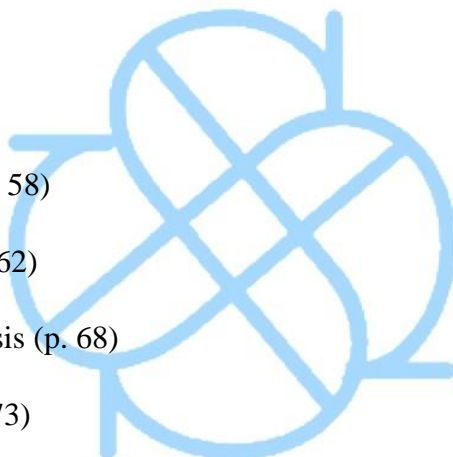


Forensic Science Course Study Guide

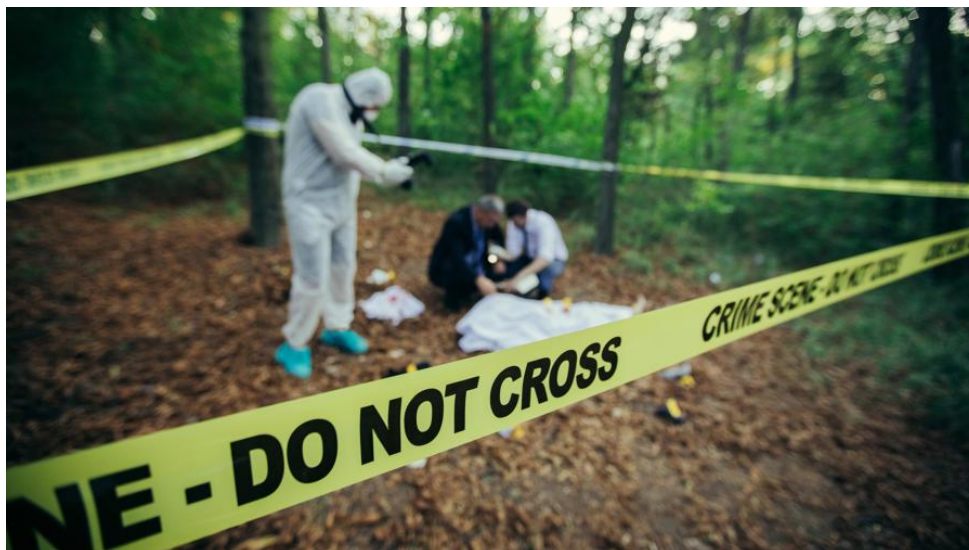
From Simple Studies, <https://simplestudies.edublogs.org> & @simplestudies4 on Instagram

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1. General Information About Forensic Science



From [HYPERLINK "https://www.aetv.com/real-crime/why-its-ok-to-leave-dead-bodies-in-the-woods-and-other-strategies-for-not-messing-up-a-crime-scene"](https://www.aetv.com/real-crime/why-its-ok-to-leave-dead-bodies-in-the-woods-and-other-strategies-for-not-messing-up-a-crime-scene)<https://www.aetv.com/real-crime/why-its-ok-to-leave-dead-bodies-in-the-woods-and-other-strategies-for-not-messing-up-a-crime-scene>

History & Development of Forensic Science

- Criminalist: Forensic Scientist

TV Forensics vs Real Forensics

TV	Reality
Interrogate suspects & kick down doors	Never interrogate suspects; often go to crime scenes long after the crime
Make judgements about guilt/innocence	Should never make judgements about guilt or innocence (can compromise impartiality of scientist and scientific method)
Operate independently of other investigators (go to crime scenes without permission)	Work as part of an investigative team, usually in a subordinate role (police are ultimately in charge)
Usually have multiple expertise (everyone is an expert in everything)	Usually do not have multiple expertise
Act like detectives (ask “why” - why would someone do this and not that; rely on feelings)	Deal with only observable and quantifiable phenomena to reach theories and conclusions (see NAS report)
Get DNA results in a day	Get DNA results in 2-3 weeks average

History & Development

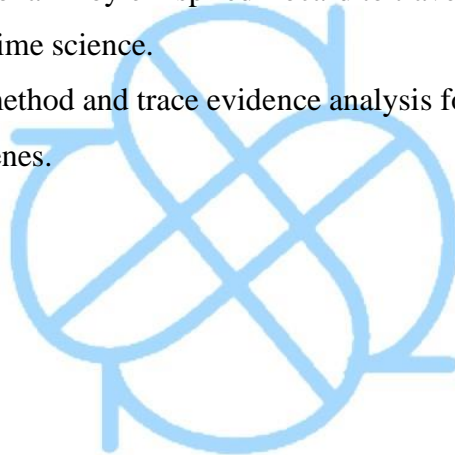
- Sir Arthur Conan Doyle
 - Sherlock Holmes
 - Applies new principles long before investigators used them
 - Serology, fingerprinting, firearm identification, and questioned document examination
 - *A Study in Scarlet*, published in 1887

Important People

- Mathieu Orfila: Father of forensic toxicology (poison); 1814 book.
- Alphonse Bertillon: Anthropometry (system of body measurements) for identification
- Francis Galton: First definitive study and classification of fingerprints; 1892 book.
- Leon Lattes: Determined blood group of dried blood; 1915.
- Hans Gross: First to suggest combining police investigations and science; 1893.
- Calvin Goddard: Ballistics (matching a bullet to a gun)
- Albert Osborne: Document examination; 1910

Edmond Locard (1910)

- Born in France.
- Obtained Ph.D. in legal medicine (1902) & passed the bar exam (1907).
- Works of Hans Gross and Conan Doyle inspired Locard to travel to major cities of the world to study police agencies and crime science.
- Incorporated the scientific method and trace evidence analysis for crime scene investigation and reconstruction crime scenes.
- Started the first crime lab.



- In 1932 under the directorship of J. Edgar Hoover, a national laboratory was established to offer forensic services to all law enforcement agencies in the country.
- The FBI lab is the largest forensic science lab in the world.
- Performs over one million examinations every year.
- The FBI's Forensic Science Research and Training Center was established in 1981.
 - Conducts experiments to develop new and reliable scientific methods that can be applied to forensics.
 - Trains other crime lab personnel.
- Crime Lab Services:
 - Physical science, biology, firearms, document examination, photography, fingerprint, ballistics, polygraph, voice analysis, evidence collection, trace evidence, arson, toxicology, computer crimes
- Scientific Forensic Services:
 - Pathology, anthropology, entomology, psychiatric, odontology
 - Engineering, accounting, documents, chemistry, biology, botany

Frye vs United States (1923)

- In rejecting the scientific validity of the lie detector (polygraph) in 1923, the District of Columbia Circuit Court set forth what has since become the standard guideline for determining the judicial admissibility of scientific examinations.
- To meet the Frye standard, the court must decide if the questioned procedure, technique, and principles are "generally accepted" by a meaningful segment of the relevant scientific community.

Daubert vs Merrel Dow (Pharmaceutical 1993)

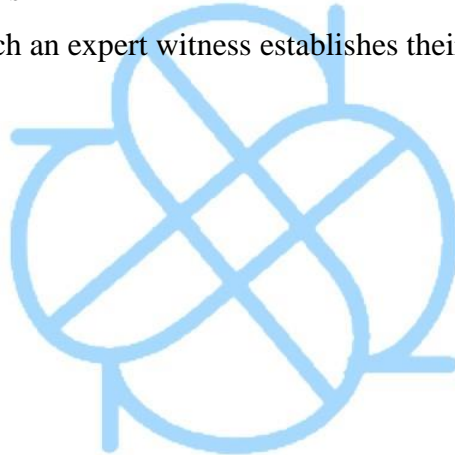
- Judge determined admissibility of scientific evidence based on expert testimony.
- Judges did a preliminary assessment of whether the reasoning or methodology underlying the testimony is scientifically relevant and reliable.

Determining Admissibility

- Judges must consider:
 - If the information in question could be/has been tested.
 - If the theory of technique went through peer review and publication.
 - The known or potential rate of error.
 - If the theory or technique has gained general acceptance in the relevant scientific area.

Expert Witness Testimony

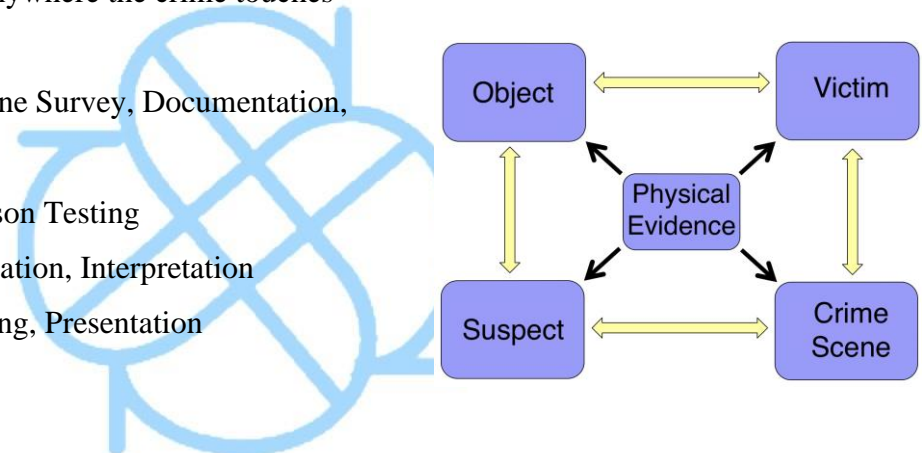
- To qualify as an expert witness:
 - Education/higher degrees
 - Experience in field
 - Published
 - Professional organizations
- Voir dire: A process by which an expert witness establishes their qualifications



The Crime Scene

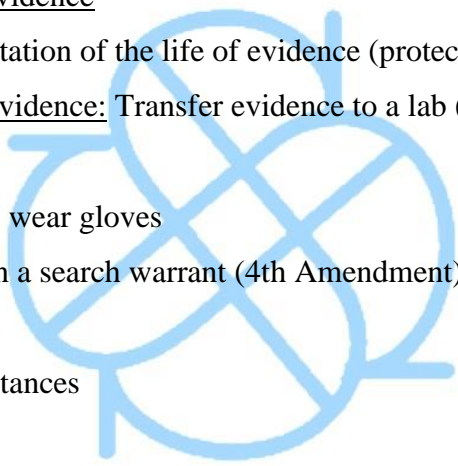
Notes

- Forensic Science begins at the crime scene
 - If you mess up, you probably can't fix it
 - You only get 1 chance
- Look for:
 - What is there that should not be there - Obvious items that stand out
 - What is not there that should be there - Subtle things that indicate something is not right
- Types of Crime Scenes:
 - Outdoor: Small area or miles long
 - Indoor: Easier to control (fewer environmental issues, but more crowded with personnel)
 - Conveyance: Involves transportation
- Primary Crime Scene: Where the crime took place
- Secondary Crime Scene: Anywhere the crime touches
- Crime Scene Investigations
 - Recognition: Crime Scene Survey, Documentation, Collection, Preservation
 - Identification: Comparison Testing
 - Individualization: Evaluation, Interpretation
 - Reconstruction: Reporting, Presentation



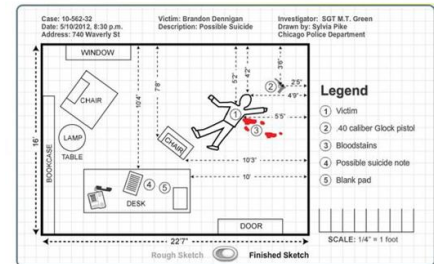
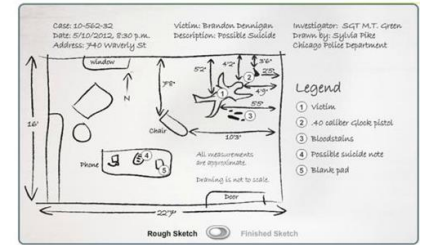
Processing The Crime Scene

- Secure and Isolate: Preserve and Protect the Scene

- Make scene safe, provide medical attention, establish perimeter (overestimate; may need to be multi-level), focus on 3 dimensions, establish ingress/egress point, assign officer to log all personnel in and out
 - Walk-Through
 - Record the Scene
 - Photography: Overview (whole scene) & Itemized (specific item); Photo Log
 - Sketches: Rough (with measurements) & Finished (scaled - shows where everything is in relation to everything else)
 - Notes
 - Search for Evidence: Establish search patterns
 - Collect and Package: Always use paper bags (except for arson evidence - use airtight canisters)
 - Never shred or destroy evidence
 - Chain of Custody: Documentation of the life of evidence (protects integrity of evidence)
 - Obtain Controls & Submit Evidence: Transfer evidence to a lab (limited access vaults); complete paperwork
 - Crime Scene Safety: Always wear gloves
 - Legal Considerations: Obtain a search warrant (4th Amendment)
 - Warrantless Searches:
 - Exigent (urgent) circumstances
 - Plain view
 - Probable cause (has/will commit a crime)
 - Prevent from destroying evidence (needs of society > needs of individual)
 - Safety of officer
- 

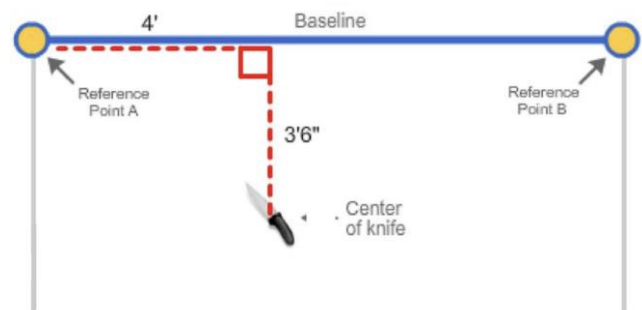
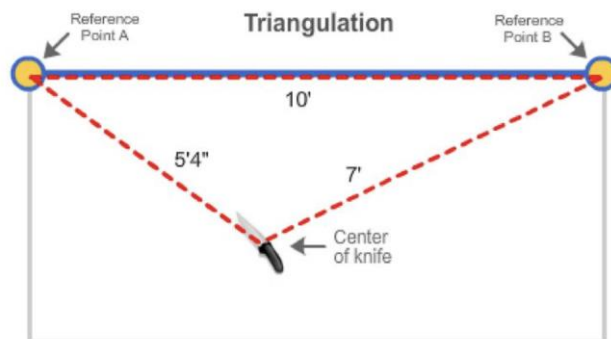
Sketches

- Know where everything is in relation to everything else
- Rough Sketch: Include measurements
- Final Sketch: Proportionate (measurements are not always included)
 - Not always made
- Basic Case Information: Time, Date, Location
- Measure 90° from wall to object
- Black Line Drawing: Shown instead of pictures sometimes
 - Pictures are distracting and induce emotion
- Triangulation Measurement: Measure item based off two fixed points
 - Walls, big trees, building corner, telephone pole, street lamp, fire hydrant, sewer grate
- Baseline Measurement: Run tape measure (baseline) along crime scene, measure from baseline to item
 - Measure in a straight line from a fixed object
- Laser Scanner: Creates replica of crime scene
 - Gives all measurements, marks evidence points



Rough vs Final Sketch
From HYPERLINK
["https://slideplayer.com/slide/121"](https://slideplayer.com/slide/121)

•3D Diorama



From HYPERLINK

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From HYPERLINK

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Physical Evidence

- Impossible to list all objects that could be important to a crime.
- Almost anything can be physical evidence.
- Physical evidence is collected and analyzed.
- A jury ultimately decides the importance of a piece of evidence in a case.

Examples of Physical Evidence

- Objects: Tools, firearms, displaced furniture, notes/letters, vehicles, cigarettes, weapons, documents, drugs, explosives, fibers, glass, paint, petroleum products, plastic bags, rubber polymers, powder residues, serial numbers, soil, vehicle lights, wood/vegetative matter.
- Body Materials: Blood, semen, hair, tissue, saliva, urine, feces, vomit, hair, organs, fluids.
- Impressions: Fingerprints, tire tracks, shoe prints, toolmarks, bullet holes, dents, scratches, newly damaged areas.

Class Characteristics

- Characteristics shared by at least one other item.
- Many are part of the manufacturing process: size, spacing, tread design, etc.

Individual Characteristics

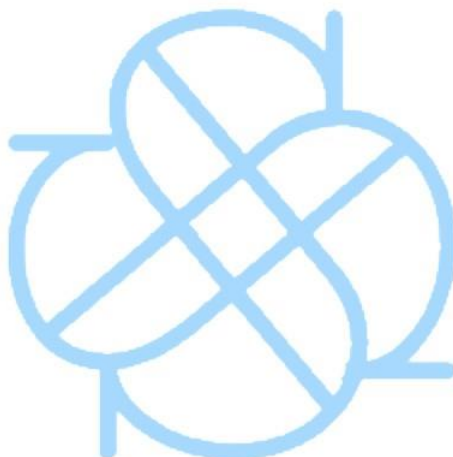
- Characteristics that are unique and random.
- Establishes a link between a questioned impression and one object.

Wear Characteristics

- Changes in the surface of an object due to the erosion of portions of the surface.
- Not individualizing - Possible for two or more things to wear in similar manners

Forensic Databases

- The Integrated Automated Fingerprint Identification System (IAFIS): National fingerprint & criminal history system, FBI
- The Combined DNA Index System (CODIS): Crime laboratories can electronically exchange and compare DNA profiles
- The National Integrated Ballistics Information Network (NIBIN): Firearm markings on bullets and cartridge casings
- The International Forensic Automotive Paint Data Query (PDQ): Chemical and color information for original automotive paints
- Shoeprint Image Capture and Retrieval: (SICAR): Shoe Print database



CSI Effect

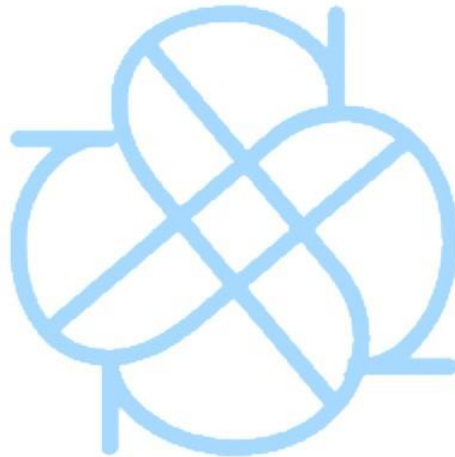
- Prosecutor's believe that crime programs are skewing juror's courtroom expectations, ultimately making it more difficult to win their cases and convict defendants.
- Some believe technology in general is at fault, but the belief is persistent - crime programs (e.g. CSI) are influencing jurors and the courtroom.
- Studies suggest that regular CSI viewers have higher expectations for courtroom evidence.

Negative Effects

1. More difficult to prosecute defendants
 - Jurors want more hard evidence (e.g. smoking gun & DNA proof), which doesn't always exist.
 - Circumstantial evidence and eye-witness accounts are not good enough (jurors want sophisticated science in every trial).
2. Harder to find jurors
 - Some states allow lawyers to dismiss potential jurors from the pool based on the TV programs they watch.
 - Flag or remove jurors who frequently watch crime programs.
3. Straining already tight resources
 - Some investigators run useless tests to get more evidence to strengthen their case and satisfy jury members.
 - Wastes money and time.
4. Manipulating crime scenes
 - Criminals use crime shows to help them not get caught (e.g. wear gloves, bleach incriminating evidence).
5. Defense lawyers are spending too much time educating juries
 - Defense teams must present and explain forensic evidence to juries, who have difficulty understanding it.
 - Calculated in probabilities rather than certainties

Positive Effects

1. Jurors are becoming more knowledgeable
 - CSI-viewers show patterns of higher legal knowledge (expect relevant evidence and dismiss irrelevant evidence).
2. Interest is increasing in the criminal justice field
 - Raises interest and awareness to legal, medical, and investigative professionals and their work (potential jobs).



2. Death Investigation

TRIGGER WARNING



From [HYPERLINK "https://alienredqueen.wordpress.com/2012/11/11/the-not-so-walking-dead-](https://alienredqueen.wordpress.com/2012/11/11/the-not-so-walking-dead-)



Death Investigation

TV Myths

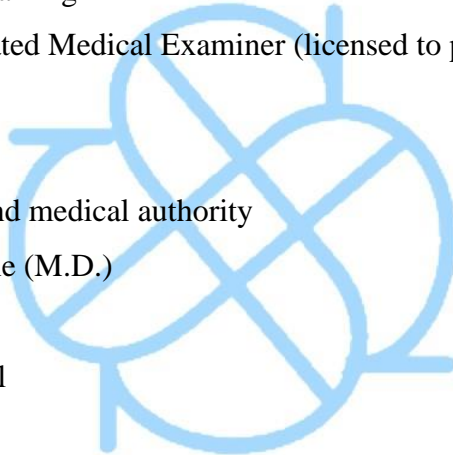
- Quickly tell time of death
- Recreate the “death scene” in their heads
- Determine hand dominance
- All suicides leave a note
- A Medical Examiner can always determine the cause of death

Coroner System

- Quasi Judicial function
- Determined cause of death
- No particular education or training
- Massachusetts: 1877 Legislated Medical Examiner (licensed to practice medicine)

Medical Examiner (ME)

- Replaces Coroner as legal and medical authority
- Licensed to practice medicine (M.D.)
- Training:
 - 4 years in medical school
 - 1 year internship
 - 4 years residency in anatomic/clinical pathology
 - 1 year in large ME office (fellowship)
 - 2 to 3 day examination for Board Certification (Some go on to JD (law) degree)



Medicolegal Investigator (MLI) Minimum Qualifications

- Degree in Criminal Justice or Biological Sciences (preferred - includes anatomy or physiology)
- 3 years of full time experience as medical investigator, deputy coroner, law enforcement officer, mortician, emergency medical technician, or related field
- Paramedic or physician assistant
- Pass a background investigation (includes prior driving, work, and criminal history)

MLI Knowledge, Skills, Abilities, Competencies

- Medical investigative practices and techniques
- Proper handling and processing of evidentiary material
- Proper grammar and spelling
- Office policies and procedures
- Medical terminology, anatomy, and physiology
- State and local laws regarding deaths and human remains
- Still working with human remains
- Digital photography
- Dealing with distraught, upset, and violent family members
- Preparing accurate, complete, and concise reports (including type written narrative section & diagrams)
- Exercise mature judgement, react effectively in emergency/stressful situations, exercise persuasive and tactful authority
- Assist with autopsies
- Establish and maintain an effective working relationship with other agencies and the public

Cause & Manner of Death

- Cause of Death: A medical determination or finding based on evidence and opinion.
- Manner of Death: A legal determination; circumstances by which cause of death came to be.
 - Natural, Accidental, Homicide, Suicide, Undetermined

Time of Death (TOD)

- Establish a Postmortem Interval (PMI) (window of death)
- Sometime between the last time __ was seen alive and the time __ was found dead

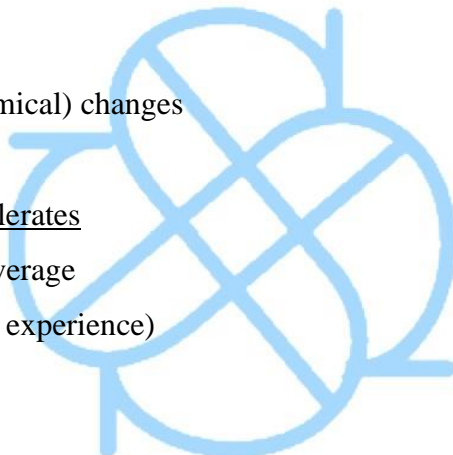
Establishing Time of Death

Two Methods/Strategies

- Rate: Measures changes in the body by process which take place at known rates.
 - Rigor, Algor, and Livor Mortis
- Concurrence: Compares the sequence of events that took place at known times with the time of occurrence of the event under investigation.
 - A wrist watch stopped by a blow during an assault.
 - The extent of digestion of the last known meal.

Rigor Mortis: Stiffness of Death

- Classic marker of death
- Rigidity of the body
- Produced by metabolic (chemical) changes
- More rapid in small muscles
- Heat accelerates - Cold decelerates
- Full Rigor: 6-24 hours, 12 average
- Very subjective (depends on experience)
- Scientifically Unreliable



Algor Mortis: Temperature of Death

- Body temperature is a narrow range (not fixed).
- Illness, decomposition, infection, and absorption of heat can raise body temperature.
- Many formulas to determine TOD.
- Clothing, bodies of water, fatness, ventilation, age, weather conditions.
- Rectal or liver temperature needed.

Livor Mortis: Color of Death

- Settling of blood to dependent parts of the body.
- Cardiac activity stops, hydrostatic pressure of the blood no longer keeps the blood vessels open.
 - Hydrostatic Pressure: The pressure exerted by blood on walls of blood vessels, keeping them open.
- Color depends on skin pigment and additional compounds in the blood (e.g. carbon monoxide).
- Generally dark blue/purple.
- Body areas touching the ground will be blanched (white).
- Usually reaches maximum appearance 8-12 hours.

Dependent vs Fixed Lividity

- Dependent: Just after death, blood flows to the dependent parts of the body and settles.
 - Lowest parts of the body due to gravity.
- Fixed: After a period of time, blood becomes fixed in its location and will not move (even if the body is moved).

Patterned Livor Mortis

- Can give class evidence where the person died and was laying.

Documentation

- The lividity is consistent with the position of the body.

Stages of Human Decomposition

4 Stages

- Fresh: Initial Decay (Autolysis)
- Bloated: Putrefaction
- Decay: Black Putrefaction
- Post Decay: Butyric Fermentation

Stages & Times of Decomposition

- 12-36 hrs: Blue green discoloration of skin. Right & left lower quadrant & abdomen.
 - Marbling: Green black discoloration in blood vesicle distribution
 - Hemolyzed blood reacts with hydrogen sulfide
- 36-48 hrs: Bloating (most marked in areas of loose skin - scrotum, penis, eyelids)
- 60-72 hrs: Entire body decomposition
- 4 to 7 days: Skin Slippage (glove formation on hands/feet)
- Several Months: Saponification/Adipocere (prolonged exposure to moisture. White slippery appearance. From subcutaneous fat)
 - Mummification: Drying interrupts decomposition. Bacterial growth interrupted if moisture content <50%
- Weeks/Years: Skeletonization

Decomposition Length

- $Y = \frac{1285}{X}$
 - Y = Number of days it takes to become skeletonize or mummified
 - X = Average temperature (Centigrade/Celsius) during decomposition

Bacteria

- Break down organs (melt them).
- Gas bubbles form.
- Liquified organs come through the esophagus and mouth.

Autopsy - To See For Oneself

Purpose

- Provide critical information in determination of the true cause and manner of death

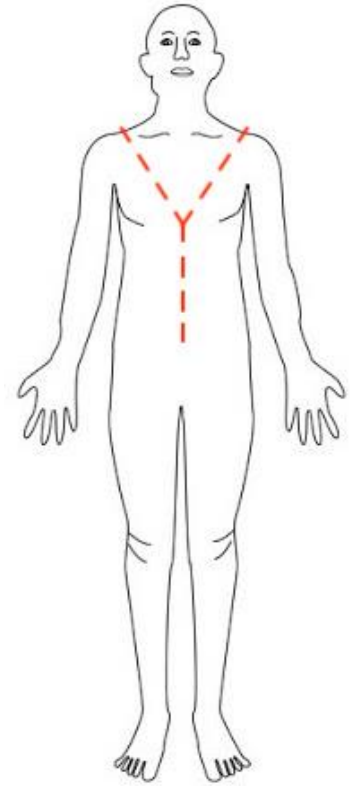
When is an Autopsy Performed?

- Sudden natural and/or violent death
- Cause, manner, and TOD may be unexplained at the time

How an Autopsy is Performed (The Basics)

1. Take notes (or get a voice recorder and dictate notes aloud)
2. Document height, weight, age, gender, distinguishing characteristics (birthmarks, scars, tattoos)
3. Take fingerprints (may be needed in police investigation)
4. Examine body very closely, meticulously, under magnification
 - Check clothing and skin for any marks that look out of the ordinary (fibers, blood droplets, organic materials, residues found on clothing, bruises, wounds, marks on skin - trace evidence)
 - If foul-play is suspected, carefully check under the victim's fingernails (often find blood/skin from attacker)
5. Check for any dental work (dental records are often used to identify bodies)
 - Perform x-ray to find any broken/fractured bones or medical devices (e.g. pacemaker) (records can identify subject)
6. Check the genital area for any signs of rape (bruising & tearing common in such cases)
5. Take photographic record of the body, clothed & nude
 - Take special care when removing clothing (may be needed for police investigation)
 - Take close-up shots of the marks, bruises, blood patches
8. Take blood sample (used for DNA and toxicology)
6. Open body cavity with thoracoabdominal incision (Y-incision from each shoulder, across the chest, to the diploid process, down to belly button)
7. Split the ribcage, open it up, examine heart and lungs (note abnormalities & take blood sample directly from heart)

8. Examine, weigh, record anything notable, and take tissue sample from each organ in the chest cavity individually
9. Repeat step 11 for all organs in lower body (partially digested food can be used to determine TOD)
10. Take urine sample from bladder with syringe (toxicology)
11. Carefully examine the eyes/petechial hemorrhages (tiny broken blood vessels in eyes, sign of choking/strangulation)
12. Examine the head. Check for any trauma to the skull (e.g. fractures or bruises)
13. Remove the top of the skull, then the brain. Examine, weigh, and take a sample
14. After the autopsy is completed, finish notes. State the cause of death and reasoning. Mention every detail
15. Based on findings (licensed coroner), The Chief Medical Examiner will issue a Death Certificate
16. The body will be returned to surviving family members for funeral arrangement



Thoracoabdominal Incision
From [HYPERLINK](http://20.b2.overdick-partner.de/blank-anatomical-diagrams-)
"http://20.b2.overdick-partner.de/blank-anatomical-diagrams-

What do MEs Look For

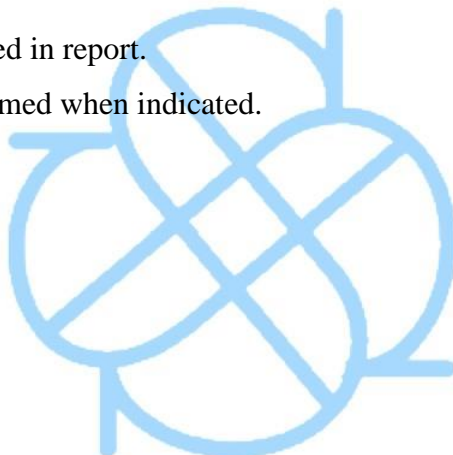
- Abrasion and contusions, defensive wounds
- Fingernail marks: Crescentic abrasions (vertical & horizontal)
- Fingertip bruises
- Trauma to the neck (usually bony structures - hyoid)
 - Blood at fracture site indicated pre-mortem injury
- Petechial hemorrhages
- Internal examination of all organs
- Evidence of sexual assault

Amount of Pressure to Cause Asphyxiation

- Jugular Veins: 4-5 lbs
- Carotid Arteries: 11 lbs
- Trachea: 33 lbs
- Vertebral Arteries: 66 lbs

Performing a Forensic Autopsy

1. A complete history of the circumstances surrounding the death (obtained prior to autopsy).
2. The ID of the decedent should be documented.
3. The complete, detailed external exam of the body and clothing (save all clothing).
4. A complete autopsy should be performed and injuries should be documented with diagrams, photos, and x-rays.
5. Pertinent negatives included in report.
6. Toxicologic studies performed when indicated.



Internal Exam

Mechanical Asphyxia (e.g. Strangulation)

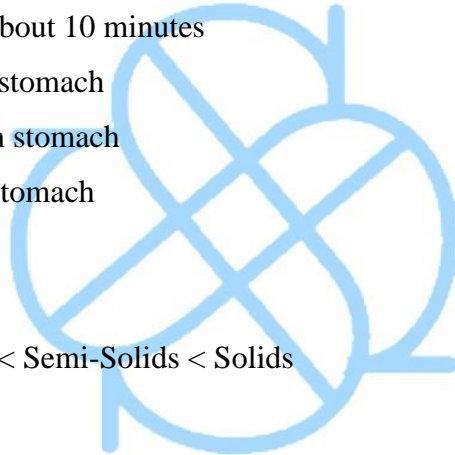
- Can be marked by the appearance of petechial hemorrhages on the conjunctiva.
- Signs of Strangulation: Bruises, marks on neck, bleeding in throat, fracture of hyoid bone (U-shaped bone at the base of the tongue).

Drugs

- Sometimes, people will swallow drugs in containers (e.g. condoms) to transport them.
- These containers may rupture or leak, inducing a drug overdose.

Last Meal

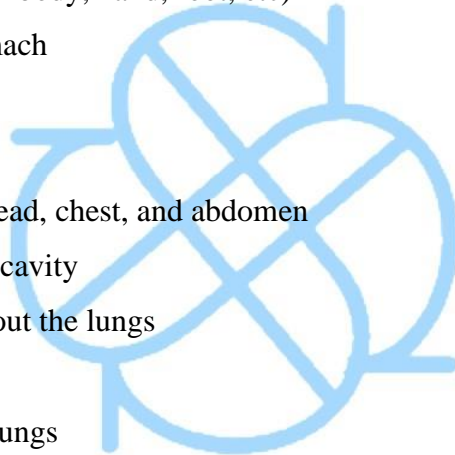
- Stomach starts to empty in about 10 minutes
- Light Meal: 1.5 - 2 hours in stomach
- Medium Meal: 3 - 4 hours in stomach
- Heavy Meal: 4 - 6 hours in stomach
- Variations: Stomach Issues
 - Emotional State
 - Digestion Rate: Liquids < Semi-Solids < Solids



Medical Terminology

Anatomy

- Anterior: Toward the front
- Aorta: The large artery connected to the heart which distributed blood to the other arteries
- Artery: Thicker walled blood vessels, under pressure, which carry blood from the heart to the body
- Cardiac: Relating to the heart
- Cerebral: Relating to the brain
- Cerebrospinal Fluid (CSF): The fluid around the brain and spinal cord
- Coronary Arteries: The blood vessels supplying the heart
- Dorsal: Towards the back (of body, hand, foot, etc)
- Gastric: Relating to the stomach
- Lateral: Toward the side
- Medial: Toward the middle
- Midline: The center of the head, chest, and abdomen
- Peritoneum: The abdominal cavity
- Pleural: The chest cavity about the lungs
- Posterior: Toward the back
- Pulmonary: Relating to the lungs
- Vein: Thin walled blood vessels which return blood to the heart

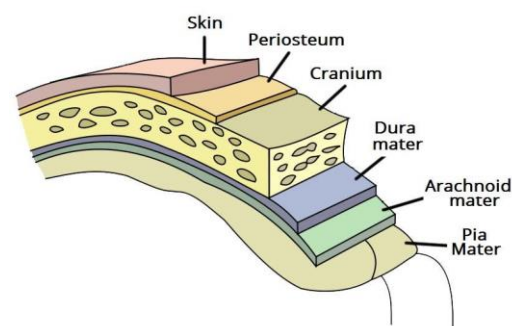


Disease

- Aneurysm: A weakening of the wall of a blood vessel with dilation of the vessel and often rupture of the vessel causing severe bleeding
- Arteriosclerosis: “Hardening of the arteries” - An aging process marked by narrowing of food vessels by build-up of cholesterol and scar tissue
- Cerebra-Vascular Attack (CVA): A stroke, severe injury to the brain resulting from spontaneous hemorrhage or thrombosis (blood clot within blood vessel)
- Embolus: A thrombus (clot) which breaks away from where it formed and travels to another area of the body
- Hemorrhage: Bleeding either outside the body or into one of the body cavities
- Infarction: Dead tissue in an organ due to insufficient circulation of blood
- Myocardial Infarction: “Heart Attack” - Death of an area of heart muscle

Injury

- Bruise/Contusion: The bluish swelling of blood beneath the skin
- Comminuted Fracture: A break of a bone with separation of the broken ends
- Laceration: A tearing of the skin
- Incision: Cutting of the skin due to a blade
- Subarachnoid Hemorrhage: Bleeding, often spontaneous, sometimes from an injury, between the brain and the arachnoid
- Subdural Hemorrhage: Bleeding, almost always from an injury, between the inside of the skull and the dura. This accumulation of blood produces pressure on the brain

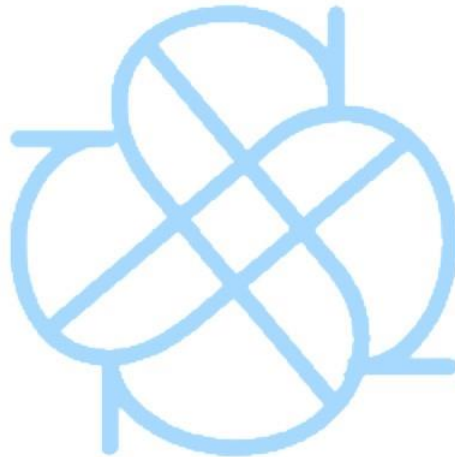


Layers of the Head
From [HYPERLINK](https://teachmeanatomy.info/neuroanato)

"<https://teachmeanatomy.info/neuroanato>

Other

- Asphyxia: A condition of severely deficient supply of oxygen to the body that arises from abnormal breathing (e.g. choking)
 - Inability of an individual to acquire sufficient oxygen through breathing for an extended period of time
 - Can cause generalized hypoxia, coma or death
- Hypoxia: A condition in which the body/region of the body is deprived of adequate oxygen supply
 - Deficiency in the amount of oxygen reaching the tissues and cells



3. Forensic Photography



From HYPERLINK "<https://www.l-tron.com/police-photography-camera->

Forensic Photography

Role of Forensic Photographer

- Produce truthful and objective images.
- Represent the scene as it was found.
- Produce images for measurement and analysis (accompany forensic, medical, or scientific reports).

Digital Imaging

- Original image preserved with redundancy.
- Digital processing steps (changes) are logged.
- End result is presented as an enhanced image.
 - May be reproduced by applying the logged steps to the original image.
- Benefits:
 - Immediate results
 - Cost
 - Admissibility in court (passed Frye in 1996)
 - Security & storage
 - Some photos stored on internet less computers (anti-hacking).
 - Only certain people were allowed into the room.
 - Phones that no one else has access to (passcode & ID to get in).

Alteration vs Enhancement

- Alteration: To change what the image represents
 - NEVER make any alterations!
- Enhancement: To make the image easier to view (changing brightness, contrast, sharpness, cropping, etc.)
 - Allowed as long as every enhancement is logged.

Depth of Field

- How much is in focus in front of and behind the subject.
- **Shallow DOF:** Only subject is in focus (macro photography)
 - Blurry directly in front of and behind the subject
- **Long DOF:** Everything in focus (crime scene photography)
 - In focus in front of and far behind the subject

Image File Formats

- **RAW:** Uncompressed file format (preferred for high detail images).
 - Evidence comparison photos
 - Large number of pixels
- **JPEG:** Compressed file format (high compression will affect image detail).
 - General crime scene photography
 - Fewer number of pixels
- GIF, EPS, Bitmap, Pict, etc.



RAW Image (Left) vs JPEG Image (Right)

From [HYPERLINK](#)

["https://www.youtube.com/watch?v=wrckVIY5vwU&list=LLs1R5Ig0knc69mYZtbpp1ew&index=2&t=0s"](https://www.youtube.com/watch?v=wrckVIY5vwU&list=LLs1R5Ig0knc69mYZtbpp1ew&index=2&t=0s)<https://www.youtube.com/watch?v=wrckVIY5vwU&list=LLs1R5Ig0knc69mYZtbpp1ew&index=2&t=0s>

Lighting

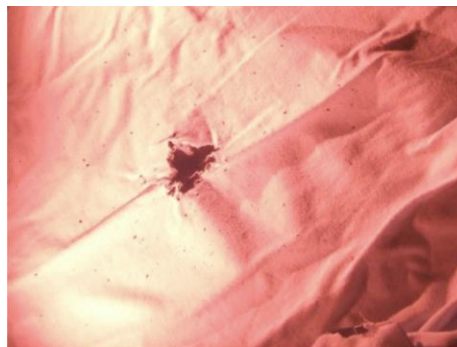
- **Fill Flash:** Fills in the space of darkness
 - Fixes backlighting problems
- **Infrared Photography:** Removes colored designs on items



No Fill Flash (Left) vs With Fill Flash (Right)

From [HYPERLINK](#) ["https://www.crime-scene-photography.com/2012/05/01/flash-photography/"](https://www.crime-scene-photography.com/2012/05/01/flash-photography/)

- Finds gun powder residue



Crime Scene Photography Kit

- Cameras, normal lens (24-70 mm), wide angle lens (14-24 mm), macro lens, flash, batteries (camera & flash), tripod, flashlight, memory cards, owner's manuals, notebook, pen, photo scales.

Important Photographs

- Overview (generally in corners) (always note direction photograph was taken in photolog)
- Intermediate (mid-range)
- Overview/Intermediate with markers
- Itemized evidence
- Evidence comparison images
 - RAW, 90°, Photo Scale

IR Photography Showing



Overview Photo
From [HYPERLINK](#)

<https://www.dailymail.co.uk/news/article-2551981/Amazing-70-year-old-crime-scene-photos-bodies-WWII-Airforce-pilot-wife-died-murder-suicide-near->

- Photo Log!
- Never put anyone in the photo (except decedents)

Special Lenses

- Macro Lens: Extremely close up image of a subject (the subject fills up the whole field of view)
 - Have special flash for macro photography
- Wide Angle Lens: Great for overview (14-24 mm, 24-70 mm)

Meta Data

- Describe everything about the image (e.g. pixels, shutter speed)
- Show where or when an image was taken
- Cannot be changed easily

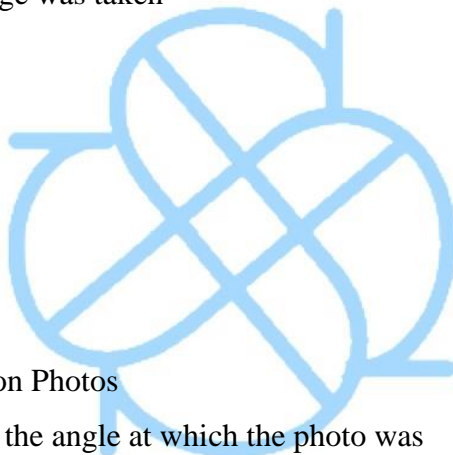
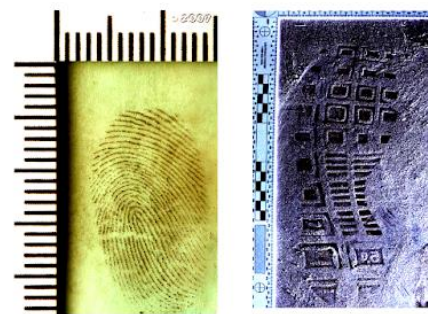


Photo Scales

- Used in Evidence Comparison Photos
- The circles are used to show the angle at which the photo was taken
 - If $< 90^\circ$, the circles will be ellipsis

Alternate Light Sources

- Help to see things not visible in visible light



Evidence Comparison Photos
From HYPERLINK
"<https://www.forensicscienceexpert.com/2019/12/forensic-photography-need->

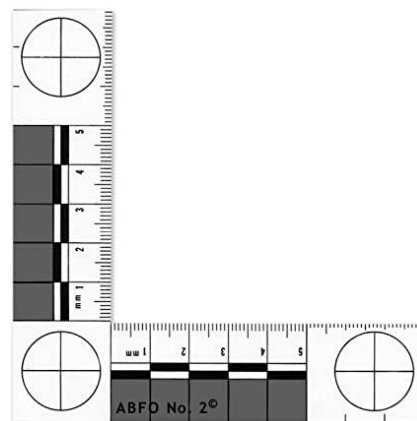


Photo Scale
From HYPERLINK
"<https://www.amazon.com/Forensics-Source-6-3875-Bitemark->



4. Fire Investigation



From HYPERLINK
"<https://bangordailynews.com/2020/07/24/news/portland/portland->



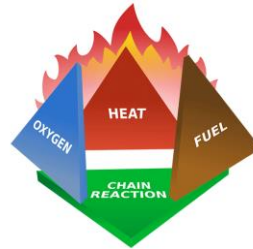
The Chemistry and Physics of Fire

Arson Investigation Focus Areas

1. Proof of Incendiarism: Comes from an examination of the fire scene by a qualified cause and origin investigator.
2. Proof of Opportunity: Focuses on the security of the building/place when the fire was discovered and who had access.
3. Proof of Motive: focuses on the Insured's Financial Condition, profit/loss from questions, cash flow, revenge, anger, etc.

4. Miscellaneous Connecting

Evidence: Includes. An examination of the insured's insurance history, operability of fire and burglar detection systems, how insured learn about the fire, etc.



The Fire Tetrahedron
From HYPERLINK
"<https://fire-risk-assessment-network.com/blog/fire->



V Pattern
From HYPERLINK
"<https://www.thinglink.com/scene/732952651032952832>"http

The Fire Tetrahedron

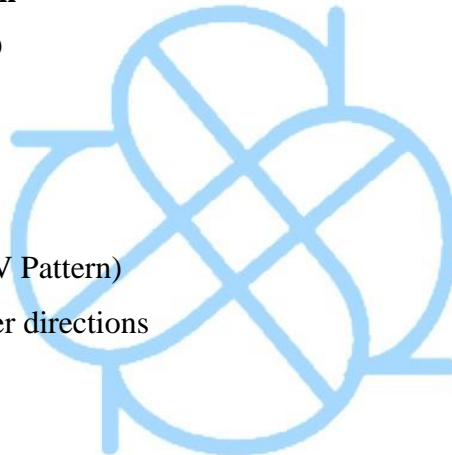
- Take one away and the fire goes out.

Chemistry of Fire - Oxidation

- $\text{CH}_4 + 2\text{O}_2 \longrightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- $4\text{Fe} + 3\text{O}_2 \longrightarrow 2\text{Fe}_2\text{O}_3$

Physics of Fire

- Naturally burns up and out (V Pattern)
- Investigate any burns in other directions

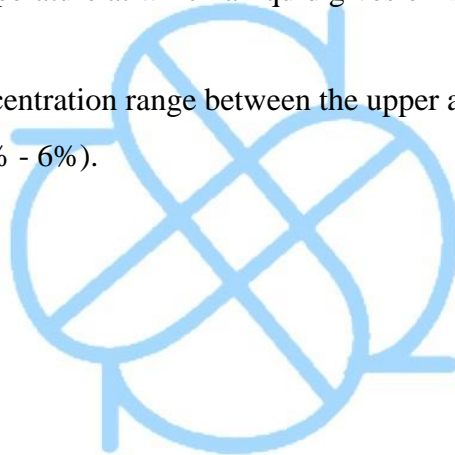


Transfer of Heat

- Conduction: Transfer of heat between substances that are in direct contact with each other.
- Convection: Thermal energy is transferred from hot places to cold places when warmer areas of a liquid or gas rise to cooler areas in the liquid or gas.
- Radiation: Heat transfer that does not rely upon any contact between the heat source and the heated object.
 - Heat is transmitted through empty space by thermal (infrared) radiation.

Important Definitions

- Oxidation: Oxygen combining with other substances to produce new products (e.g. rust).
- Heat of Combustion: The excess heat energy given off as heat and light.
- Flashover: The temperature at which anything that can combust will combust (1100°F).
- Exothermic Reaction: One that gives off heat energy.
- Glowing Combustion: Combustion on the surface of a solid fuel in the absence of heat high enough to pyrolyze the fuel (e.g. cigarette).
- Pour Pattern: A pattern left by the vaporization of flammable liquids.
- Ignition Temperature: The temperature a fuel must reach to allow the heat energy input to exceed the energy barrier.
- Flash Point: The lowest temperature at which a liquid gives off sufficient vapor for combustion.
- Flammable Range: The concentration range between the upper and lower limits for combustion (gasoline = 1.3% - 6%).



Chemistry of Fire - Solids & Liquids

- Liquids are heated and the vapors that form burn.
- Solids decompose into gaseous products which burn (pyrolysis).

- Solid and liquid matter do not burn! Only gaseous matter burns!



Pour Pattern

From HYPERLINK "<http://4n6.com/arson-fire-patterns/>"



Combustible & Smoke Color

Wood/Paper/Cloth: Gray/Brown

Cooking Oil: Brown

Oil/Kerosene/Gasoline: Black

Accelerants

Spread the fire around quickly

Speed up burning rate

The Investigation

Firefighters Look For:

- Smoke and flame color
- The crowd
- Cars in area
- Owners/Residents of property
- Knowledge of everyone
- Beginning of the Investigation

Smoke & Fire Color

- Temperature of fire
- Type of material burning

Temperature & Event

- 1000°F: Steel loses $\frac{1}{2}$ strength
- 1220°F: Aluminum melts
- 1400°F: Glass softens
- 1980°F: Copper melts
- 2900°F: Sand melts



Gasoline Burning
From HYPERLINK

"http://sayforward.com/ext/images/burning-double-tanker-gasoline-truck-sends-smoke-skyward-

Fire Setting Mechanisms

- Ignition Devices: To start the fire (matches, capsules, chemicals, gas).
- Plants: To feed the fire (newspaper, rags, wood shavings, waste).
- Trailers: To transport the fire (accelerant, rags, newspaper, black powder).
- Accelerant Residues: Residues left after the fire by flammable liquid

Searching The Fire Scene

- From the least burnt area to the most burnt area.
- 4th Amendment - You can search any room affected by the fire without a warrant.

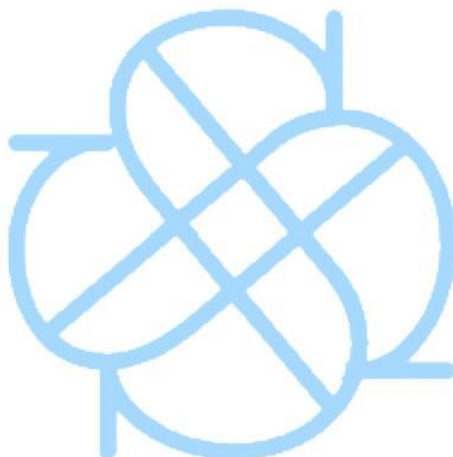
- Collection of Arson Evidence - Warrantless search (exigent circumstances)
- Accelerants, ignition devices, interviews

Fire Evidence

- Smoke Demarcation Line: Damage due to heat not fire.
- No smoke damage to one side of door: Door was closed during fire.
- Burn patterns on floor: Remove furniture from the floor.
- No damage to contacts or internal wires: Not electrical fire.
- Low Burning/Alligating: High Heat



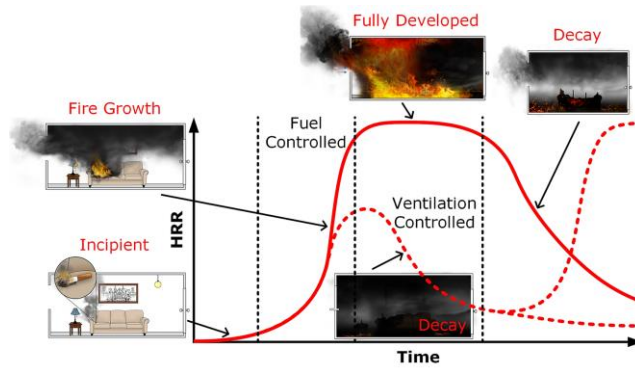
Smoke Demarcation Line
From HYPERLINK
"https://ssem.eku.edu/sites/ssem.eku.edu/files/hicks_gorbett_thurman-full_scale_single_fuel_package_fire_patter



Flashover - 1100°F

- The temperature at which anything that can combust will combust (including people).
- Death of any person trapped in the room.
- End of growth stage - Fire is in fully developed stage.
- Change from a contents to a structural fire.

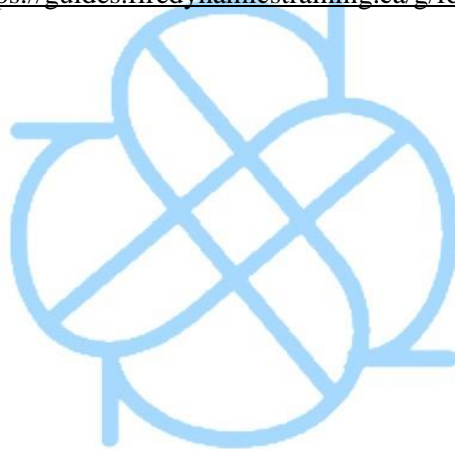
- If there is not enough heat present, the fire will not achieve a high enough temperature to produce a flashover.



Stages of a Fire

From [HYPERLINK](#)

["https://guides.firedynamicstraining.ca/g/fd203-](https://guides.firedynamicstraining.ca/g/fd203-)



Evidence Collection & Analysis

Collection of Evidence

- Photograph ALL evidence first!
- Use appropriate tools (hands, small tools, shovels).
- Wear gloves and always store in airtight containers.
- Label all containers and seal with evidence tape.

Analysis of Evidence

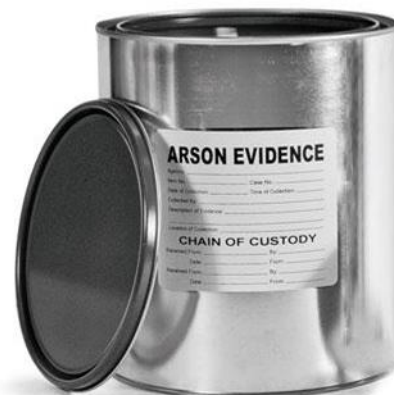
- Many different types of tests.
- Accelerants.
- Gas Chromatograph: Separates all components of accelerants.

Determining Cause of Death

- Fire: Soot/Carbon Monoxide in Blood
- Prior to Fire: No Soot/Carbon Monoxide in Blood
 - Possible Homicide (Foul Play)

Pugilistic Stance

- Contraction of muscles caused by extreme heat (can break bones and skin).
- Appears to be a defensive posture.



Arson Evidence Can
From HYPERLINK

["https://www.arrowheadforensics.com/products/arson-](https://www.arrowheadforensics.com/products/arson-)



Pugilistic Stance
From HYPERLINK

["https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-)

Cause & Origin Investigation

Motives for Arson

- | | | |
|-------------------------|-----------------|----------------------|
| 1. Effort to Hide Crime | Revenge | Thrill (Pyromaniac, |
| 17. Fraud (Insurance) | Riots/Vandalism | Juvenile, Sexual) |
| 18. Jealousy | | Terrorism (e.g. Drug |

Fire Scene Red Flags

- | | | |
|--------------------------------|--|--|
| 1. Large Amount of Damage | “For Sale” Sign (Long Time) | Hand Delivered Proof of Loss (Property Damage Insurance Claim) |
| 19. Low Burning (Altitude) | Fuel cans | Fires Occurring Near Insurance Expiration Date |
| 20. Unidentifiable Origin | Fire Extension Beyond Perimeter of Structure | Over Insured Property |
| 21. <u>No V Pattern</u> | Fires Occurring at Night | Property for Sale |
| 22. Lack of Accidental Cause | Insure Out of Town/Alibi | Alarm System not Set |
| 23. Separate/Unconnected Fires | Recently Issued Policy | Decline in Utility Use |
| 24. Unusual Burn Patterns | Insured Overly Pushy | Liquor (License to Sell Liquor) License Revoked |
| 25. Windows Blown Away | Familiarity with Insurance Terms | Stock Obsolete |
| 26. Forced Entry | | Many Antiques |
| 27. Missing Inventory | | “Destroyed” |
| 28. Missing Personal Items | | |
| 29. Previous Fires | | |
| 30. Unkempt Yard | | |

Order of Operations

- | | | |
|--------------------------------------|--------------------------------------|---|
| 1. <u>Contact Incident Commander</u> | Search Surrounding Area for Evidence | Photograph Scene |
| 31. Interview First Responding Unit | Secure Witnesses | Find all Witnesses Possible |
| 32. Interview First-In FireFighter | Exterior Examination | Create Potential Suspect List |
| 33. Walkthrough First-In FF | Examine Crowd | |
| 34. Establish Ingress/Egress Point | Examine Block | Canine Search All Areas |
| 35. Establish Perimeter | Walkthrough | Rule-Out (Electric, Incendiary, Accidental) |
| 36. Security of all Doors/Windows | Tenant/Owner | |
| | Location of Room | Scene Diagram |

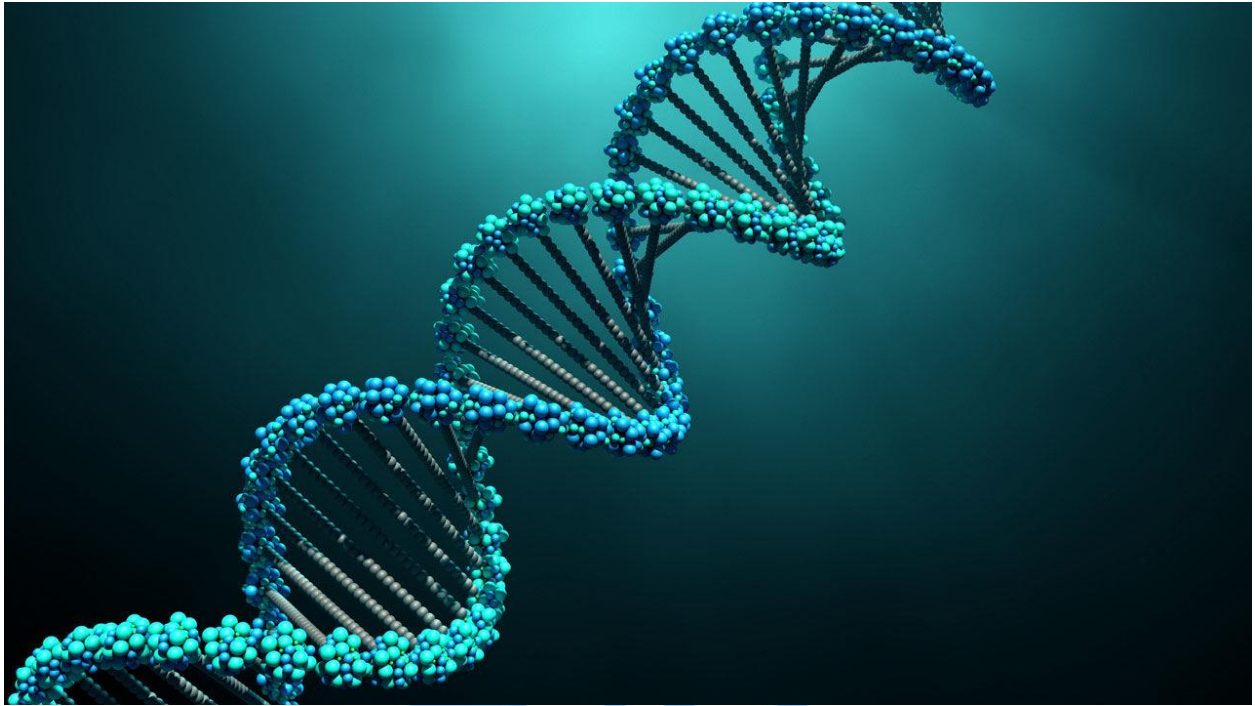
Fire Setting Mechanisms

- Can be intricate mechanical/chemical contraption that will go off hours to weeks after it is set.
- Allows arsonists to get a safe distance away and provides them with an alibi.

Ignition Devices

1. Matches: Source of most fires.
 - Juveniles & Pyromaniacs hold matches to pile of trash.
 - Sophisticated arsonists may combine matches with cigarettes to create a delay.
 - Used in connection with mechanical devices (telephones, alarm clocks, doorbells).
 - Preserve any burnt matches found (physical match with those of suspect).
2. Capsules: Gelatin capsules filled with water activated mix (e.g. silver nitrate magnesium powder, sugar-sodium peroxide, sulphuric acid).
5. Candles: Very effective, but leave wax deposit ($\frac{3}{4}$ inch diameter burns at about 1 inch/hour).
 - Place the candle in an easily combustible container (in or close to accelerants).
4. Chemicals: Ignite upon contact with air (Phosphorous) or water.
 - Most leave residue and/or have a particular odor (many arsonists don't use chemicals properly).
5. Gas: Venting from the kitchen stove comes into contact with pilot light and explodes (lighter-than-air gas rises, then sinks to escape).
 - Often used in suicide attempts (arson is always a possibility).
 - Well recognized gas odor.
 - Time elapsed between initial release and explosion depends on room size, number of openings, type of gas, etc.
 - For a standard 10 x 15 ft well sealed kitchen:
 - Single Burner: 5 hrs
 - Oven Jets: 2 hrs
 - 4 Burners & Oven: 1 hr

5. DNA



From [HYPERLINK "https://www.sciencemag.org/news/2019/11/judge-said-police-can-search-dna-millions-americans-without-their-consent-what-s-](https://www.sciencemag.org/news/2019/11/judge-said-police-can-search-dna-millions-americans-without-their-consent-what-s-)



Forensic DNA

Nitrogenous Bases

- Adenine (A)]
- Thymine (T)]
- Cytosine (C)]
- Guanine (G)]
- Sugar Phosphate Backbone

DNA Applications

- Medical Research, Gene Therapy
- Cloning, Gene Engineering
- Paternity Testing
- Missing Persons, Body Identification
- Biological Warfare Detection Systems
- Human Evolution Studies
- Human Genome Project
- Forensic Science

Biological Sources From Evidence

- Blood (White Cells Only)
 - Red:White = 400:1
- Roots of Hair
- Bone
- Teeth
- Epithelial Cells (Saliva, Skin)

Short Tandem Repeats (STR)

- Small regions along the DNA chain where a particular sequence of bases repeat consecutively.
- The number of repeats in a region can vary from person to person.

Transfer of Biological Fluids

Identification: Blood, Saliva

Individualization: Determine source through DNA analysis

Forensic Science Compares

Unknown to Unknown

Unknown to Known

People, Places, Objects

Inclusions or Exclusions

Types of Evidence

Clothing

Chewing Gum

Weapons

Cigarette Butts

Stamps/Envelope

Bottles

s

2 Types of DNA

Nuclear DNA (nDNA)

~3 billion base pairs

STR testing

Mitochondrial DNA (mtDNA)

~16,600 base pairs

mtDNA testing

Analytical DNA

- 20 different DNA locations are analyzed as part of a DNA profile.
 - Known as STRs and have no known function.
 - Profiles do not include DNA for any visible traits (e.g. race, eye/hair color, diseases).

Testify

- DNA Match: The Frequency of Occurrence of that DNA is so low that the probability of it being someone else barely exists.

DNA Profile Generator

- Extraction of DNA from samples
- Quantification: Is there enough DNA for testing

DNA Amplification

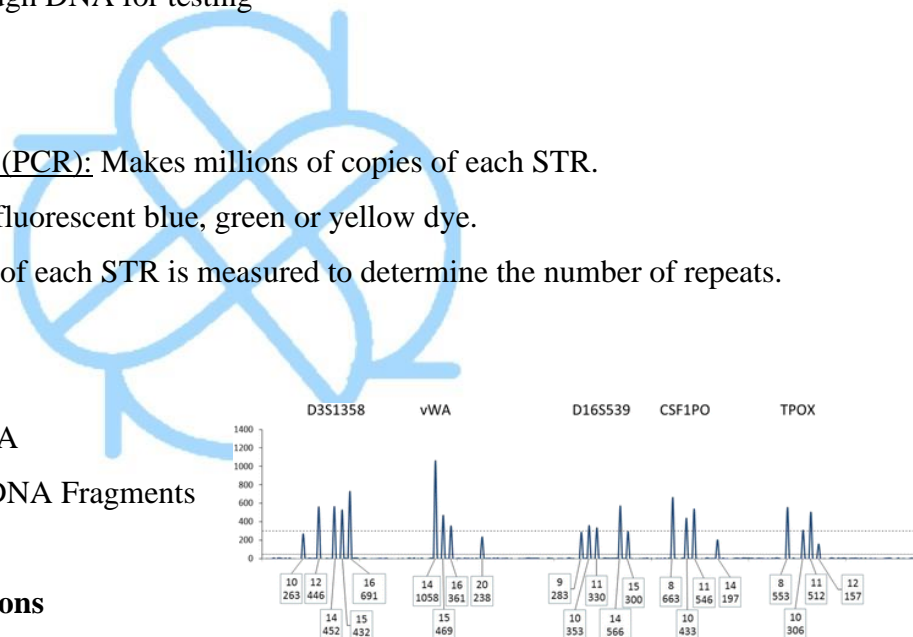
- Polymerase Chain Reaction (PCR): Makes millions of copies of each STR.
- Each STR is labeled with a fluorescent blue, green or yellow dye.
- Electrophoresis: The length of each STR is measured to determine the number of repeats.

Equipment

- Thermo-Cycler: Copies DNA
- Gel Electrophoresis: Sizes DNA Fragments

Interpretations & Comparisons

- Profiles within a case (same source?)
- Profiles between cases (pattern?)
- Profiles to known victim/suspect exemplars (inclusion/exclusion?)



An STR Profile in an Assumed 2 Person Mixture
From HYPERLINK
["https://bmcgenet.biomedcentral.com/articles/10.1186/s1](https://bmcgenet.biomedcentral.com/articles/10.1186/s1)

Simple Mixture Deduction

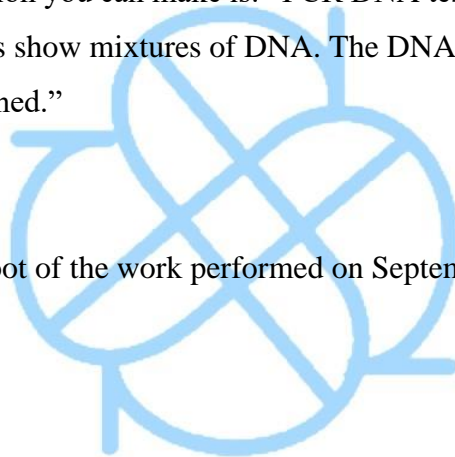
- You can deduce the profiles of the contributors of a mixture if:
 - You know how many contributors you have.
 - You have a comparison sample for one of those contributors.
 - One of the contributors is the major DNA donor to the sample.
- Sometimes even with a comparison sample you can't deduce a mixture when:
 - There are more than two contributors to the sample.
 - The known contributor shares many alleles with the unknown contributors.
 - There is no clear major DNA donor.

Complex Mixtures

- Sometimes the only conclusion you can make is: "PCR DNA testing was done on the following sample; the results show mixtures of DNA. The DNA profiles of the individual donors could not be determined."

DNA Missing Persons

- Formed in 2004 as an offshoot of the work performed on September 11, 2001.



- Since 2004, this group has worked on over 1,000 cases of unidentified, tentatively identified, and missing person cases.

Identification Process

- NYPD Missing Persons Fingerprints
- Dental
- Radiology (X-Ray)
- Forensic Anthropology
- DNA
- Identification Unit
- Medical Examiner



Tissue Inside a Paraffin Block
From [HYPERLINK](https://www.geneticistinc.com/blog/paraffin-embedded-tissue-what-is-)
"<https://www.geneticistinc.com/blog/paraffin-embedded-tissue-what-is->

Direct Matches

- Compare DNA profile from Postmortem Item (PM) to DNA profile from Medical/Known Specimen of individual.
- Freeze sample; Paraffin Block - Preserve Evidence

Kinship Cases

- Compare DNA Profile from Postmortem Item to DNA profiles from Buccal (Inside Cheek) Swabs from Relatives to see likelihood of genetic relationship

High Sensitivity Low Copy DNA Testing

- To identify DNA contributors to challenging biological samples which may be degraded, inhibited, or of a minute quantity using reliable, state of the art technology.

Bind Victims

Cord
Laces
Rope
Wire
Zip-ties

Touched Clothing Requirements

Victim Exemplar
Knowledge of area where clothing was touched
Neck of shirt
Right wrist
Head of jacket



Buccal Swab

From HYPERLINK

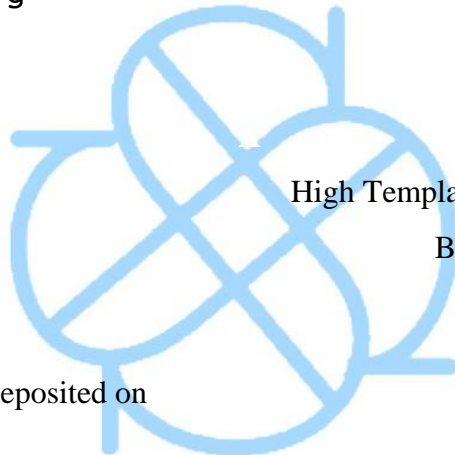
["https://dnacenter.com/blog/swabs-vs-blood-samples-dna-](https://dnacenter.com/blog/swabs-vs-blood-samples-dna-)

High Sensitivity Testing

- < 100 pg of DNA (16 cells)
 - 1 pg = 10^{-12} g
 - 1 Paperclip \approx 1 g
 - 1 Cell \approx 6 pg DNA

Sample Triage

- Low Template
 - Comprised Samples
 - Touched Objects
 - Skin (Epithelial Cells) Deposited on Samples
 - Handled Samples
 - Weapons, Tools, Wallet
 - Single Contact Samples
 - Window Sill, Door Knob



High Template

Body Fluids Rich in DNA

Blood
Semen
Saliva
Tissue
Bone

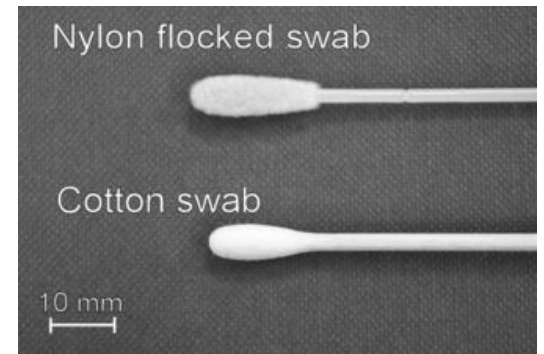
Weapons

- Guns: Handle, Trigger, Magazine, Bullet
- Baseball Bat
- Knife
- Screwdriver

- Metal Pipe
- Scissors

Swabs

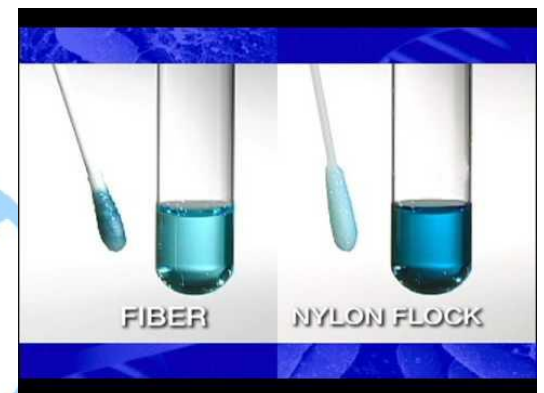
- Cotton: Sample stays entrapped in fiber want.
- Flocked: Sample is released quickly and in higher amounts.



Cotton vs Flocked Swab (Dry)

From [HYPERLINK](#)

["https://onlinelibrary.wiley.com/doi/abs/1](https://onlinelibrary.wiley.com/doi/abs/1)



Cotton vs Flocked Swab (Wet)

From [HYPERLINK](#)

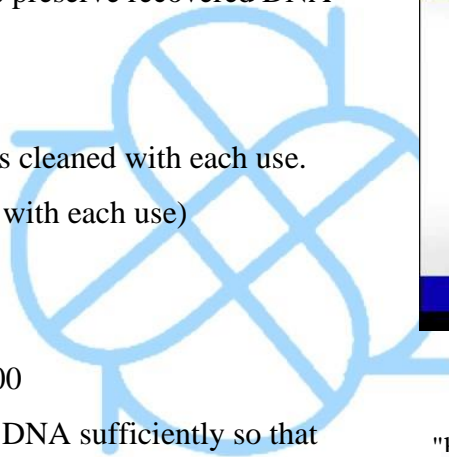
["https://www.youtube.com/watch?v=OCn](https://www.youtube.com/watch?v=OCn)

Focus Touch DNA Recovery Swab

- Neither has to be dried nor requires special storage.
- SIM Buffer Solution: Antimicrobial & Anti-bacterial
 - Preservative to protect & preserve recovered DNA

Cleaning

- Work surfaces & instruments cleaned with each use.
- Bleach solution (made fresh with each use)
- Water & 70% ethanol
- Air dry
- Irradiated in Stratalinker 2400
 - UV Irradiation degrades DNA sufficiently so that DNA testing is not feasible.
 - At OCME, all plastic-ware, instrumentation, swabs, water and many buffers.



UV Stratalinker 2400

From [HYPERLINK](#)

["https://www.artisanng.com/Scientific/532-74-1/Aoilent-Genomics-StrataGene-](https://www.artisanng.com/Scientific/532-74-1/Aoilent-Genomics-StrataGene-)

Swabbing for DNA Analysis

1. Moisten a clean, sterile swab with 3-4 drops of sterile water.
2. Swab area to be tested.
 - For revolvers/semi-automatic handguns: Grip, trigger, hammer

- For long guns: Buttstock, trigger areas, hand guard (forward grip)
3. Use different swabs for each area tested.

Preferred Post-Mortem Samples

1. Non-Clotted Blood
3. Red Muscle Tissue (Deep)
4. Bone (Compact)
5. Any Muscle Available
6. Any Bone Available

Preferred Reference Samples

Medical/Known Specimens
Family Members
Personal Item

Medical/Known Specimens

- Biopsy Samples (Paraffin Embedded Tissue)
- Blood (Bone Marrow Donor Program)
- Pap Smear Specimen
- Sperm Bank Samples
- Baby Teeth
- Dried Umbilical Cord

Family Reference Samples

Buccal Swabs from Parents, Children,

Siblings

At Least 2 Family Members

Preferred Family Members

Both Parents

All Children/Spouse

ALL FAMILY MEMBERS

Personal Items

- Issues: Item taken from where body was found such as an apartment.
 - Prone to mixtures.

NamUs.gov

- Launched in 2007 as Unidentified Decedent Reporting System.
- Missing persons component added in 2008.
- Two-way searches enabled in 2009.

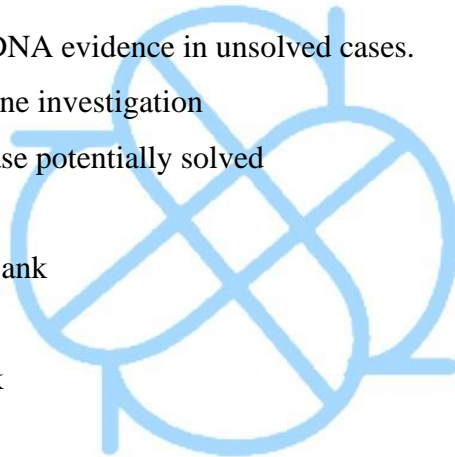
- Accessible to MEs, law enforcement, and the general public.
- Cases range from 1998 to present.
- Coordinate to ensure within agency dental, anthropology, DNA, metadata are all complete.

Exhumation From Potter's Field (NYC)

- Coordination with Department of Sanitation and Department of Corrections for ~30 unidentified human remains so far under 2009 NIJ award

Combined DNA Index System (CODIS)

- Collection of DNA profiles from convicted offenders.
- Three Houses: Convicted Felons, Unidentified Persons, Profiles Generated from Crime Scenes.
- Nationwide comparison of DNA evidence in unsolved cases.
 - Case to case hits: Combine investigation
 - Case to offender hits: Case potentially solved
- 171 labs in 48 states.
- NDIS: FBI National DNA Bank
- SDIS: State DNA Databank
- LDIS: Local DNA Databank

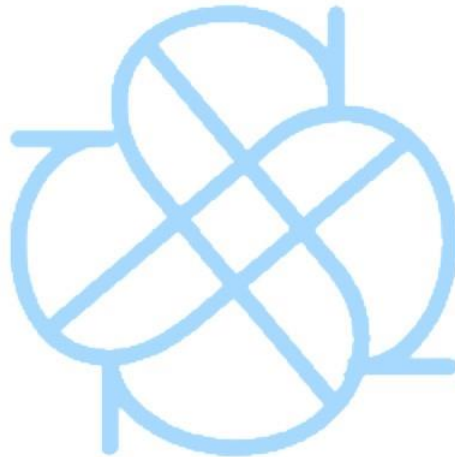


OJ Simpson - June 1994

- Nicole Brown Simpson & Ron Goldman found brutally murdered in OJ's house (CA).
- Flagship case for Forensic DNA (after it passed Frye hearings, it was established as accepted science).

6. Fingerprints





Fingerprints

Historical Facts

- 1883: Alphonse Bertillon: Anthropometry
- Chinese used to sign legal documents
- Indians used to sign contracts
- 1880: Henry Fauld: Ridge patterns could be used for identification

- 1901: Sir Edward Richard Henry (1897): Henry system of classification

General Facts

- Minutiae: Ridge characteristics
- Point by point comparison (8-16 points)
- 150 individual characteristics on each finger (average)
- 1973 International Association for Identification: No predetermined number of points required

Essential Principles

1. Formed during fetal life; remain unchanged
7. Fingerprints are unique
8. Can be classified systematically
 - Pattern of friction ridges
 - Present on fingers, palms, toes

Types

Latent, Visible, Plastic



Patterns

- Loop (1 Delta): Ulnar, Radial
- Whorl (2 Deltas): Plain, Central Pocket
Loop, Double Loop, Accidental
- Arch (0 Deltas): Plain, Tented

Different Fingerprint Patterns (Deltas Are Circled)
From HYPERLINK

"http://handlines.blogspot.com/2005/09/do-you-have-

Components

- Water, Salts, Oils, Amino Acids

Latent Fingerprint Locating Tools

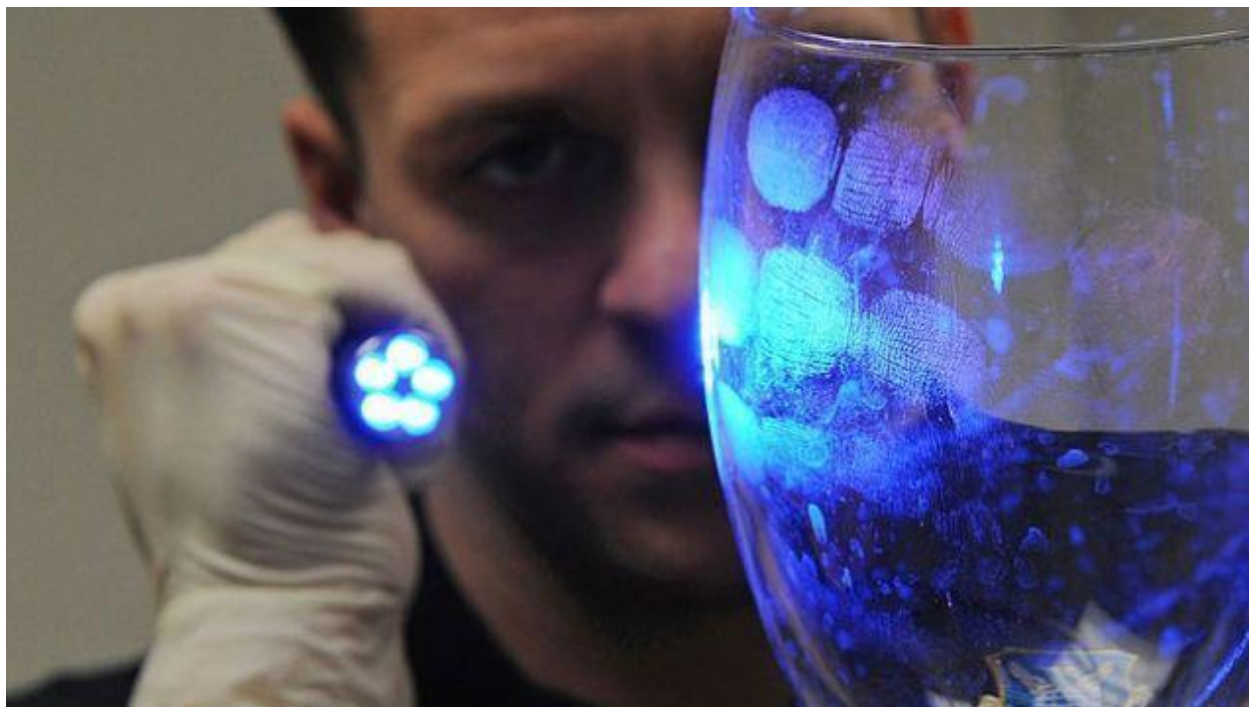
Powders, Chemicals, Alternate Light
Sources, Oblique Lighting

Ideal Surface

- Hard, Smooth, Non-Porous (e.g. Glass)

Latent Print Locations

- Walls, Tables, Windows, Cars, Tools, TV Remote, Guns, Knives, Destroyed Material, Items at Scene, Cell Phones, Bathrooms



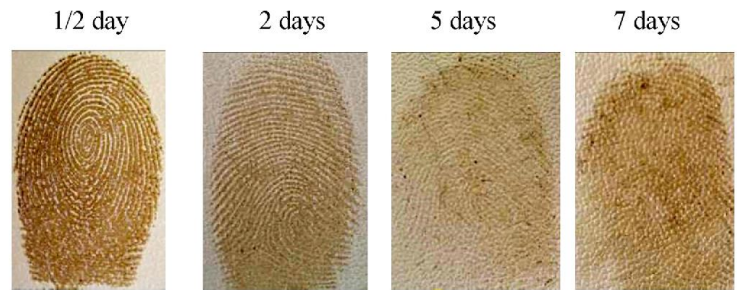
Latent Fingerprints on a Glass Shown by ALS
From [HYPERLINK "https://www.in-the-loop.net.au/quantum-mechanics-fingerprints-](https://www.in-the-loop.net.au/quantum-mechanics-fingerprints-)



Chemical Methods (Absorbent Surfaces)

Iodine Fuming

- Oldest Chemical Method
- Iodine: Solid Crystal; Sublimates
- Combines with Fatty Oils
- Possibly Combines with Residual Water
- **Rust** Color
- Fades Over Time



Iodine Fumed Print
From HYPERLINK

["https://www.semanticscholar.org/paper/The-effectiveness-and-practicality-of-using-%2526-for-A-Zheng-](https://www.semanticscholar.org/paper/The-effectiveness-and-practicality-of-using-%2526-for-A-Zheng-)

Ninhydrin

- Forms **Purple-Blue** Color
- Reacts with Amino Acids
- Sprayed onto Porous Surfaces
- Usually Mixed with Acetone
- Prints Appear Within 1-2 Hours
- Heat Speeds up Reaction
- Can Locate Prints up to 15 Years old



Ninhydrin Print
From HYPERLINK

["https://www.pinterest.com/pin/688417493015099493/](https://www.pinterest.com/pin/688417493015099493/)



Silver Nitrate Print
From HYPERLINK

["http://www.bvda.com/en/silver-](http://www.bvda.com/en/silver-)

Silver Nitrate

- Reacts with Salts
 - Chloride Ion; Forms Silver Chloride
- Prints Develop by Exposure to UV Light
 - Prints turn **Brown**



Super Glue Fumed Prints
From HYPERLINK
"<https://www.labconco.com/articles/ca-fuming->

Cyanoacrylate (Super Glue Fuming)

- Workers at Super Glue Factory found white fingerprints on the walls of the factory
- When heated it vaporizes; vapors adhere to fatty oils
- Prints are white and permanent

Lasers & Alternate Light Sources

- Cause objects to fluoresce when illuminated by lasers and viewed through barrier filters.
- Many times fluoresces off of perspiration.
- Prints can also be treated with chemicals to help them fluoresce.
- Quartz, Xenon monochromatic light sources.
- Portable

Adermatoglyphia

Rare genetic disorder where people are born without fingerprints.

Chemicals

- Leuco Crystal Violet (LCV): Blood
- Crystal Violet: Blood
- Amido Black: Blood
- Adhesive Side Developer: Tape
- Small Particle Reagent: Glass



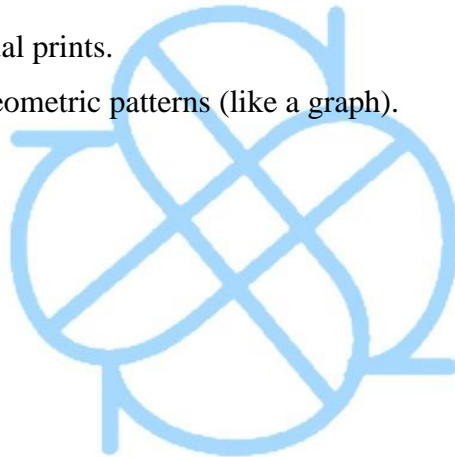
The Fingers of a Person with
Adermatoglyphia
From HYPERLINK
"<https://www.sciencemag.org/news/2011>

Scientific Reliability of Fingerprints

- Fingerprint examiners have not adopted a single standard for determining when a fragmentary latent fingerprint is sufficient to permit a comparison.
- Unique nature of fingerprints is counterintuitive to the establishment of such a standard.
- Through experience, each examiner develops a comfort level for deciding how much of a fragmentary print is necessary for comparison.

AFIS: Automatic Fingerprint Identification System

- Images are scanned and marked by a technician.
- Computer makes matches based on where points are plotted.
- Can do in 20 minutes what one detective looking at 1.7 million print cards would need 67 years.
- Look at a full set or individual prints.
- Creates digitally recorded geometric patterns (like a graph).



ACE-V

Analysis

- Condition of Skin, Type of Residue, Mechanics of Touch, Nature of Surface Touched, Development Technique, Capture Technique, Size of Latent Print, % of Surface Available.
- If the latent print does not have sufficient detail for either identification or exclusion, it does not undergo the remainder of the process and ends the examination.

Comparison

- Discerning, visually measuring and comparing the details that correspond.
- Shape, Anatomical Aspects, Ridge Flows and Counts, Core, Delta Location, Scars etc.

Evaluation

- Point by Point
- The agreement of the friction ridge formations in the two prints.
- The sufficiency of the detail present to establish an identification.

Verification

- Another qualified examiner repeats the observations and comes to the same conclusion.
- Confirmation Bias: Tendency to seek confirming rather than disconfirming evidence

Reporting of Results

- SWGFAST: 3 acceptable conclusions resulting from latent print comparison.
- Individualization: Latent was left by the same 'person of interest' who provided the known.
- Exclusion: Latent was left by another person other than the 'person of interest.'
- Inconclusive: Insufficient information in the latent or known print (or both) to conclude as to the source of the latent.

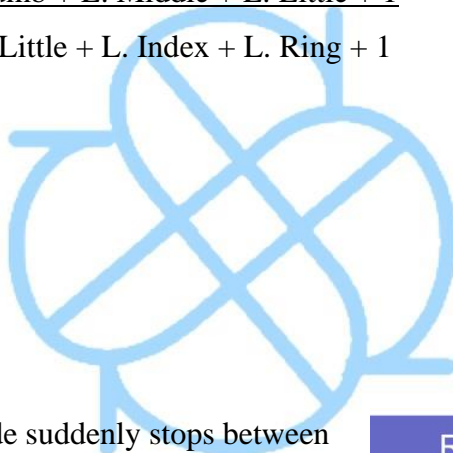
ACE-V does not specify particular measurements or a standard test protocol, and examiners must make subjective assessments.

Classification of Fingerprints

- Henry system: Scotland Yard 1901
- Converts ridge patterns on all 10 fingers into a series of numbers to form a fraction.
- Can only accommodate 10,000 files.
- FBI System

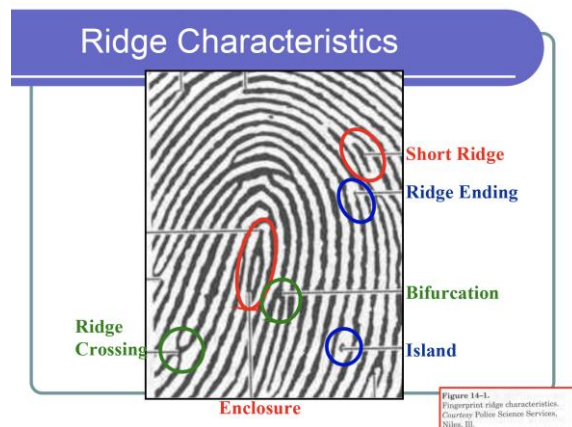
Primary Classification

- Part of the original Henry System.
- First step in the FBI System.
- Using this classification alone, all fingerprint cards in the world could be divided into 1024 groups.
- R. Index + R. Ring + L. Thumb + L. Middle + L. Little + 1
R. Thumb + R. Middle + R. Little + L. Index + L. Ring + 1
- 16 + 8 + 4 + 2 + 1 + 1
16 + 8 + 4 + 2 + 1 + 1
- Only Whorles Get Points



Ridge Characteristics

1. Ridge Endings: When a ridge suddenly stops between 2 other ridges.
 - AFIS automatically flags ridge endings.
2. Bifurcation: A split in the ridge (like Y)
3. Short Ridge: Short friction ridge with 2 ends between 2 other friction ridges.
4. Enclosure: 2 Bifurcations back to back.
 - Usually found towards the center of print.
5. Island: A dot between 2 ridges.
5. Ridge Crossing: 2 ridges cross over each other (like X).



7. Firearms Investigation



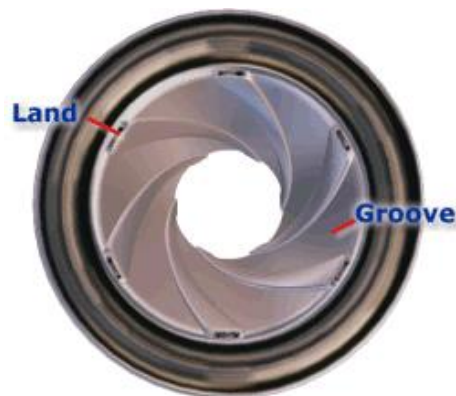
From HYPERLINK "<https://www.amazon.com/Pellet-Rifle-5-5mm-Caliber->



Firearms Investigation

Firearms Examiners Can:

- Match a bullet/casing to a gun.
 - Structural variations and irregularities caused by scratches; nicks and breaks.
- Determine:
 - Firing Distance
 - Angle of Shot
 - Caliber of Weapon
 - Operability of Weapon

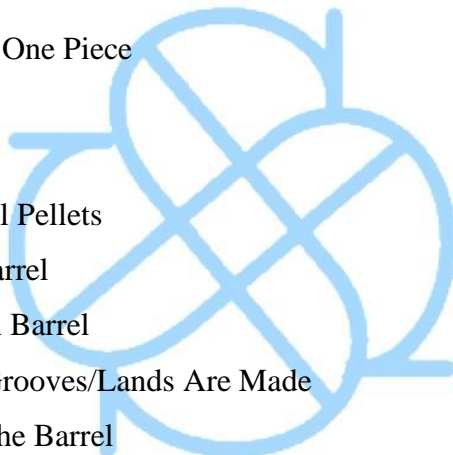


Rifling In A Barrel
From [HYPERLINK](#)

["http://www.firearmsid.com/A_bullet"](http://www.firearmsid.com/A_bullet)

Important Terms

- Pistol: Barrel & Chamber in One Piece
- Revolver: Rotating Cylinder
- Rifle: Long Gun
- Shotgun: Shoots Many Small Pellets
- Caliber: Diameter of Gun Barrel
- Gauge: Diameter of Shotgun Barrel
- Rifling: Process by Which Grooves/Lands Are Made
- Grooves: A Depression In The Barrel
- Lands: In Between Grooves
- Striations: Microscopic Scratches Left In Barrel From Drill
- Bullet: Expelled From Gun
- Casing: Loaded Into Chamber



Land (A) and Groove (B)
Impression on Bullet
From [HYPERLINK](#)

["https://slideplayer.com/slide/14071427/"](https://slideplayer.com/slide/14071427/)["https://slidepl](https://slidepl)

Marks On Bullet

- Lands & Grooves from the barrel will leave an impression on the fired bullet.
- Right or left handed

Integrated Ballistics Identification System (IBIS)

- Images of projectiles and cartridge casings recovered from crime scene or produced from evidence weapons are entered into the database and searched.
- Links multiple crimes to a single weapon.
- Potential hits are compared by an examiner on a comparison microscope.
 - Hits are not made by simply looking at the images in IBIS.

The Precise Distance From Which A Firearm Has Been Fired Can Be Determined By:

- Comparison of the powder residue pattern located on the victim's clothing or skin against test patterns made when the suspect weapon is fired at varying distances.

Wound Size

- Exit wounds are usually much larger than entrance wounds.
- Even without a bullet, entrance and exit wounds are easily identifiable.
- Exit wounds may not exist (meaning the bullet is still inside the body).

Abrasion Collar

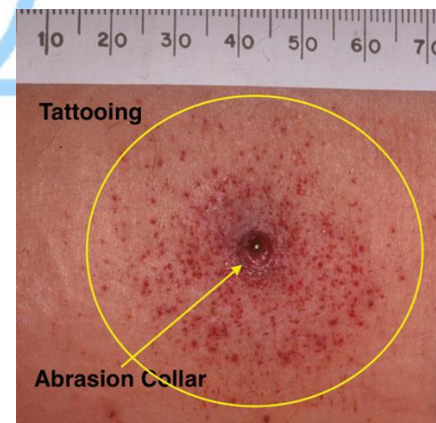
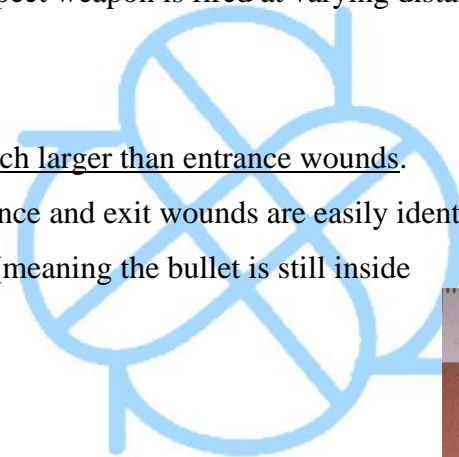
- Abraded area of tissue surrounding the entrance wound created by a bullet when it dents and passes through the skin.
- Varies with angle of impact.

Close Range Gunshot Wound

- Possible to have blood spatter and shooting on the hand of the person firing the weapon.

How a Gun Works

When you pull the trigger, the hammer hits the back of the cartridge, causing a small explosion. The burning gunpowder



From [HYPERLINK](https://aneskey.com/clinical-)
 "https://aneskey.com/clinical-

Kinetic Energy

$$KE = \frac{1}{2} mv^2$$

Primer Residue Left On Hand

- Powder Residue is left from the barrel of the gun and cylinder.
- Muzzle Flash: Flame from the end of the barrel.
- **Collection of Firearm Evidence**
- Rubber coated or taped tools
- Remove moldings (if necessary)
- Mark bullets only on nose or base
- Record serial numbers of guns
- Mark all moving & removable parts
- Unload loaded weapons
- Mark cylinder hammer position (revolvers)
- Do not clean
- Remove moisture by cleaning (note in record)
- If found in water, keep in water
- Box for transport
- All ammo of suspect should be seized.

Bullet Proof Vests

Kevlar: Very strong & light fabric.

Absorbs energy of bullet.

Primer

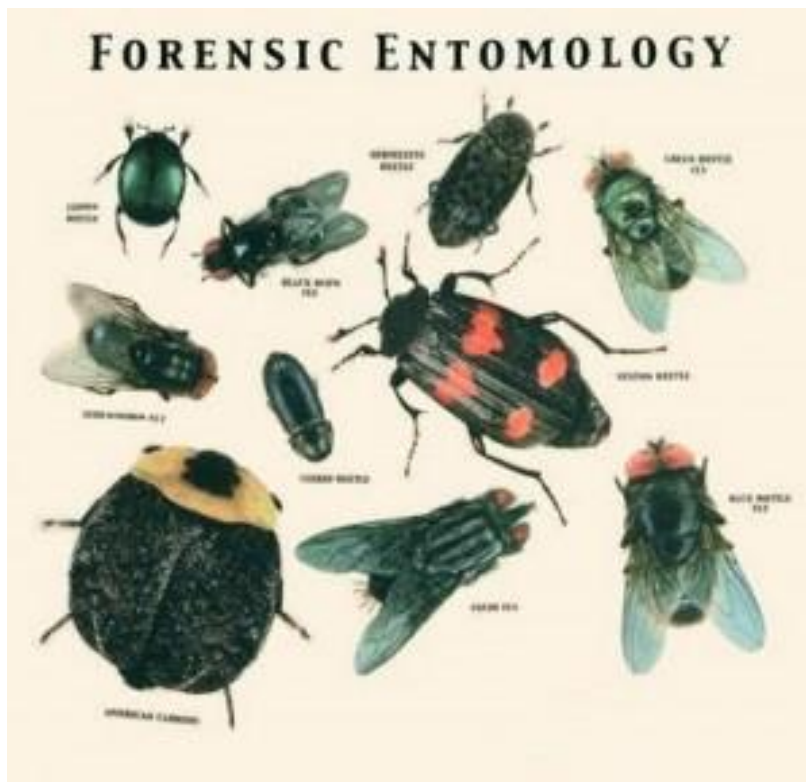
Chemical responsible for initiating combustion

Barium, Antimony, Lead

Handguns & Rifles

- Handguns fire bullets slightly lighter than rifles.
 - Shorter barrels with smaller explosive charges.
 - 700 to 1300 ft/s
- Rifles have longer barrels and greater charge
 - 1500 to 3000 ft/s

8. Forensic Entomology



From [HYPERLINK "https://www.crimemuseum.org/crime-library/forensic-investigation/forensic-](https://www.crimemuseum.org/crime-library/forensic-investigation/forensic-)

Forensic Entomology

Uses

- Determine TOD
- Identify a Suspect
- Locardian Transfers
- Locate Victim or Evidence
- Toxicology
- Create Crime Scene Timeline

History

“Discovered” 13th Century China.

Homicide by farmer’s sickle.

Lined up sickles and left them outside.

Flies went to the sickle that had blood on it.

Fly Facts

- One or two species find the body shortly after death (5 min - hours).
- Initial egg laying (oviposition) activity will attract other flies to deposit eggs.
- Oviposition frenzy.
- Different ages of eggs, larvae or puparia associated with a corpse.
- Oldest specimens provide maximum TOD; Youngest specimens provide minimum TOD.
- Flies neither fly nor lay eggs at night.
- Flies will become active after sunrise and only if the temperature is above 50°F.

Fresh Stage - Initial Decay (0 to 3 Days)

- 0 to 3 days post mortem.
- Body is not yet decayed.
- Appears fresh from outside.
- Autolysis is taking place inside.
- Bacteria break out of the intestine and start digesting the surrounding internal organs.
- The body’s own digestive enzymes (normally in the intestine) spread through the body.

Bloated - Putrefaction (4 to 10 Days)

- Bacteria break down tissues and cells, releasing fluids into body cavities.
- They often respire in the absence of oxygen (anaerobically) and produce various gases.
- The build up of gas creates pressure within the body causing bloating.
- Bloating forces fluids out of cells and blood vessels and into the body cavity (seepage)

Decay - Black Putrefaction (10 to 20 Days)

- The skin of the corpse breaks as the maggots feed allowing gases to escape and the corpse deflates.
- Strong distinctive odor of death.
- Maggots form large feeding masses inside and on the surface of the corpse.
- Insects have completed their larval development and depart the corpse to develop as pupae in the soil.
- Bloated body eventually collapses.
- Flesh has creamy consistency.
- Exposed parts of the body are black.
- Very strong smell of decay.
- Large volumes of fluids drain from the body and seep into surrounding soil.
 - Other insects and mites feed on this material.

Maggots

- Feed on body tissue.
- Secrete enzymes to slice through tissue.
- As numbers increase, they move through the body consuming all in its path.
- Once the larvae reach their final stage/instar, they crawl away from the corpse and bury themselves in dirt.
 - In a house they seek dark crevices (e.g. folds in bed sheets).
- Larval skins harden and shrink into pupae case.
- Adults emerge 6-14 days later.

Post Decay - Butyric Fermentation (20 to 50 Days)

- Flies and maggots are superseded by beetles. Body dries out.
- Increases number and diversity. Cheesy smell (butyric acid)
- Skin and cartilage are consumed. Attracts new organisms.
- Body reduced to bones, hair, and teeth. The surface of the body In contact with
- Remaining flesh is removed. the ground becomes covered in mold as the
- Most insects are absent. body ferments.

Dry Decay (50 to 365 Days)

- Only hair and bone remain.

The Common Blowfly

- Known as the common housefly.
- 3 developmental stages (instar).
- Attracted to the smell of death.
- Lay eggs in moist warm spaces.
- Temperature influences the rate at which larvae develop.

Common Blowfly Time Table

8-14 hours to hatch from time eggs are laid.

8-14 hours to complete first instar.

2-3 days to complete 2nd instar.

7-8 days to complete 3rd instar.

Total of 10-13 days between egg and pupae.

- Send chemical signals that attract other flies.

Faunal Regression

- Insect “parade”
- Carrion beetle
- Parasites that feed on body
- Other insects feed on parasites
- Lacks precision of “maggot reading”
- Moths circle the decayed and desiccated body
- Animals feed on corpse

Blow Fly Species

- Blue Bottle Fly (*Calliphora vicina*): Cooler parts of the year
- Green Bottle Fly (*Phaenicia sericata*): Warmest parts of the year
- Green Bottle Fly (*Lucila illustris*): Open, brightly lit habitats
- Black Blow Fly (*Phormia regina*): Shade

Blow Fly Eggs

- Small (2-3 mm), whitish yellow, somewhat elongate
- Warmer months: Packed into natural body openings
- Cooler months: Few, difficult to locate, more deeply recessed in cryptic locations
- Typically hatch within 1-3 days (depends on species and environmental conditions)
- Dissection of egg samples and analysis of the state of embryonic development can give the time since oviposition

Blow Fly Maggots

- 3 growth stages (instars) noted by mounts before becoming fully grown
- Typically large numbers of larvae hatch together and move around the corpse as a group

Cheese Skipper Fly

Arrives no later than 1 week post mortem.

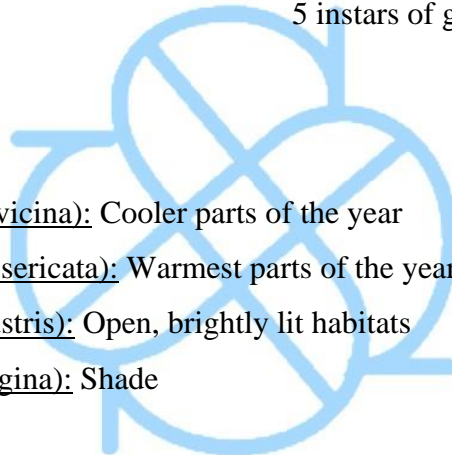
After 1 month, they pop off the corpse into the soil.

Cheese Skipper Larvae mean < 34 days.

Soldier Flies

Show up after about 20 days.

5 instars of growth.



- Disseminate bacteria and secrete enzymes - enables them to consume nearly all soft tissue of the corpse



Blowfly Maggots
From HYPERLINK

Investigators Must:

- Get local temperature readings.
- Ground surface temperature readings.
- Temperature of the Maggot Mass.
- Indoors will add 48-72 hours to TOD.

Collection of Insect Evidence

- Collect both alive and preserved specimens.
- Don't mix different species.
- Freeze insects used for toxicological analysis.
- Put live specimens in a breathable container.
 - Liver as food substance.
- Place dead specimens in ethyl alcohol for preservation.
- Ship immediately to lab.
- Provide date, time, and location.



Cheese Skipper Fly
From ~~HYPERLINK~~ Blowfly
From ~~HYPERLINK~~ fl
"https://en.wikipedia.org/wiki/Cheese_fl"
"https://www.rotter.com/pests/profile/b

Neal Haskell, Ph.D.

- Degrees:
 - Doctorate, Forensic Entomology
 - Master of Science, Forensic Entomology
 - Bachelor of Science, Entomology
- Saint Joseph's College & Purdue University

Dr. William Bass

- Forensic Anthropologist
- The Body Farm
- Research to determine how bodies decay in different situations.
- Entomology research



Black Soldier Fly
From HYPERLINK

["https://www.pinterest.com/pin/483151"](https://www.pinterest.com/pin/483151)

9. Bloodstain Pattern Analysis



From HYPERLINK ["https://www.pbs.org/wgbh/nova/article/forensics-bloodstain-pattern-](https://www.pbs.org/wgbh/nova/article/forensics-bloodstain-pattern-)

Bloodstain Pattern Analysis

Is It Blood?

- Not always an easy determination.
 - Stains on clothing: Presumptive & confirmatory testing
 - Stains not visible: Luminol & blue star
- Is it human blood?

Blood Spatter May Reveal...

- Origin
- Distance of bloodstain from target
- Direction from which blood impacted
- Velocity
- Position of victim vs suspect

Drop Shape & Target Surface

Smooth Surface: Spreads out smoothly.

Irregular Surface: Surface tension of spreading edge is broken.

- Number of blows/shots

Liquid Blood

- Physical Properties
 - Viscosity
 - Surface Tension
 - About the same as water
- Behaves as a Projectile in Motion
 - Gravity as only force: Falls vertically
 - Gravity and another force: Falls vertically and horizontally

General Features

- Direction, Angle, Surface Tension, Origin, Movement, Number of Strikes

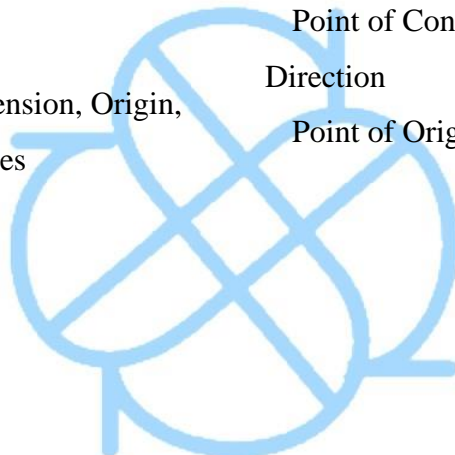
Dripping Blood

Gravity is the only force acting.
 Blood drop grows until it can't anymore
 Single drop breaks free (tear drop shape)
 Surface tension pulls in vertically & horizontally
 Shape settles into sphere (0.5 mL)

Tracing Origin of Bloodspots

Point of Convergence: 2D, Shows Direction

Point of Origin: 3D, Includes Height



Dripping Pattern

- Free-falling drops dripping into wet blood
- Falling from a stationary object
- Large irregular central stain
- Small round & oval satellite stains

Splash Pattern

- Volume > 1 mL
 - Subjected to LV impact
 - Thrown
 - Tipped
- Large central irregular area surrounded by elongated peripheral spatter pattern.



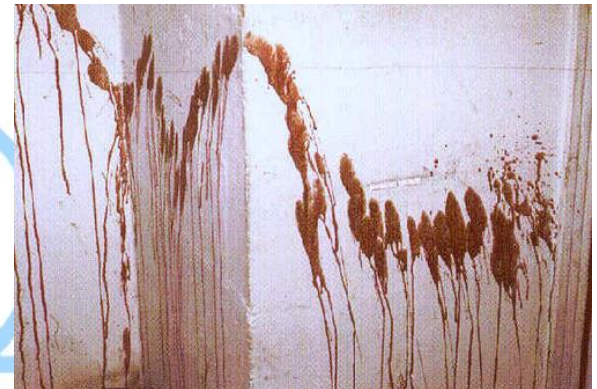
Splash Pattern

From [HYPERLINK](#)

<https://physicsworld.com/a/the-physics-of-blood-splatter/><https://physicsworld.com/a/the-physics-of-blood-splatter/>

Arterial Spurt Pattern

- Blood exiting the body under arterial pressure (120 mm Hg); corresponds to heart beating.
- Large stains with downward flow on vertical surfaces; air bubbles present if the lung was punctured.
- Creates a wave-like appearance.



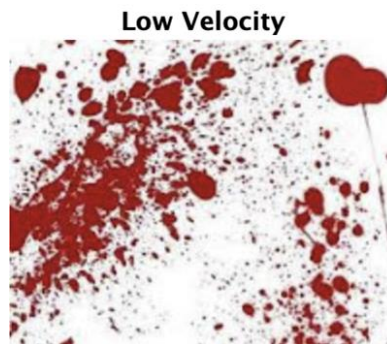
Arterial Spurt Patter

From [HYPERLINK](#)

<https://quizlet.com/193575042/unit-6-blood-splatter-flashcards/><https://quizlet.com/193575042/unit-6-blood-splatter-flashcards/> Card 1

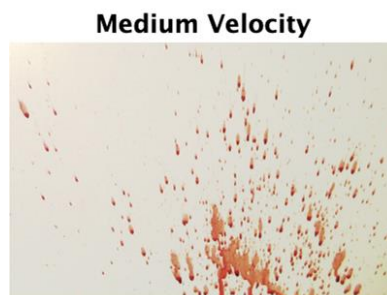
Low Velocity Blood Spatter

- < 5 ft/s, 1.5 m/s, 3.5 mph
- Spot diameter: Mostly 4-8 mm
- Free falling drops
- Cast off from fist, weapon, etc.
- Dripping (blood droplets into themselves)
- Splashing (stepping, throwing)
- Arterial spurting



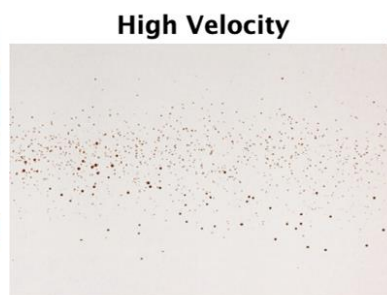
Medium Velocity Blood Spatter

- 25-100 ft/s, 7.5-30 m/s, 17-68 mph
- Spot diameter: Mostly 1-4 mm
- Blows with weapon (e.g. baseball bat)



High Velocity Blood Spatter

- > 100 ft/s, 30 m/s, 68 mph
- Fine mist: Spot size < .1 mm
- Small mass limits spread to 1 m
- Some larger droplets reach further
- Gunshot: Both back & forward spatter
- High speed machinery



Other Patterns

- Bloodstain patterns that have been altered (objects, gravity, etc.)
- Includes wipe, swipe, transfer, and flow patterns

From [HYPERLINK](https://sites.google.com/site/bloodspatteranalysisforensics/bloodstain-pattern-)
["https://sites.google.com/site/bloodspatteranalysisforensics/bloodstain-pattern-](https://sites.google.com/site/bloodspatteranalysisforensics/bloodstain-pattern-)

Transfer Patterns

- Wet, bloodied object contacts a secondary surface
- Transfer from: Hand, fingers, shoes, weapons, hair
- Transfer to: Walls, ceilings, clothing, bedding
- Produces mirror-image of bloodied object

Flow Patterns

- Blood flows horizontally & vertically
- Altered by contours, obstacles
- Often ends in pool



Transfer Pattern
From [HYPERLINK](https://sites.google.com/site/crimesceneanalysis/blood-5-)
"<https://sites.google.com/site/crimesceneanalysis/blood-5->



Flow Pattern
From [HYPERLINK](https://www.medicaldaily.com/how-does-bloodstain-pattern-analysis-actually-work-heres-what-dexter-was-)
"<https://www.medicaldaily.com/how-does-bloodstain-pattern-analysis-actually-work-heres-what-dexter-was->

10. Impression Evidence



From [HYPERLINK "https://coronertalk.com/tool-impression-evidence"](https://coronertalk.com/tool-impression-evidence)<https://coronertalk.com/tool->

Impression Evidence

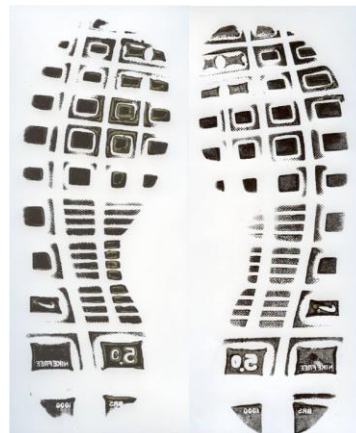
- Objects or materials that have retained the characteristics of other objects or materials through direct physical contact.

Types of Impression Evidence

- Shoe prints, Tire tracks, Toolmarks, Fabric impressions, Weapon impressions.

Recognition & Detection

- Based on other evidence at the scene, determine most likely places for impressions.
- Use oblique lighting & ALS to visualize impressions.
- Use electrostatic lifting techniques to detect & lift latent impressions (after scene documentation).



Inked Shoe Prints
From [HYPERLINK](https://commons.wikimedia.org/wiki/File:Test_impressions_known.jpg)
["https://commons.wikimedia.org/wiki/File:Test_impressions_known.jpg"](https://commons.wikimedia.org/wiki/File:Test_impressions_known.jpg)
<https://commons.wikimedia.org/wiki/>

Terminology

- 2-D Impressions: Have length & width, but no depth
 - Positive Impressions: Residue visually represents the areas of the sole that came in contact with the surface.
 - Negative Impressions: Contact areas of the sole remove residue from a surface.
- 3-D Impressions: Have length, width & depth.
- Dry Origin Impressions: Shoe & substrate are dry when impression is made.

- Wet Origin Impressions: Shoe and/or substrate are wet when impression is made.



2D Positive Impression
From HYPERLINK
"<https://aboutforensics.co.uk/impression->



3D Impression

Documentation

- Notes, Sketches, General crime scene photography, examination quality photography.

Enhancement & Collection

- Electrostatic lifting techniques, Adhesive lifting, Blood, Dust, Soil enhancements, Powdering, Casting techniques

Making Test Impressions

- Ink on paper
- Powder dusting and adhesive lifting
- Identicator
- Transparencies: Photocopy test impression or actual tread pattern

Class Characteristics

- Characteristics that are shared by at least one other item.
- Many are part of the manufacturing process: Size, spacing, tread design, etc.

Individualizing Characteristics

- Characteristics that are unique and random.



Dental Stone Casted Shoe
Print
From HYPERLINK
"<https://dps.mn.gov/division/s/bca/bca-divisions/forensic-science/Pages/forensic->

- Can establish a link between a questioned impression and one object.

Wear Characteristics

- Changes in the surface of an object due to the erosion of portions of the surface.
- Not individualizing, since it is possible for two or more people to wear out the sole in a similar manner.

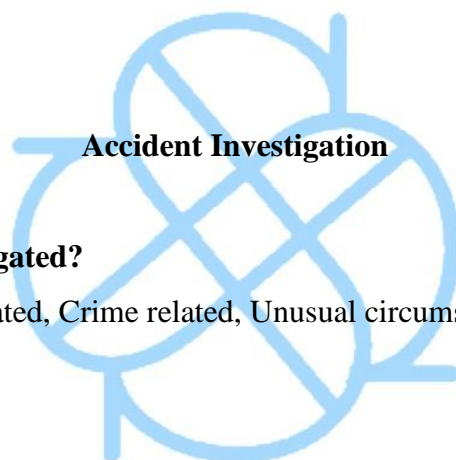
Casting Materials

- Dental Stone: Bulk, Premixed with Water

11. Accident Investigation



From [HYPERLINK "https://pittsburgh.cbslocal.com/2019/08/05/route-8-accident-north-pioneer-](https://pittsburgh.cbslocal.com/2019/08/05/route-8-accident-north-pioneer-)



Accident Investigation

When is an Accident Investigated?

- Fatality, Injury, Alcohol related, Crime related, Unusual circumstances, Large amounts of damage.

Required Skills

- Math, Physics, Common Sense, Analytical Skills, Experience

Basic Concepts

- An object in motion will stay in motion unless acted upon by an outside force.
- The faster you are traveling, the longer it will take to stop.
- Alcohol slows down reaction time.
- Slick roads reduce the coefficient of friction.
- Driving a motorcycle into a car hurts.

Mph to F/S

Determining Vehicle Speed

Skid marks, Damage to car & surrounding area, Injuries, debris trail, Speedometer “pinning.”

- 30 mph = 44 f/s
- 60 mph = 88 f/s
- 100 mph = 146 f/s

Reaction Time

F = Drag Factor for Road Surface

N = Braking Efficiency (%)

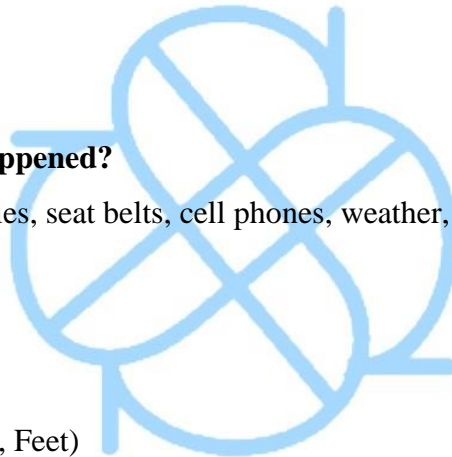
- The average person takes $\frac{3}{4}$ second to react in an emergency.
- This means if you are going...
 - 30 mph, you will travel 33 feet before you hit the brakes.
 - 60 mph, you will travel 66 feet before you hit the brakes.
 - 100 mph, you will travel 109 feet before you hit the brakes.

How Do We Know What Happened?

- Location of vehicle(s), injuries, seat belts, cell phones, weather, driver & witness accounts.

$$S = \sqrt{(30DFN)}$$

- S = Speed (mph)
- D = Skid Distance (Decimal, Feet)



Brakes

- Each wheel on a car provides a certain amount of the total brake force available.
- If all 4 wheels are braking evenly, leaving 4 distinct skid marks, braking efficiency is 100%.
- If the Rear brakes are not functioning at all, then 40% of the brake force is not available.
- For rear wheel drive cars, the brake force can be assumed to be 30% for each of the front wheels and 20% for each of the rear wheels.

Air Bag & Black Box Crash Data Available (Depending on Year & Model)

1. Vehicle Speed (in 5 1-second intervals preceding the impact)
2. Engine Speed (in 5 1-second intervals preceding the impact)

3. Brake Status (in 5 1-second intervals preceding the impact)
4. Throttle Position (in 5 1-second intervals preceding the impact)
5. Driver Seat Belt State (on/off)
6. Passenger Airbag State (on/off)
7. Airbag Warning Lamp Status (on/off)
8. Time from Vehicle Impact to Airbag Deployment
9. Maximum Delta-V (DV) for Near-Deployment Event
10. DV vs Time for Frontal Airbag Deployment Event
11. Time from Vehicle Impact to Time of Maximum DV
12. Time Between Near-Deploy and Deploy Event (if within 5 seconds)

Additional Crash Data (2006 & Newer GM Vehicles)

1. Low Tire Pressure Warning System Status
2. Traction Control Status
3. Anti Lock Brake Status
4. Transmission Range
5. Service Engine Lamp Status
6. Vehicle Door 2/4 Status (Open/Closed)
7. Outside Air Temperature (°F)
8. Passenger Seat Belt Switch
9. Yaw Rate
10. Lateral Acceleration
11. Steering Wheel Angle
12. Principle Direction of Force Degrees (PDOF)



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