place below the height of the desk or table.)
- BPA can range from investigation and analysis of bloodstain patterns at the crime scene to bench work in the laboratory analyzing and DNA profiling the blood. Limited analysis can also be done using only photographs of the scene.

ANALYSIS OF A BLOOD STAIN: Gun Shot Injury



ANALYSIS OF A BLOODSTAIN: The Use of Luminol

- Luminol is a chemical agent that exhibits luminescence in form of a blue glow when mixed with an appropriate oxidizing agent.
- Haemoglobin in blood contains iron(Fe) which is the oxidizing agent. It reacts with Iron in the blood to produce luminescence.
- Some bloodstains cannot be seen with the naked eye. Investigators use Luminol to find and photograph bloodstains. When sprayed on blood, *Luminol* glow lasts for about 30 seconds which can be captured with a long-exposure photograph for documentation.

ANALYSIS OF A BLOODSTAIN: The Use of Luminol

A simulation of luminol at work: Before spraying luminol, there's no sign of blood. After spraying luminol, the latent blood traces emit a blue glow.

Investigators will spray a suspicious area, turn out all the lights and block the windows, and look for a bluish-green light. If there are any blood traces in the area, they will glow. 03217962487 28/33

Limitations & Drawbacks of the Use of Luminol

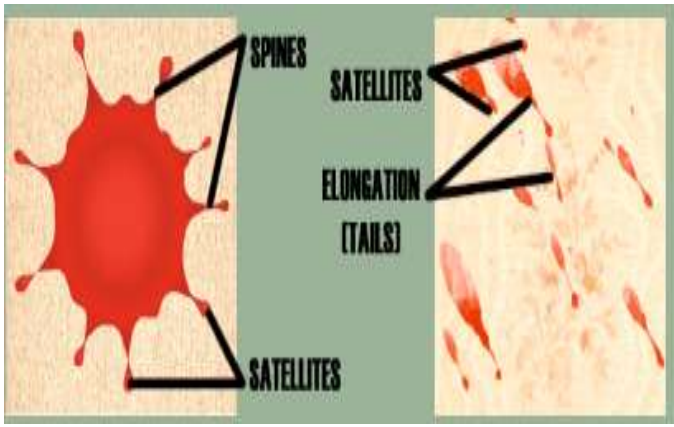
- Luminol chemiluminescence can also be triggered by a number of substances such as copper-containing chemical compounds and certain bleaches. As a result, if someone cleans a crime scene thoroughly with a bleach solution, organic evidence such as blood will be effectively camouflaged.
- Luminol can detect the small amount of blood present in urine. Hence evidence can be distorted if animals' urine is present in the room being tested.
- Luminol reacts with faeces, causing the same glow as if it were blood.
- Luminol's presence may prevent other tests from being performed on blood. For this reason investigators explore a lot of other options before using it. It is definitely a valuable tool for police work, but it's not quite as prevalent in crime investigation as presented on some TV shows. The police don't walk into a crime scene and start spraying luminol on every visible surface.
- Excessive smoke in an enclosed space—for example, a car that someone frequently smokes in—can cause positive results with Luminol.

ANALYSIS OF A BLOODSTAIN: Alternatives to Luminol

- Investigators may use other chemiluminescent chemicals, such as **fluorescein**, instead of luminol. These chemicals work the same basic way, but the procedure is a little bit different.
- Steam thermography: This has been found not to affect DNA testing of the blood, plus it isn't fooled by bleach, rust or coffee stains – all of which can be misread as blood by luminol.

INTERPRETING THE PATTERNS

- When blood is impacted, droplets are dispersed through the air.
- When these droplets strike a surface, the shape of the stain changes depending on the angle of impact, velocity, distance travelled and type of surface impacted.
- Generally, the stain shape will vary from circular to elliptical, with tails or spines extending in the direction of travel.
- Smaller satellite stains may also break away from the initial drop. By measuring the width and length of the stain, the angle of impact can be calculated.



INTERPRETING THE PATTERNS

- As the angle of impact changes, so does the appearance of the resulting stain.
- A blood drop striking a smooth surface at a 90° angle will result in an almost circular stain with evenly distributed spines and satellites.
- As the angle of impact decreases, the spatter stain elongates, becoming more elliptical, and the spines, etc., become more predominant opposite the angle of impact.
- At very low (acute) angles, a single satellite may break off to form a second stain; this is the distinctive "exclamation point" stain.

INTERPRETING THE PATTERNS

- **Void Patterns**

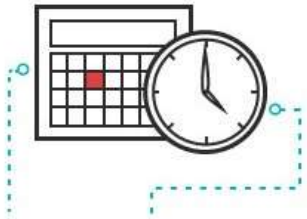
A void occurs when a person or object blocks the path of the blood. They are important because voids can show investigators if objects are missing from the scene, where a person or persons were at the time of the incident, and if a body was moved. An object that leaves a void in a bloodstain pattern will have a matching bloodstain pattern on its surface, allowing analysts to replace it in the scene if found. Void patterns are most useful for establishing the position of the victim(s) and assailant(s) within the scene.

INTERPRETING THE PATTERNS: Questions that can be answered through BPA

- Where did the blood come from?
- What caused the wounds?
- From what direction was the victim wounded?
- How were the victim(s) and perpetrator(s) positioned?
- What movements were made after the bloodshed?
- How many potential perpetrators were present?
- Does the bloodstain evidence support or refute witness statements?

WHAT BPA CAN DETERMINE

fig. 1

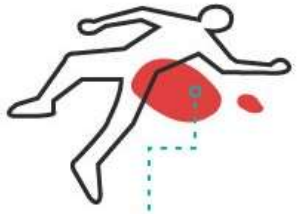


Date and time of crime

fig. 2

Type and velocity of weapon

fig. 3



Movements/position of those involved

fig. 4

If the assailant was left or right handed

fig. 5

Types of injuries dealt

fig. 6

Whether death was immediate

HOW BLOOD STAIN EVIDENCE IS COLLECTED

- Bloodstain samples can be collected for BPA by cutting away stained surfaces or materials
- photographing the stains
- drying and packaging stained objects.

The tools for collecting bloodstain evidence usually include

- high-quality cameras (still and video)
- sketching materials
- cutting instruments
- Evidence packaging.

HOW BLOOD STAIN EVIDENCE IS COLLECTED

- The most frequently used method of capturing bloodstains is high-resolution photography. A scale or ruler is placed next to the bloodstain to provide accurate measurement and photos are taken from every angle. Video and sketches of the scene and the blood stains is often used to provide perspective and further documentation.
- Analysts or investigators will typically soak up pooled blood, or swab small samples of dried blood in order to determine if it is human blood and then develop a DNA profile.

BENEFITS OF BPA TO A CRIME INVESTIGATION

- More accurate reconstruction of the crime event
- Corroboration of statements from witnesses
- Corroborate laboratory investigations
- Corroborate post-mortem findings
- Includes and excludes potential perpetrators from the investigation
- Answer questions like: What occurred? Where did the events occur? Approximately when and in what sequence? Who was there? Where were they in relation to each other? What did not occur?

SHORTFALLS OF BPA TO CRIME INVESTIGATION

- It cannot recreate the entire scenario, as there are unknown variables that analysts cannot account for using scientific methods.
- The analyst cannot tell if a perpetrator was older or younger, if an attack was planned or spontaneous, or if drugs or alcohol influenced the perpetrator (unless their blood was left behind).

CONCLUSION

- BPA is invaluable to investigation of crime scenes.
- It majorly requires intellectual resource and can be immediately started at the crime scene with easily accessible tools.
- A well carried out BPA can revolutionise an investigation and solve mysteries.

THANK YOU.