blood found at a crime scene resulted in data with the following characteristics: Type A, N, Hp-1, Rh–, PGM-2. What is the probability of someone having all of these blood proteins?

The probability of finding another person in the population with the same blood type can be calculated by finding the product of the individual probabilities:

Type A × N × Hp-1 × Rh– × PGM-2 = occurrence of this combination in the population. Substituting, 0.42 × 0.22 × 0.14 × 0.15 × 0.06 = 0.000116, or about 1 in every 8,600 people should have this combination of blood-type proteins. By testing for more blood-type proteins, the probability for uniqueness continues to increase, and the number of other people with the same combination as our suspect decreases.

* Put in blood spatter packet.

BLOOD SPATTER

When a wound is inflicted and blood leaves the body, a blood-spatter pattern may be created. A single stain or drop of blood does not constitute a spatter. Instead, a grouping of bloodstains composes a blood-spatter pattern. This pattern can help reconstruct the series of events surrounding a shooting, stabbing, or beating.

HISTORY OF BLOOD-SPATTER ANALYSIS

In 1894, Pitoroski wrote the earliest reference to blood-spatter analysis. In 1939, Balthazard was the first researcher to analyze the meaning of the spatter pattern. In 1955, blood-spatter evidence was used by the defense in the Sam Shepard case, helping to exonerate him. In 1971, Dr. Herbert MacDonnell used blood-spatter analysis as a tool in modern forensic examinations. Today, blood-spatter evidence is used to explain events at a violent scene.

BLOOD-SPATTER ANALYSIS

In the laboratory activities in this chapter, you will study how blood-spatter patterns can be used to recreate a crime scene. Given blood-spatter patterns, it is possible to determine the direction the blood was traveling, the angle of impact, and the point of origin of the blood. Blood-spatter patterns can help determine the manner of death, based on the blood velocity. Instructions on blood-spatter analysis are provided within each activity.

Did you ever wonder why blood forms droplets as it falls from a wound? If blood is a mixture, then why doesn't it separate in the air before it hits the ground or an object? Why does a drop of blood have a curved surface when it lands on a flat surface instead of spreading out flat? The answers to these questions have to do with what happens when the forces of gravity, cohesion, adhesion, and surface tension act on blood.

Recall that blood is a thick mixture of blood cells and plasma. When a person is injured and is bleeding, gravity acts on blood, pulling it downward toward the ground (Figure 8-12). The blood droplet has a tendency to become longer than it is wide as a result of gravity (Figure 8-13). Blood is cohesive. This means that the blood mixture is attracted to similar blood mixtures and tends to stick together and not separate as it falls (Figure 8-14).

Figure 8-12. *A falling droplet of blood.*

Figure 8-13. *The effect of gravity on blood.*

Figure 8-14. *The cohesive forces in a blood droplet.*

The effect of the downward force of gravity combined with the cohesive force of the blood results in a net effect on the blood droplet as it falls. Thus, the blood maintains a circular or round appearance.

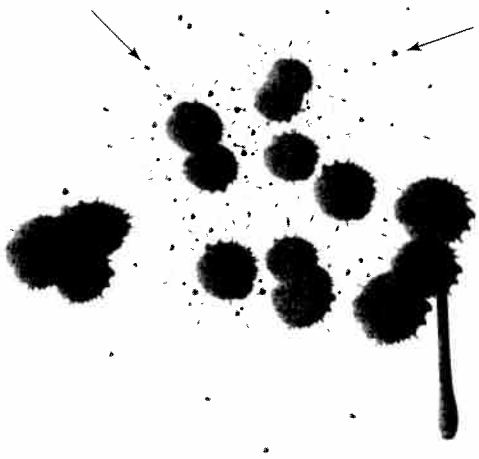
When a drop of blood falls on a flat surface, the blood drop will have a curved surface. The blood drop does not totally flatten out (Figure 8-15). The reason for this shape is the cohesive nature of blood causing the blood to pull together and resist flattening out on a surface. The result is that the surface of the blood is elastic, giving the top of the blood spatter a spherical appearance.

Figure 8-15. *Cohesive forces resist droplet flattening.*

If any of the blood does overcome cohesion and separate from the main droplet of blood, it will form small secondary droplets known as **satellites** (Figure 8-16).

Figure 8-16.

Note the smaller satellites are not attached to the main drop of blood but have broken free

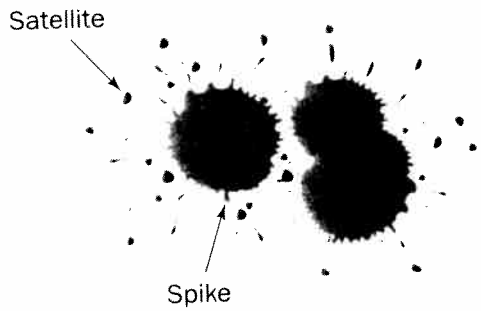


If blood is dropped onto a smooth surface, such as glass or marble, the edge of the blood drop appears smooth and circular. However, if the blood lands on a porous surface, such as wood or ceiling tile, then the edge of the drop of blood may form small spikes or extensions (Figure 8-17). Notice that spikes are still connected to the main droplet of blood, whereas satellites are totally separated.

In 1902, Dr. John Glaister first described the six patterns into which blood spatters could be classified. They include:

1. Blood falling directly to the floor at a 90-degree angle will produce circular drops, with secondary satellites being more produced if the surface hit is textured. This is known as a passive fall.
2. Arterial spurts or gushes typically found on walls or ceilings are caused by the pumping action of the heart.
3. Splashes are shaped like exclamation points. The shape and position of the spatter pattern can help locate the position of the victim at the time of the attack.
4. Smears are left by a bleeding victim depositing blood as he or she touches or brushes against a wall or furniture.
5. Trails of blood can be left by a bleeding victim as he or she moves from one location to another. The droplets could be round or smeared or even appear as spurts.
6. Pools of blood form around a victim who is bleeding heavily and remains in one place. If the bleeding victim moves to another location, there may appear to be droplets or smearing connecting the first location with a second.

Figure 8-17. *Satellites and spikes in a blood drop pattern.*



The size and shape of blood droplets help identify the direction from which the blood originated. Round droplets, for example, are caused by blood dripping downward at a 90-degree angle. Blood droplets with tails or satellite droplets help us determine the direction from which the blood originated.

Spatter patterns can help the investigator determine the type of wound. A fine-mist spatter pattern is produced by a high-velocity impact, such as a gunshot wound. A beating with a pipe will produce blood cast off with a lower-velocity pattern. Voids (empty spaces) in the spatter pattern could help determine the presence of a person or object moved after the attack.

By using the spatter pattern to determine the angle of impact of various blood droplets, the examiner can determine the point of impact or convergence, a two-dimensional representation of the location of the victim at the time of the injury.

The **point of origin** can next be determined by the mathematical relationship between the width and length of the blood droplets. These relationships will be addressed in the activities section.

EXAMINATION OF DIRECTIONALITY OF BLOOD

The shape of an individual drop of blood provides clues to the direction from where the blood originated. A circular drop of blood (width and length are equal) indicates that the blood fell straight down (90-degree angle of impact). This is typical if the blood was passively produced (without any force). This would be typical of blood dripping from a wound.

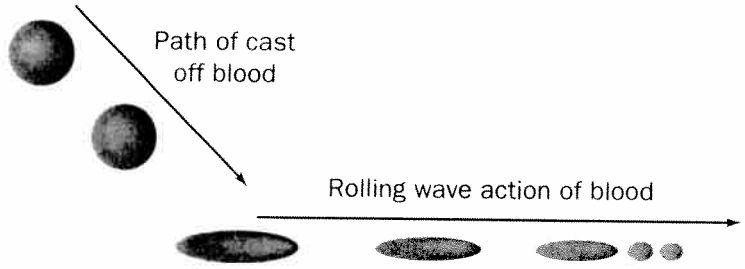
When a blood drop is elongated (longer than it is wide), it is possible to determine the direction the blood was traveling when it struck a surface.

As moving blood strikes a surface, several forces affect the droplet of blood. These forces are cohesion, adhesion, and surface tension. *Cohesion* is a force between two similar substances. *Adhesion* is a force between two unlike surfaces, such as blood and the surface of a wall. *Surface tension* is an elastic characteristic along the outer edge of a liquid caused by the attraction of like molecules.

When blood comes into contact with another surface, the blood tends to adhere or stick to it. As a result, the point of impact may appear to be darker and wider than the rest of the drop of blood spatter (Figure 8-18).

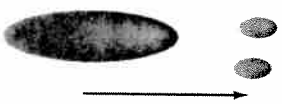
Perpetrators often try to remove blood evidence from a crime scene. If blood has fallen on a floor, even if the floor is washed hundreds of times, blood can still be detected with Luminol.

Figure 8-18. *Pattern of cast-off blood.*



Momentum tends to keep the blood moving in the direction it was traveling. As it travels, some of the blood adheres to the new surface. However, because of cohesion, most of the blood tends to remain as one drop. As blood droplets move away from their source, the blood droplet elongates and may produce a thinner tail-like appearance. The tail points in the direction of blood's movement. Smaller satellite or secondary droplets may break away from the main drop of blood. These satellites will appear in front of the moving droplet of blood (Figure 8-19). Note that satellites are not connected to the main drop of blood.

Figure 8-19. *Satellite drops.*

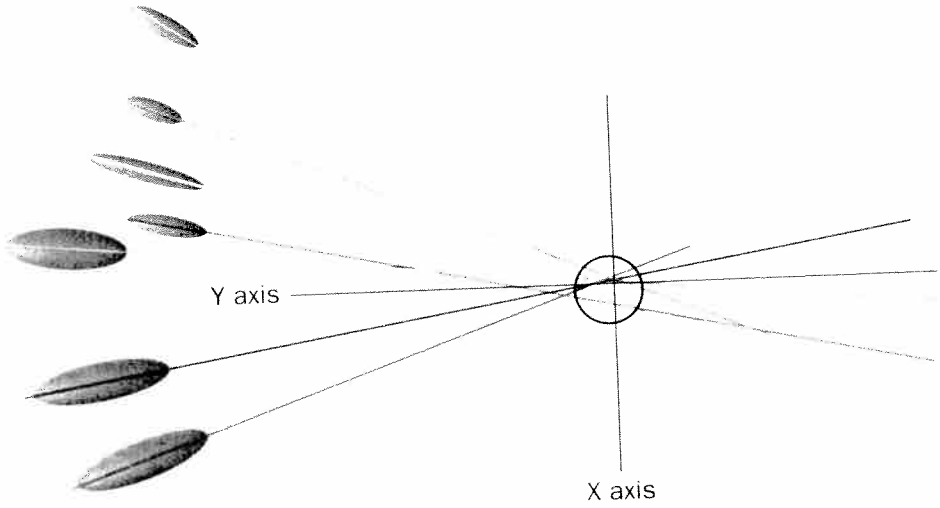


Direction blood is traveling

LINES OF CONVERGENCE

The location of the source of blood can be determined if there are at least two drops of blood spatter. By drawing straight lines down the long axis of the blood spatter and noting where the lines intersect, this will indicate the **lines of convergence** (Figure 8-20). When there are numerous blood spatters, the area where the lines of convergence meet is where the source of blood originated. One can draw a small circle around this intersecting area to note the area of convergence. The circle locates the area of convergence and identifies in a two-dimensional view the location of the source of the blood.

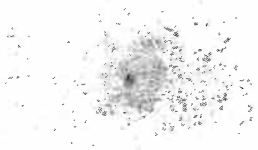
Figure 8-20. Lines of convergence.



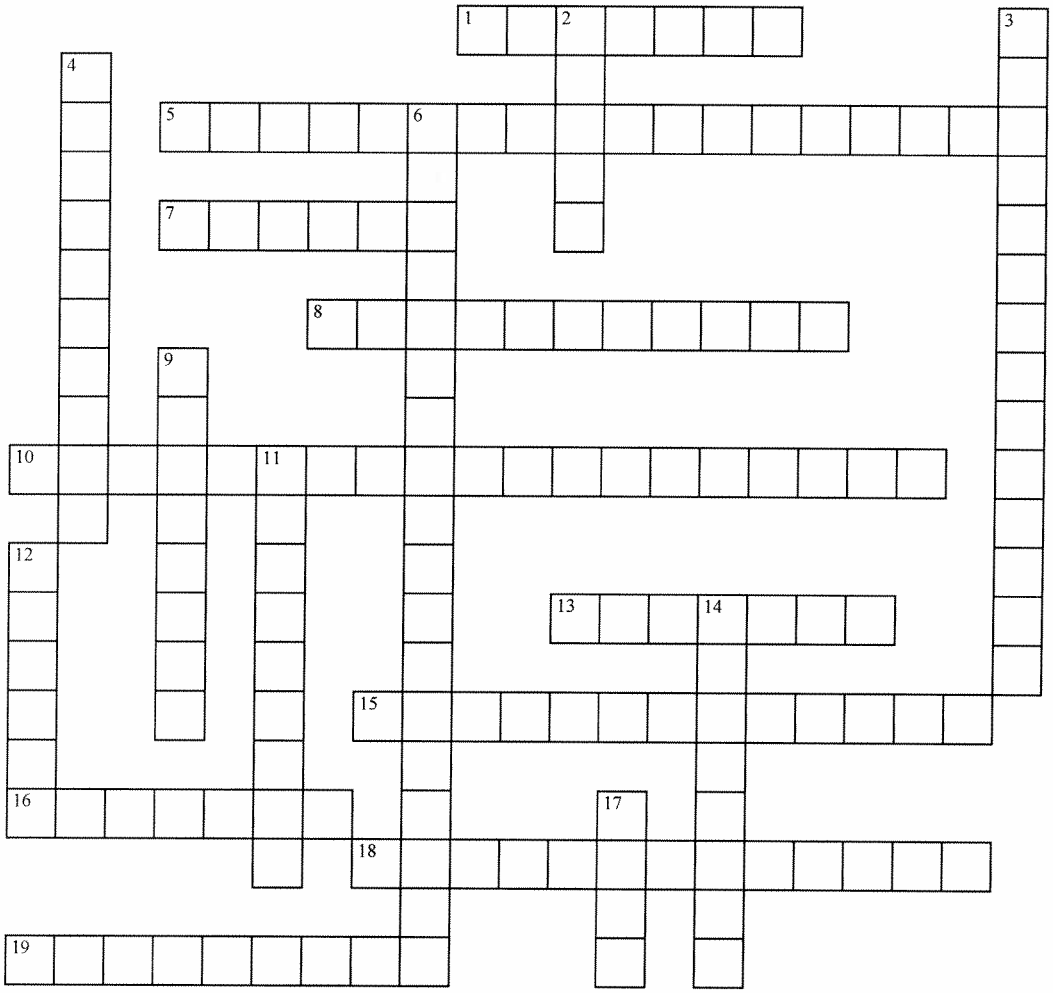
BLOOD SPATTER TYPES

Blood spatter may also be classified by its speed or velocity on impacting a surface (Figure 8-21).

Figure 8-21. Table of blood-spatter parameters.

Velocity	Size of Droplets (mm)	Visual Image	Velocity of Blood	Examples of Injuries
High	Less than 1		100 ft/sec.	Gunshot wounds
Medium	1–4		25 ft/sec.	Beating, stabbing
Low	4–6		5 ft/sec.	Blunt object impact

Blood Spatter Vocabulary



Glue on page 49.

After you're done, draw 5 pictures to represent some of the terms you learned about.

Pictures go on page 48.

ACROSS

1 Results when blood flies off an object in motion (2 words)
5 Spatter pattern that can result from impact with blunt object
7 Point where the blood came from
8 Blood dropping from 90 degrees (2 words)
10 Fine mist spatter resulting from gunshot wound (3 words)
13 Force that pulls an object down
15 Blood pattern that results due to pumping action of the heart (2 words)
16 A grouping of bloodstains
18 Angle at which a blood droplet strikes a surface (3 words)
19 Blood that breaks free from a main drop of blood

DOWN

2 Transfer of blood onto a surface by a bloody object
3 Force caused by intermolecular forces at the surface of a liquid
4 Path left by a bleeding victim as they are moved from one location to another (2 words)
6 Identifies the location of the source of blood
9 Force that holds blood molecules together
11 Longer than it is wide
12 Pointed edges of a stain (connected to main drop)
14 Speed
17 An area inside a bloodstain that is absent of blood