

BALLISTICS

NOTES





Central Focus



- Students can **explain** ballistics including types of evidence collected. Students can **describe** and **interpret** ballistics evidence including bullet marking and trajectory paths .



Standards



- **SFS1. Students will recognize and classify various types of evidence in relation to the definition and scope of Forensic Science.**
- **SFS4. Students will evaluate the role of ballistics, tools marks and evidence of arson in forensic investigation.**
 - a. Identify firearm lab tests used to distinguish the characteristics of ballistics and cartridge cases.
 - b. Analyze the physics of ballistic trajectory to predict range of firing.



Day 1 - Essential Questions



- What is ballistics?
- How are guns classified?
- How are bullets classified?





Learning Targets. I can...



- **SFS4a – LK7:** **Explain** ballistics and its role in forensic science
- **SFS4a – LK8:** **Explain** basic working of a firearm
- **SFS4a – LR5:** **Compare/contrast** types of firearms
- **SFS4a – LR6:** **Compare/contrast** bullets, slugs, and shot



Ballistics

- Ballistics -scientific analysis of firearms, bullets, and the travel of projectiles in flight
- Firearm: weapon (ex. gun) capable of firing a projectile using a confined explosive.





Ballistics – finding the facts

- Ballistic experts establish facts during shooting-related crimes including...
 - type of firearm
 - caliber of bullet
 - how many bullets fired
 - where the shooter was positioned during the crime
 - whether the weapon has been used in previous criminal cases.

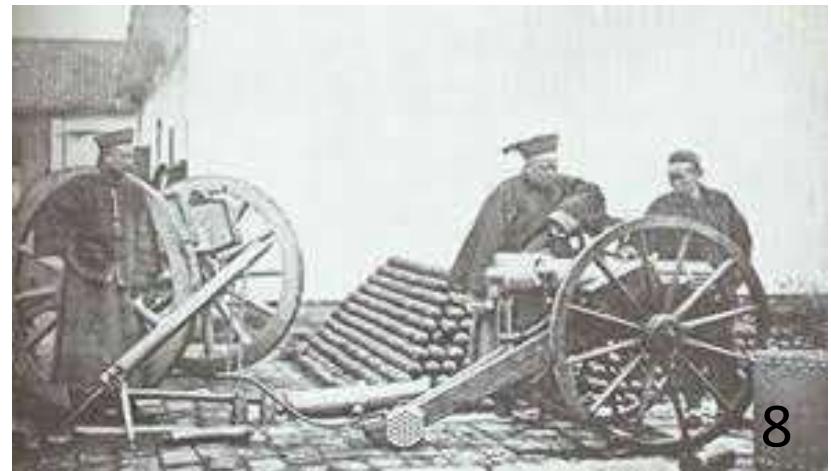




History of Firearms

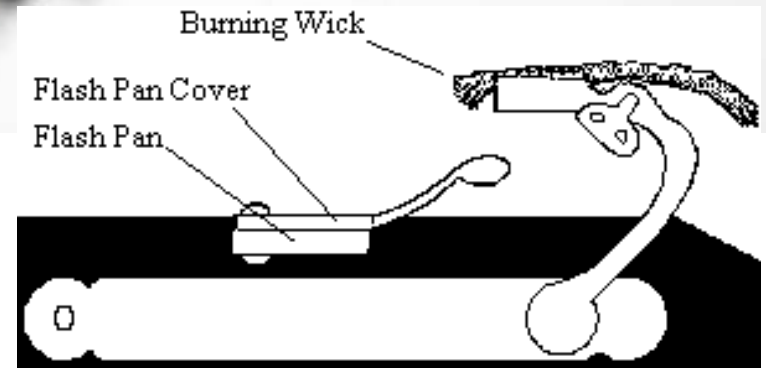
The Chinese invented gunpowder >1000 years ago to make fireworks and weapons.

- Gunpowder: mix of potassium nitrate, charcoal, and sulfur.
- gunpowder expands upon ignition and causes a violent explosion.





matchlock weapons: first firms; used wicks to ignite the gunpowder.



The Matchlock secured a lighted wick in a moveable arm which, when the trigger was depressed, was brought down against the flash pan to ignite the powder. This allowed the musketeer to keep both hands on the gun, improving his aim drastically.

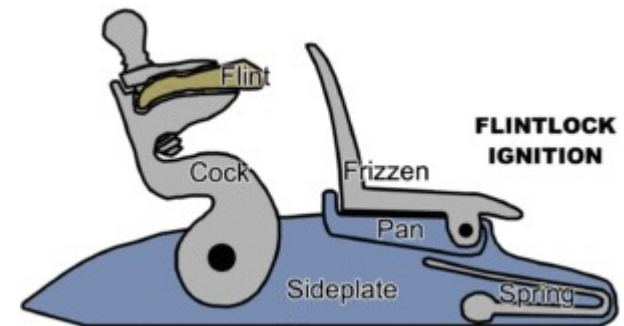




History of Firearms



- Flintlock weapons used **flint** to ignite the gunpowder.
- Improvement over matchlock
 - an open flame was no longer needed as it was replaced with a simple **spark**.





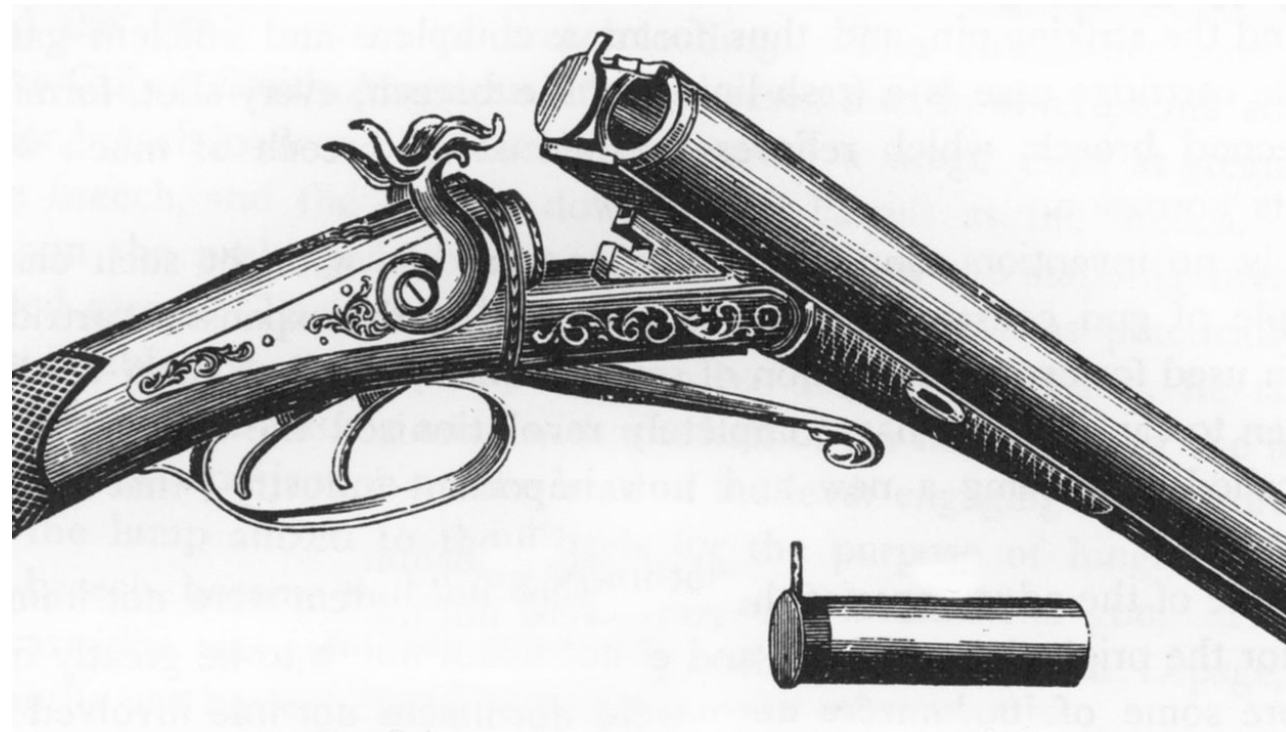
Muzzleloaders

- any firearm into which the **projectile** and (usually) propellant is loaded from the gun's **muzzle***
 - *from the open end of the gun's barrel.





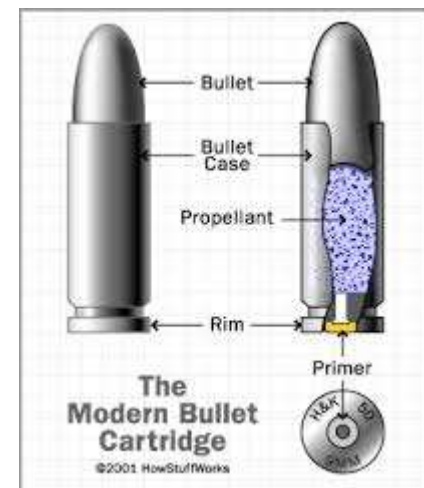
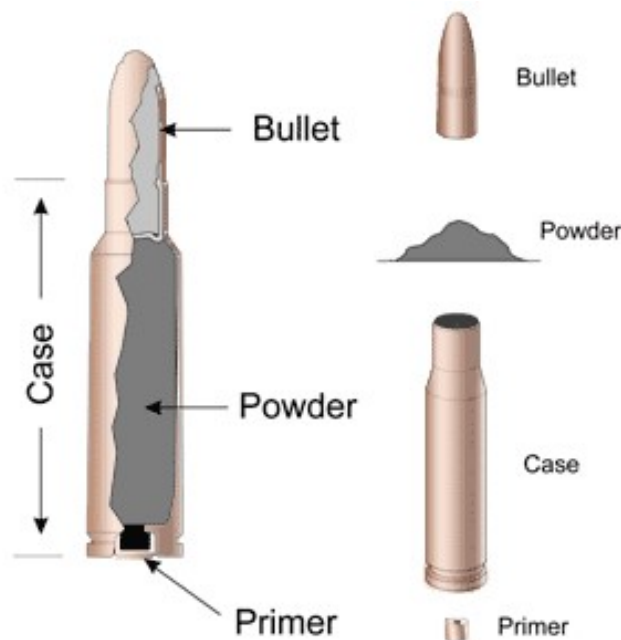
Muzzleloaders were replaced by **breech**-loading firearms with the advent of the cartridge.





Cartridge or **round**

- a case that holds a bullet, a small amount of exploding **primer powder**, and the gunpowder.
 - correct and accurate name for the "entire package".
 - "Bullet" is inaccurate, as the bullet is **one** of multiple components

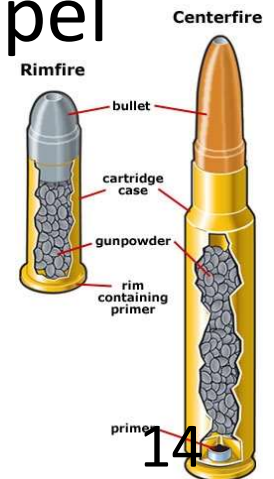




Cartridge Components

- **primer** - volatile compound that ignites when struck by the gun's firing **pin**.
 - detonates the **propellant** in the cartridge.
- **Propellant** = gunpowder
 - forms **gases**, which push the bullet out of the cartridge and the gun barrel.
- The casing is left behind and does **not** propel with the bullet.

Primer may be placed either in the rim of the case (rimfire) or in the center of the base of the case (centerfire). →








Bullets

- **projectile** propelled from a firearm.
- made of metals, such as copper, lead, brass, bronze, steel, aluminum, etc





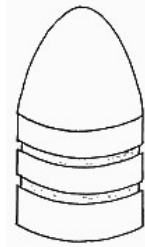
Three Basic Bullet Compositions:

Lead		
<ul style="list-style-type: none">• Cheap		
		

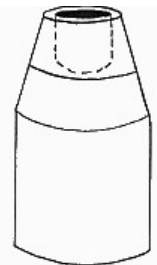


Bullet Shapes

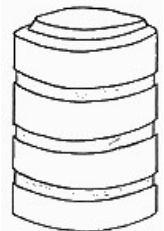
- **"round-nose"** - end of the bullet is blunted for maximum penetration.
- **"hollow-point"** - a hole in the bullet creates more damage, inhibits penetration, and spreads or mushrooms on impact.
- **"jacketed"** - soft lead is surrounded by another metal, usually copper, that allows the bullet to penetrate a target more easily.
- **"wadcutter"** - front of the bullet is flattened
 - used exclusively as a practice load
 - rips a hole in target paper which is visible by the shooter.



ROUND NOSE



JACKETED
SEMI-WADCUTTER
HOLLOW POINT



WADCUTTER

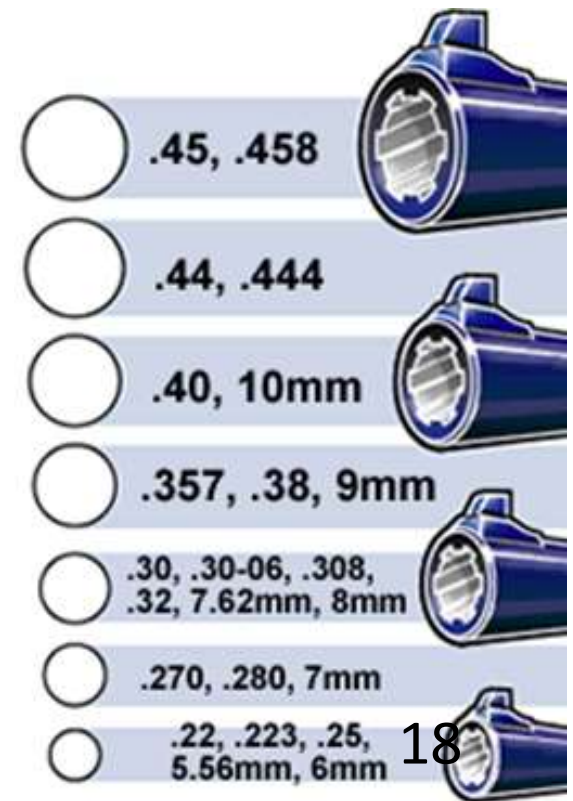


Bullet Caliber

- Caliber - the diameter of the inside of a firearm's **barrel**.
- Caliber –also matches the **diameter** of the bullet, usually expressed in hundredths of an **inch** (0.22 cal) or in millimeters (9 **mm**).



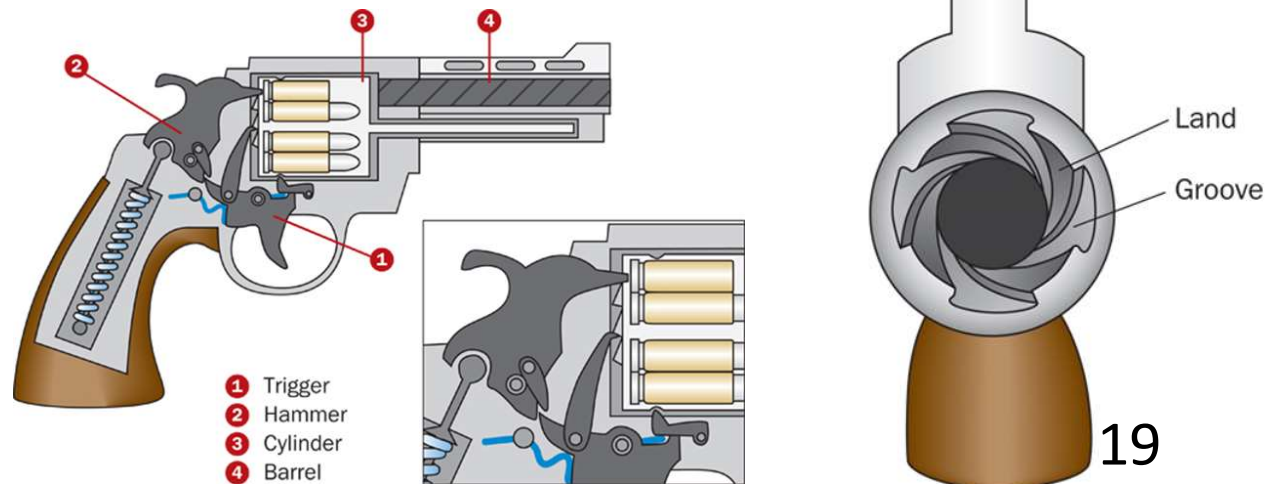
Common handgun cartridges (left to right): 3-inch 12-gauge magnum shotgun shell (for comparison), size “AA” battery (for comparison), .454 Casull, .45 Winchester Magnum, .44 Remington Magnum, .357 Magnum, .38 Special, .45 ACP, .38 Super, 9 mm Luger, .32 ACP, .22 LR





How a firearm works

1. The firing pin hits the base of the cartridge, **igniting** the primer powder.
2. The primer powder **sparks** through the flash hole to the main propellant supply
3. The pressure of the explosion **pushes** the bullet from the casing into the barrel
4. The bullet follows **lands and grooves** to spiral out of the barrel





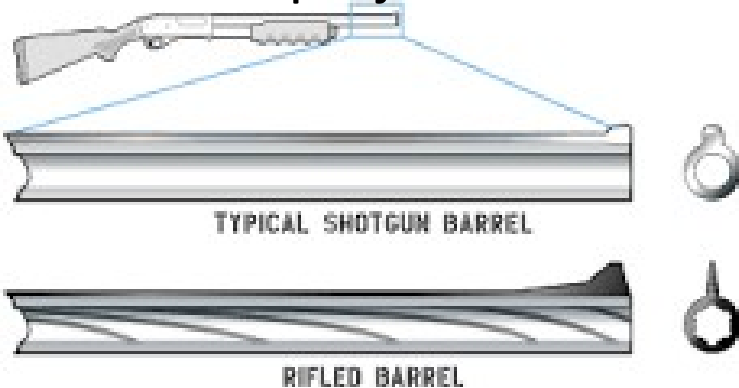
Modern Firearms

- Two categories: Handguns and Long guns



Long guns

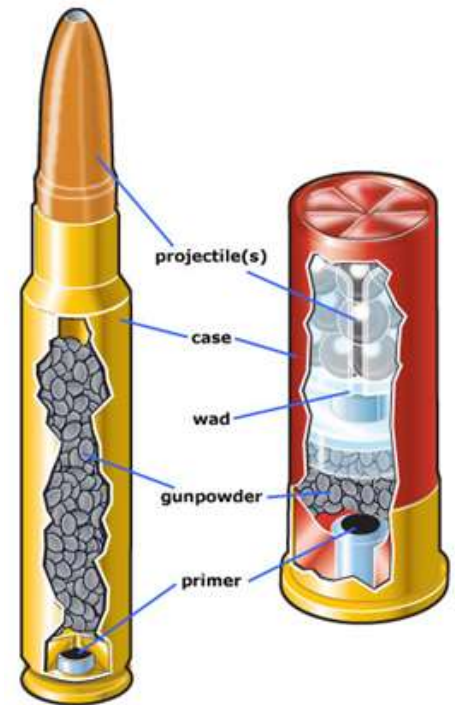
- require two hands for accurate shooting
- rifles and shotguns
 - Rifles fire bullets; barrel is “rifled” with lands and grooves
 - Shotguns fire small round pellets called shots, or single projectiles called slugs; barrel is smooth





Shotgun shells vs rifle or pistol cartridges

- All contain a case, primer, and gunpowder.
- Shotgun shells also contain a wad of plastic or fiber
 - **separates** the shot from the gunpowder.
 - “**shot**” – small, round pellets usually made of lead or steel.
 - Replaces the bullet
 - A shotgun shell can contain anywhere from 6 ball-bearing-type pieces of metal to 1,300 pellets
 - can also contain a slug, which is a solid piece of metal
- Wad forms a seal allowing gases from the burning powder to push the shot down the barrel uniformly





Second Category: **Handguns**

- **Pistol**
 - Fired one-handed
- **Revolver**
 - A pistol that holds several cartridges that can be fired one after another



Revolvers are usually easier for first time shooters to learn how to shoot safely. The recoil seems to be less and lighter loads can be used.

The majority of civilian firearm injuries are sustained from handguns (86%), followed by shotguns (8%) and rifles (5%).

Semiautomatic Pistol vs. Revolver

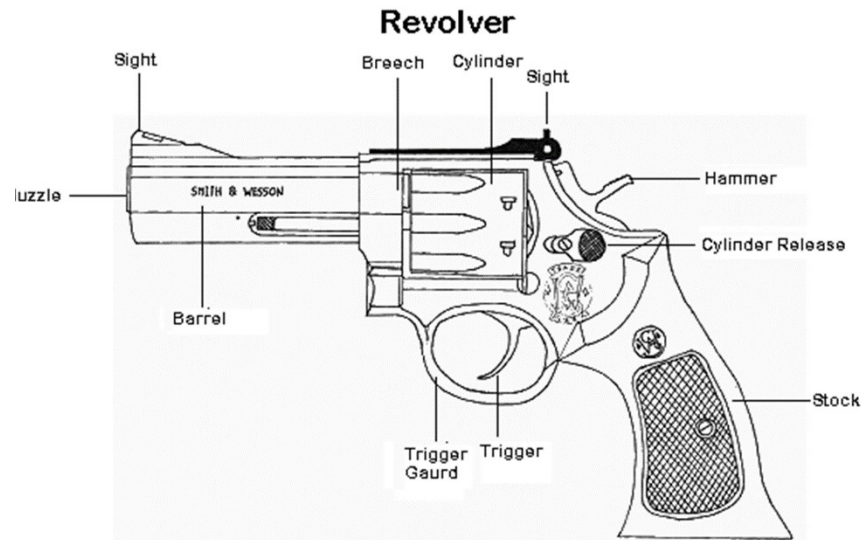




Grouping Handguns - Revolver

- **Revolvers**

- around since the 1830s
- hold **6** cartridges (“six shooter”) stored in a **rotating cylinder**
- Cocking the hammer rotates the cylinder and drops a round into the chamber, aligning it with the hammer and barrel

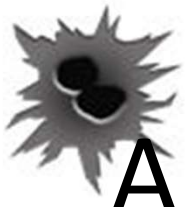




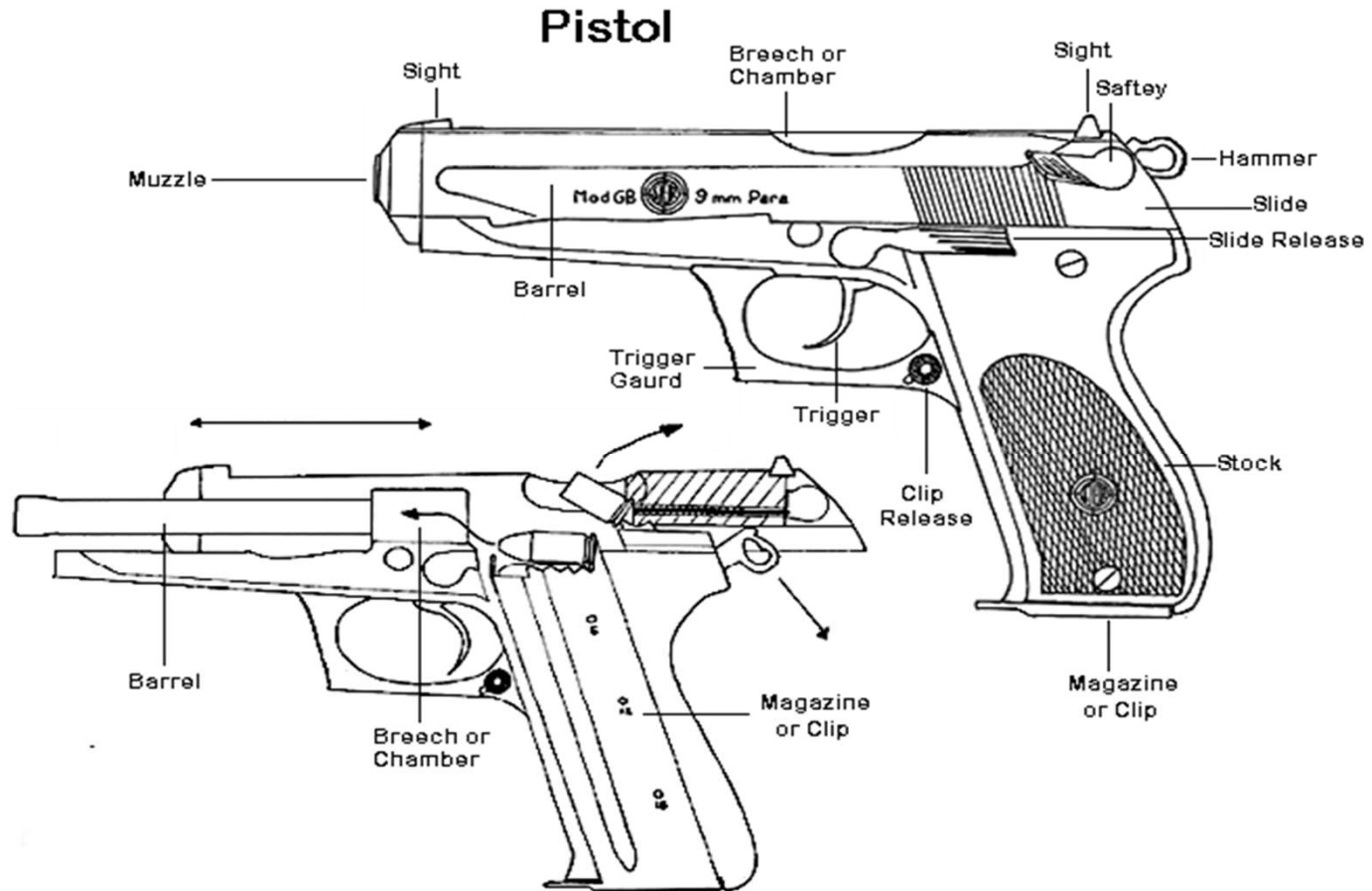
Grouping Handguns - Semiautomatic

- **Semiautomatic pistol**

- Around since the 1890s
- load up to **10** cartridges in a magazine clip
- fire **one** bullet per trigger pull (vs automatic weapons that **continuously** fire as long as the trigger remains pulled)
- most semiautomatic pistols use the spent gasses of the fired round to move the whole or part of the slide rearward to extract and eject the empty case.
- Forward motion of the slide will chamber a new round and make it ready to fire.



Anatomy of a Semiautomatic Pistol





Semiautomatic - Glock



- debuted in the 1980s
- 17 rounds instead of 6
- trigger pull is ~ 5 pounds, increases accuracy
 - traditional revolver+ 12-pound trigger pull
- Light
 - Comfortable as a service weapon
- durable and functions even if it's not cleaned properly or regularly.



Day 2 - Essential Questions



- How can you distinguish among the various forms of firearms evidence, including rifling, markings on cartridges, and marks on projectiles?





Learning Targets. I can...



- **SFS1d, SFS4a – LR7: Classify** bullet evidence, including rifling patterns, breech marks, firing pin impressions, and extractor marks, based on the categories from Unit 2 (class vs individual, indirect, transfer, etc.)
- **SFS4a – LK9: Identify** ballistic databases.
- **SFS4b – LR8: Predict** the trajectory of a bullet.
- **SFS1a – LK3: Match** historical forensic scientists with their role in crime scene investigations.



Matching a gun to a bullet

- extremely difficult to convict someone of murder without possession of the murder weapon
- For a shooting, matching a bullet with a gun is essential in most cases
- Obviously, this does not prove WHO was firing the gun; more evidence would need to be presented to convict beyond a reasonable doubt

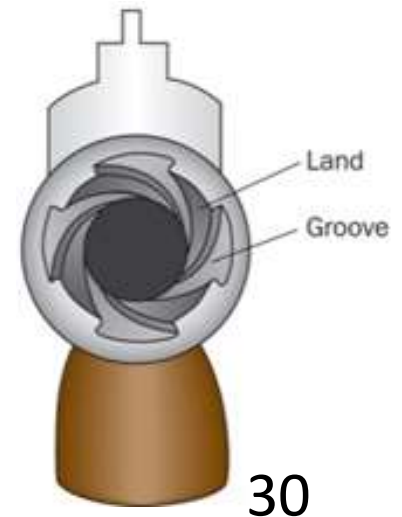


Bullets and casings

- A bullet or casing at a crime scene **can be linked** back to the weapon that was used to fire it based on several unique markings.



Individualized evidence!



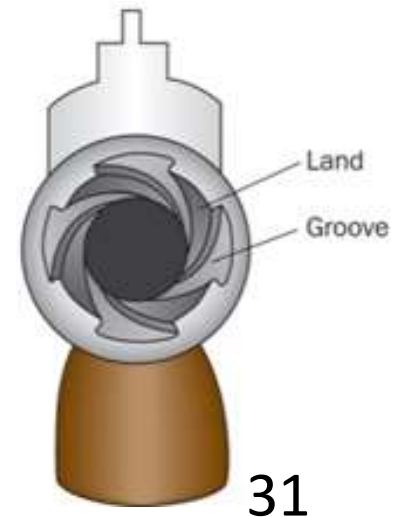


Unique Marking #1: Rifling Pattern

- Rifling: grooves cut in a spiral down the barrel of a firearm
 - increases range and accuracy.
 - Even though two guns may be the same model, the rifling inside the barrels will differ



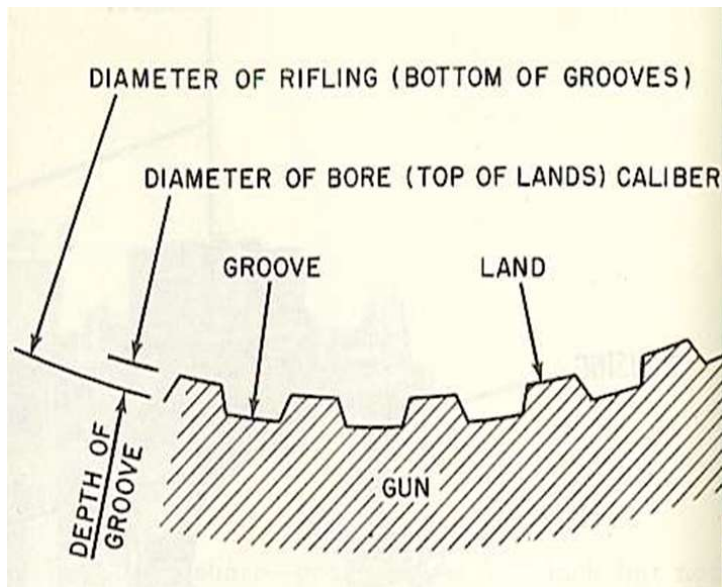
Individualized evidence!





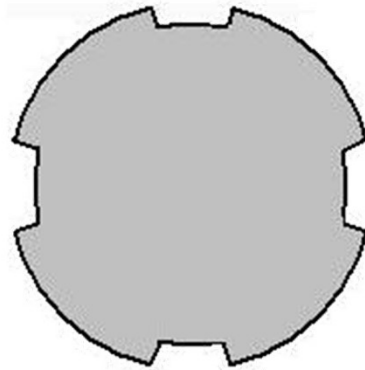
Rifle Patterns – lands and grooves

- bullets can be matched to the **exact** gun from which they were fired.
- **lands and grooves** scar each fired bullet with a pattern unique to that gun.

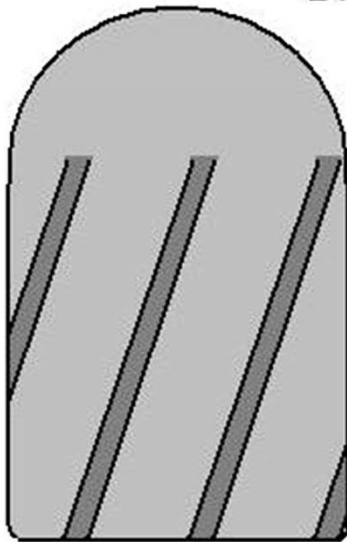




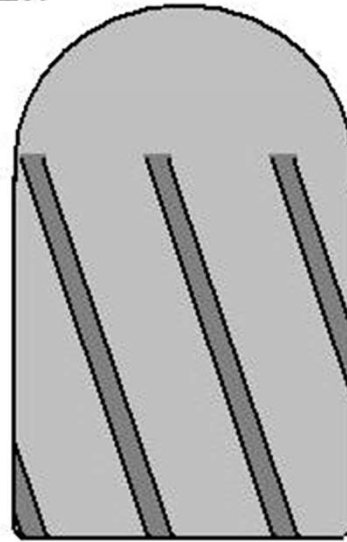
Rifling Pattern



Base of Bullet

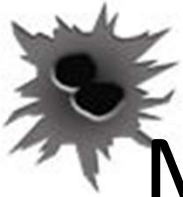


Right Twist



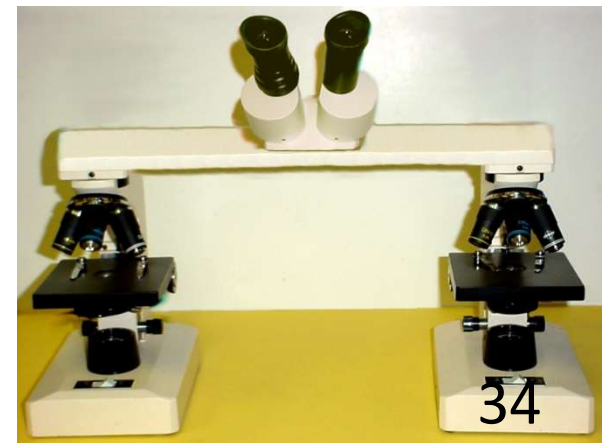
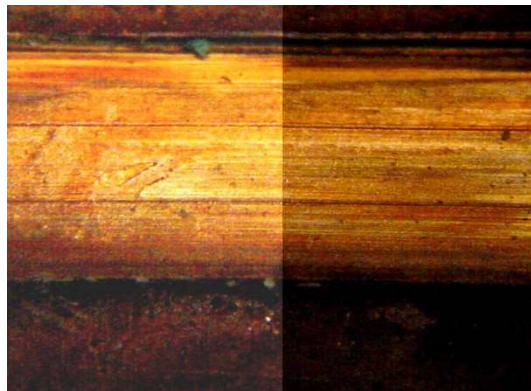
Left Twist

- hold the nose of the bullet pointing away from you,
- the direction the impressions run **away** from you (either to your left or right) determines the direction of twist.



Matching Procedure - Rifling pattern

- Calvin Goddard – pioneer of forensic ballistics
- Fire bullets from a suspected weapon
- Use a **comparison** microscope to compare these “test fires” to the questioned bullets
- **Striations** must be identical for a positive match
 - Striation – lines created going through grooves and lands. A “barcode” for identification





Unique Pattern #2: Breech Marks

- A **breechblock** prevents a cartridge from shooting backwards towards a user as it **recoils**
- **Unique** marks are produced on the **casing** as it moves backward and hits the breechblock.

Individualized evidence



Breech mark itself: class evidence



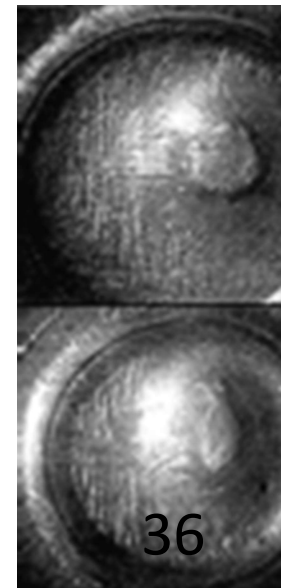
Unique Mark #3: Firing Pin Impression

- impressions are made on the **bottom** of the cartridge by the firing pin as it strikes to fire.

Fire pin impression itself: class evidence

- can appear on the **rim** or the **center** of the used cartridge
 - depends on the firearm and type of cartridge
- May get unique marks from a specific gun

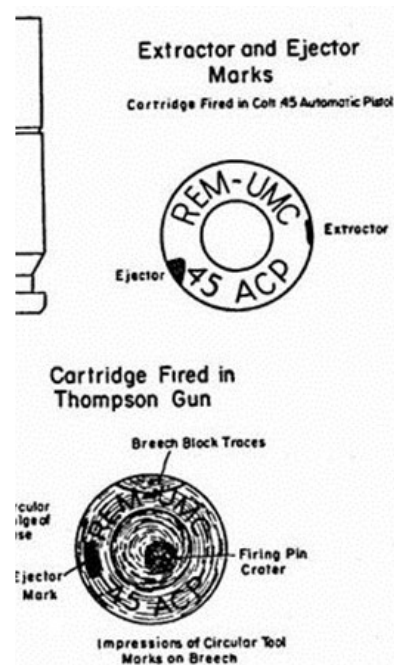
Individual Evidence





Unique Mark #4: Extractor/Ejector Marks

- found in semiautomatic and automatic weapons
Marks: class evidence
- tiny scratches formed from the insertion and removal of cartridge from the firing chamber



Individual evidence





Ballistic Databases



- Firearm databases: match ballistic evidence from a crime-scene to registered weapons.
- Created in 1999, National Integrated Ballistics Information Network, or NIBIN, is composed of two combined databases:
 - Integrated Bullet Identification System (**IBIS**)- has records of ballistic markings of firearms used in previous crimes
 - Drugfire- FBI multimedia database imaging system that holds data on cartridge casings and bullets





Trajectory

- Trajectory - path of a propelled bullet
- Ballistic evidence can help experts determine trajectory, and therefore figure out where a shooter was located during a crime.





Trajectory

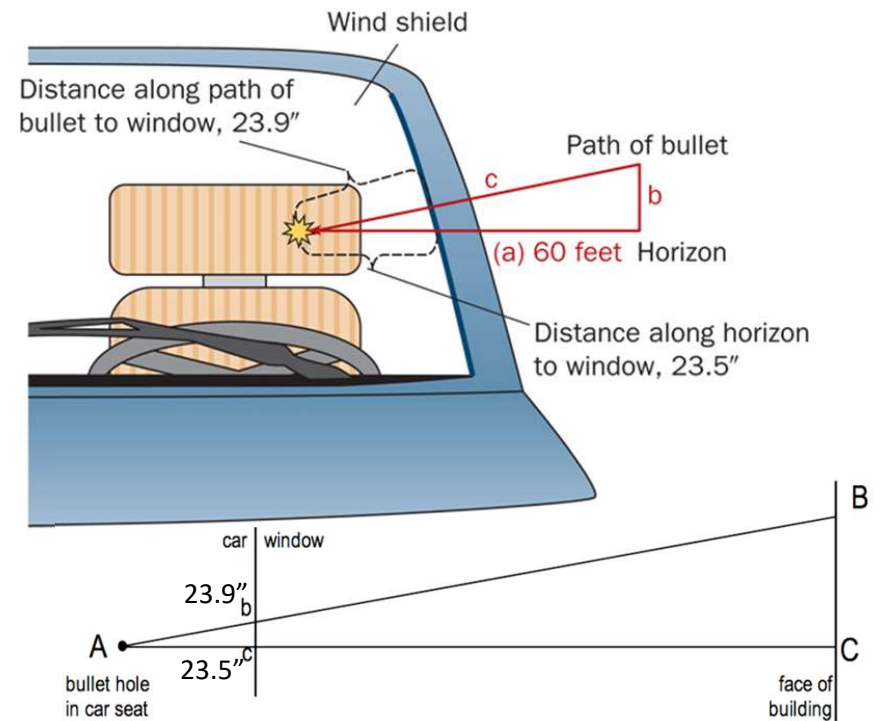
Two reference points are needed to calculate the trajectory

- Reference points can be bullet holes, gunshot residue, empty cartridges, and entry/exit points on a victim
- Pythagorean's theorem can be used for triangulation with reference points.
- Lasers can also trace a straight-line path to determine the position of the shooter; investigators can figure the shooter discharged the firearm somewhere along that line.





Building is 60 feet away along the horizon line; Bullet hole is 4 feet above the ground. Where is the shooter located?



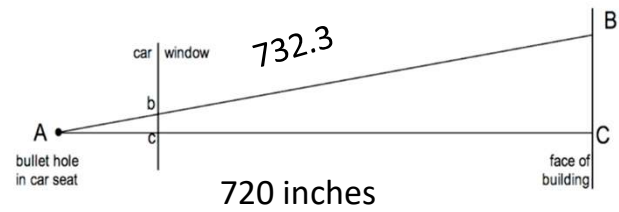
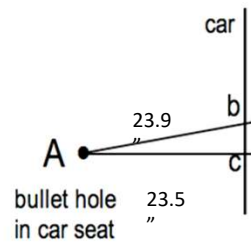
$$\frac{\text{Distance to window (Ab)}}{\text{Distance along horizon (Ac)}} = \frac{\text{distance to shooter (AB)}}{\text{distance to side of building (AC)}}$$

$$\frac{23.9 \text{ in}}{23.5 \text{ in}} = \frac{\text{distance to shooter}}{720 \text{ inches}}$$

$$AC = 60 \text{ ft} * 12 \text{ in/ft} = 720 \text{ inches}$$

$$\frac{23.9 \text{ in}}{23.5 \text{ in}} = \frac{\text{distance to shooter}}{720 \text{ inches}}$$

$$\text{distance to shooter} = 732.3 \text{ inches}$$



Now use Pythagorean's theorem to find BC



Building is 60 feet away along the horizon line; Bullet hole is 4 feet above the ground.

Where is the shooter located?

distance to shooter = 732.3 inches

Use Pythagorean's theorem

$$AB^2 = AC^2 + BC^2$$

AB = distance to shooter

AC = distance to building

BC = height of the shooter from the horizon (not from the ground)

$$(732.3 \text{ in})^2 = (720 \text{ in})^2 + BC^2$$

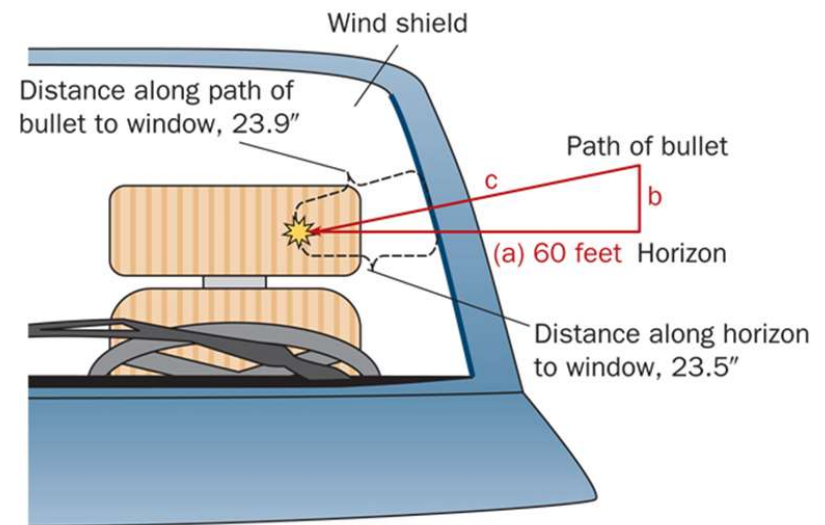
$$BC^2 = (732.3 \text{ in})^2 - (720 \text{ in})^2$$

$$BC = \sqrt{536,263 \text{ in}^2 - 518,400 \text{ in}^2} \quad (\text{square root})$$

$$BC = 133.1 \text{ inches}$$

$$BC = 11.1 \text{ feet}$$

Shooter is 11.1 feet higher than the bullet hole, which is 4 ft. Shooter was 15.1 feet about the ground (on a second floor)





Alternate methods for solving math

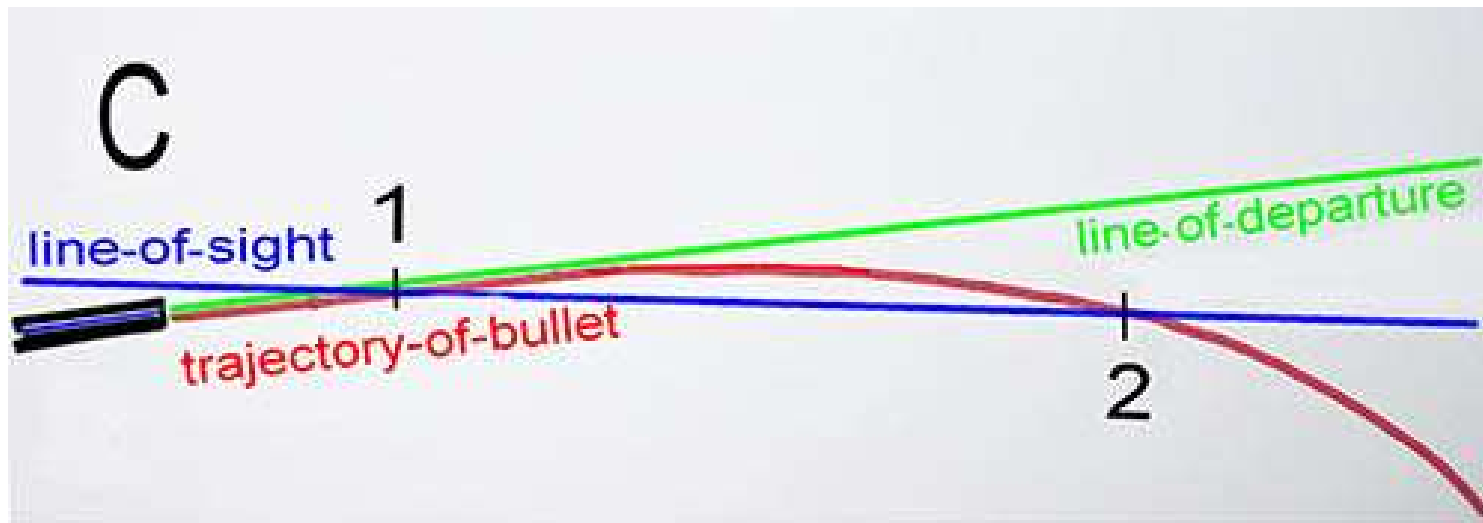


- See Google Classroom for two other ways to answer the math



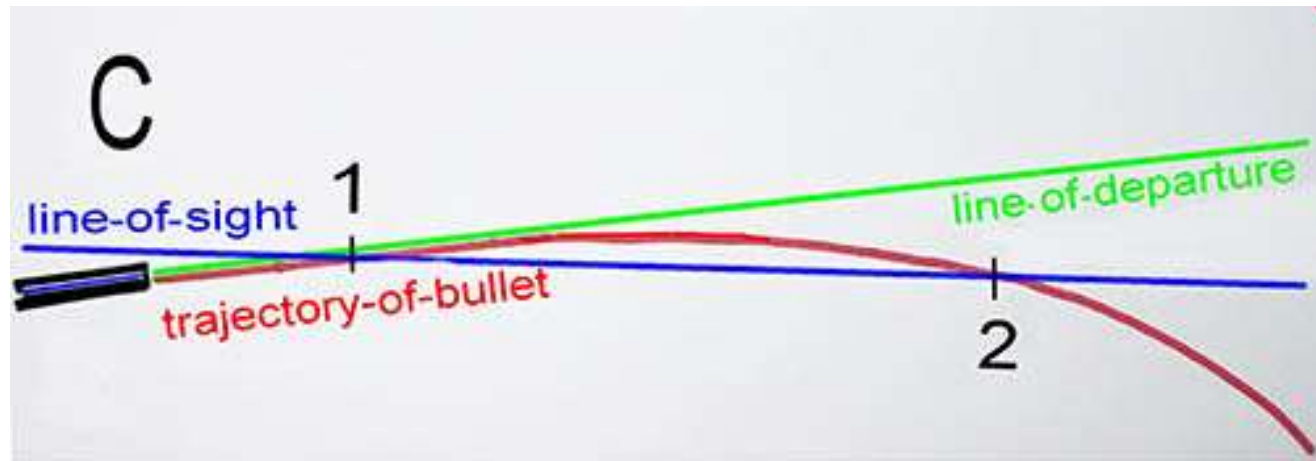
Trajectory

- a bullet's path may be slightly curved due to **gravity** as it propels forward, especially when shot from **long** distances.
 - **Wind** speed and direction may also affect trajectory.





Line-of-Sight



- by placing a sight on top of a rifle, we compensate for the differences between straight-line optics and curved trajectory by combining the two.
- This angle (exaggerated in the illustration) is what accounts for the idea of the rising bullet.
- Although the bullet does pass through the line-of sight from below, it never rises above the line-of departure.
- In a sense, a bullet is both rising and falling at the same time! It may be rising in relation to the ground, but it is still falling from the line-of-departure, even when the rifle is aimed and the bullet is fired in an upward angle.



Day 3 Essential Questions



- How is ballistic evidence packaged?
- How is gunshot residue processed?
- What information can investigators obtain from bullet wounds?



Learning Targets. I can....



- **SFS1c– LK10:** **Explain** proper packaging of ballistic evidence.

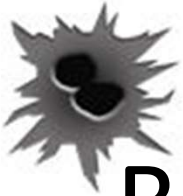


- **SFS1d– LR9:** **Compare/contrast** entrance and exit wounds



- **SFS4a– LR10:** **Interpret** tests for gunshot residue





Ballistic Evidence- Firearms



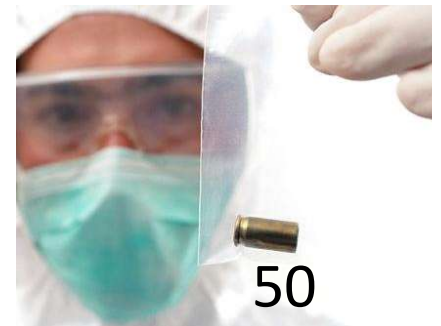
- Never submit a **loaded** gun to the laboratory
- Avoid excessive handling to avoid destroying latent prints
- Never pick up a weapon by placing a **pencil** or other object in the end of the barrel.
- **Record** serial number, make, model, and caliber of the weapon.
- Place weapons in well packed, strong cardboard or wooden **boxes** to prevent shifting of guns in transit.
 - If blood or any other material is on the gun, place a clean **paper** around the gun and seal it with tape to prevent movement of the gun and loss of the sample during shipment.





Ballistic Evidence – bullets and casings

- Wrap recovered bullets and casings in paper
 - seal in separate labeled pill boxes or envelopes.
- Bullets recovered from a body should be air dried and wrapped in paper.
 - washing may destroy trace evidence.
- If possible, recover unused ammunition for comparison purposes.





Ballistic evidence – gunshot residue

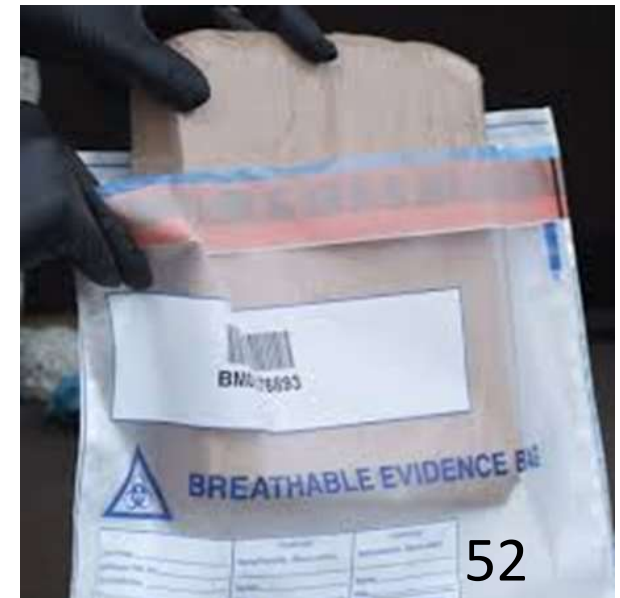
- extremely fragile evidence
- should be collected ASAP
 - preferably within **3** hours of the discharge of firearm
- Hand Protection Bags
 - "bag" the hand when suicide is suspected or to preserve valuable evidence on the hands of suspects or assault/sexual battery victims.
 - prevents the loss of GSR from hands during transport to the medical examiner's office





Evidence – clothing

- any **clothing** or other material showing evidence of gun powder residue or shot holes
- wrap carefully in clean paper and folded as little as possible to prevent dislodging powder particles
- package each item separately





Gunshot Residue (GSR)

- Because of the explosion of gunpowder in a firearm, guns leave residue when fired.
- GSR: trace evidence made of smoke and unused powder particles
 - can land on the hand, arm, face, hair, and clothing of the shooter and victim
 - even if washed, chemical tests can detect residue
- amount of GSR decreases as the distance between the firearm and shooter increase
 - GSR patterns can be examined to help determine the distance from victim to shooter



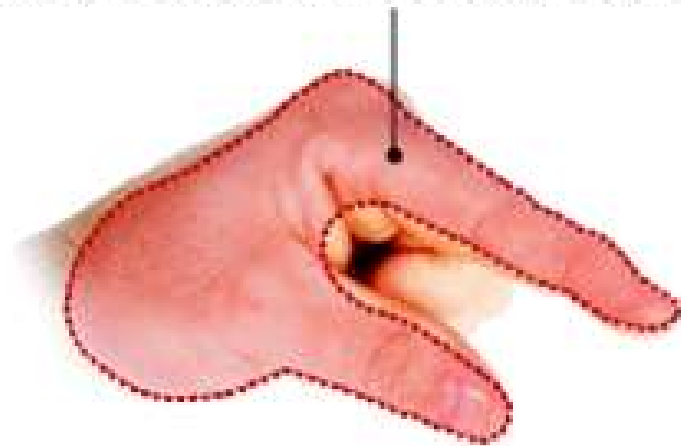
Gun Shot Residue (GSR)

Gunshot residue collection

- 1 When a gun fires, gunshot residue is released. Traces of the residue land on the hand.



- 2 Police swab this area of a suspect's hands to collect any residue present.



- 3 Analysts using an electron microscope inspect the swab samples to see if the particles are, in fact, gunshot residue.



How to detect gunshot residue

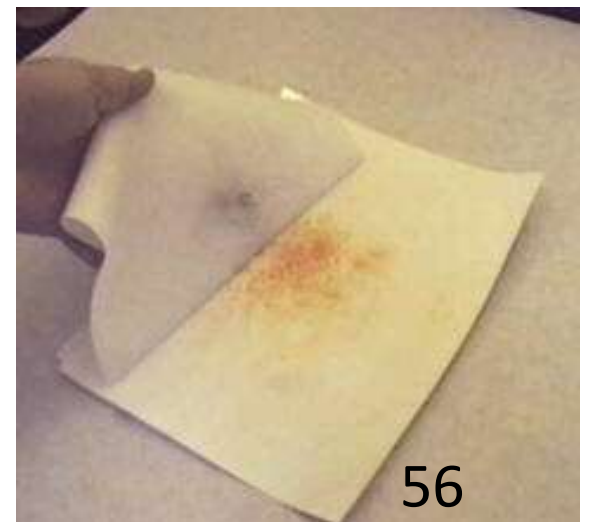
- Step 1: visually and microscopically examine the evidence.
 - Document presence of any gunshot residues around the bullet hole as well as the shape and appearance of the hole
- Step 2: chemically processes the exhibit for gunshot residues
 - **Modified Griess Test** –
 - First test because it will not interfere with later tests for lead residues.
 - detects the presence of nitrite residues, a by-product of the combustion of smokeless gunpowder.
 - primary test used by firearms examiners to determine a muzzle-to-garment distance.





The Modified Griess Test

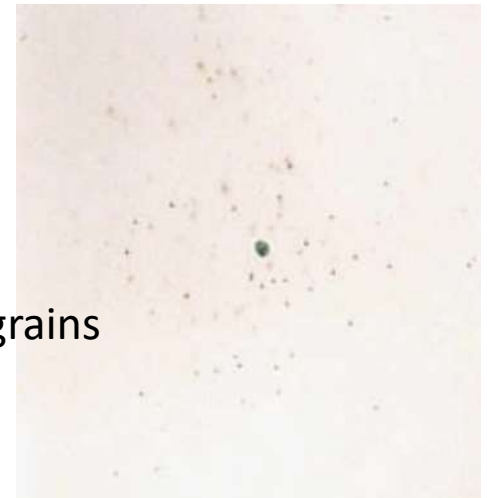
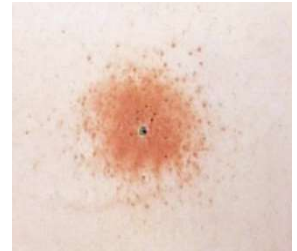
- Treat desensitized photography paper with a chemical mixture of sulfanilic acid/distilled water and α -naphthol/methanol.
- evidence is placed **face down** against the treated photo paper, with the bullet hole centered on the paper.
- The back of the exhibit being examined is steam ironed with a dilute acetic acid solution instead of water.
 - acetic acid vapors penetrate the exhibit
 - acetic acid reacts with **nitrite** residues on the exhibit and the chemicals in the photographic paper.
 - appears as orange specks on the piece photographic paper





Typical Patterns of Gunshot Wounds

- 1 inch
 - Heavy concentration of smoke-like vaporous lead surrounds bullet hole. Clothing/skin will show scorch marks from flame discharge of weapon.
- 12-18 inches
 - Halo of vaporous lead (smoke) deposited around bullet hole
- 25-36 inches
 - Scattered specks of unburned and partially burned powder grains can be found
- More than 3 feet
 - Will not deposit any residue on target's surface.
 - Only visual indicator is a dark ring around the bullet hole called bullet wipe →





Bullet Wounds

- Eyewitness accounts are not always accurate,
 - Forensic evidence confirms or disputes witness accounts.
- Bullet wounds can be helpful in re-creating a scene of a crime



Expert in gunshot wounds: Dr Vincent di Maio holds up a picture of the closeup of Trayvon Martin's gunshot wound and explains the markings surrounding it and what it means



Bullet Wounds

- First, determine if a bullet wound is from entrance or exit of bullet:
 - Entrance wounds –
 - tend to be smaller because the skin stretches as a bullet enters
 - Clothing fibers may embed in the wound
 - Gunshot residue may be found around the wound
 - If the bullet is from a close contact muzzle, there will also be burn marks caused by the gun's hot gases as they release.



Bullet Wounds – entrance wound

- The abrasion ring, and a very clear muzzle imprint, are seen in this contact range gunshot wound. →
- **Abrasion ring** - forms when the force of the gases entering below the skin blow the skin surface back against the muzzle of the gun.





Since the barrel contacts the skin, the gases released by the fired round go into the subcutaneous tissue and cause the star-shaped laceration. Note also the grey-black discoloration from the soot, as well as the faint abrasion ring.

Powder tattooing is seen in this intermediate range gunshot wound. The actual entrance site is somewhat irregular, because the bullet can tumble in flight.





Bullet Wound - Exit

- tend to be **larger** because the bullet **carries** tissue and bone that it picked up as it moved through the body
 - Bullets usually do not travel **smoothly** through a victim, and in many cases will ricochet off bones before exiting, or may not **exit** at all
 - Fast-moving **high** caliber bullets tend to pass through a victim
 - Small caliber and **low**-velocity bullets tend to stay lodged in the body



Bullet Wound - exit

Here is a slit-like exit wound. Note that there is no powder or soot visible



There may be no exit wound at all if the bullet's energy is absorbed by the tissues. Some bullets (such as a hollowpoint) are designed to deform so that all their energy will be converted to tissue damage and not exit.

