BALLISTIC imaging is a technique used to link a bullet to the specific gun from which it was fired. Additionally, it may also be used to link multiple crimes together in which the same gun was used in what is often referred to as a “cold hit”. This recognition may be done by computers or trained individuals. In the case of computers, programs analyze and identify markings left on the bullets after they are fired, and this information is then compared with a database of known bullet marking patterns from different types of firearms.

Cartridge based firearm ammunition is composed of four essential parts:

1. Bullet – the metal projectile that is propelled from the gun
2. Cartridge – a case that holds the bullet, primer, and gun powder
3. Gunpowder – the source of energy to project the bullet
4. Primer – a shock sensitive material located at the base of the cartridge that ignites the gunpowder when struck by the firing pin

To understand the ballistic markings on a bullet, it is useful to understand the mechanics of how each firearm works. In a semiautomatic firearm (i.e. a gun that does not require the user to manually cock the gun’s hammer or set a bullet before every shot fired), the bullet is fired by pulling the trigger which releases a spring that rams the firing pin into the end of the cartridge. This causes the primer to ignite the gunpowder that supplies the energy to project the bullet from the barrel of the gun. As the bullet travels down the barrel it is squeezed through spiral grooves, called barrel rifling, which cut into the side of the bullet and impart a spin upon the projectile. This stabilizes the bullet as it exits the muzzle of the weapon, improving accuracy in the same manner in which a quarterback’s spiral pass improves the accuracy of a football. The markings made by the rifling on the bullet are called striations, or striae. The grooves (or scratches) and lands (or raised surfaces) are the portion of the bullet examined by the computer programs and experienced professionals to link crime scene bullets to the gun that fired them. Only bullets used from handguns and rifles can be used for ballistic imaging because shotguns fire a cartridge that contains tiny pellets or a metalslug and possess a smooth, un-rifled barrel that does produce consistent markings. The cartridges from a fired bullet will also have identifying marks on its surface. With semiautomatic firearms, the cartridge is automatically ejected from the gun and is usually left at the scene unless the criminal has equipped their firearm with a spent cartridge catcher. Cartridges are often not present at the crime scene if a revolver is used, however, as the used cartridges are manually removed from the gun during reloading.

These markings have the potential to be consistently made over and over again on each bullet that is fired, with each individual gun leaving a similar pattern. Many people refer to this as ballistic fingerprinting. The word “fingerprinting” implies that the mark is unique and unchangeable from each bullet fired. The truth, rather, is that these markings change over the lifetime of a gun as the barrel rifling is worn down by bullets traveling through the chamber and by cleaning. The barrel of a gun can also be easily altered with a nail or metal file or by shooting the bullets after putting dirt, powder, or even toothpaste on the bullets or in the gun barrel. This makes the investigator’s job much more difficult, or even impossible.

By the year 1500, barrel rifling had been introduced by the German Emperor Maximilian. This new way
Ballistic Imaging

of making gun barrels was thought to improve accuracy and precision. The lands and grooves left on bullets after firing them, however, was not used to link a gun and bullet together until much later, as it was not until the end of the 1800's that this idea was introduced as a form of firearms identification. Alexandre Lacassagne (1844-1921) of France was one of the first to attempt to identify and match an individual bullet to a gun barrel. A physician working in the forensic medicine division of the University of Lyon, Lacassagne wrote an article outlining his findings which served to pave the way for further development of the science of ballistic imaging.

As this new concept began to enter into the field of forensic analysis, a more sophisticated and precise technology was developed to compare questioned bullets and the standards fired by the gun in question. Calvin Goddard, one of the men that developed this technology, designed a microscope to closely compare marks left on multiple bullets to one another. At that time, the design of typical microscopes enabled an examiner to look at just one bullet at a time, making bullet comparison difficult. The examiner had to remember the pattern of marks on one bullet and then separately view the other bullet. In 1925, the comparison microscope was invented, comprised of two microscopes connected by an optical bridge. This design allowed separate objects to be viewed simultaneously in a split-view window. The viewer could then immediately note findings between the two items without having to use two separate microscopes or having to switch back and forth between the two items. When using a comparison microscope today to compare striae, the comparison objects are lined up to find similarities. If similarities are not found between the bullets, they cannot be associated with a common gun. Bullets are typically examined under a reflective light with a magnification between 5x and 100x.

Comparison microscopes are still today used in ballistic imaging comparisons, however many improvements to their accuracy and efficiency have been made since that time. Modern comparison microscopes have video capabilities, digital imaging, and fiber optic illumination allowing photos to be taken for future reference and courtroom presentation while the bullets are in the microscope. Visualization tools have also been developed that mimic
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the operation of the comparison microscope. These
programs often give the viewer the option of a 2D
or 3D view of the surfaces and even allow the ex-
aminer to examine striiae in comparison with one
another by overlapping the two. While many re-
finements have been made to the original model,
remarkably, it remains the same basic concept
Goddard developed nearly a century ago. With this
important technological advancement, ballistic im-
ageing became an important aspect of the forensic
sciences.

When examiners are looking at the evidence at a

Handguns, rifles, and shotguns are the most common small arms used by criminals. Rifles have long bar-
rels that help to provide a more accurate bullet trajectory. They are designed for long range targets up to
300 meters. Handguns have short barrels and are designed primarily for close range targets less than 45
meters. Shotguns are designed for short to medium range targets up to 100 meters.

The caliber of a firearm and the bullets used in
the gun are a measure-
ment of the diameter of the barrel. The diam-
ter of handguns and
rifles are measured in
inches or millimeters.
The guns or bullets that
are measured in inches,
such as 0.22 inches, are
referred to as a 0.22
caliber (read as: twen-
ty-two caliber). A pistol
that uses 9mm bullets
is simply referred to as
a “9mm pistol.”

Each gun has a twist ra-
tio that is related to the
barrel, caliber of the
bullet, and weight of the bullet. The twist ra-
tio determines the best
bullet weight for each
caliber and the velocity of the bullet by giving it the correct rotational velocity (spin) to keep the bullet
from turning end-over-end. This gives the gun better accuracy. The twist is given as a ratio, such as 1:10,
where the 1 is 1 twist and the 10 means 10 inches in the length of the barrel. Together, the numbers mean
that the bullet rotates one time for every 10 inches it travels down the barrel.
Ballistic Imaging

A controlled environment is called a standard. Once a consistent pattern is seen among these standards, the standards may be compared and examined closely by the expert. A comparison microscope is used by the expert to see if the lands and grooves of the bullet from the crime scene match the lands and grooves exhibited by the standards. Most positive matches use the lands at the base of the bullet because the base is usually the least damaged on impact. As most bullets collected at crime scenes are damaged when they are fired, it is often more accurate to examine the markings on the cartridge case left by the gun. These markings are more likely to be consistent each time the gun is fired.

The ability to link a bullet to the gun that fired it has been very useful in the forensics field. Several cases have been solved with ballistic imaging. In drive-by shootings, frequently the expelled bullet may be the only evidence left behind. In September 1995, a 19-year-old factory worker died as the result of a gunshot wound to the head from a bullet fired from a passing car. It was not until August 2003, that the Chicago Police Department was able to identify the firearm that shot the fatal bullet. During a vehicle traffic stop for an ordinance violation, the driver was arrested for unlawful possession of a firearm. When the firearm was compared with the National Integrated Ballistic Information Network (NIBIN), a match was made to the bullet from the 1995 murder. After further investigation, it was determined that the firearm was purchased one day prior to the murder. The purchaser then transferred the firearm to the shooter, and the shooter sold the firearm shortly after the murder. The shooter was convicted of murder in November 2007, and received a 50 year sentence.

Another ballistic imaging case occurred in the areas of West Palm Beach, Palm Beach Gardens, and Riviera Beach, Florida, where a violent crime spree that took place between August and December 2004. In August, police responded to two double homicides; one near a shopping mall and another on a public street. In October, a meat distributor’s truck and another car were both carjacked by
armed criminals, and, in December, a shooting occurred outside of an area restaurant. In November 2004, the Riviera Beach Police found an abandoned .380 caliber (9mm) pistol and were able to arrest a suspect. Then, in December 2004, the Palm Beach Gardens Police found a discarded .40 caliber pistol at the scene of the armed carjacking. Two suspects, including a felon, were then arrested, and, using NIBIN, the .40 caliber pistol was linked to both of the double homicides and the shooting at the restaurant. The .380 caliber pistol was linked to one of the double homicides, and all three suspects were charged, convicted, and sentenced to 20-40 years imprisonment.

In an effort to maximize the results of forensic bullet analysis, databases of bullet standards have begun to be utilized in several states, such as California, Massachusetts, and New York, and, recently, there has been a push by legislatures to create a comprehensive national database that would require all current gun holders, gun manufacturers, and purchasers to register their bullet standards. These databases would be used to match the pattern of a bullet in question to a gun that was pre-registered in the database. In theory, this would give law enforcement the ability to track the gun back to the original purchaser.

The proposed database would produce a list of possible gun matches and give law enforcement a “match score” according to the similarity to the bullet or cartridge case. Despite the improvements created by such a database, the logistics of compiling a database is complicated by the fact that, in the United States, there are already over 200 million firearms, and implementing such a database questions a variety of legal and constitutional issues. The Bureau of Alcohol, Tobacco, Firearms, and Explosives (BATFE), however, has amassed a national database (the National Integrated Ballistic Information Network, NIBIN), that compiles ballistic images from bullets and cartridge cases, and this database is utilized to compare images in the database with guns that have been collected from crime scenes or confiscated from criminals. Over 1.6 millions im-
As investigators collected evidence from inside and around the cabin, they discovered a bullet lodged in the mud outside. After searching for other bullets or bullet holes, both inside the cabin and out, no additional bullet evidence was located. They collected the bullet for further evidence processing.

When the blue Ford Ranger with the Tumbling Water Land Development Co. logo was found in New Mexico, authorities searched the truck for evidence. Under a blanket behind the seat, they discovered an unloaded handgun. The firearm was collected, packaged, and sent to the Highland Park authorities for processing and analysis where authorities hoped to determine if the bullet found at the cabin was fired by the gun found in the truck. A bullet from the gun found in the truck was test-fired to compare the striae to the bullet collected from the cabin crime scene.
Persons of Interest

The Mondelos

Louise Ann Mondelo, the 38 year old wife of Lyle Mondelo and mother of Wally and Jan, 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, the 40 year old husband of Louise Mondelo and father of Wally and Jan, is a part owner of Tumbling Water Land Development Company along with his wife.

John Wayne Gretzky

John Wayne Gretzky is 41 years old. He is a friend and business partner of the Mondelo’s in the Tumbling Water Land Development Company. According to rumors, 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.

An unknown woman of similar height and build has been identified as Louise Mondelo. Although her identity is uncertain, this other woman was found either driving the Mondelo family car with two children preliminarily identified as Wally and Jan, or in a remote fishing cabin with a man who has been preliminarily identified as Louise’s husband Lyle Mondelo.
1. What are the four essentials parts of a bullet?

2. How is ballistic imaging a useful forensic technique?

3. How does a bullet receive striations when it is fired?

4. What are lands and grooves?

5. What is a comparison microscope?

6. Why do investigators look for the cartridge case at the scene of the crime?

7. What is the typical controlled environment for firing a bullet to examine the striations?
Lab Procedure

Lab 1: Learning to look at striations

1. Examine Bullet A with a magnifying glass or under a microscope at a very low magnification. Examine the striations on the fired bullet.

2. On your data collection sheet, record the patterns you see. Describe, or draw, the marks observed, paying close attention to the distance between the striae and the length of each individual mark. Rotate the bullet and record the striations you see from another angle. Firearm examiners examine the entire bullet, so be thorough in your observations.

3. Examine Bullet B with a magnifying glass or under a microscope at a very low magnification. Examine the striations on the fired bullet.

4. On your data collection sheet, record the patterns you see. Describe, or draw, the marks observed, paying close attention to the distance between the striae and the length of each individual mark. Rotate the bullet and record the striations you see from another angle. Look for similarities and differences between the two bullets.

5. Place both bullets side by side under the microscope or magnifying glass. Slide them back and forth and rotate them in attempt to detect similarities between them.

6. In your group, determine whether the same gun fired these two bullets or if they were fired from different guns.

Activity 1: Web Research on Guns and Bullets

7. The web activity portion of this lab may be found at www.firearmsid.com.

   Click on Resource Area > Virtual Comparison Microscope

8. In your groups, log on to the website and explore the links to learn more about bullet striations.

9. Experiment with the comparison microscope until you have matched the striations.

Lab 2: Examining the Evidence

1. Examine the evidence photos. One photo (Bullet 1) is of the bullet that was found at the cabin, while the other set of photos (Bullet 2) is of the bullet fired from the gun found in the abandoned truck.

2. As a group, record measurements between the striations.

3. Each person in the group should be responsible for taking measurements on one photo for each bullet. Draw the pattern from your photo and record the length of the marks and the distance between them.

4. As a group, compare your drawings and the lengths and distances from the photos and formulate a hypothesis about whether these bullets were fired from the same gun. With the knowledge you have gained, determine the events surrounding the crime.
# Data Collection and Calculations

**Bullet Examination:**

<table>
<thead>
<tr>
<th></th>
<th>Bullet A</th>
<th>Bullet B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight in mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of grooves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width of grooves (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of lands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width of lands (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rifling twist observed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color variations observed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other observations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Evidence Examination:**

Examination of photo: Photo Name ____________

<table>
<thead>
<tr>
<th></th>
<th>Bullet from cabin</th>
<th>Bullet from gun in truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of grooves visible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width of grooves (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of longest groove (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of shortest groove (in mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of lands visible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width of lands (in mm)</td>
<td></td>
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</tr>
</tbody>
</table>

Detailed diagram of bullet photo:
Post-Lab Questions

1. What similarities did you find between the two bullets you examined under your microscope or magnifying glass?

2. What differences did you find between the two bullets you examined under your microscope or magnifying glass?

3. What conclusion did your group reach? Were the bullets fired from the same gun?

4. What was the easiest way to compare the bullets?

5. What was the most difficult aspect of comparing the striations?

6. According to your research, what are land and groove impressions?

7. When looking at the evidence photographs, what conclusion did your group come to? Did the same gun fire the bullets? What led you to this conclusion?