Prevalent use of firearms in US

- In 2005, 11,346 persons were killed by firearm violence and 477,040 persons were victims of a crime committed with a firearm.
- In 2006, firearms were used in 68 percent of murders, 42 percent of robbery offenses and 22 percent of aggravated assaults nationwide.

http://www.nij.gov/topics/crime/gun-violence/

Firearms examination

Firearm identification has evolved from visually matching class characteristics to microscopic identification of individual characteristics. Every firearm leaves unique, reproducible markings on expended bullet and cartridge cases that it fired. The barrel, firing pin, firing chamber, extractor, ejector and other parts of the gun leave these marks, called toolmarks, on the bullet and cartridge case faces.

- Involves the examination of
  - Firearms (Guns)
  - Cartridge cases
  - Bullets
Firearms Identification

“This discipline is concerned with determining whether a bullet or a cartridge was fired by a particular weapon. It is not to be confused with ballistics, which is the study of a projectile in motion.”

Sometimes the word “ballistics” is used inappropriately.


Forensic Ballistics

- Interior Ballistics- study of projectile behavior from propellant ignition to barrel exit.
- Transitional (Intermediate) Ballistics- study of projectile behavior from barrel exit to point where pressure behind projectile is equalized (between interior and exterior).
- Exterior Ballistics- study of projectile behavior from point where pressure behind projectile is equalized to target interaction (primary forces acting on projectile are air resistance and gravity).
- Terminal Ballistics- study of interactions of projectile with target.

Firearm Types

- Rifled barrels
  - Designed to fire 1 projectile
    - Types
      - Pistols (handguns)
      - Rifles
      - Submachine guns
      - Machine guns
- Smooth-bore barrels
  - Designed to fire multiple projectiles
    - Types
      - Shotguns
Barrels

- Rifled Barrel
- Smooth-Bore Barrel

Pistols

- Single Shot
- Derringers
- Revolvers (revolving pistols)
- Self-loading (semi-automatic)
  - Recoil operated (locked breech)
  - Blowback (unlocked breech)
- Automatic

Semi-Automatic Operation

- Blowback
  - Bolt and barrel NOT locked
  - Held together by recoil spring pressure
- Recoil Operation
  - Bolt and barrel locked together
  - Remain locked for some distance after discharge
Hammer/Trigger Actions

- Single Action Only
  - The hammer must be cocked to discharge firearm
- Double Action Only
  - Firearm discharged with trigger pull only
  - Hammer/firing pin cocked during trigger pull
- Double-Single Action
  - Firearm discharged using either mechanism

Bore Diameter = Caliber

Caliber is measured between the diameter between opposite lands

Caliber

The diameter of the bore of a rifled firearm. The caliber is usually expressed in hundreths of an inch or millimeters for example:

- .22 caliber = 22 hundreths of an inch
- 9 mm = 9 millimeters
Common Rifled Bore Diameters (calibers)

- .50
- .45, .458
- .44, .444
- .40, 10 mm
- .357, .38, .380, 9mm
- .30, .30-06, .308, .32, 7.62 mm, 8 mm
- .270, .280, 7 mm
- .22, .223, .25, 5.56 mm, 6 mm

Smooth-Bore Barrel Bore Diameter

- Bore Diameter is expressed as Gauge
  - Number of balls produced from one pound of lead
  - Bore diameter is equivalent to one ball
- Example: 12 Gauge
  - One pound of lead produces 12 balls of equal size
  - Diameter of one ball equivalent to bore diameter of 12 gauge

Manufacture of Rifled Barrels

- Common Methods
  - Gang Broach
  - Rifling Button
  - Hammer Forging
  - Electrochemical etching
- The process of rifling creates both
  
  **Class characteristics:** Lands, Grooves, Caliber
  **Individual Characteristics:** Striations (fine lines that tend to run the length of the barrel). No two rifled barrels will have the identical striation marks.
Broaching

- Round steel bar drilled and reamed
  - Hole size is desired diameter
- Grooves cut with gang broach
  - Forced through the barrel
- Successive cuttings performed with broaches of increasing size
  - Stopped when desired groove depth attained

Button Rifling (Swaging)

- Round steel bar drilled and reamed
  - Hole smaller than desired bore diameter
- Grooves pressed into barrel with rifling button
  - Button is forced through barrel
  - Button contains negative impression of lands and grooves
- Simultaneously rifles barrel with expansion to desired bore diameter

Hammer Forging

- Round steel bar drilled and reamed
  - Hole larger than desired bore diameter
- Barrel placed over mandrel (cylindrical rod possessing rifling characteristics)
- Barrel pressed/hammered around mandrel then removed
- Simultaneously rifles barrel with reduction to desired bore diameter
Electrochemical Etching

- Round steel bar drilled and reamed
  - Hole size is desired bore diameter
- Barrel interior coated with polymer strips
- Electrolyte solution and electrode placed in barrel
- Application of voltage to produce etching of exposed metal (grooves)
- Etching stopped when desired groove depth attained

Rifles

- Single Shot
- Pump Action
- Lever Action
- Bolt Action
  - Turn bolt
  - Straight bolt
- Semi-Automatic
  - Blowback
  - Recoil Operated
    - Short
    - Long
- Gas Operated
- Automatic

Common Shotgun Gauges

- 10 gauge = .775 inch
- 12 gauge = .727 inch
- 16 gauge = .662 inch
- 20 gauge = .617 inch
- 28 gauge = .550 inch
Silencers

- They may cause additional problems for criminalist
  - Additional markings on projectiles surface
  - Alteration of distribution of GSR on target surface

Discharging of Firearms

- Firearm cocked (hammer/firing pin under tension)
- Trigger pulled to release hammer/firing pin
  - Hammer strikes firing pin, if present
- Firing pin impacts primer causing detonation of explosive
- Detonation ignites propellant
- Propellant burns (deflagrates) creating gases
- Expanding, hot gases force bullet from cartridge case into barrel
- Further propellant combustion propels bullet through barrel

Ammunition

- Components
  - Projectile (bullet)
  - Propellant
  - Primer
  - Cartridge Case
Projectiles

- **Basic Configurations**
  - Soil lead alloy (or lead)
  - Alloyed with antimony or tin
  - Jacketed lead alloy core
- **Types**
  - Semi-jacketed
  - Full jacketed
- **Jacket Material**
  - Copper, copper-nickel alloy, brass, aluminum, steel

Morphology

- Round nose, wadcutter, semi-wadcutter, hollow point

Mass

- Measured in grains
- 1 grain = 64.7989 mg
- 1 pound = 7000 grains

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Projectile

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Propellant

- **Types**
  - Black Powder
  - Smokeless Powder
- **Types**
  - Single-Base
  - Double-Base
  - Triple-Base (uncommon, for large caliber military)
- **Roles**
  - Firearm discharged; propellant begins to deglaze
  - Combustion generates hot gases that force bullet from cartridge case into barrel
Primers

- Common Constituents
  - Lead styphnate
  - Antimony sulfide
  - Barium nitrate
  - Tetracene
  - Some are lead azides
  - Lead free (Sintox)

Primer Types

- Rimfire
- Centerfire
- Boxer
  - Most ammo produced in USA (1 flash hole)
- Berdan
  - Most ammo produced outside the USA (2 flash holes)

Cartridge Cases

- Composition
  - Brass
  - Nickel-plated brass
  - Aluminum
Cartridge Headstamps

- Manufacturer
- Nominal Caliber
- Cartridge Type
- Other Information

Shot Shells

- Projectiles
  - Pellets
  - Single Lead Ball
  - Slug
    - Rifled
      - Foster
      - Brenneke
    - Sabot
Shotgun Shell Variations

Pellet Size

Evidence left at the crime scene involving a shooting

Evidence at a shooting crime scene (may be a place & or a body) may vary but the types of evidence that may be recovered include:

- a weapon
- unfired ammunition (cartridge + bullet or shotgun cartridge)
- fired cartridges
- bullets or portions of bullets
- Materials from ammunition (wadding)
- Gun shot residue

All of these should be collected and examined

2/6/12
Examination of Fired Bullets

- Trace evidence adherent to projectile
- Pattern impressions
- Class Characteristics
  - Caliber
  - Lands/Grooves
  - Rifling
- Individual Characteristics

What happens to a bullet as it is fired in a gun?

Gross impressions visible to the naked eye are made in the surface of bullets as they pass down the bore of the barrel. The clockwise or counterclockwise grooves inside a barrel result in groove impressions (higher areas) on the surface of a fired bullet. The areas between the grooves inside a barrel (lands) result in land impressions (lower areas) on the surface of a fired bullet. These gross impressions can be associated with a number of brands and models of firearms of certain classes. In the field of firearms identification, these class characteristics are called general rifling characteristics (GRC). Although GRCs cannot identify a specific firearm, they are a useful investigative tool. They can provide invaluable lead information to investigators concerning the type of firearm.

Measuring the Class Characteristics

Caliber
Number of Lands/Grooves
Direction of Twist
Width of Lands/Grooves
Measuring Caliber

The caliber of the bullet can be determined using a Vernier caliper. Measure the base of the bullet to the hundredths of a millimeter.

Types of Rifling

Rifling is classified as being either “Cut” or “Polygonal”

Polygonal (P) rifling has a smooth transition between lands and grooves

Cut (C) rifling has defined shoulders

Counting the Lands and Grooves

The grooves of the bullet should be counted
Direction of Twist

The twist is determined by sitting the bullet on a flat surface and observing the direction of the rifling.

Width of the Lands and Grooves

Calipers are used to measure the width of the bullet lands and grooves.

Weight of the Bullet

The bullet weight is determined in grams. Convert the weight from grams to grains:

1 gram = 15.43 grains
Using the bullet diameter, weight, and construction characteristics, determine the bullet type by comparing it to available databases.

This information may also be useful in determining the type of weapon using GRC FBI General Rifling Characteristics (GRC) File Standards

The FBI GRC file is a collection of well-documented, known GRC data that can be used as a standard for comparison of class characteristics of no-gun submission evidence bullets. The GRC digital database file can be searched electronically or in print form. The data obtained from a fired bullet provides the input data for searching the GRC file, includes:

• caliber,
• number of lands and grooves,
• direction of twist,
• land and groove impression measurements,

The examiner must use experience, skill, and judgment to determine and refine the parameters of the search criteria entered into the GRC file. The GRC search produces a list of potential firearms from which the bullet could have been fired.

Determining the Possible Make of Firearm Based on Class Characteristics

Using GRC, a list of possible makes of firearms can be established.
Crime Scene Examination of Firearm

- Safety First!!!!
- Condition of firearm must be recorded upon discovery.
- Unload prior to packing

Laboratory Examination of Firearm

- Safety First!
- Visual examination
- Latent fingerprint processing
- Trace evidence examination
- Firearm identification
- Operability (can it be fired?)
- Collection of test-fired bullets
- Collection of test-fired cartridge case

Test Firing of Weapon

- Weapons that are to be examined are “test fired” and the resulting bullets and cartridge cases are compared to the evidence.

A submitted firearm will be fired into a Water Tank in Range several times. Lids on the tank are closed and locked and the muzzle of the firearm is placed in the open tube at the end of the tank and fired. Friction from passing through the water slows the bullets down and they end up on the bottom of the tank about halfway down its length.
Comparison Microscope

Specially designed microscope that allows for side by side comparison of items. Critical equipment for bullet and cartridge comparisons

Needed to identify individual characteristics

- striations on bullets
- tool marks on cartridges

Tool Marks on Cartridge Case

- Firing pin impression
- Shear marks
- Extractor marks
- Ejector marks
- Breech face impressions

Firing Pin Impressions

Firing pins are made in a variety of shapes and sizes and leave different types of marks
Shear Marks

- Glocks have a rectangular firing pin hole and results in shear marks

Extractor and Ejector Marks

Extractor Marks

Ejector Mark

Breech Face Impression

The breech face marks are made from the cartridge case coming in contact with the breech face of the slide of the firearm.

The marks can come in a variety of patterns including: parallel, circular, smooth, and arched.
Comparison of Land/Groove Impressions

Bullet Lead Analysis

- **Weighing Bullet Lead Analysis**
  - 2004
  - Examined FBI’s process used since 1960’s (JFK)
  - Bullet Lead Compositional Analysis
  - Seven elements were analyzed by Atomic Emission Spectroscopy (plasma-optical emission spectroscopy)
    - arsenic, antimony, tin, copper, bismuth, silver and cadmium
  - Analysis tech gave correct results
  - Criticized the stats given
  - FBI discontinued the analysis after the report.

Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)

Mission: ATF is responsible for investigation of violations of federal laws involving
  - use and trafficking of firearms
  - use and storage of explosives,
  - acts of arson and bombings,
  - diversion of alcohol and tobacco products.
Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)

History:
- In 1918, originally formed as a group within the Department of the Treasury to investigate the illegal production of alcohol.
- In 1972, ATF, moved from primarily the investigation of illicit alcohol to crimes involving firearms, explosives and arson.
- In 2003, moved to Department of Justice

ATF Forensic Laboratories
- The ATF Laboratory Services Division provides analytical and advisory services on scientific matters with the following organizational groups
  - Forensic Science Laboratory (FSL), with facilities in Atlanta, San Francisco and Washington;
  - Fire Research Laboratory (FRL); and the

Services at ATF Regional laboratories
- The regional laboratories perform a variety of examinations using forensic chemists, firearm and toolmark examiners, fingerprint specialists, and document examiners.
  - Arson Examinations – Fire debris collected at suspected arson crime scenes is examined to identify accelerants, incendiaries, and incendiary device components.
  - Explosives Examinations – Evidence collected at explosive scenes is examined to identify explosives, blasting caps, fuses, timing mechanisms, energy sources, radio control components, igniters, containers, wires, tapes, and other component parts.
  - Firearm and Toolmark Examinations – Examiners compare markings on bullets and cartridge casings, serial number restoration, weapon operability testing, bullet trajectory determinations, crime scene reconstruction of shooting incidents, and distance and shot pattern determinations. Toolmark examinations include the comparison of fractures and impressions caused by cutting, drilling, gripping, and prying tools.
Services (continued)

Automated Ballistic Identification – Electronic images of markings on bullets and cartridge cases recovered from crime scenes and suspect weapons are entered into NIBIN for search and comparison against other bullets and cartridge cases.

Trace Evidence – Examiners perform microscopic, chemical, physical, and instrumental comparisons of a wide variety of physical evidence collected at crime scenes.

Questioned Document Examinations – Document examinations are performed to identify handwriting, hand-printing, mechanical impressions (such as typewriters), and counterfeit cigarette tax stamps; detect altered and forged documents; restore and decipher eradicated, obliterated, and charred documents; and detect and decipher indented writing.

Latent Print Examinations – The majority of evidence is examined for latent prints. Evidence examined includes documents, component parts of explosives and incendiary devices, and firearms. Techniques used include dye staining, super glue fuming, laser, and traditional powder methods.

Automated Ballistic Identification Systems (ABIS)

Automated Ballistic Identification Systems (ABIS) are specialized computer hardware/software combinations designed to capture, store and rapidly compare digital images of bullets and cartridge casings.

ABIS have four key components:

• The Ballistic Scanner, which captures the images of the bullets and cartridges
• The Signature Extraction Unit, which uses a mathematical algorithm to extract unique signatures from the images
• Data Storage Unit, which serves as the main storage,
• The Correlation Server, which handles the actual comparison of images.

History of automated ballistic identification in United States

• 1993 FBI developed Drugfire to capture images of cartridge casings into computers, and automate the process of comparing a suspect cartridge against the database.
• 1993 ATF developed Bulletproof, and imaged only bullets. It was later upgraded to handle cartridge casings and was renamed as the Integrated Ballistic Identification System (IBIS).
• US had two systems until in 1999 FBI phased out Drugfire, and ATF established NIBIN on the IBIS platform.
National Integrated Ballistic Information Network.
Established in 1999 by the ATF.
Used Integrated Ballistic Identification Systems (IBIS) to acquire digital images of the marking made on fired cartridge cases and bullets recovered from a crime scene or crime gun test fire. Compare it against NIBIN entries via electronic image comparison.
In 2001, U.S. Department of Justice and Department of the Treasury directed that their law enforcement components enter ballistic information into NIBIN.

- 155 NIBIN partner agencies
- 93 NIBIN locations
- 235 NIBIN (IBIS) systems
- NIBIN partners have completed more than 2 million acquisitions
- NIBIN partners have confirmed more than 40,000 NIBIN hits
- Since ATF and its partner agencies began using this technology, over 1,612,000 pieces of crime scene evidence have been entered and over 34,700 “hits” have been logged.

Association of Firearm and Tool Mark Examiners (AFTE)

"In recognition of the need for the interchange of information, methods, development of standard and the furtherance of research, a group of skilled and ethical firearm and/or toolmark examiners met together regularly prior to 1969. In that year they formed the Association of Firearm and Tool Mark Examiners recognizing that firearm and toolmark identification, though involving similar disciplines, require separate and distinct basic knowledge."

AFTE Bylaws Preamble
Objectives (AFTE)

A. To conduct and sponsor seminars involving the theory and practice of firearm and toolmark examination and its related subjects.

B. To foster the exchange of information between scientific crime laboratories on the improvement and standardization of the development of firearm and toolmark identification and techniques.

C. To publish and issue to members a journal covering the latest developments in firearm and toolmark examination.

D. To make unrestricted gifts to universities and those who are listed in the United States Internal Revenue Service Cumulative List.

E. To engage in the testing of firearms, components, ammunition, and examiners for the benefit of public safety.

F. To respond to requests from courts, judicial tribunals, executive and legislative branches of the government for the names of qualified expert witnesses in the field of firearm and toolmark identification.

Certification (AFTE)

Qualified applicants can choose any or all of the three areas in which they want to be certified.

- Firearm Evidence Examination and Identification
- Toolmark Evidence Examination and Identification
- Gunshot Residue Evidence Examination and Identification

The certification procedure consists of the successful completion of both a written and a practical examination in each of the areas they have selected.

Scientific Working Group-Gun Shot Residue (SWGGSR)

Established by FBI in June 2005.

Mission: to make recommendations for internationally accepted guidelines for the forensic examination of gunshot residues.

- Promote professional development in gunshot residues analysis;
- Provide a means of information exchange within the forensic science community;
- Provide guidelines for gunshot residues investigations, examinations, and reporting;
- Perform collaborative exercises;
- Specify requirements for analysts’ knowledge, skills, and abilities;
- Establish quality assurance guidelines;
- Gain national/international acceptance of SWGGSR guidelines.

Scientific Working Group for Firearms & Toolmarks (SWGGUN)
The purpose of SWGGUN is to develop a series of consensus guidelines for the firearm and toolmark discipline and to disseminate SWGGUN guidelines, studies, and other findings that may be of benefit to the forensic community. The objectives of SWGGUN shall be:

- To recommend and disseminate discipline guidelines for quality assurance and quality control,
- To establish requirements for laboratory management to ensure qualifications of Firearm and Toolmark Examiners and the reliability of examination results,
- To discuss, share and exchange ideas regarding forensic analysis methods, protocols and research,
- To bring together organizations and/or individuals actively pursuing relevant analysis methods for the purpose of exchanging and disseminating information,
- To cooperate with other national and international organizations in developing relevant standards.
- To monitor and disseminate research and technology related to the discipline.

Gunshot Residue (GSR)

- Also called Firearms Discharge Residues (FDR)
- Source: primer, propellant, projectiles, and some other sources.

Detection of GSR

- Visualization
  - Light backgrounds
  - Dark backgrounds with infrared illumination, alternate light source (ALS), or x-ray radiography.
- Chemical
  - Diphenylamine Test
  - Modified Griess Test
  - Sodium Rhodizonate Test
  - Dithiooxamide Test
Chemical Tests

- Diphenylamine Test
  - Tests for nitrates and nitrites
  - Produces a blue color
- Modified Griess Test
  - Test for nitrates
  - Produces an orange color
- Sodium Rhodizonate Test
  - Tests for Lead
  - Produces a red-violet color
- Dithiooxamide Test
  - Tests for copper and nickel
  - Green color for copper, blue or pink color for nickel, yellow may indicate lead, and brown color may indicate cobalt

Detection of GSR

Collection of GSR

- Swabbing
  - Moisten material with solvent and then extract and analyze
- Use Tape, adhesive lifters, or gelatin lifters
  - Particles can be removed or extracted
- Vacuum Lifting
  - Use of vacuum with a filter to remove particles from clothing or other target material
Bullet Impact Marks (BIMs)

- The impact of projectiles with a target that results in a transfer of material from one surface to the other (Locards Principle)
  - Materials from the projectile transfer to the target like parts of the projectile and adherent materials.
  - Materials from the target transfer to the projectile.

Range of Fire

Muzzle-to-Target Distance Estimation
- Contact
  - Muzzle in contact with target
- Close-Range
  - Target close enough to muzzle to receive GSR deposits
- Distant
  - Target far enough away from muzzle that no GSR is present

Contact Gunshots

- Fabric/other materials
  - Little if any GSR
  - Tearing
- Skin
  - Little if any GSR
  - GSR in wound
  - Destruction of skin
Close-Range Gunshots

- Presence of GSR around bullet hole
  - Stippling or tattooing
    - Abrasions caused by propellant particles
  - Soot or Smudging
    - Very fine particles of propellant
  - Fouling
    - Very fine metallic particles from projectile
- Very close range, muzzle flash may singe skin, hair, fabrics and other surfaces

Distant Gunshots

- Bullet hole may possess marginal dirt ring
- Point where no GSR can be detected
Shotgun Pellet Patterns

- **Range-of-Fire Estimation**
  - If they are close enough the can deposit GSR onto the target.
  - If no GSR present, the size and shape of the pellet pattern can help estimate range.

Beltway Sniper Case

I liked this image but was the only good one I could find!
Recognition/References

Information taken from Mr. Ralph R. Ristenbatt III. Instructor for FRNSC 201 & 401.

http://library.med.utah.edu/WebPath/TUTORIAL/GUNS/GUNGSR.html
http://www.nij.gov/training/firearms-training